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## PART II.

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### HISTORY OF ORGANS BELONGING TO THE VEGETATIVE SPHERE.



§. 432. **T**HE reasons (§. 49.) which appeared to justify us, when treating of the superior animal structures, in separating them into two series of formations, do not operate to the same extent as regards the organs of the Vegetative Sphere; for though in the higher species of animals there is no want of distinct gradation in the vascular system, the characteristic member of this sphere, yet, it is not such as to establish a difference between inferior and superior species equally decided with that dependent on the appearance of a Spinal Marrow, Brain, and Skeleton: nay, the perfection of even the human frame is here less absolutely recognizable; and consequently, nothing hinders that we should trace the developement of the Systems belonging to this Sphere in a continuous series from the Polype to Man.

As I conceive that in the Introduction (§. 17. 18.) I have established the necessity of distinguishing between individual reproduction and generation, we shall here first treat

of the Systems subservient to the uniform continuance of the change of materials in the individual Organism, viz. the Digestive, Circulatory, Respiratory, and Secretory Organs;—and subsequently, of the organs engaged in the generation of new individuals; concluding with the exposition of whatever is most important in the organization and different stages of development of the latter.

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## BOOK I.

### HISTORY OF THE ORGANS SUBSERVIENT TO INDIVIDUAL REPRODUCTION.

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#### CHAP. I. *Organs of Digestion.*

#### I. IN ANIMALS WITHOUT SPINAL MARROW AND BRAIN.

##### SECTION I. *Zoophytes.*

§. 433. The name alone of this Class sufficiently expresses the fact that the organs of the Vegetative are more developed than those of the Animal Sphere; of which a closer examination will still farther convince us, especially if a comparison be made with what has been already (§. 51; &c.) said of the organs here belonging to the animal

Sphere. But the organization for the functions even of this Sphere is extremely simple, nutritive matter being introduced in general by mere imbibition, the more complicated organization for the intus-susception of extraneous matter (organs for biting and masticating) being the product of a more advanced formation. The Infusory Animalcules, consisting merely of little living animal cellules, appear to absorb their materials of nutrition through the parietes of the body, without any mouth. To these nearly approximate the Medusa-like animals (Berenice, Rhizostoma, &c.), which sometimes absorb their nutriment without a mouth, at others by numerous apertures. In the true Medusæ, on the contrary, there is a single aperture for suction (Tab. I. fig. IX. A. a.) on the inferior surface of the body, the cavity of which in the Medusa *aurita* leads by four apertures into a like number of sacs or stomachs excavated in the gelatinous substance of the body, which, in a manner almost inconceivable, are capable of digesting very hard bodies, *e. g.* small prickly Fishes.\* The mouth and stomach are equally simple in the Wheel-animals, (*Furcularia rotatoria*,) Polypes, (Tab. I. fig. II. IV. B. VIII. C. a.) and the inhabitants of Corals and Sponges, where, as the Intestine of several individuals frequently communicates, (*e. g.* in the animal of the Pennatula, Sea-feather,) the whole in fact form but a single animal in the manner of the Rhizostoma. In the Actiniæ, the mouth, surrounded by numerous Tentacula, opens into a blind sac or stomach perfectly distinct from the mass of the body, and which empties itself by rejecting its contents, so that one aperture combines the two offices of mouth and anus. (Tab. I. fig. X. A. d.)†

\* Gæde *Beiträge zur Anat. und Phys. der Meduser*, s. 16.

† In the Medusæ, the Stomach occupies the base of the pedicle of the animal: from it a series of tubes radiate towards the superior hemispherical

§. 434. In the Echinodermata, which are already somewhat removed from this Class by the commencement of a Nervous System, the intestinal canal frequently presents a more perfect organization. In the Asteriæ, indeed, as in the Actiniæ, it still consists of a simple blind sac, which can be protruded through the single opening,\* in many instances beset by five little teeth, so as to seize fish, shells, &c. the indigestible parts of which are subsequently rejected. Here, as in nearly all the inferior genera, the creature lives on animal food. In the Holothuriæ, the mouth, according to CUVIER, is surrounded by a circle consisting of six bones, which, however, are not to be considered as organs of mastication: besides this, there is also another circle of numerous blind sacs around the mouth, which

part of the body, communicating by lateral branches, and forming a complicated network, by means of which nutriment is conveyed directly to every part of the body: near the surface these vessels are particularly numerous and form an absolute lace-work. In some species of Medusæ there is but a single large mouth: in others, on the contrary, instead of a mouth there is a number of tufted tentacles, on each of which is the orifice of a little canal uniting with those in its vicinity, so as ultimately to form four large trunks leading to the stomach, and conveying thither the fluids collected by the little orifices of the tentacles, of which there are sometimes upwards of eight hundred. Of the animals thus characterised, M. CUVIER has formed the Genus Rhizostoma, remarking that they appear to be nourished by a kind of root, and that in them, as well as in the other Medusæ, the stomach to a certain extent supplies the place of the Heart.

In the Veretilla (*Pennatula cynomorium*), the body of each Polype presents a little brownish stomach from which proceed five tubes, performing (as in the Medusæ) at once the office of Intestines and Vessels. These Intestines are at first yellowish and undulated, but having reached two-thirds of the way through the animal, they become straight and smaller, and then entering the common stalk to which the Polypes are attached, diverge in order to meet the corresponding vessels, and to form with them a net-work within the trunk. (CUVIER. *Comp. Anat.* iv. 145.)—Translator.

\* TIEDEMANN in MECKEL'S *Archiv.* b. i. h. 2.

appear to be salivary vessels. The intestine is tolerably uniform in size; forms three turns; and is supported by a kind of mesentery: according to OKEN,\* it usually contains a black earthy excrement, and opens by means of an anus into the respiratory cavity. In the Echini, the organs of mastication are peculiarly developed, the aperture in the shell corresponding to the mouth, having adapted to it a very remarkable frame-work with five converging portions (Aristotle's Lantern), where each portion (a kind of jaw) contains a long tooth moved by several muscles. (Tab. I. fig. XIII.) In the large English Sea Hedge-hog, according to HOME, a narrow Oesophagus extends from the mouth to the stomach, from which again proceeds an intestine forming two turns: here the intestine terminates in an anus opposite to the mouth, but in other instances, at one side; it is also confined within the globular shell by peculiar vessels and membranes (a Mesentery). (Tab. I. fig. XII.)†

\* *Zoologie*, b. i. s. 331.

† In the Sipunculi the alimentary canal is small and uniform in its first part, running from one extremity of the body to the other: it then returns, making spiral convolutions around this first straight portion, and terminates by a lateral anus very near the mouth being altogether 6 or 8 times the length of the body. In the Asterias, the membranous sac or stomach situated in the centre of the body has two caeca, corresponding to each branch of the body, and subdividing into numerous minute ramifications supported by membranous mesenteries. (CUVIER, *Anat. Comp.* iv. 144.)

—Translator.

SECTION II. *Mollusca.*

## A. ACEPHALA.

§. 435. Even here the mouth is still nothing more than a sucking aperture, without jaws, tongue, or teeth: in the *Teredo*, however, the deficiency of teeth is supplied by some small detached pieces of shell (Tab. II. fig. XV. a. a.); that of lips by small gill-like laminae about the mouth in the *Bivalves* (fig. VII. b. b.); and lastly, that of the tongue by the tentacula about the mouth (§. 98.) in the *Balani*, and in *Oysters*, &c. by transverse folds of the *Pharynx*. The organization of the alimentary canal in other points is very varied. In the *Ascidia*, the short tube of the mouth terminates by a valvular opening in a large but delicate membranous sac, (Tab. II. fig. II. a. d.) which in some respects appears to be a kind of crop, and in others a respiratory cavity. At the lower part of it is the commencement of the *oesophagus* which leads to the stomach, and then the intestine. The convolutions of the latter are placed between the *Gill-bag* and the general muscular sac or *Cloak* (§. 125.), and are either wholly unattached, or, as was the case in a large species examined by myself, buried in the substance of the liver. The *Rectum* terminates unattached opposite to the second aperture of the body, (fig. III. II.)

§. 436. According to HOME,\* the intestinal canal in the *Teredo*, presents some important peculiarities: from the mouth a narrow and not very long *oesophagus* extends

\* *Philosoph. Trans.* 1806. p. 283.

downwards into the worm-shaped body, and there expands into a cylindrical stomach, of considerable length, which is divided by a vertical partition into two cavities, communicating with each other inferiorly, and, according to the examination of HATCHETT, in those species which bore into wood contains a fine ligneous powder. The stomach terminates in a long and narrow intestine, which first descends, then ascends, runs over the double-bellied muscle of the boring shells, then stretches along the respiratory organs for the whole length of the body, and terminates at its posterior part in the shortest of the two tubes found there. (Tab. II. fig. XIV.)

§. 437. In the Bivalves, *e. g.* the Fresh-water Muscle, (*Unio pictorum*,) the œsophagus is very short, but tolerably wide; the stomach and convolutions of the intestine are placed in the Foot, as it is called: (fig. IX. A. IX. B.) the former, like that of the Medusa, (§. 433.) is scarcely formed by any distinct membrane, but is excavated in the substance of the liver, and presents several tolerably large openings of biliary ducts. The intestine makes five turns in the Foot amidst the ovary, and then as Rectum runs posteriorly along the back of the animal beneath the hinge and above the respiratory organs, passing through the midst of the heart, and opening above the posterior muscle closing the shells, beneath the small tube (§. 125.) of the Cloak. (Fig. XI. s.) This description applies generally to most Bivalves: in the Oyster, however, the Rectum does not pass through the heart: in the Pholas, &c. there is externally, at the commencement of the intestinal canal, a singular cartilaginous style, the point of which passes through the side of the intestine, and a peculiar septum belonging to it. It is probably analogous to the teeth of the Echini, (§. 434.) or may, perhaps, be connected with the sexual functions.

B. GASTEROPODA.

§. 438. The mode of taking in nutritive matter is much farther perfected in this than in the preceding Order, the organs for the purpose not being merely an apparatus for suction, but including also organs of mastication and of perfect deglutition. These organs approach most closely to the apparatus for suction of the inferior species in those animals of this Order which are provided with proboscides, —as Buccinum, Murex, Voluta. The proboscis of the Buccinum undatum has been particularly examined by CUVIER:\* like the tentacula of Snails, (§. 98. 110.) it has the power of elongating itself by circular fibres, and is retracted by longitudinal ones; its cavity is partly occupied by the aperture of the œsophagus, (Tab. III. fig. IX. g.) and partly by a tongue (fig. IX. h.) beset with hooks or teeth. In the Snails which have not a proboscis, e. g. Helix, Limax, Aplysia, the mouth is provided with broad lips; and internally there is either a kind of horny upper jaw with several tooth-like projections, as in the Helix pomatia and in Slugs (Tab. III. fig. VI.); or else a similar jaw on each side of the mouth, as in the Tritonia, on the authority of CUVIER. The tongue noticed in the Buccinum here also exists, presenting itself as a small elevation on the floor of the mouth behind the jaws, and furnished with minute prickles. The cavity of the mouth itself, into which open salivary ducts, to be hereafter noticed, is usually very fleshy, and forms a round pharynx, moved by several muscles. (Tab. III. fig. VII. a. fig. X. XI. p.)

\* Annales du Muséum d'Hist. Nat. t. xi. p. 447.

§. 439. The course of the intestinal canal is extremely various in the different genera of this Order. It is sometimes more simple, at others more complicated, but always composed of distinct coats, and, together with the other abdominal viscera, lies either in the general muscular sac, (§. 131.) *e. g.* in the Slug and *Aplysia*, (Tab. III. fig. VII.) or external to it within the shell, (§. 132.) covered by the peritoneum like a hernial sac, *e. g.* in the Snails. (Tab. III. fig. I. II. X. XI.) There is no true mesentery. It is remarkable that here also it is usual to find the Rectum in immediate juxta-position with the respiratory organs. (See §. 434, 436, 437.) The *Helix pomatia* and the *Slug*, as minutely described by SWAMMERDAM, afford instances of the more simple formation of the alimentary canal. In the former the œsophagus descends through the nervous circle of the neck, (Tab. III. fig. III. *e.*) and then expands into a membranous stomach, divided into two parts by a slight depression, (*l. b.*) and receiving the bile into its posterior extremity (*b.*); the intestine then commences, which makes a turn upon the liver, (fig. II. *q. r.*) and running as Rectum close to the Gill-sac, (fig. III. *b. c.*) terminates at the edge of the respiratory aperture. (Fig. I. *f.*) The same description applies in all essential points to the Slugs and several nearly related species. In the *Helix stagnalis*, however, the stomach differs so far from the form here described, as it is much smaller, and is provided with extraordinarily thick fleshy sides. I have not myself been able to detect the crop described by CUVIER as being connected with the œsophagus in these animals.\*

\* In the *Onchidium* the first stomach is a true Gizzard, very like that of Birds, perforated at its commencement by two hepatic ducts, and lined by a membrane of cartilaginous consistence: the second stomach is funnel shaped, and furnished with deep longitudinal grooves, and corresponding ridges projecting at their upper part in such a manner as must very much retard the

§. 440. The stomach of the *Aplysia* is peculiarly remarkable, as well for the great increase in the complicity of its structure, as for the manner in which it is armed internally; in which latter respect it appears to present a further development of the style found in Bivalves. (§. 437.) According to CUVIER, the narrow œsophagus running through the nervous circle of the neck (Tab. III. fig. VII. d.) expands into a spacious and delicately membranous Crop, (g. g.) convoluted in a half spiral shape (something similar to which we have already noticed in the *Ascidia*, §. 435); it then terminates in a narrow but very muscular stomach, (h.) which is furnished on its internal surface with rhomboidal semi-cartilaginous laminae, (fig. VIII. b.) that appear to act like grinding teeth. The third stomach (i.) is pretty similar to the preceding one, and is also armed on its internal surface with hook-shaped teeth (fig. VIII. c.) directed forwards: it contracts at its posterior part in order to form the commencement of the intestine: at which point open into it the biliary canals, (fig. VIII. f.) together with a peculiar cœcum, (e.) which here, as well as in several other genera, appears to form the prototype of the Pancreas, in the same manner as the blind

passage of food from the Gizzard: the third stomach is short, cylindrical, and disposed in folds, less deeply, however, than the second. In the *Pleurobranchis* the *Œsophagus* dilates into a membranous crop, at the lower part of which the bile is poured in. It communicates by a narrow cardia with the second stomach, which is a Gizzard with thin but muscular parietes. The third stomach is membranous, and precisely resembles the plicated stomach of Ruminants in being disposed in large but delicate folds, by means of which the alimentary matter confined in it is moulded into long whitish cords. The fourth stomach is membranous like the crop, but smaller. It is remarkable that the Gizzard contains a narrow groove running through its whole length, leading from the first to the fourth stomach, and probably subservient to a species of Ruminations. (CUVIER, *Anat. Comp.* iv. 118.)—*Translatio.*

sac at the mouth of the Holothuriæ (§. 434.) does of the salivary organs. The subsequent course of the intestine has nothing very remarkable, making some turns on the liver (fig. VII. k.) as in Slugs, and ending in the Rectum, (l.) which opens into the anus (m.) close to the Gills. (v. w.) According to CUVIER, the stomach in the Genus *Bulla* is most powerfully armed; for though the rest of the intestinal canal pretty closely corresponds with that of the *Aplysia*, the laminæ of the second stomach of the latter are here found extraordinarily enlarged, and converted into true calcareous shells. These were long considered as actual shells, and distinguished as a new species (*Tricla*). It is singular to find in this instance the internal surface of the intestine with the same power of secreting calcareous matter as the external surface of the body (§. 121-24.); in the same manner that lime is deposited by Zoophytes, sometimes internally, at others externally. These laminæ are here three in number, nearly of this shape  $\square \nabla D$ ; and as they are connected together by strong muscular fibres, must possess considerable power as stomacal jaws or grinding teeth.

### C. CEPHALOPODA.

§. 441. In the *Sepiæ*, and particularly in the *S. octopodia*, there is, as in most Snails, a thick fleshy pharynx, (Tab. IV. fig. II. a.) which, in proportion to the bulk of the animal, is here of considerable size. It lies in and in front of the ring-shaped cartilage of the head; and externally (not internally, as in the preceding Order) is armed with two powerful horny jaws, of the shape of a parrot's bill, but not articulated to the cartilage of the head. This

beak, consisting of a superior and inferior portions, (Tab. IV. fig. X. a. b.) is possessed of considerable muscular power, and is surrounded by a fleshy funnel or-lip, as well as by the circle of arms. (§. 135, 136.) The mouth contains a small cartilaginous tongue, which, as in the preceding Order, has but little motion: the salivary ducts also discharge themselves here. The œsophagus (Tab. IV. fig. II. h.; fig. XIII. c.) is rather narrow; passes through the cartilaginous ring of the head and the nervous circle placed there, and in the natural position of the animal, when the mouth, as in the Echini and Asteriæ, is directed downwards, runs upwards; it then enters the cavity of the abdomen formed by the peritoneum, and, in the *Sepia officinalis* and *loligo*, expands into a spacious fleshy stomach, leading by a rather narrow aperture to a second expansion at the commencement of the intestine, having appended to it a spirally convoluted cœcum, into which, precisely as in the *Aplysia*, (§. 440.) the bile is discharged.\*

§. 442. The stomach of the *S. octopodia*, however, comes nearest to that of the *Aplysia*: the œsophagus in the same manner expands into a large crop-like cavity; then again into a second, but imperfectly separated from the true fleshy stomach, which terminates in the intestinal canal, and at the same time has appended to it the usual spiral-shaped cœcum. (Fig. II. i. k. l. m.) The intestine itself in the *Sepiæ* is never attached by a true mesentery: it is included, together with the stomach, in the delicate sac formed by the peritoneum, and is usually of no great

\* The spiral Cœcum forms one turn and a half, and is provided internally with a spiral valve, which forms numerous and closely approximated convolutions. In the Calmar it forms a long sac with thin parietes descending to the bottom of the abdomen, without any trace of a curve or of transverse folds except just at its origin. (Cuvier, *Mém. sur les Mollusques*. 1817, 4to.)

—Translator.

length. In the Calmar it is broad, and, like the Stomach, has longitudinal plicae on its internal surface. (Fig. XIV. t.) It here no longer forms convolutions around the liver, and ultimately terminates by a free extremity, nearly as in the Ascidia, (§. 435.) within the large funnel-shaped aperture (fig. I. a.) at the fore part of the neck, which serves for the discharge not only of excrement, but, as we shall hereafter find, of ova, semen, and the black fluid peculiar to these animals. As to the latter, it is the product of the membranous sac lined internally by a villous membrane; and, in the *S. officinalis*, is situated at the lower part of the abdomen, but somewhat higher near the liver in the Calmar (*S. loligo*): in the former, as well in the *S. octopodia*, (fig. II. q. p.) it empties itself by a distinct excretory duct of some length; in the latter it opens by a short canal into the orifice of the rectum. (Fig. XIV. g. i.)

### SECTION III. *Articulata.*

#### A. VERMES.

§. 443. It has been already more than once noticed, that the inferior species of this Order converge towards Zoophytes in the same manner as is the case in the Acephalous Mollusca in certain instances, and, as may probably be still more clearly shewn, by the examination of species already known, or by the discovery of new ones. Intestinal Worms, for instance, might frequently be considered as true Zoophytes; an idea confirmed by the structure of their nutritive organs. The mode of taking in nutritive

matter is usually by apertures adapted for suction, or even (as in the Rhizostomata, §. 433.) by several such: in the Hydatid, for instance, commonly found in the brain of Sheep (Cœnurus), there is a limpid bladder, having attached to it several bodies or necks, capable of being elongated or retracted like the horns of Snails, each of which has a head provided with four sucking apertures, surrounded by a circle of hooks. As in these animals there is no longer any intestine, properly so called, we may either, as already observed, consider this structure as similar to that of the Rhizostomata, or else view each of the bodies attached to such a bladder as an individual animal, deriving, like the animals of the Pennatula, (§. 433.) nutriment from a common source. The approximation to the lowest genera of Zoophytes (§. 433.) is still more evident, when, as in the greater number of Intestinal Worms, the whole surface presents itself as an organ of absorption of considerable activity.\*

§. 444. These animals, as we have already remarked, have no intestine, being, in fact, nothing more than a stomach with several openings for the admission of food. It is interesting to mark the manner, in which they gradually advance towards a more perfect organization. First, the bladder or stomach becomes smaller, and has only a single tube for suction opening by four mouths; as, for instance, in the *Cysticercus pisiformis*, which I have occasionally found enclosed in distinct membranous sacs, in vast numbers, between the uterus and rectum of the Hare. In other species the neck or body is longer, disposed in transverse plicæ, and jointed, with a bladder appended to the posterior extremity: such is the case in the *Cysticercus fasciolaris*, which is very common in the Liver of the mouse, and like the former is contained within a sac formed of the organ

\* RUDOLPHI, *Entozoorum Historia Nat.* vol. i. p. 275.

in which it is lodged. Here, as in so many instances among Zoophytes, the anus is wanting. Next come the *Tœnia*, in which there is a head with a jointed body, often of extraordinary length, the head itself being provided with from two to four sucking apertures, as well as with a proboscis armed with hooks. From the sucking orifices run fine canals, more like vessels than intestines, connected by little transverse vessels, and frequently united in their course through the body so as to form two instead of four. It has not yet been satisfactorily determined whether there be any anus; but this much is certain, that in these animals nutrition is effected not only by the intestine, but also by absorption from the whole surface of the body.

§. 445. On the other hand, the organs of digestion are more perfect in the *Ascarides* and several similar species. The aperture of the mouth is simple; occasionally surrounded by little tubercles, but still a true sucking orifice. The intestinal canal, which is of pretty uniform size and tolerably wide, runs through the whole length of the body, and terminates in an anus at its posterior extremity; a form of organization in which they evidently approach to those species of Worms, that do not live in other animals. In the *Lumbricus terrestris*, for instance, there is a sucking orifice as in the *Ascarides*; posterior to it is a fleshy pharynx; then, in succession,—a narrow œsophagus; a small dilatation; a fleshy roundish stomach, precisely like that of certain Snails, *e. g.* *Helix stagnalis*, with a hard lining membrane that easily separates; and lastly, an intestine, usually of an orange-red colour, with many transverse plicæ and a longitudinal ridge,—connected, as are also the stomach and œsophagus, by means of numerous transverse ligaments to the integuments,—and terminating in an anus at the posterior extremity of the body. (Tab. V. fig. II.

III.) In the Leech (*Hirudo medicinalis*), the sucking orifice is triangular, with little sharp edges for the division of the skin: attached to it is a strong fleshy pharynx, which is the principal agent in sucking blood; next to this follows a long and capacious stomach with thin membranous sides, pretty closely connected to the integuments, and divided by several septa into large cells communicating with each other by oval apertures. Somewhat more than midway down the body the narrow intestine arises from this stomach by a small and funnel-shaped valvular opening: it runs backwards between two imperforate sacs appended to the stomach, and terminates in a minute anus placed at the superior edge of the posterior sucking disc.\* (Tab. V. fig. VIII.) These organs are still more developed in the great Marine Worms, *e. g.* the Nereis; where the mouth, or pharynx, which can be protruded like the stomacal sac of the Asterias, presents small horny teeth, placed in opposition to each other, with a lateral motion, and occasionally also small cœca appended to the stomach (Tab. V. fig. XIII.): the latter exist in great number in the Amphitrite *aculeata*, being found in pairs in each joint of the body, ramifying, however, still farther, and being mutually connected.† ‡

\* The slowness of the digestion of this animal is remarkable, blood being found to remain unchanged in its stomach for months. Something similar may be remarked in many of the superior cold-blooded animals. It must also be considered as an approximation to the inferior stages of organization, that the Leech should more frequently discharge its excrement from the mouth than through the narrow intestine. (BLUMENBACH *Handbuch. der Vergl. Anat.* s. 177.)

† MECKEL, *Translation of CUVIER'S Comp. Anat.* vol. iii. p. 167. and OKEN *Zoologie*, b. i. s. 375.

‡ In the Amphinoma *capillata* and *tetradra* there are in succession, in a fleshy mass of the mouth or proboscis, a narrow œsophagus; a stomach

## B. CRUSTACEA.

§. 446. The organization of the alimentary canal is much more complicated in this than in the preceding Order, and remarkable from the important fact of the developement of organs of mastication (jaws) simultaneously with the lower extremities, and in every respect in most intimate connection with them. In the description of the lower jaw of the superior Classes of Animals I have already noticed the relation between the manner in which it is composed of two lateral rami, and the structure of the jaws in the Articulata. (§. 204.) If we carry our examination still farther, I think it possible to prove, also, that the lateral motion of the jaws in the Articulata corresponds to a still lower stage of organization, in fact, to the structure of the bivalve shells. Thus, in some vermiform *Acephala* (*Teredo*, §. 435.) we found moveable shells acting as jaws; with these the lateral jaws or teeth of the *Nereides* (§. 445.) completely coincide; and these again, as their jaws are horny, form a transition to the larvæ of perfect Insects, Caterpillars, which are in many points related to them,—and by that means pass into the superior Orders.

§. 447. In Crustacea we find similar jaws with lateral enormously dilated, with sacculi like those of a Colon; its folds being fixed by a tendinous line situated on the ventral surface, and occupying the upper two-thirds of the length of the body; and then a short but capacious intestine. In the *Lumbricus marinus* there is not any fleshy mass of the mouth: the œsophagus extends through one-eighth of the length of the animal: the stomach, which is more dilated, occupies one-third; it is of a beautiful yellow colour, its surface being arranged in lozenge-shaped sacculi, with the divisions between them marked by vessels of a bright red colour. (Cuvier, *Comp. Anat.* iv. 140.)—*Translator.*

motion, though here we may divide them into two kinds: Mandibulæ, which, from their size, strength, hardness, and resemblance in shape to grinding-teeth, appear to correspond with the moveable shells of the Terebines and teeth of the Nereides; and Maxillæ, which appear to be formed merely by the continuation of the legs towards the opening of the mouth. If we examine these parts in the Cray-fish (*Astacus fluviatilis*), we shall find that the mouth, which, as in the Echini and Asterias, is turned downwards, presents a small longitudinal fissure, or rather an elongated triangle, (Tab. VI. fig. I. a. seen from within,) having at its anterior extremity two strong Mandibulæ, as large as peas, with teeth on their inner surfaces, and elongated internally into a bony style on each side, moved by a strong muscle attached to the dorsal plate. At each side of, and diverging from, these Mandibulæ is a series of six pairs of Maxillæ; the innermost of which is merely a thin lamina, whilst the outermost, on the contrary, is strong, and in form precisely similar to a leg of the animal. (Tab. VI. fig. VII.) Internally, these Maxillæ, like the legs, (§. 144.) are elongated into horny laminae, which, in the two largest of the Maxillæ, have Gills attached to them, like those of the legs. Above the mouth, also, there is a fleshy projection, or lip; all the jaws, too, Mandibulæ as well as Maxillæ, support small Feelers (Palpi), which, on the three largest of the Maxillæ, are very large and jointed: they appear to serve the purpose of touching or examining the food, and, in so far as they ascertain its sensible qualities, may perhaps be viewed in the light of organs of taste.\* At least, of all the species of animals hitherto considered, there are none in which the existence of that sense is more probable than here, because of its intimate

\* We may either consider such Feelers as tongues around the mouth, or the tongues of the superior animals as similar organs within it.

connection with touch; which justifies us in supposing that the same development of perfect extremities, which is accompanied by the presence of organs for the latter, may also be attended with similar results as regards the sense of taste. (See §. 103, 104.) The description of the organization of the organs of mastication here given is applicable in the most essential points to other Crustacea, though there are occasional variations, particularly in the form and number of the Maxillæ; thus, according to CUVIER, a Molucca Crab has five pairs with large feelers like legs, and terminating in nippers.

§. 448. The Œsophagus of the Cray-fish is generally very short, (Tab. VI. fig. V. a.) and formed by thin membranes; it quickly expands into a very large membranous stomach, which, more particularly at its upper part and in the region of the pylorus, is supported by a peculiar bony frame, and by the same means rendered more capable of bruising the contained food. This remarkable mechanism consists of five flat bony masses, moved by muscles supposed to be voluntary; to them are attached on the inner side three larger and two smaller teeth, surrounding the pyloric opening of the stomach (Tab. VI. fig. VI. a. a. a. b. b.); an organization, of which we find traces in the mode in which the stomach is armed in several Mollusca. (§. 440. 437.) The remark already made (§. 440.) as to the similarity of the lining membrane of the stomach and the common integuments, in so far as both are capable of secreting calcareous shells, is still more applicable here; for in this case the bony matter and teeth of the stomach are included, together with the external shell, in the annual separation and regeneration of these parts. HOME (*Lect. on Comp. Anat.*) supposes that the round discs (§. 143.) which are found at that time at each side of the stomach admit of being rubbed against each other, like those in the stomach of the Bullæ:

this, however, is not probable, inasmuch as they are only temporary; and, according to OKEN,\* are thrown off at the same time as the old coating of the stomach. The intestine is not fixed by a mesentery: it extends from the pyloric end of the stomach in the form of a straight and narrow canal along the body to the anus, which is placed below the broad terminal plates or scales of the tail. The same form of organization, according to CUVIER, prevails pretty generally through most of the corresponding species; in some, however, the stomach is merely membranous, and provided with small teeth.

#### C. INSECTA.

§. 449. In the varied Genera of this Order we find almost all the forms of the alimentary canal already described, as well as a multitude of new and peculiar formations. The organs of mastication, deglutition, and suction here present such remarkable differences, that the arrangements of modern Systems of Entomology have been chiefly founded upon them. We need here notice only the most important varieties by producing a few characteristic examples; it is interesting, however, to remark how the organization of the apparatus for taking in nutritive matter forms a complete series. Thus, Scorpions, Spiders, Millepedes, &c. are related to the Crustacea, not only with regard to their general form, but also by the mode in which they take their food, the developement of powerful organs of mastication, &c. In this particular, Beetles, Orthoptera, and Neuroptera approach nearest to these Gnathaptera. In the Hymenoptera we already find the animal deserting

\* *Zoologie*, b. i. s. 393.

the coarser kinds of food, living chiefly on juices, and, in this respect, approaching nearer to the true aërial nature of the most perfect Insects. In them, also, we again find the same mode of taking in nutritive matter as in the lowest stages of the animal kingdom, viz. by means of organs of suction, which here, however, are combined with organs for mastication. These organs of suction are still more developed in the Hemiptera and Diptera; and in the Butterflies, which are almost wholly independent of solid nutritive matter, present themselves in the greatest perfection, and without any addition of teeth, &c. In their Larvæ, however, we find a repetition of the inferior organization; and Caterpillars are, consequently, provided with powerful jaws. The Aptera among Insects appear to bear the same relation to the external surface of other animals as the Intestinal Worms to the inner surface of their alimentary canal: so, likewise, they resemble them in the mode of taking their food, and have organs of suction armed with hooks, &c.

We must next consider the different organs employed in taking food, and then the varied forms of the alimentary canal, as well as of its mode of termination. I may first, however, remark, that in this Order of Animals nutrition by vegetable substances is much more common than in those below it.

A. *Organs of Mastication and Suction in Insects.*

§. 450. The type of formation of the jaws in Insects is essentially the same as in the preceding Order: they are usually moved by strong bundles of muscular fibres. Here, also, they move in the same manner in a horizontal plane; and in the same manner a division may here also be established into Maxillæ and Mandibulæ; nay, in the Woodlouse (*Oniscus*), there are several pairs of Maxillæ; and in the Spider, as in the Cray-fish, the lower lip is wanting,—a part which is found in all other Insects with jaws. Feelers or Antennæ (probably organs of taste) are also found in Insects, according to CUVIER, being absent in the *Julus* only. Here, however, they are placed only on the Maxillæ and upper lip.\* (Tab. VII. fig. XX. A. b. c.) The Mandibulæ are rarely wanting, as is the case in the *Ephemera*; and the Maxilla in the *Ricinus*.

§. 451. Among the Gnathaptera the Spiders are remarkable for having strong Mandibulæ armed with a moveable curved tooth (Tab. VII. fig. I. II.), which is perforated by a canal conveying venom. The Maxillæ are very small, but have attached to them long leg-like feelers; which, according to TREVIRANUS,† are spoon-shaped at their extremities in the male, and serve to excite the female organs. In the Scorpion, the process of the under lip, which is usually called the tongue in Insects, is provided

\* According to TREVIRANUS, (*Ueber den innern Bau der Arachniden*, s. 2.) however, the nipper-like feelers of the Scorpion are placed on the Mandibulæ, and not on the Maxillæ.

† *Loc. cit.* p. 33.

with a kind of lingual bone. (Tab. VII. fig. IX.) In the Orthoptera, *e. g.* the Cockroach, (*Blatta orientalis*;) the Mandibulæ are pretty strong; the Maxillæ are less so, and are provided with feelers; there are also an upper and a lower lip. These organs are most particularly developed in Beetles; except that occasionally the Maxillæ are wanting in the larva state: the Mandibulæ are frequently of extraordinary strength, as in the *Cerambyx textor*; or elongated in the form of antlers, as in the Stag-beetle (*Lucanus cervus*). The jaws of most Neuroptera, *e. g.* the Libellulæ, approach very closely to the lateral halves of the lower jaw in the superior animals; for here each Mandibula has a long, curved, and sharp tooth anteriorly, and posteriorly a crown-shaped projection; the Maxillæ being also provided with long and sharp teeth. The lower lip, also, is distinguished for its size, covering the organs of mastication like a mask, and being so moveable in the larva as to serve the purpose of an organ of prehension. In all these genera the name of Tongue has been given to a membranous elongation of the lower lip: it deserves this name chiefly in some Orthoptera being there placed below the opening of the pharynx, and not serving merely for an organ of suction, as in this Order. (See Tab. VII. fig. XX. A. d.)

§. 452. In the Hymenoptera, (*e. g.* Bees,) to which some Neuroptera (*Panorpa*, *Ephemera*) appear to form a transition, the cylindrically rolled tongue is elongated into a sucking tube, over which a perfect internal and external sheath are formed by the elongation of the Maxillæ. The Mandibulæ still remain, but are more spoon-shaped, and unarmed, being no longer used in mastication, but rather as weapons, &c.; the proper cavity of the mouth being wanting generally in those Insects which

\* TREVIRANUS, on the Suction of Insects, in the *Essays of the Wettarian Society for Zoology*.

suck, as opposed to those which masticate. Even where the tongue is not elongated, the opening of the pharynx is found below it; and, consequently, it cannot act as a tongue, properly so called. The Mandibulæ of the Larvæ of this Order act, however, as true organs of mastication.

The structure is nearly similar in the Diptera and Aptera, in which a proboscis, apparently representing the elongated lips, contains a sucking tube, and sometimes, as in Gnats, several penetrating points in addition. In the Larvæ of the former (Diptera), there is an apparatus for chewing, composed of two jaws; nay, in the larvæ of those which live within the intestines of other animals, (*e. g.* in the larvæ of *Cestrus equi*, so common in the Horse's stomach,) there are, as in many Intestinal Worms, (§. 152.) little hooks on the head, by means of which the animal is enabled to attach itself. Lastly, in the Butterflies, the only one of these organs which remains is a flat and spirally-rolled tongue or sucking tube: it is only in the larva state that we again find either powerful Mandibulæ (Tab. VII. fig. XI. a.), or else small and almost proboscis-like rudiments of Maxillæ and a lower lip.

#### B. *Intestinal Canal in Insects.*

§. 453. I here first notice the intestinal canal of the Arachnida, which, in accordance with the mode of nutrition, differs remarkably from that of other Insects. According to TREVIRANUS,\* the *Cesophagus* in the Spider is straight, small, and with thin coats: it communicates

\* *Ueber den innern Bau der Arachniden.*

with four blind stomach-like pouches\* in the thorax, and then runs towards the posterior part of the body, where it disappears in a delicate web inseparable from the fatty substance around. (Tab. VII. fig. I.) It is probably at this point that the nutritive materials pass immediately into this fatty body, which we find in most Insects (fig. XXIII.) as a kind of mesentery or omentum, in which these materials are deposited in the form of little globules of fat or chyle. This deposition of fat from the intestinal canal is still more distinct in the Scorpion; for here, according to TREVIRANUS, five vessels, (fig. IX.) comparable to the lacteals in Man, arise from each side of the stomach, and are diffused through the fatty bodies.†

\* Similar blind appendages to the intestinal canal are tolerably common in Insects, and appear to be of the same nature as the *Cœca* already noticed in several Mollusca, *i. e.* prototypes of the Pancreas.

† In Scorpions, the short Œsophagus is succeeded by a cylindrical elongated stomach, with four pairs of lateral branches opening into it, and receiving the hepatic vessels, which are composed of an infinite number of rounded glands, usually filled with a thick brown fluid. The Duodenum is shorter and more capacious than the Stomach, and separated by valves, as well from it as from the Rectum: at its lower part open into it two lateral branches, which are probably chyloferous vessels. In the Onisci, the Œsophagus is wide, but short: the Stomach is long, occupying more than three-fourths of the body, and is distinguished from the Œsophagus only by its greater diameter. The Rectum is smaller than the Stomach, and is separated from it by a valve very distinctly marked externally. According to CUVIER, the hepatic vessels are four principal trunks inserted close to the termination of the Œsophagus. The characteristic of the alimentary canal of Spiders is its ramified structure: the Œsophagus has two lateral branches; the Stomach four; the Duodenum and Rectum are also ramified. The Stomach is the only dilated part of the canal; its shape is quadrilateral, the branches arising from its sides. The hepatic organs, consisting of an infinite number of little glands containing a peculiar, thick, brown fluid, are attached to the branches of the alimentary canal, and occupy the greater part of the abdomen. (MARCEL DE SERRES, *Mém. du Muséum*, v. 63.)—Translator.

§. 454. We may take the intestinal canal of the *Dytiscus* as a specimen of its structure in Beetles, the more so, as, according to CUVIER, the Genera *Carabus* and *Cicindela* are similar in this point. As is the case in many Insects and several Genera of the Orders already described, the *Œsophagus* expands into a crop-like cavity, and then passes into a small roundish muscular stomach, (nearly as in certain *Mollusca* and *Vermes*, §. 445.) which is beset internally with little horny teeth, and is chiefly devoted to the object of dividing the food. RAMDOHR\* distinguishes this by the name of the plicated stomach. Next to it follows a long piece of intestine, the first half of which is surrounded externally with shaggy appendages (probably small secreting *Cœca*, §. 453.), whilst the lower is smooth and formed of thin membrane. Both together form the true stomach, which, according to RAMDOHR, comprehends the whole extent of the space to the insertion of the biliary vessels to be hereafter noticed, and consequently, in many instances, forms by far the largest portion of the alimentary canal. Next follows a simple small intestine of nearly equal length, which, in the last place, terminates in a distinct large intestine with long blind appendages, the nature of which will be considered hereafter. In the Larva these subdivisions of the intestine are less strongly marked; the whole canal appears shorter in proportion to the body; more uniform in size, like that of *Vermes*, and provided with a longer *cœcum*.†

\* *Ueber die Verdauungswerkzeuge der Insekten.* Halle. 1811.

† As regards the Intestinal Canal, the *Coleoptera* may be arranged in two divisions, according to the absence or presence of a Gizzard. Of the former kind are *Curculio*, *Cerambyx*, *Cebrio*, &c. where the stomach is immediately continuous with the *Œsophagus*, and is succeeded by a Gizzard with six firm coriaceous laminae projecting from its internal surface. In the *Carabi*, *Cicindela*, &c. the Stomach opens laterally from the *Œsophagus*,

§. 455. In the Orthoptera, *e. g.* the Grylli, we generally find in the Larva, as well as the perfect Insect, a short and straight intestinal canal, a fact which perfectly coincides with the voracity and rapacity of these animals. The Œsophagus first expands into a crop-like cavity, which is followed by a small, roundish, muscular stomach, plentifully furnished with horny teeth on its internal surface; next comes a circle of little cœca,\* or, as in some Species, a heart-shaped expansion with large folds at its inner and upper part; and lastly, a narrow gut-like stomach. (Tab. VII. fig. XX. XXII.) On account of this complicated structure, which is pretty closely imitated in the ruminating Mammalia, and also from the results of numerous observations, the power of ruminating has been ascribed to these Insects. I have myself frequently seen their jaws in active motion, though not employed in eating. M. DE SERRES,† however, conceives that the organization of their intestinal canal is opposed to the idea of their rumination. In the Neuroptera, which are generally rapacious, and in which we found the organs of mastication so powerful, we find the intestinal canal short, as compared with the body, *i. e.* nearly of the same length with it. The Œsophagus terminates in a muscular stomach provided with little horny

and is followed by a Gizzard of considerable size, but without having inserted into it any cœca or hepatic vessels. In the Coleoptera without a Gizzard, *e. g.* Scarabeus, Geotrupes, Chrysomeles, &c. the narrow Œsophagus opens into a small stomach, which, like the Duodenum, is covered by hepatic vessels. The Genera Tenebrio, Blaps, &c. differ from the latter only in having an additional portion of small Intestine interposed between the Duodenum and Rectum. (M. DE SERRES *Mémoires du Muséum*, v. 143.)  
—Translator.

\* In an excellent Essay on the Organs of Digestion in Insects, (*Annales du Muséum d'His. Nat.* vol. XX.) MARCEL DE SERRES calls these Cœca the superior biliary vessels.

† *Loc. cit.* p. 365.

teeth; then follows a long and membranous stomach, which is immediately succeeded by an expansion forming the commencement of a large intestine of no great length. In the Larva the whole intestinal canal is proportionally wider; but here more particularly the proper and peculiar character of the large intestine is displayed, inasmuch as we find in it the seat of the respiratory organ, (little gill-laminae, to be hereafter described;) and consequently discover in this portion of intestine a repetition of the preceding formations, where the intestine either opened immediately into the respiratory cavity (§ 434, 436, 439, 442), or the anus was closely connected with the Gills or respiratory cavity. In the Ephemera, the perfect development of the body, according to CUVIER, is accompanied by an extraordinary contraction of the intestinal canal, its functions ceasing almost completely, the animal no longer taking in any nutriment. Nay, in the Larva of the Myrmeleon *formicarius*, (Art-Lior,) the stomach is a blind sac closed inferiorly, as is the case in many Zeophytes.†

† The forms of the Stomach and Intestinal Canal present considerable varieties in the different species of Orthoptera. In Acheta and Gryllo-talpa the Stomach is shaped like a bag-pipe, and situated at the side of the Oesophagus, communicating with the Gizzard by a narrow cervix. The Gizzard is very large, and corresponds to the insertion of the coeca, or superior hepatic vessels, as they are called by M. DE SERRES. In Locusta, the Stomach is immediately continuous above and below with the Oesophagus and the Gizzard. The latter is still very considerable, and, as in the former case, is placed immediately above the insertion of the coeca, which, at their unattached extremities, terminate in secreting vessels. In the Acheta and Gryllo-talpa the inferior hepatic vessels open into the Duodenum by a common trunk.

In the Genera Gryllus and Truxalis, where the superior hepatic vessels are more developed, the Gizzard is proportionally diminished in size. The inferior hepatic vessels here form long capillary canals which adhere to the parietes of the Duodenum. In the Genera Mantis and Blatta, the Stomach is immediately continuous with the Oesophagus, and the Gizzard, which is

§. 456. As to the Hymenoptera, the organs of digestion in Bees are important, not merely as such, but also as organs for the preparation of honey and wax. The slender Oesophagus opens into a membranous crop, in which apparently the nectar that has been sucked is converted into honey, and then thrown out into the cells of the comb.\* This honey-stomach is succeeded by a contracted portion, and then by the true stomach, which, extending to the insertion of the gall-vessels, exceeds the first in length and breadth. It is probably in this second stomach that the wax-meal (bee-bread) is converted into the Wax which escapes through the rings of the abdomen; it is collected as pollen from flowers, is accumulated in a fossa on the thigh, and after having been mixed with some fluid, is deposited in the cells partly for a supply of food, and partly for the formation of wax.† The small intestine which succeeds is but short, and terminates in a large intestine of considerable width and containing five little elevations, which are probably excretory organs: these elevations may be ranged with the Gills contained in the large intestine of the Larva of the Libellulæ, (§. 455.) and shew the connection between the functions of secretion and respiration. In the Larvæ, the intestinal canal is much more simple, consisting almost solely of a broad sac-like stomach, from which, as in the Ant-Lion, there is no communication to the intestine.

much developed, is attached to it laterally. The remaining parts of the alimentary canal, which generally consist of a Duodenum and a Rectum, are much more uniform in size and structure. (M. DE SERRES *Memoires du Museum*, v. 106.)—Translator.

\* SWAMMERDAM *Bibl. Nat.* p. 162.

† SPRENGEL'S *Briefe ueber Botanik.* Th. i. s. 336.

§. 457. In the Hemiptera, *e. g.* Bugs, there are usually two stomachs, the posterior of which, according to RAMDORF, has annular bands upon it, and is composed of four half-canals. Besides a small, there is also a large intestine of considerable size, which generally has a cœcal appendage to it. The intestinal canal of the *Tettigonia plebeia*, as described by MECKEL,\* is very singular, the second stomach leading to a long canal, which ultimately terminates in the first. In the Diptera, *e. g.* Gnats, the intestinal canal is of tolerable length, and the most remarkable part of it a sac-like appendage to the œsophagus of considerable size, which, probably, is accessory to suction (§. 452), and usually contains little air-vesicles. In the Larvæ, which are provided with jaws, this appendage does not exist. In the Larva of the Cheese-fly, SWÄMMERDAM found a roundish muscular stomach, followed by a circle of four cœca, a long gut-like stomach, and an intestine of uniform size.

§. 458. In the Papiliones, which, in every stage of their development, live solely on vegetable matter, the intestine is narrow and does not materially exceed the body in length. Here also we find a sac-shaped appendage at the side of the œsophagus, frequently containing air,† and similar to that found in the Diptera, as an agent in suction: next follows a roundish stomach interrupted by many transverse folds; then a cylindrical stomach; and then the small intestine, which ultimately terminates in a large one of considerable width, and generally provided with a cœcum. (Tab. VII. fig. XVI.) It is remarkable to observe how

\* *Beiträge zur Vergleichenden Anatomie.* Th. i.

† May we not view this sac containing air and appended to the œsophagus, as the prototype of the lungs, which also in the superior animals are concerned in the action of suction?

the Caterpillar is distinguished from the perfect Insect by its intestinal canal, as much as by its general form and the structure of the organs of mastication. Thus, in some Caterpillars, I find the whole of the intestinal canal perfectly straight, and almost exclusively formed by the monstrously long and broad stomach, which reminds us of that of several Vermes, *e. g.* the Leech. The great size and the straight course of the intestinal canal in these animals perfectly coincides with their extraordinary voracity, some of them devouring in 24 hours more than three times their own weight. The parietes of this stomach consist of six half-cylinders, and have deep transverse furrows upon them. Below it are placed two globular swellings, and then a large but short intestine. (Tab. VII. fig. XI. XII.) This intestinal canal, which, from the nature of the food, is generally green in the Caterpillar, contracts very considerably in the Pupa. In a Pupa of twelve days, I found it scarcely half as long, and only one-sixth as wide, as in the Caterpillar (fig. XV.); and ultimately in the perfect Insect only the upper globular and transversely plicated swelling of the stomach remains.

In the parasitic Insects of the skin, the intestinal canal, as far as we may conclude from SWAMMERDAM'S examination of the Louse, is tolerably simple: the stomach is wide and long; has two cœca at its upper part; and terminates inferiorly in a curved small intestine, followed by a wide large intestine.

As to the mode of attachment of the intestinal canal in Insects, it is usually effected by means of numerous air tubes which ramify upon it. There is not any mesentery, properly so called; and the place of Omentum is supplied by the fatty substance already mentioned, (§. 453.) and forming a deposit of chyle, the nature of which is elucidated by the fact that it is always found large in the imper-

fect Insect, *e. g.* Caterpillars; and is much reduced in the perfect one, *e. g.* Butterflies.\*

C. *Of the Termination of the Intestinal Canal in Insects.*

§. 459. The intestinal canal of Insects invariably opens at the posterior extremity of the body, in front of, or below the genitals: hence, the opening of the anus will require a more particular description in those cases only, in which it is furnished with peculiär weapons, such as a sting and poison-glands, or with an equally remarkable organ for spinning. In the Scorpion, we find a weapon of the kind alluded to, the anus being placed between the penultimate and terminal segments of the body; the last ending in a horny point, (Tab. VII. fig. IX. k.) the aperture† of which gives exit to the poison. The little poison-gland lies in the globular swelling of the last segment of the body, and is surrounded by powerful muscular fibres. (Tab. VII. fig. IX. k.) A similar apparatus exists in several species of Hymenoptera, *e. g.* Bees and Wasps. In the former,

\* The alimentary canal in Insects is fixed only by means of the tracheæ distributed to it, without the assistance of mesentery, vessels, or even cellular tissue: hence, when an Insect is opened in water, the folds of the canal are raised and stretched by means of the air contained in their tracheæ. The name of peritoneum may be assigned to the delicate membrane which lines the inner surface of the abdomen, and which is covered externally by the segments of the skin and the muscles belonging to them. (CUVIER *Comp. Anat.* iv. 158.)—*Translator.*

† Although TREVIRANUS (*loc. cit.* p. 14) could not discover such an opening, there can be no doubt of its existence, for REDI long ago observed the venom escaping from the point of the tail.

the Queen and the Workers only are possessed of stings and poison-bladders, with the organization of which we are acquainted chiefly by means of the excellent descriptions of SWAMMERDAM. The sting is here also placed on the last segment of the body above the opening of the rectum: at its basis is lodged the little poison-bag, the coats of which are very firm and surrounded by strong muscular fibres; the latter, however, do not compress the bladders equally on every side, but merely flatten them. At the upper part of the little bag are two long narrow vessels, which appear to secrete the poison.\* The sting itself consists of two rami at its upper part bent to each side, the opposed surfaces presenting deep grooves serving for the lodgment of the excretory ducts of the venom-bags. Each half of the sting is beset externally with a row of barbs, by which it is retained in the wound it makes, with a fatal result to the animal to which it belongs. Lastly, the two halves are again inclosed within a distinct sheath, the whole weapon being moved by a peculiar apparatus of voluntary muscles.

§. 460. The spinning organs are almost peculiar to Spiders. They consist of four tubercles placed immediately below the anus, having their rounded extremities perforated in a cribriform manner, so as to permit the passage of the viscous fluid which forms the thread. (Tab. VII. fig. IV. c. r.) Within are numerous ramified sacs, of various length, and variously formed in the different species, usually occupying a large portion of the back part of the body, (fig. III) and serving to secrete the glutinous matter. Close to the tubercles are two little extremities, which are

\* As we shall hereafter find, a true vascular system is apparently wanting in Insects, and consequently, all the secretory organs must collect their peculiar fluids from the general cavity of the body by means of similar vessels.

singularly similar to the feelers of the jaws, and probably serve to interweave the four threads issuing from the tubercles. Something similar exists in the larvæ of some of the more perfect Insects: according to RAMDOHR, in that of the Ant-lion, where an expansion of the large intestine forms the receptacle for the silky substance.

As to the nature of these poison-organs and spinning apparatus; on the one hand, with many other secretions in the vicinity of the anus, (§. 455.) these may recal to our recollection the relation already noticed between the termination of the intestine and the respiratory organs, *i. e.* the frequent repetition of respiration in secretion, (compare for instance the descriptions of the spinning organ of the larva of the Ant-lion, and of the excretory organ in the large intestine of Bees, §. 456.): on the other hand, we observe a close analogy between them and the salivary and poisonous organs of the mouth,—the Mandibulæ in Spiders being armed precisely like the anus in the Scorpion,—the sting of Bees having considerable similarity to the penetrating proboscis of Gnats,—and lastly, organs for spinning, similar to those which in the Spider are placèd near the anus, being situated about the mouth in the larvæ of the more perfect Insects, which, as being in the vicinity of the salivary organs, and in many respects resembling them, will best be considered hereafter.

CHAP. II. *Of the Organs of Digestion in Animals with  
Brain and Spinal Marrow.*

§. 461. As the great diversity in the structure of the individual parts of the alimentary canal in the four superior Classes of animals renders a more precise consideration of these parts necessary, we shall (in each Class) examine their organization under three different heads; viz. 1st. the Teeth, or organs of mastication, together with those of taste, suction, and deglutition; 2d, the Oesophagus and Stomach; and lastly, the intestinal canal with its termination:

SECTION I. *Organs of Digestion in Fishes.*

A. *Of the Organs of Mastication, Taste, Suction, and  
Deglutition.*

§. 462. The form of the mouth in Fishes, as well as the mode of its motions, are partly explained by what has been already said (§. 176, 178.) as to the various forms of the bones of the jaws, and I need here only refer to a point that has been before briefly noticed (§. 204. Remark); viz. that the nature of the lateral rami of the jaws in Fishes, as well as in the following Classes, is explained by the form of the lateral jaws of the Articulata. But, if we still farther compare the bones forming the cavity of the

mouth in the four superior Classes of animals with the organs of mastication in the Crustacea and Insects, we shall be led to assimilate the lateral segments of the Upper Jaw in the former to the Maxillæ of the latter;—the Intermaxillary Bone (which, in Fishes, has usually (§. 176.) a moveable connection with the Upper Jaw) to the Upper Lip; the lateral segments of the Lower Jaw to the Mandibulæ; and the Lingual Bone to the Lower Lip of these inferior species of animals. As concerns the situation of the mouth, I may notice as a remarkable analogy with the inferior formations, that in many of the superior species of Fishes, *e. g.* Rays, the Sturgeon, &c. the mouth is placed on the inferior surface of the body, in the same manner as in the higher Species of Zoophytes, which present so many points of comparison with Fishes, (§. 38.); *e. g.* in the Echinodermata. (§. 434.) It is still more interesting to observe how perfectly the form of the sucking aperture in several Worms appears to recur in the fleshy, funnel-shaped, sucking orifice attached to the circular jaw (§. 178.) of the Lamprey (Tab. VIII. fig. IV. A.): it is by this means that the fish attaches itself so closely as to admit of being raised out of the water with a stone of 10 or 12 pounds adhering to its mouth. In the Shark, (Tab. VIII. fig. VI.) also, the lateral segments of the superior and inferior maxillæ, which are almost completely separate from the Cranium, may be considered as a repetition of the similar structure of the Sepiæ. (§. 441.)

§. 463. As to the organs of mastication in Fishes, it is remarkable, that as in the inferior Classes we frequently met with hooked points or actual teeth, partly in the mouth, as in snails (§. 438.), partly in the Oesophagus and Stomach, as in the Aplysia, Nereis, and Cray-fish, without any connection with a true skeleton,—so also, in Fishes, the teeth are found, sometimes having a slight connection with the,

skeleton, at others placed not merely in the jaws, but also on the palate, the tongue, or even (as in the Nereis) in the pharynx. The imperfect connection of the teeth with the skeleton altogether corresponds with the general want of compactness in the latter, and is particularly evident when we trace the mode of formation of the individual teeth. The most usual kind of teeth in Fishes, *i. e.* the pointed, hook-shaped, found in the Pike, in which they are surrounded by a membranous retractile sheath, and the flat triangular teeth of the Shark, wholly differ from those of man, in being formed in the gums instead of in cavities of the jaws. Without any great incorrectness we might consider them as the papillæ of the gums, palate, tongue, &c. indurated and covered with a tooth-like substance, and which are only gradually connected to the bones of the jaw or palate over which they happen to be placed. Hence, we find them in the Pike originally adhering to the gum alone, and not united to the subjacent bone by bony substance until a later period. In the Shark there are several rows of teeth one behind the other, a new tooth raising itself forwards whenever one is lost,\* but still without having any connection with the bone. According to CUVIER, in those Fishes which have flat or cutting teeth (*e. g.* the Spari), they are renewed rather in the same manner as in man.

§. 464. In the different Genera of this Class there are endless varieties, as well in the situation as the shape of the teeth. In the Pike they are exclusively hook-shaped, and situated in all parts of the mouth, except the Superior Maxillary Bone, (§. 176.): viz. on the lower jaw, where they are very strong; on the palate bones; on the Vomer

\* Even this erection may remind us of the turgescence of the papillæ of the tongue.

(§. 176.); on the tongue; in the pharynx (§. 170.); and on the thoracic Ribs, or arches supporting the Gills. (§. 165.) In the Carp there are none in the mouth; the jaws of the pharynx have strong flat teeth, which are pointed in the smaller species of the Genus *Cyprinus* (Tab. VIII. fig. V. c.); a distinct tooth-like lamina of bone also rests upon a process of the Occipital bone. (§. 172.) In the Genus *Sparus* we find anteriorly wedge-shaped cutting teeth, like the incisors of man, and posteriorly hemispherical teeth closely crowded together. (Fig. VIII.) The Lampreys have their brownish hook-like teeth internally upon the fleshy funnel of the mouth. (Fig. V. 2.) The Sturgeon is altogether without teeth. Rays and Sharks approximate to the superior animals in so far as they have teeth only in the upper and lower jaws (fig. VI.): the Ray, however, is singular from the numerous teeth, or rather teeth-like laminae, placed close together. According to CUVIER, the *Anarrichas lupus* is remarkable for hemispherical bony excrescences, which, though they drop out themselves like teeth, have originally little teeth upon them. In the Genera *Tetrodon* and *Diodon*, mastication is performed by tooth-like elevations of the jaws, consisting of numerous horizontal parallel laminae, which are gradually exposed on the masticating surface which crosses the direction of the laminae obliquely.

§. 465. The muscular apparatus employed in biting and chewing,\* as well as in opening and shutting the mouth, is subject to many varieties according to the form of the jaws, &c. We usually find, however, that the depression

\* In this, as well as most of the inferior Classes of Animals which live upon animal food, there are but few instances of true mastication, properly so called.

of the lower jaw is effected by a muscle on each side, (Genio-hyoideus, Tab. VIII. fig. XII. u.) proceeding from the lingual bone to the edge of the lower jaw, and its elevation by another (Temporalis, fig. XII. t.) running below the eye. When the Superior Maxilla and Inter-Maxilla are moveable, as in the Carp, (§. 176.) they have peculiar muscles belonging to them. (Fig. VII. r. s.) The principal agent, however, in elevating them is an elastic ligament, (fig. XII. o.) performing pretty nearly the same office as the cervical ligament of the long-necked Mammalia. (§. 425.)

§. 466. The Tongue has here no claim to be considered as an organ of taste, but rather, (as in Snails and Sepiæ, §. 438. 441.) as an apparatus for ingestion, inasmuch as it is not only almost completely deprived of motion, but likewise generally composed of cartilage, covered with an insensible membrane, or even armed with teeth. (§. 464.) We have already described (§. 179.) the osseous girdle which supports the lingual cartilage (Tab. VIII. fig. I. II. V. VII. n.); it is only necessary in this place to remark, that, on the one hand, either the tongue or its cartilage are wanting in certain Genera,—the former in Rays, the latter, according to CUVIER, in the Genus Trigla and the *Esox belone*; on the other, that the size of the tongue is in some cases very considerable, *e. g.* in the Pike, the Perch, and, according to CUVIER, particularly in the Conger. The organ which, in some respects, supplies the place of the tongue in the Lamprey, merits particular remark: it consists of a quadrangular, dentated, and almost bony projection, quite at the base of the funnel-shaped mouth; its office appears to me to be that of closing the posterior part of the cavity of the mouth in the action of suction (§. 462.), by which means that part is enabled to act precisely like the sucking organ of a Sepia. (§. 136.)

§. 467. The fauces in Fishes are in no other way separated from the cavity of the mouth than by the openings for the Gills at each side, to be hereafter noticed. They are continued backwards into the pharynx, which is marked by a contraction depending on the presence of a circle of muscular fibres, and which in many species is strengthened by the maxillæ of the Pharynx, (§. 170.) and the muscles belonging to them. The Œsophagus, again, is immediately continuous with the pharynx, and it is only in the Lamprey that a peculiar description is rendered necessary by the unusual formation of the part. In that animal two canals or passages open into the lower part of the pharynx, of which the anterior or lowest leads to the respiratory organ (a membranous canal with lateral pouches and apertures), and the posterior or superior to the Œsophagus; an arrangement which evidently corresponds to the relative position of the pharynx and larynx in the superior animals, and even in Man himself. From the commencement of the Œsophagus the spouting tube ascends, which has been already noticed, (§. 348.) and the communication of which with the pharynx has been recently, though incorrectly, denied by HOME (*Philosoph. Trans.* 1815.) Lastly, we must notice here the temporal holes, as they are called, of Rays and Sharks, which open externally behind the Eyes, and convey water to the fauces and Gills. They are to be considered as farther (double) developements of the spouting hole of the Lamprey and Gastrobranchus *cacus*.

B. *Of the Œsophagus and Stomach of Fishes.*

§. 468. In proportion to the body the intestinal canal of Fishes is extraordinarily short, frequently extending in a straight line through the abdomen, and being, consequently, as the anus is placed at the anterior extremity of the caudal vertebræ, much inferior in extent to the body of the animal; as was also the case in Worms and Insects. This shortness of the intestinal canal would render digestion almost impossible, were it not compensated by the length of time that the food, which is usually animal, is detained in it.\* It is also probable that Fishes in general are supported by other means than the mere taking of food into the stomach: this is sufficiently shewn by their long-continued residence, and even growth, in water alone, without any supply of food; a circumstance that again reminds us of Zoophytes, in which we found the nutrition of so many species effected by general absorption without any evident intestinal canal.

§. 469. In those Fishes where the alimentary canal stretches directly through the abdomen, the only means of estimating the extent of the stomach is afforded by the point at which the gall-ducts penetrate; consequently, in the Lampreys for instance, we must consider as the Œsophagus that narrow portion of the canal which runs above or behind the respiratory organ; and as the stomach the somewhat more expanded part which lies behind the liver. It is only in a few species, however, that the structure of

\* HOME (*Lect. on Comp. Anat.* p. 340) mentions that a Perch took food but once in from ten to fourteen days.

the intestinal canal is thus simple: in far the greater number the Œsophagus is of considerable width, has longitudinal folds on its internal surface, (Tab. IX. fig. XIX. q. XX. XXI. XXII. a.) after a short course insensibly expands into the stomach,\* the structure of which is nearly similar, and communicates by a canal with the swim-bladder. According to HOME, (*Phil. Trans.* 1815,) the Œsophagus is most extraordinary in the Myxine (*Gastrobranchus cœcus*), which, besides the six lateral branchial foramina, has a single hole opening externally, and probably in some respect connected with the respiratory function.†

§. 470. The form of the stomach is very various in the different kinds of Fishes, though its cavity is ordinarily

\* In rapacious Fishes, the Pike for instance, we not unfrequently find a portion of the prey still lodged in the Œsophagus, whilst the rest extends into the stomach; a proof that the same functions are common to both organs.

† The distinction between the large and small intestine in Fishes cannot always be established with certainty. Sometimes it is the part next to the anus that is smallest, at the same time that its parietes are thinner than those of the intestine above it: such is the case in Rays, Sharks, the Sturgeon, and the Bichir, where the first part of the intestine has a spiral valve; and in the Syngnathy, Ostracions, and Balistes, where the first is separated from the second part of the intestine by a circular valve. In other cases there is no difference in the diameter of the two divisions of the intestine; which, however, are distinguished by variations in the structure of the mucous membrane, by the different direction of the fibres of the muscular membrane, or even by the presence of a circular valve. In many other species the second part of the canal is more dilated than the first, *e. g.* in Siluri, Chetodon, Scianæ, Scombri, Pleuronectes, Trigla, Gadi, Murenæ, &c. There is not any appendage to the intestine at the point where its two divisions (when they exist) communicate, the one portion inosculating with the other in such a manner as not to leave any cul de sac of sufficient importance to deserve to be distinguished by any particular name. (CUVIER, *Comp. Anat.* iii. 471.)

—Translator.

simple: in the Frog-fish (*Lophius piscatorius*) alone, according to HOME, it is divided into two parts by a groove of no great depth. (Tab. IX. fig. XXI. b. b.\*) The most usual form, however, as it presents itself in the Pike, Burbot, (*Gadus lota*,) (Tab. IX. fig. XIX.) Sturgeon, (fig. XX.) Eel, Electric Eel, (fig. XXII.) &c. is that of a blind sac, which, reascending and lessening in size, terminates in the intestine by a Pylorus, which is usually not very much contracted. The structure of the parietes is generally pretty much the same as in man: the muscular coat is evident, and frequently very much developed: there are but few glands: the internal membrane is usually thrown into many longitudinal folds, particularly at the lower part of the organ: occasionally, also, there are several transverse folds, giving somewhat the appearance of a reticulated structure. As instances of peculiarities in the form of the stomach, I may mention the Conger (*Muraena conger*) and *Tetrodon oblongus* as described by CUVIER. In the latter it forms a broad globular swelling, into which the Œsophagus penetrates at its superior extremity, whilst the intestine commences at the point diametrically opposite. In the former the blind sac of the stomach turns upwards as is usual, and contracts to the point of its termination in the intestine, but has, in addition, at its inferior part a long appendage terminating in a pointed extremity. The stomach of Rays and Sharks in general corresponds so closely to the usual form of the organ in Fishes as not to require any particular description. In the *Squalus maximus* (Basking Shark), however, HOME† found a structure differing from the common in this respect,—that the first or ordinary stomach communicated by a very narrow aperture with a second roundish and smaller one, which again opened into the intestine by an equally narrow pylorus. The stomach

† *Philos. Trans.* 1809, p. 216.

itself contained many stones; which we may therefore suppose supply the deficiency of grinding teeth as well as of the stomacal teeth observed in many Mollusca.†

### C. Of the Intestine in Fishes.

§. 471. As we have already noticed the shortness of the alimentary canal generally, and of the intestine itself particularly, we may at once direct our attention to the blind appendages so universally found in the vicinity of the pylorus in Fishes, and so evidently presenting a repetition of the cœca so frequently found both in Mollusca and Insects. (§. 440.) In certain species these appendages are extremely small, and but few in number; according to CUVIER there are but two short ones in several species of Sole (*Pleuronectes*), and two larger in the *Lophius piscatorius*. (Tab. IX. fig. XXI.) In other instances, on the contrary, they are extremely numerous, as in the Gym-

† “Fishes whose food is inclosed in shells have an apparatus for breaking the shells, which is not always placed in the mouth, but sometimes in the stomach, forming a Gizzard similar to that of Birds. This structure is most conspicuous in the stomach of the Mullet: it is confined to the pyloric portion, the muscular coats of which are extremely thick, while those of the cardiac are very thin. It is also met with in the Gillaroo Trout in Ireland, though in a less degree. In that Fish the form of the stomach is exactly the same as in the Salmon and common Trout, only having the coats of the pyloric portion two-thirds thicker. The common Trout lives upon the same kind of food occasionally, and swallows stones for the purpose of assisting in breaking the shells; so that it is probable that the coats of the pyloric portion in the Irish Trout acquire their increased thickness from being more constantly employed in this exertion, in like manner as the Sea-Gull's gizzard becomes increased in strength after it has lived some time upon grain.” (HOME, *Comp. Anat.* i. 354.)—Translator.

notus *electricus* (fig. XXII.); of considerable length, as in the *Gadus lota* (fig. XIX. t.); or consolidated together into a mass of glandular appearance, as in the Sturgeon. (Fig. XX. c.) As there is a considerable secretion of mucus from these blind sacs, and as the secreted fluid is poured out at the same spot as the pancreatic juice in the superior animals, we find an additional reason for admitting the correctness of the opinion already expressed, (§. 440.) that these organs correspond to the Pancreas of Man.

§. 472. On the other hand these appendages are altogether wanting in many other species, *e. g.* the Carp, Pike, Eel, Lamprey, Ray, Shark, &c.: in the two latter, however, there is another structure of a very singular nature,—the inner membrane of the intestine being raised in a broad fold immediately below the stomach, continuing in spiral turns through the canal, and terminating in the rectum. This spirally convoluted fold, when examined from below, has the appearance of a rose not full blown. In a Shark (*Squalus maximus*) thirty feet six inches long, the stomach was followed by an expanded portion of intestine, into which the biliary duct opened. The small intestine was four feet ten inches long, and furnished with a strong spiral valve,\* (fold of the internal membrane.) That organ appears to compensate for the shortness of the intestinal canal, and to impede the too rapid passage of its contents. The remaining part of the course of the intestine is infinitely various in the different species, not only as relates to its convolutions, but also its structure, the internal surface being sometimes furnished with serpentine longitudinal folds, as in the Eel; at others reticulated, as in the Sturgeon, &c. In the Pike I find the external membrane of the first half of the intestine extraordinarily thick, and of nearly cartilaginous consistence. As to the convolutions, they are almost

\* HOME, *Lect. on Comp. Anat.* p. 391.

wholly wanting when the intestine proceeds direct to the anus, as in Lampreys, Rays, and Sharks: in most other species it makes a few turns, which are rarely very serpentine, as, for instance, in the Sturgeon, (Tab. IX. fig. XX.) the Burbot, (fig. XVIII.) the Frog-fish, (fig. XXI.), Electric Eel, (fig. XXII.), &c. In the latter, HOME\* states that the rectum reascends towards the stomach, and notices this fact, together with the position of the anus near the anterior extremity of the body, as a coincidence with the course of the intestine in several Mollusca, *e. g.* the Sepiæ. (§. 442.) In most Fishes the intestinal canal expands at its posterior extremity, and, in the same manner as in Insects, (§. 445, where the original character of this structure is pointed out,) forms a large intestine, into which the small intestine frequently projects with a fleshy circular fold. (See this large intestine in the Burbot, Tab. IX. fig. XVIII. XIX. l.) This part of the alimentary canal is rarely wanting, as is the case in the Carp: in other instances it is extremely large, as, according to CUVIER, in the Sparus *melops*, or furnished with a spiral valve, as in the Sturgeon. (Fig. XX. d.) In Sharks a hollow glandular sac opens into the rectum by a little excretory duct, and is compared by HOME to the ink-bag of the Sepiæ. This, like many other secretions in the vicinity of the anus serves to remind us of the original relation existing between this spot, where indigestible matters are collected, and the respiratory organ (the apparatus for the volatilization of organic materials)—(§. 434. 436. 439.); and also of the connection between the respiratory and secretory organs, so intimate that the latter appear to be merely repetitions of the former, a fact which will be still more evident in considering their history.

\* *Loc. cit.* p. 387.

The rectum of Fishes usually opens by a round anus, immediately in front of the urinary and genital aperture, into a longitudinal groove before the anal fin. In Rays and Sharks this groove is deeper, and has more the appearance of a final expansion (Cloaca) of the intestine, through which, as through the funnel of the Sepiæ, are discharged feces, ova, semen, and urine. As to the attachment of the intestine, it is here no longer effected, as in the preceding Classes, by vessels merely, but by means of a true mesentery. Its laminae which are usually very fine are formed by a duplicature of the peritoneum, and are reflected either from the vertebral column, or, when as in the Burbot, the Swim-bladder is firmly attached to the spine, (fig. XIX.) from the Swim-bladder itself. The whole intestinal canal, together with the liver and spleen, is inclosed within the bag of the peritoneum, which we already found in Snails and the Sepiæ. It lines the abdominal cavity internally, and in all essential points is organised as in Man. In Rays and Sharks, however, it has one distinguishing peculiarity, viz. that a free access of the surrounding medium into its cavity is permitted by two small openings placed at the sides of the anus—a peculiarity, the true character of which we shall hereafter have occasion to examine in connection with the description of the respiratory and sexual organs.

SECTION II. *Organs of Digestion in the Amphibia.*A. *Of the <sup>Organs</sup> of Mastication, Taste, and Deglutition.*

§. 473. It is unnecessary to give any farther description of the position and external form of the mouth than has been already done in considering the jaws, which applies the more accurately as those bones are here not covered by any great quantity of soft parts, and frequently merely by the dense and generally scaly integuments. It is, however, physiologically important that suction in this, and also in the following Class, (Humming-Birds excepted,) does not present itself as the first and simplest mode of conveying nutritive matter into the alimentary canal. As to the muscles of the jaws,—the lower jaw is here also raised principally by a temporal muscle (Tab. XII. fig. II. 36.); it is depressed in a peculiar way, viz. by a muscle corresponding to the Digastric in Man, which, descending from the back part of the neck, is inserted into the process behind the articulation. (See it in the Crocodile, Tab. XI. fig. X. i.)\* In proportion as this process is drawn up, the extremity of the Maxilla† Inferior must be depressed, (Tab. XII. fig. II. 48.) the articulating process of the Temporal Bone (§. 184, 191, 203.) forming the centre of

† According to GEOFFROY (*Annales du Museum d'Hist. Nat.* vol. ii.) it is not improbable that the Crocodile, as stated by HERODOTUS, moves the superior Maxilla (together with the Cranium) rather than the inferior. This motion, which is possible even in Man, is a natural consequence of the great length and size of the Lower Jaw. (See Tab. XI. fig. X.)

motion. In Serpents we have also to notice an apparatus consisting of several small muscles, by means of which not only the bones of the superior maxilla, but also the lateral branches of the inferior can be approximated or separated, so as to increase the extent of the aperture of the fauces; a motion which appears to be an evident repetition of the lateral action of the jaws in the Articulata.

§. 474. The teeth of the Amphibia, like the pointed or hook-shaped teeth generally found in Fishes, are calculated rather for lacerating and holding than for masticating food. In form too, they ordinarily coincide with them, being fixed, as pointed hollow cones, partly to the arches of the jaws, and partly to the bones of the palate. The succession of these teeth has been observed chiefly in the Crocodile, and is there effected by the formation of new germs or rudiments within the old teeth, the full number of which, according to CUVIER, is found in the young animal. The position of the teeth is not the same in all Amphibia. They are altogether wanting in Tortoises, the deficiency being in some degree supplied by a firm horny coating on both jaws. In the Frog there are very minute teeth in the Upper Jaw and on the bones of the palate (Tab. XI. fig. I. d.\* fig. III. v.\*): in the Salamander there are some below also. In Serpents, likewise, there are two rows of teeth on the palate parallel to the edge of the jaw: besides these, the upper jaw itself is furnished with two fangs in the poisonous species, and in those which are not so, with two long rows of teeth; whilst the lower jaw in all is armed with numerous sharp hook-like teeth, pointing backwards. (Fig. VII.) The poison fangs are the most remarkable, on the one hand coinciding in point of structure with the mandibular hooks of Spiders, (§. 451.) and on the other, with the teeth of Sharks (§. 463.) as regards their succession. As to the first point, the venom-fang is provided with

a canal opening by a fissure, the poison secreted by a peculiar gland (Tab. XII. fig. III. d.) being propelled through it by the action of a muscle (fig. III. c.), and thus infused into the wound inflicted by the tooth. As to the succession of teeth; several rudiments are placed in the gum one behind the other, and, according as those in front are lost or worn away, rise up and become attached to the bone. Lastly, in Lizards (a few only excepted, as the Iguana, where there are also teeth on the palate) the teeth are confined to the two jaws as in Rays and Sharks.\*

§. 475. In considering the tongue in the Amphibia we must make a close examination of the different forms presented by the lingual bone. If for that purpose we turn our attention to the lingual bone of Fishes, (§. 179.) which forms almost an integral part of the branchial apparatus, (§. 164.) we shall, from the forms it there presents, be better enabled to estimate the true character of those which occur here. For, in the same manner as the lingual bone in Fishes presents itself as a bony belt, (like the arches of the jaws, gills, or ribs,—all equivalent to anterior vertebral arches,) the rami of which support the lingual cartilage at the point where they meet in front,—are connected posteriorly with the Sternum, and in addition are frequently beset with repetitions of the branchial arches, (rays of the

\* The Gayman has 19 teeth on each side, both in the upper and lower jaw: in the Crocodile there are 19 above, and only 15 below. In the Gavial there are 27 above, and 25 below. In the Tupinambis 16 above, and 13 below. In common Lizards, and in the Iguana, they are sharp and more or less serrated, in the latter there are 20 on each side, of which many have six or eight notches. In the Stelio they are triangular, and slightly serrated both anteriorly and posteriorly. The horny substance covering the jaws of Tortoises is essentially similar to that of the beak of Birds. Its edges are sometimes merely terminated by an acute angle; at others minutely serrated, or divided into large tooth-like processes. (Cuvier, *Comp. Anat.* iii. 199.)—Translator.

branchial membrane,)—so also, in the Amphibia, we find a middle piece supporting the tongue, and frequently terminating in a point; two large lateral cornua analogous to the rami of the lingual bone in Fishes, and which in the same manner have attached to them a point turned backwards; and several smaller cornua analogous to the rays of the branchial membrane or the arches of the gills.

§. 476. Thus, in Frogs, we usually find a quadrangular cartilaginous lamina with four cornua. (Tab. XIII. fig. VI. a.) The great lateral rami arise from the front angles of this lamina in the form of slender cartilaginous threads, proceed forwards, and then, bending backwards towards the joints of the jaws, are ultimately attached to the cranium. The smaller posterior cornua are bony, shorter, and placed at each side of the larynx. In the Surinam Toad (*Rana pipa*),\* the body of the lingual bone has only two small cornua in front, whilst the posterior larger cornua expand from slender threads into considerable cartilaginous laminae about an inch long, which are broadest in the female and longest in the male. In the Salamander, on the contrary, the Lingual bone is slender and pointed in front, whilst the great cornua are separated from the body of the bone in the form of moveable lateral laminae. (Tab. XIII. fig. III. a.) In Tortoises, too, according to CUVIER, the lingual bone appears usually to consist of one broad lamina with several cornua. The representation given by MEYER of the lingual bone in the Fresh-water Tortoise has a very striking resemblance to the lingual bone and branchial apparatus of Fishes. (Tab. XI. fig. IV. a.) In Serpents, the lingual bone, when the tongue is small and admits of being concealed in a sheath, is also very small and shaped like a *A*; in the Amphibœna, for instance:—on the con-

\* BREYER, *Observationes Anat. circa fabric. Ranae pipa.* Berol. 1811. p. 14.

trary, when the tongue can be protruded to a considerable extent, the rami of the lingual bone are much elongated posteriorly; such is the case in most Serpents. In Lizards we again meet with these various forms: the lingual cartilage is sometimes *A* shaped, as CUVIER and I found in the Gecko; at others, with a point anteriorly penetrating the substance of the tongue, and with several lateral cornua, as in the common Lizard (*Lacerta agilis*); or lastly, is furnished with a flat scutiform body and two large lateral rami, as in the Crocodile. The muscles of the lingual bone proceed as in Man, partly to the lower jaw, partly to the tongue, and when it exists, also to the Sternum. (See in the Frog. Tab. XII. fig. I. 1. 2. 3. 4.)

§. 477. The tongue itself is usually much more completely formed than in the preceding Class, though still very imperfect as an organ of taste. In the Frog it forms a kind of valve, the root of the organ being attached close to the anterior edge of the lower jaw, and the cloven extremity turned towards the opening of the glottis, thus performing the office of an Epiglottis. (Tab. XII. fig. XVIII. f.) In the Surinam Toad the tongue is small, and, as in the Salamander, firmly attached to the floor of the mouth. In the latter, and also in Tortoises, where likewise it does not admit of being protruded, it is furnished with short satin-like villi; in the Frog, on the other hand, it is very soft, smooth, and slimy. Such also, according to CUVIER, is the case in the Amphibœnæ: in the remaining Serpents, on the contrary, it is distinguished by its length and mobility. Thus, in a *Coluber natrix*, thirty-three inches long, the length of the tongue with its retractor muscles was 4 inches; its breadth only about two lines, and its thickness nearly the same. This long and moveable tongue, which reminds us of the sucking tube of Insects, and the proboscis of many Mollusca, is usually vermiform

or nearly cylindrical,—its point being cloven\* and coated with a dark horny covering. It is moved in the following manner: the membrane lining the mouth is reflected in front of the aperture of the glottis, so as to form a cylinder surrounding the lower part of the tongue like a sheath; to the root of this sheath are attached two muscles arising from the long parallel rami of the lingual bone, and, consequently, serving to draw the tongue back; another pair, on the contrary, extends between the same part of the sheath and the lower jaw, by means of which the tongue can be protruded. In Lizards, also, the tongue is usually elongated and cloven; in the Chameleon it is even susceptible of vermiform motion.\* In the Crocodile, on the contrary, the tongue is so large as to occupy nearly the whole of the space between the rami of the lower jaw, but at the same time is immovably attached to the floor of the mouth: it is covered by a firm membrane with rhomboidal furrows, and but little calculated for receiving gustatory impressions: it terminates posteriorly by a small projecting border placed transversely, and partially covering the aperture of the glottis.

§. 478. In Amphibia, as in most Fishes, the cavities of the mouth and fauces run almost insensibly into each other, particularly when, as in Frogs, Serpents, and Tortoises, the internal apertures of the nares are placed immediately behind the edge of the jaw. (Tab. XII. fig. XVIII.) In such instances, as we shall hereafter find, the aperture of the glottis lies considerably forwards, and there is no trace of a Velum Palati. This applies also to several

\* This division of the tongue is to be explained only by viewing in it the fact of the composition of the organ of two lateral halves, which are separate even in the human fœtus: which composition must itself be considered as a consequence of the separation already remarked in the tongue and lateral feelers of the Articulata (§. 447. 452.), but more particularly of the lateral portions of their jaws.

Lizards, as I found in the Gecko for instance. But in the Crocodile, where, as already stated, (§. 350.) the internal aperture of the nares is placed so far backwards, I find in several small specimens a kind of Velum, though without a Uvula, by means of which, together with the posterior raised margin of the tongue, a separation is established between the mouth and the cavity of the fauces. In several species of Frogs and Lizards the cavity of the fauces is much enlarged by an expansion of the skin in front of the larynx. In the male Frog there are two such pouches placed one on each side: in the Iguana, Draco, &c. there is a single one placed inferiorly. These laryngeal sacs, as they are called, appear to be receptacles for air rather than food, for although not connected with the larynx,\* they are extraordinarily distended in rage, &c. Instead of the branchial openings, which in Fishes were found at the sides of the cavity of the mouth and fauces, the Oesophagus is here, as in Man, crossed by the course of the air from the nasal canal to the aperture of the glottis, and at the points where we before found the openings of the gills, we meet in most Amphibia with the orifice of the Eustachian Tube. But when we shall hereafter have to remark that true Gills actually exist in some Amphibia, properly so called, (Siren and Proteus,) and that the Gills of the Larvæ of some other Amphibia are seated in the Tympanum,† we must consider these facts as throwing much light on the real character of the Eustachian Tube, inasmuch as we find that canal, on the one hand, forming a repetition of the respiratory aperture, on the other presenting itself as the primary external auditory passage in the

\* According to CUVIER, they are connected with the Larynx in the Chameleon only.

† As is the case, according to the remark of DUTROCHET. See MECKEL'S *Archiv. b. i. h. l. s. 157.*

animal series (§. 363.); and lastly, in the superior animals again forming a canal for the conveyance of air to the organ of Hearing.

B. *Of the Œsophagus and Stomach in the Amphibia.*

§. 479. The close connection between this and the preceding Classes is shewn as well in the structure of these organs, as in the general proportional shortness of the intestinal canal. The Œsophagus is a funnel-shaped canal continued from the fauces, and of smaller diameter: in consequence of the contraction of the muscular coat, the internal membrane is usually disposed in longitudinal folds. Its width is nearly uniform with that of the stomach, particularly in Serpents, in which the whole intestinal canal, by its very direct course, approaches closely to that of the Lampreys. According to CUVIER and BLUMENBACH, the Œsophagus in several marine Tortoises (Turtles) is furnished with numerous horny points directed backwards, like the teeth on the tongue, palate, and pharynx of Fishes, and apparently serving to prevent the escape of the food of these otherwise nearly toothless animals. In the Eft, HOME\* found a crop-like dilatation of the Œsophagus.

§. 480. The form of the Stomach in the Amphibia is usually very simple: its glands are but little developed, and its position is principally on the left side. In Serpents, as already remarked, it is a direct continuation of the Œsophagus; in Frogs, Salamanders, (Tab. XIII. fig. III. a.) and Tortoises, (fig. I. II. b.) it is a simple longitudinal expansion, which turns upwards, and gradually contracts into the intestine. HOME† has described the remarkable

\* *Lect. on Comp. Anat.* p. 322.

† *Loc. cit.* p. 327.

thickness of the muscular membrane, in a species of Turtle (*Testudo mydas*) that lives on vegetable food; where, as in many other instances, the strength of the coats of the stomach appears to compensate for the absence of teeth. According to the same authority, the stomach is nearly similar in the Siren with two legs, which lives on vegetable food, and in which the intestine is found to contain little pebbles to assist in triturating the food: it has also a horny beak like the Turtle, with two teeth behind it in each jaw.† In the Pipa‡ the stomach is divided into two parts; of which the first and largest is more than an inch long, one-third of an inch wide, and communicates by a narrow contraction with the second, which is roundish, and of the size of a large pea. Such, also, is the case in the large globular stomach of the Crocodile, (Tab. XII. fig. XIX. o.) where we find a peculiar distinct portion in the region of the pylorus, which is close to the cardiac orifice of the organ. This simplicity in the form of the stomach, together with the shortness of the alimentary canal generally, and the coldness of the blood, appear to be the chief causes of the tardiness of digestion noticed in these animals by several observers. Thus HOME remarked that an Alligator took food but once in several days, and found, as the animal lived chiefly on birds, that the feathers and other indigestible parts passed through the alimentary canal. The fact established by GRUITHUISEN,|| viz. that the Frog has the power of completely protruding the stomach through the mouth, reminds us in a forcible manner of some Zoo-phytes, (*Asterias*, §. 434.) in which the food is taken in a similar manner.¶

† *Loc. cit.* p. 328.

‡ BREYER, *Observat. Anat.* p. 16.

|| REIL's *Archiv. f. Physiol.* b. viii. h. 2.

¶ According to HOME, (*Comp. Anat.* i. 321,) the stomach of the Crocodile bears a considerable resemblance to those of birds of prey. It is tole-

C. *Of the Intestine in Amphibia.*

§. 481. The close resemblance existing between Amphibia and Fishes, as regards the stomach, extends likewise to the remaining portion of the intestinal canal; which is usually placed chiefly on the right side, is short, and but little convoluted. We almost always find a distinction between the small and large intestine, the latter being proportionally long and strong. Where the small intestine is inserted into it, there is a circular projecting fold, or rather an intussusception. Such is the general disposition of the parts in Frogs, Salamanders, (Tab. XIII. fig. III. c. d.) Tortoises, (fig. I. II. c. d.) and Lizards. (Tab. XII. fig. XIX. r. s. t.) According to HOME, however, there is a long contracted portion in the lower part of the large intestine, and also a little cœcum at the insertion of the small intestine. CUVIER, also, states, that the inner surface of the small intestine in the Egyptian Crocodile is covered at its upper part with small villi, and inferiorly with a glandular stratum. The intestine is shortest in Serpents; where it is usually of less extent than the body, and (in the *Coluber natrix*, for instance) runs direct to the anus, the only indication of the large intestine consisting in the increased size of the internal longitudinal plicæ. On the

rably large for the size of the animal: it is surrounded by a digastric muscle, as in birds, the middle tendons of which are each about the size of a shilling, the bellies of the muscle resembling in size those of the gizzard of an Eagle. The orifice of the pylorus is at a short distance from that of the cardia, and is extremely small: beyond it is a dilatation, forming a small cavity before the duodenum begins.—*Translator.*

other hand, HOME\* states that the intestine in the Water-Snake is long, and much convoluted; and that there is a long cœcum in a large African Serpent. Immediately before the anus the intestine of the Amphibia (as in Rays and Sharks) forms the Cloaca, as it is called, *i. e.* a small expansion, into which open the rectum, urinary and sexual organs. (Tab. XII. fig. XIX. *z*; Tab. XIII. fig. III. *e*.) The anus itself is T shaped in Frogs; in the Salamander is a longitudinal fissure with two prominent lips; and is transverse in Serpents and Lizards.

As to the attachment of the intestinal canal, it is usually effected, as in Fishes, by means of a delicate mesentery: as is well known, the transparency of this part, particularly in Frogs, renders it peculiarly suited for observing the course of the circulation.†

### SECTION III. *Organs of Digestion in Birds.*

#### A. *Of the Organs of Mastication, Taste, Suction, and Deglutition in Birds.*

§. 482. As the organs of digestion in the Amphibia approached to those of Fishes, so, also, on the other hand, the same organs in Birds approximate in a most remarkable degree to those of Amphibia. From what has been already

\* HOME, *loc. cit.* p. 394.

† In the Iguana and Scincus, which live on vegetable food, the Intestine is of considerable length, and is distinguished by the existence of a small Cœcum at the point where the small enters the large Intestine: such, also, is the case in the Chameleon. (HOME, *Comp. Anat.* i. 396.)—Translator.

(§. 221—224.) said as to the form of the bones of the jaws in Birds, it will be easy to deduce the shape of the aperture of the mouth, and of the organs of mastication. The Bill is formed by two jaws, and being covered with a horny lamina, nearly resembling that of the claws, constitutes the organ of prehension, (not mastication,) the influence of the form of which on every other part of the animal is such as to render it a most essential element in the formation of ornithological systems. But, as the most important points relating to the internal structure and mobility of the two portions of the bill have been already exposed, and as the differences in its external form are objects rather for Zoology than physiological Zootomy, I think it necessary only to notice some few particulars in the structure of this part, in which I may add, that we have a very evident repetition of the beak of the Sepiæ. On the one hand, we have already remarked (§. 342.) that the bill for the most part is completely covered with horn, whilst in others, *e. g.* the Goose, Duck, Snipe, it is furnished with a soft membrane, copiously supplied with nerves, which, supplying the place of lips, must serve as an organ of taste:\* on the other, it is remarkable that not infrequently, *e. g.* in the Goose and Duck, Falcon, Shrike, &c. there are either entire rows or merely single tooth-like projections from the horny covering of the bill. But as these little teeth are not firmly fixed to the bones of the jaws, they rather resemble the tooth-like irregularities on the jaws of Insect. than the true teeth of the higher Classes of Animals.

§. 483. The most remarkable circumstance in the mode of motion of the two portions of the bill is, that besides that the lower jaw admits of being drawn away and separated from the upper, the latter also has a peculiar motion

\* The Cere, also, at the root of the bill in several birds of prey appears to have a similar character.

of its own *upon*, and not, as in the Crocodile, (§. 473.) *with*, the Cranium. (See §. 220.) As in Amphibia, (§. 473.) the lower jaw is depressed, chiefly by one or more muscles (of which the largest and most uniformly present is called *Pyramidalis* by *HERISSANT*) attached to the process of the lower jaw behind the articular pit, (Tab. XIV. fig. v. q.) and to the occiput, (Tab. XV. fig. X. b.) and, consequently, acting upon a lever so as to depress the fore part of the jaw, and open the bill. It is elevated partly by a large muscle analogous to the Temporal and Masseter, (Tab. XV. fig. X. a.) and partly by one or two Pterygoid muscles arising from the Palate bones. When there is a joint in the lateral ramus of the lower jaw, as in the Goat-Sucker, (§. 224.) the *Pyramidalis* appears to serve the purpose of expanding, and the *Pterygoidei* of contracting, that part, whilst both together communicate a certain degree of lateral motion to the whole lower jaw. The motion of the upper jaw is produced partly by muscular action, and partly by the elasticity of the Nasal and Intermaxillary Bones. (§. 220.) In opening the bill the upper jaw is raised up as by a lever through the medium of the Zygoma and Palate Bones acted upon by some muscles attached to the *Os Quadratum*: on the other hand, in shutting the bill, when the *Os Quadratum* resumes its original position, the upper jaw is brought down chiefly by the elasticity of the lamina which forms the sole connection between it and the Cranium. The mechanism of these motions is very curious in the Cross-bill (*Loxia curvirostra*), as described by *TOWNSON*;\* where the dissimilar formation of the two rami of the lower jaw favours a peculiar lateral motion of the two halves of the bill.

\* *On the Structure of the Bill of the Crossbill, in Tracts and Observations in Natural History.* London, 1799.

§. 484. The lingual bone of Birds (Tab. XVI. fig. I. II. III.) is in many respects analogous to that of the Amphibia: it consists of a long but narrow body, placed parallel to the vertebral column, its posterior part having attached to it a long cornu curved upwards on each side. These cornua usually consist of an anterior bony, and a posterior cartilaginous, portions: in the Falcon, however, I find that the second piece is also bony, and that there is an addition of a third cartilaginous portion. The course of these cornua is most remarkable in the Woodpecker; where the long vermiform tongue reminds us of that of Serpents. (§. 477.) The cornua of the lingual bone here, like those of Serpents, are long and filiform; are attached at acute angles to the posterior part of the body of the bone; run upwards on each side of the vertebral column along the posterior surface of the cranium, where they are continued in peculiar grooves to the root of the bill, and are ultimately connected to a canal on the right side of the bill by means of a tendon, which, however, is double in the first part of its course. The body of the bone supporting the narrow dart-like process contained in the tongue is itself nearly filiform, but has not the posterior straight process usually found in other instances, as well as in many Fishes and Amphibia. In the Pelican and Spoonbill CUVIER found a flat pentagonal shape of the body of the hyoid bone, which reminds us of the flat lingual bone of the Frog.

§. 485. The tongue itself is usually supported by a bone or cartilage, connected in various modes with the anterior edge of the body of the lingual bone. In the Goose, for instance, it is by means of a hinge-like joint; where, however, the projection of an anterior and superior process of the body of the bone prevents any other than lateral and downward motion of the great lancet-shaped process entering the tongue. In the Falcon, on the other

hand, where the bone of the tongue is smaller, I find it divided posteriorly into two rami, between which the body of the lingual bone is inserted. Several muscles contribute to the motions of the lingual bone, and of the tongue itself. The latter is carried forwards by a kind of Genio-Hyoideus, the conical shaped muscle of *VICQ D'AZUR*,\* (Tab. XV. fig. X. f.) which turns round the cornu of the lingual bone, is attached anteriorly to the lower jaw, and is of great length in the Woodpecker. It is retracted chiefly by a kind of Stylo-hyoideus, which runs from the posterior hook-like process of the lower jaw to the lingual bone (Serpi-hyoideus, fig. X. e.); and in the Woodpecker is fixed by a muscle proceeding from the cornu of the lingual bone to the trachea. Besides these there are also a Mylo-hyoideus, a Cerato-hyoideus, (fig. X. g.) and a Thyro-hyoideus. As may be supposed, from the attachments of the bone of the tongue, the latter organ has but little motion, and but few muscles of its own.

§. 486. The form of the tongue is subject to many varieties, and presents many approximations to the earlier formations. Thus the long tube-shaped tongue of Humming-Birds,† employed in sucking the juices of flowers, is a perfect repetition of the sucking-tube of Bees‡ and Butterflies. The dart-shaped, soft, and slimy tongue of Woodpeckers, of which the anterior part is horny, and the posterior beset with bristles turned backwards, is also remarkable; particularly as by the mechanism already described it can be protruded beyond the bill to the extent of several inches, in order to seek for insects beneath the bark of trees. Here, also, as in several Amphibia, we find the

\* *Memoires de l'Academie des Sciences*, 1772, 1773.

† *TIEDEMANN, Zoologie*, th. 2, s. 116.

‡ It is to be remembered, likewise, that in Bees the elongated Mandibles form a sheath for the tongue nearly in the same manner as the two portions of the Bill in Birds.

tongue sometimes cloven, *e. g.* in several rapacious Birds, or even divided into several fringes at the extremity, as in Thrushes, Starlings, &c. The tongue is also very generally furnished with sharp points turned backwards, and resembling the lingual teeth of Fishes. Such is the case in several aquatic Birds, and to a certain extent at the root of the tongue in most species. In Parrots the tongue is particularly soft and fleshy: hence the propriety of considering it in them as a true organ of taste instead of an organ of ingestion, as in many other instances.

§. 487. There is not any very absolute distinction between the cavities of the mouth and fauces in Birds, the Velum Palati being deficient, and the posterior aperture of the nares, together with the opening of the glottis, presenting themselves as two correspondent longitudinal fissures beset with papillæ. It has been already stated that the two Eustachian Tubes open into a mucous fossa behind the internal aperture of the nares. In some Birds, too, we find sac-like expansions of the cavity of the mouth similar to those already described in several Amphibia. Of that kind is the great pouch-like dilatation of the floor of the mouth in the Pelican, as well as the laryngeal sac, which in the Bustard opens anteriorly below the tongue: according to TIEDEMANN,\* the latter exists both in the male and female; but according to HOME,† is not found in the young bird. These dilatations, which in the Amphibia appear to serve for the reception of an increased quantity of air during the occasional increase of respiration, *e. g.* in rage, &c. are here employed rather as receptacles for food or water. In one species of Heron, however, (*Ardea argala*,) according to HOME, there is a laryngeal sac filled solely with air, and communicating not with the mouth, but with the air-cells of the neck.

\* *Zoologie*, b. ii. s. 399.

† *Lect. on Comp. Anat.* p. 277.

B. *Of the Œsophagus and Stomach in Birds.*

§. 488. The Œsophagus, which is formed by the gradual contraction of the fauces, by its extraordinary length in Birds forms a striking contrast with that of the preceding Classes, and is placed in front of the cervical vertebræ, sometimes behind, and sometimes, also, a little to the right of the trachea. (Tab. XV. fig. XIII. i. fig. XI. a.) The breadth and extensibility of the Œsophagus are usually very great, particularly in rapacious and aquatic Birds, Grallæ, &c.; where, as in many Fishes and Amphibia, these are such as to permit not only the swallowing of entire animals, but also (at least, in accipitrine Birds) the rejection of the indigestible parts, feathers, bones, &c. Besides, a part of the Œsophagus actually supplies the place of a stomach; for in Herons, Storks, &c. we frequently find Frogs, &c. partly digested in the stomach, and partly engaged in the Œsophagus.

§. 489. The most remarkable part of the Œsophagus, however, is its sac-like appendage, or Crop, (Ingluvies, Tab. XV. fig. XI. b.) which exists chiefly in granivorous, but partly also in carnivorous, Birds: in the latter, however, it appears rather as a uniform expansion of the canal, and, according to TIEDEMANN, is wanting only in the Climbers, Grallæ, aquatic, insectivorous, and struthious birds. It is covered externally by a thin muscular layer, and lined internally by a mucous membrane with numerous minute apertures that pour out a copious secretion serving the purpose of softening the food. If we seek for the true character of this organ in the history of the development of

the animal series, we shall see cause for identifying it with the Gill-bag, which, in the inferior Classes, *e. g.* the Ascidiæ, presents itself with the form of a Crop. For, in the same manner that the origin of a large intestine and cœcum (a Crop of the anal part of the intestinal canal) was the result of the termination of the intestine in the respiratory cavity of other species among the inferior Classes of animals, *e. g.* the Holothuriæ and Larvæ of Insects, so also a Crop is produced by the commencement of the intestine from the same part, as is the case in some other species. Besides, in several Insects there are similar appendages to the Œsophagus (§. 457. 458.); there, however, containing air only, and serving as lungs in sucking. The knowledge, too, of this relation between the dilatation of the Œsophagus in Birds, and the Gill-sacs and air receptacles of inferior animals, will prepare us to receive with less surprise the remarkable fact, observed by HUNTER,\* of a milky secretion in the Crop of Pigeons, which takes place when the young birds are hatched, and is subservient to their nourishment; inasmuch as there is a most remarkable connection, as we shall hereafter find, between the respiratory organs and the generation, as well as nutrition, of the young.†

§. 490. The Crop is placed in front of the cavity of the Thorax, resting on the furcular bone and the elastic mem-

\* *Observations on certain parts of the Animal Economy.* London. 1786. p. 191.

† In the male of certain species of Bustards, there is a long bag hanging down on the anterior part of the Œsophagus as low as the middle of the neck, and communicating with the mouth by an opening under the tongue, which appears to have a sphincter muscle. In the *Ardea argala* (Adjutant Bird), both male and female have a similar bag, which contains air, and can be filled and emptied at pleasure. In this case, however, the bag does not communicate with the cavity of the mouth, but with the large air-cells on the back of the neck. (HOME, *Lect. on Comp. Anat.* i. 278.)—Translator.

brane which connects its rami: it is succeeded by a contraction of the Œsophagus; but soon after its entrance into the Thorax, the latter again expands and forms a false or glandular stomach, (Proventriculus, Echinus,—cavitas cardiaca of HOME, Tab. XV. fig. XII. g.) the structure of which is distinguished from that of the rest of the intestinal canal chiefly by the size and number of its reddish secretory glands. These glands themselves, as HOME has shewn, are of very various structure in the different species, being generally simple in the carnivorous, and in the granivorous and graminivorous, on the contrary, larger and more complicated. In the latter species, the parietes of this cavity, which prepares the gastric juice, are thicker, its glands more numerous, and its whole structure more developed, though its size is comparatively smaller. On the other hand, in carnivorous Birds, *e. g.* Accipitres, Peckers, and likewise, according to TIEDEMANN, in the Pelican, Cormorant, Spoon-bill, and Ibis, is extraordinarily wide, short, formed of thin membranes, and more like the sac-shaped stomach of Fishes and Amphibia: in those instances, too, the secreting glands are not diffused over the whole surface of the stomach, but congregated in particular situations.

§. 491. In carnivorous Birds, (*e. g.* in the Accipitres, many Waders, and aquatic Birds, Peckers, &c.) this part terminates insensibly in a second stomach, which is distinguished from it chiefly by the absence of the gastric glands, and by the presence of a muscular stratum, which, arising from two thin, roundish, tendinous points, appears to serve the purpose of communicating a rotatory motion to the contents of the organ.\* In the Stork, Spoon-bill, Ibis,

\* This kind of motion is proved chiefly by the ejection of rolled masses from the stomach of rapacious Birds, and, according to HOME (*Comp. Anat.* p. 314), by the presence of globular masses of hairs of Caterpillars in the stomach of the Cuckoo.

Puffin, &c. these two stomachs are separated by a more decided contraction, and the muscular parietes of the true stomach are already of considerable thickness (Tab. XV. fig. V.): its muscular structure, however, is most decided in those Birds which live upon vegetables, for instance, the Dove, common Fowl, Turkey, Goose, Swan, &c. in which the muscles form by far the greater part of the stomach, their bright-red and dense fibres uniting in a very firm tendinous centre, and as the internal membrane is of a compact and horny texture, are capable of exerting great force upon the contents of the organ. Above and below this Gizzard extends a bag-like expansion where the parietes of the stomach appear in their original form. (Tab. XV. fig. XII. p. Tab. XVI. fig. VII.) The Pylorus is close to the orifice of the stomach, and does not possess any valve, by which means the seeds of plants are enabled to pass into the intestinal canal, a circumstance of some importance for their diffusion, inasmuch as, according to BANKS,\* they vegetate more quickly under such circumstances. The situation of the Gizzard in the Bird, as in Amphibia, is to the left side, below the liver. (Tab. XV. fig. XI. c.) It is usually found pretty low in the abdominal cavity, and sometimes very much so, *e. g.* in the Cuckoo, lesser Heron, &c.

§. 492. We thus find that in this Class there is a gradual transition from the uniform membranous stomach to a more complicated and more muscular structure, reminding us of the stomach of many species of Insects (§. 455.), and corresponding to the more perfect development of the system of motion in Birds. It has been shewn, also, that even in Birds of prey this muscular structure may be to a certain extent developed by a prolonged sustenance on grain, &c.† It is remarkable, that species which are ex-

\* HOME, *loc. citat.* p. 286.

† HOME, *l. c.* p. 271.

ternally similar, differ in the structure of the stomach in a manner dependent on climate and food, as has been shewn by HOME with regard to the African and the American Ostrich (*Rhea Americana*): in the former he found a large cardiac cavity, which bends upwards, and terminates in a small and very muscular Gizzard (Tab. XVI. fig. VI.); in the latter, the stomach is more capacious, but its coats are thinner. The action of a Gizzard has been very aptly compared with that of molar teeth, and if we recollect that Birds with such stomachs usually swallow stones, &c. so as to arm it as it were with extraneous teeth, we shall be less surprised at the observations of REAUMUR, SPALLANZANI, &c. which prove, not only that sharp bodies, as glass, needles, &c. may be introduced into such stomachs with impunity, but also that they are speedily crushed and blunted.

### C. *Of the Intestine in Birds.*

§. 493. The intestine in Birds proceeds from the stomach towards the right side, and forms a peculiar longitudinal convolution,\* between the two portions of which the Pancreas is inserted, the inferior of the two returning almost to the Pylorus. (Tab. XV. fig. XII. m.) The intestine itself, particularly in young individuals, is frequently of considerable thickness in this situation. From this point the intestine forms numerous convolutions (n), and finally runs in a straight line along the sacrum to the anus. This last portion (z. s.) usually has attached to it one or two

\* This formation, as we shall hereafter find, depends on the fact, that the whole of this portion of intestine is external to the abdomen in the Chick.

cæca, and then increases somewhat in size so as to form a large intestine, though by no means comparable with the size of the same part in most Amphibia. Generally, the intestine of Birds, by its comparative shortness, approaches rather to that of the inferior Classes than of Mammalia, and peculiarly in the carnivorous species. The muscular parietes are usually of considerable thickness, and the internal membrane is covered with very long villi in every part except the cæca. In several Species, *e. g.* the Snipe, Heron, common Fowl, (Tab. XVI, fig. VIII.) there is a little cæcum attached to the small intestine, which is evidently a rudiment of the canal (Ductus vitello-intestinalis) leading from the yolk-bag to the intestine of the Chick; for, according to MACARTNEY,\* the little yolk-bag itself never disappears in the Nightingale.†

§. 494. The large intestine or rectum is generally very short, except in the Ostrich, and is separated from the small intestine by a kind of valve, only in some granivorous Birds, *e. g.* Gallinæ. According to TIEDEMANN,‡ the cæca, or rather vermiform appendages, opening into the

\* *Philos. Trans.* 1811, p. 207.

† In the *Falco buteo*, the villi of the internal surface of the intestine are long and generally cylindrical. In the common Fowl, they are perhaps longer than in any other animal, at least, in the upper part of the small intestine. The inner surface of the cæca, near their insertion into the intestine, is here also villous, but only for a short distance, becoming subsequently perfectly smooth. In the Duck and Goose, particularly the latter, the villi are very numerous, being found in almost every part of the small and large intestine, and for some distance upon the cæca. They are mostly cylindrical or club-shaped, and terminate by a defined margin at a short distance from the anus. They are wanting in the King-fisher, Jackdaw, Sparrow, Cross-beak, &c. the deficiency being supplied by minute folds of the mucous membrane, which are sometimes disposed in regular zig-zag or serpentine lines, or transverse lines, mutually intersecting, so as to form a delicate network. (RUDOLPHI in REIL'S *Archiv.* b. iv. s. 347.)—Translator.

‡ *Zoologic*, b. iii. s. 456.

rectum present the following essential differences: they are particularly long in Birds which live on vegetable food, *e. g.* in the common Fowl, Pheasant, Peacock, Turkey, Goose, and Swan: less so in the Owl, Cuckoo, Crane, Snipe, Pelican, &c.; still shorter in the Dove (Tab. XV. fig. XII. r.), Raven, Thrushes, Finches, &c.; and shortest of all in diurnal Birds of prey, Titmice, Storks, Gulls, &c. In Herons, Bitterns, and Divers, there is a single and almost spirally convoluted cœcum like that of the Sepiæ. This organ is entirely wanting in Parrots, Peckers, Hoopoes, Kings-fishers, Cormorants, &c. These cœca are usually smooth internally, somewhat contracted at the point of communication with the intestinae, and for the most part filled with excrement: the cœca of the Ostrich, however, have a spiral valve of the same kind as that found in the small intestine of Rays and Sharks, and the large intestine of the Sturgeon. As to the nature of these cœca, seeing that they differ decidedly from the ordinary cœca of other animals, we may be allowed to enquire if they do not rather coincide with the gall-vessels, as they are called, of Insects, which will be hereafter described? HOME\* compares them to the secretory organs found in the vicinity of the anus in many animals, *e. g.* the ink-bag of the Sepiæ. OKEN considers them as representing the angles of the urinary bladder; but in that case the Allantois (here called Chorion) should arise from them, and not from the Cloaca.

§. 495. It is remarkable that, according to PERRAULT, in the Rectum of the Ostrich there are sacculi formed as in that of Man, by a bundle of longitudinal fibres. The mode of its termination is very nearly the same as in the Amphibia: it is surrounded by a fleshy lip at the point where it opens into the Cloaca, (Tab. XV. fig. XII. s. Tab. XVI. fig. X. a.) which presents a cavity, or expan-

\* *Lect. on Comp. Anat.* p. 404.

sion, of very various forms in the different species, though for the most part globular, and serves for the discharge of fœces, urine, ova, and semen.\* This Cloaca is surrounded by strong muscular fibres, and, as in Lizards, opens externally by a transversely oval fissure. (Tab. XV. fig. XI. n.) This, also, appears to be the fittest place to notice an organ, the nature of which will come hereafter to be considered in connection with the progress of the development of the young animal, but the functions of which in the full-grown individual, authorize us in classing it with other glandular secretory organs about the anus. It consists in a roundish, but sometimes also longitudinal, sac (Bursa Fabricii), with thick parietes, placed above the Cloaca, and communicating with it by a valvular aperture. Its parietes are lubricated internally by tenacious mucus, and, as remarked by BLUMENBACH, its size appears to increase in proportion to the age of the animal; a fact which I have found confirmed by the examination of the common Fowl, Goose; a young Heron, &c. (Tab. XVI. fig. IX.) The attachment of the intestinal canal by the Mesentery, presents nothing very remarkable in Birds, and as to the parietes of the air-cells of the abdomen, which here contribute as much as the Mesentery to determine the position of the intestine, we shall treat more fully in connection with the respiratory organs.†

\* According to CUVIER, the position of the penis in the Ostrich is such, that it can evacuate urine and feces separately.

† In the Cassowary, the Gizzard is immediately succeeded by two unequal dilatations of the Intestine, separated from each other by a circular fold. The parietes of the intestine are then much increased in thickness, until it dilates into a thin and smooth oval vesicle, imperfectly separated from the portions of intestine placed above and below it. Its cavity is filled with green bile, whilst the intestine between it and the pylorus contains nothing but yellow fluids. Beyond this part the intestine again contracts, its parietes resuming their thickness and their villous structure internally. The com-

SECTION IV. *Of the Organs of Digestion in Mammalia.*A. *Of the Organs of Mastication, Taste, Suction, and Deglutition.*

§. 496. It is a most important repetition of the earlier formations that in the present Class we find the organs for the ingestion of nutritive materials of such a kind as to be capable of serving as organs of suction; nay more, that in the earliest periods of life they are exclusively such. This disposition of them is so general as to have given to the Class the name it bears: it deserves to be remarked, however, that suction here is neither performed by the mouth, lips, and muscles of the pharynx exclusively, as in Zoophytes, Mollusca, Vermes, and some Fishes; nor solely by the Tongue, as in Insects and some Birds; but that it is effected by the united action of the lips, muscles of the cheeks, and tongue, in combination with the respiratory organs. The various forms of the aperture of the mouth, which present many and evident approximations to the human type are sufficiently known as objects of description in Natural History, and, consequently, I need notice only the following as of physiological interest. In many Mammalia, *e. g.* Mice, Hares, Bats, Cats, Dogs, Sheep, &c. there is a fissure in the upper lip extending up to the nose,

mencement of the Rectum is marked internally by a circular fold forming a kind of valve, a little beyond which the Cæca open into its cavity. The Rectum is also distinguished by its diameter, which is double that of the small intestine, by the thinness of its parietes, and by the irregular folds of its internal villous surface. (Cuvier, *Comp. Anat.* iii. 510.)—Translator.

—a proof that the superior maxillary region developed from the sides of the Cranium like costal arches, is here less perfectly closed than in other cases,—Man, for instance; a fact of which we have already found other examples in the complete separation of the bony inter-maxilla, (§. 254.) &c. It is needless to say that a similar fissure presents itself in Man as a mal-conformation (hare-lip).

§. 497. The mouth of other Mammalia differs from that of Man by its greater length from before backwards, and by the greater extent of its aperture; points in which it approaches to the bill of Birds and the mouth of Amphibia and Fishes. This depends upon the breadth of the superior maxillary bones, (Tab. XVIII. fig. VII. fig. XI. c.) and on the great length of the jaws as compared with the Cranium: but, as we have already mentioned, (§. 261.) that the jaws are much smaller in the young animal, it consequently follows that such must also be the case with the opening of the cavity of the mouth. Such a formation is in that case the more important, in so far as it tends to facilitate the action of suction: nay, in the young of the Opossum, which are so firmly attached by suction within the abdominal pouch of the mother, the mouth, according to D'ABOVILLE,\* presents itself as a simple round opening, a sucking aperture. Lastly, I may notice a remarkable repetition in the shape of the mouth of the Ornithorhynchus of a formation otherwise peculiar to the preceding Class: the bill-shaped jaws of that animal are covered, not by true lips, but by a membrane well supplied with nerves, and, according to BLUMENBACH, very similar to that of the bill of the Duck; whilst the only thing that can be considered as a rudiment of true lips is merely a plicated membrane placed at the root of the bill, and having a relation to it

\* VOIGT's *Magazin für Physik*, §c. b. v. st. 2.

analogous to the membranous ring around the beak of the Sépia.

§. 498. The mode in which the jaws are armed is very various in different instances; and in many presents recurrences to organizations already described. Some species, *e. g.*, the Ant-Eaters, like the Sturgeon among Fishes, have the jaws altogether unarmed; in others, as in the Pike and several other Fishes, we find teeth on the Palate and Tongue, unaccompanied by teeth in the jaws: thus, according to HOME,\* the *Ornithorhynchus lysteri* has twenty little horny teeth at the root of the tongue, corresponding to seven rows of similar teeth on the palate: thirdly, we find teeth on the jaws, though not wedged into them, and composed of horny vertical fibres; thus, in the *Ornithorhynchus paradoxus* there is in each half of the jaw one molar tooth, originally composed in the young animal of two, and two points in the tongue directed forwards. Fourthly, we find the Palate and superior Maxillary Bones, in the same manner as the two jaws of Tortoises, covered with numerous layers of horny laminae overlapping each other like tiles, the fibres of the laminae being arranged perpendicularly to them, and unattached at their inferior extremities; such is the case in the Whale,† the laminae of which are well known as affording Whalebone.‡

§. 499. The fifth and most usual mode in which the

\* *Lect. on Comp. Anat.* p. 303.

† It is remarkable that, according to GEORGEY, the young Whale presents some rudiments of teeth in the lower jaw.

‡ Although this mass apparently consists of felted hairs, its chemical composition is distinct, in so far as it is almost devoid of Gelatine, and consists almost wholly of Albumen and Phosphate of Lime. (HOME, *loc. cit.* p. 266.)

jaws are armed here, as well as in Fishes and Amphibia, is by Teeth; and though they here arise from cavities within, not as in Fishes and Amphibia from the surface of, the jaws, they do not arise from the bone itself, but are produced in the form of indurated sheaths or coverings around soft and vascular papillæ (pulpæ), though neither nerves nor vessels penetrate into the substance of the tooth itself. The crowns are first formed, the roots not being produced until a subsequent period, when, by their increase, they protrude the crowns forward. There are even animals in which the fangs are in constant course of formation, and where, consequently, the tooth continues to grow like the nails: such is the case with the tusks of the Elephant, and the incisor teeth of the Rodentia; which latter, however, are worn away in an equal proportion.\* The teeth in the Cetacea, however, *e. g.* the Porpoise, deviate according to HUNTER,† in a remarkable manner from this, which is otherwise the ordinary mode of their developement in Mammalia; in them, as in most Fishes, the teeth arise from the surface of the jaws, and are only received within them as they (the jaws) increase in size. This mode of developement is probably influential in obviating the succession of teeth in these animals, and as a cause why we find them completely lost in their advanced age.

§. 500. The form, position, and distribution, as well as the internal structure of the teeth in Mammalia present infinite varieties in the different species. We shall here, however, touch only on the most essential points, as they are sufficiently minutely considered in Natural History as a mode of arranging Orders and Genera. In Mammalia as in Man we find cutting, pointed, and flattened teeth;

\* F. LAVAGNA, *Esperienze e Riflessioni sopra la carie dei denti*. Genova, 1812.

† TIEDEMANN'S *Zoologie*, b. i. s. 565.

but in arranging them as Incisors, Canine, and Molar Teeth, we must also take into consideration their situation, as it by no means universally happens that Incisors, for instance, are actually cutting teeth, or that Molar teeth have grinding surfaces. As to the Canine teeth, they may be considered as the remains of the numerous sharp and conical teeth with which the whole jaw is armed in Fishes and Amphibia, and even also in several Cetacea, *e. g.* the Porpoise. (Tab. XVIII. fig. I.) In both cases they serve the same purpose of holding and lacerating rather than masticating. They are wanting in many instances, *e. g.* the Ruminants with hollow horns, the Rodentia, the Elephant, the Rhinoceros, and usually in the female of the Solipeda. In other cases they are present in one jaw only, as in the Walrus. In general we find them shaped nearly as in Man, though commonly considerably larger, and that even in Apes. (Tab. XVIII. fig. XI.) They are largest in the tusks, as they are called, of Swine: nay, in the Babiroussa, they project almost like horns above the superior Maxilla, the tusks passing out laterally through the jaws. In the Walrus, also, the two solitary tusks of the upper jaw are of great size.

§. 501. The incisor teeth are rarely altogether wanting, as in the Ornithorhynchi, Armadilloes, and Sloths; most frequently in the upper jaw, as in the Ruminants with horns and antlers, and less so in the lower jaw, as in the Elephant, Walrus, Narwhal, and Dugong. (Tab. XVIII. fig. IV.) They generally coincide pretty accurately in shape with the cutting teeth of Man; in other instances, particularly the Elephant, Narwhal,\* and Dugong, they are remarkable for their size; and in others, again, particularly

\* Although we usually find but one of the long and apparently twisted teeth in this animal, it has really two, though of unequal growth,—the right falling out at an early period, whilst the left continues to increase.

the Rodentia, for their curvature and chisel-like cutting surfaces. The molar teeth are those which are most universally found (the Narwhal alone having only its tusks). They differ in form in a remarkable manner in carnivorous and graminivorous animals; in the former they are compressed from side to side, (*e. g.* in the Dog, Cat, Polecat,) and terminate superiorly in several sharp points, like the teeth of Sharks; consequently they are adapted not so much for masticating as for cutting like scissors, a mode of action by which they always retain their sharpness. In the true herbivorous animals, on the contrary, for instance, in the Elephant, (Tab. XVIII. fig. V.) where each half of the jaw contains but one, or at most (during the period of change) but two molar teeth, in the Ruminantia, Solipeda, and Rodentia, the molar teeth form broad grinding surfaces, which frequently present transverse furrows corresponding to ridges on the surfaces of the opposite teeth, so that leaves, &c. can be crushed and ground by the lateral motions which are rendered practicable by the flat articular head of the lower jaw. The molar teeth of omnivorous animals, *e. g.* Swine, Apes, and Man, form an intermediate gradation between these two opposite forms.\*

\* The three kinds of teeth, viz. Incisors, Canine, and Molar, are found in Man; in all the Quadrumana; in all the Carnivora; in all the Pachydermata, except the Two-horned Rhinoceros and the Elephant, in Camels, Solipeda, and the Ruminants without horns, the Canine being wanting in those with horns, except the Stag, which has vestiges of them. It is only in Man, however, that the three kinds of teeth are arranged in an uninterrupted series, so that those in one jaw every where touch the corresponding teeth in the other; a fossil Genus of Animals (Anoplotherium) alone resembling him in this respect. In Apes and Carnivora, and in all species where the Canine are longer than the other teeth, there is at least a vacancy in each jaw for the Canine tooth of the other. In Bears there is even a considerable space behind each Canine. In Hedgehogs, Shrews, Phalangers, and the Tarsier, the Canine are shorter than the other teeth, and consequently there is a vacancy between their points on each side. In the

§. 502. According to HÔME,\* the teeth may be divided into three classes, as regards their internal structure. 1st, Where the Enamel, a crystalline compound of Gelatine and Phosphate of Lime secreted from the membrane of the pulp, surrounds the crown and body of the tooth. Of this kind are the teeth of Man; of the Carnivora and Omnivora, as well as the great tusks of the Elephant, &c. where, however, the coat of Enamel is very thin. 2d, Where the enamel does not surround the whole of the tooth, and where the proper dental substance, (a bony mass, the great hardness of which, according to BRANDÉ, is owing to the addition of Carbonate of Lime,) forms a part of the masticating surface. Such are, for instance, the cutting teeth of the

Makies, the Tarsier excepted, in Bats, the Galeopithecus, and in Camels, there is a large vacant space between the upper Incisors. The superior Incisors are wanting in Ruminants, and the inferior in the Walrus. Some species of Animals lose the Incisors at a certain age; such are certain species of Bats, particularly the Phyllostomata and the Sus Ethiopicus.

In other Mammalia there are but two kinds of teeth; viz. Incisors and Molares, separated by a vacant space without Canine teeth: such are the Phascolum and all the Rodentia, where there are only two Incisors on each jaw; of which, however, the superior are double in the Hare; the Kangaroo, which has two below, and six or eight above; and the Daman, which has two above and four below. The Elephant has Molares, and two tusks or Incisors fixed in the Intermaxillary bone, but no Canine or inferior Incisors. Others have Molar and Canine teeth with Incisors, e. g. Sloths, and the Dugong: The Molar teeth being the most essential are the last to disappear, except in the Narwhale. Hence, when there is but one kind of teeth it is always the Molar, e. g. the Tatus, Ornithorhynchî, Orycteropus, Two-horned Rhinoceros, and Lamantin. Here, too, may be arranged the Porpoises, which have uniform conical teeth set around both jaws; and the Cachalots, which have similar teeth on the lower jaw alone. In the Narwhale the only kind of teeth consists of two tusks lodged in the Intermaxilla, and of which one is generally wanting. Lastly, the teeth are altogether wanting in the Ant-Eaters, Pangolins, Echidnæ, and Whales. (CUIVIER, *Comp. Anat.* iii. 151.)—Translator.

\* *Lect. on Comp. Anat.* p. 176.

Rodentia, in which the Enamél covers the anterior outer surface of the tooth, and consequently by its greater hardness and resistance, as comparèd with the bony substance behind it, produces the chisel-like cutting surface: this is peculiarly evident in the teeth of the Beaver. 3d, To this head belong those teeth, where, in addition to the Enamel and dental substance, there is a third, which, according to the examination of BRANDE, approaches most closely to the true osseous texture. Of this kind are the molar teeth of the Elephant, of several ruminating animals, Rodentia, &c. In them, a point peculiarly deserving of remark consists in the complicated manner of the folding of the membrane which serves for the secretion of the Enamel, and the singular appearances of the layers of Enamel thereby produced on the masticating surfaces. Thus, in the Ruminants, the Enamel forms wave-shaped striæ penetrating to some depth: in the African Elephant, it constitutes a row of rhomboidal laminae vertical to the grinding surface (Tab. XVIII. fig. V. b.): on the contrary, in the Asiatic Elephant, these laminae present parallel waved edges on the transverse section of the tooth. As the number of these laminae increases with the age of the tooth, and as the enamel of each is evidently produced by a distinct membrane, we may in some respects consider each of them as forming a separate tooth.

The third substance of these teeth, which forms a kind of cement, is produced, according to HOME, like other flat bones, by the ossification of the membrane which secretes the enamel. CUVIER, on the other hand, considers it as a second secretion from that membrane after it has become spongy and thickened, an idea which so far appears somewhat improbable, as that it is not easy to conceive the occurrence of two distinct secretions from one and the same surface.

§. 503. As to the succession of teeth, in Mammalia in general, so far as has been observed, it takes place in the same manner as in Man: *i. e.* those teeth which first appear, and which are formed almost at the same time as the jaws, drop out, and are replaced by others; a phenomenon which is to be explained by the elongation of the jaws, and by the productive power thus re-excited. Thus, HOME\* saw in the Wild Boar sixteen primary molar teeth in both jaws, behind which, and before they fall out, the jaw is elongated so as to admit the appearance first of one, and then of a second, large and apparently double molar tooth. Consequently in the seventh year, when the sixteen teeth have been replaced, there are twenty-four molar teeth, and even subsequently to that period the ramus of the jaw is so much elongated as to permit the formation of a new cell for the rudiment of another tooth. The Ruminants, according to CUVIER, shed twelve of their twenty-four molar teeth. In the Horse the mode of succession serves the purpose of ascertaining the age up to the tenth year. At three months the foal has six primary cutting teeth, and at six months three primary molar teeth, in each ramus of the jaw. The two middle incisor teeth are changed at three years, the two next a year, and the outermost another half year later. The permanent incisors have a fossa on the cutting surface, which only gradually disappears as the teeth are worn away, *viz.* on the two middle ones in the seventh year, in the eighth on the two next, and in the two outermost in the ninth year. The canine teeth first appear in the fourth year, are somewhat blunted in the seventh, in the tenth completely so, and then appear longer from the recedence of the gums. The primary grinding teeth fall out in and after the third year, and are then replaced by new ones in greater number. There are

\* Lect. on Comp. Anat. p. 184.

many remarkable circumstances in the succession of the teeth in the Elephant: the primary tusks appear about the seventh or eighth month; they are about two inches long, are not hollow, and are shed at the end of a year: the new ones present themselves at the end of two months; are at first black and rough, but subsequently acquire a polish: in two months time they are an inch long, and at a later period attain a weight of an hundred and fifty pounds and upwards. There are eight molar teeth formed in each side of the jaw, not one by the side of the other, but behind, or rather above, each other, in such a manner that a second comes next to the first, which is worn down; so that there are two molar teeth in use at the same time. The teeth which come last, however, have always an increased number of perpendicular laminae: thus, the first molar tooth, which is formed soon after birth, has four; the next, which is in use in the second year, eight or nine; the third, twelve or thirteen; the fourth, fifteen; the seventh and eighth, twenty-two to twenty-three laminae.

§. 504. The varieties in the mode and power of the motions of the lower jaw in Mammalia have been already considerably elucidated by what has been said on the shape of the Zygoma, (§. 257.) on the conformation of the articular process of the lower jaw, (§. 260.) and on the temporal fossa. (§. 263.) The muscles, which are the immediate agents in producing these motions, are essentially the same as in Man, differing only in their relative size, position, and figure. The Temporal muscle is of very considerable bulk in those cases where the molar teeth are like shears, *e. g.* in the Carnivora, and that even in the smaller ones, as the Mole. (Tab. XVIII. fig. XIX. a.) In the Herbivora, *e. g.* the Ruminants, where the molar teeth operate rather by crushing, it is proportionally small. (Fig. XVI. 6.) The Masseter runs backwards somewhat more obliquely

than in Man. (Fig. XIX. fig. XVI. 7.) The Pterygoid muscles are the chief agents in the lateral motion of the lower jaw, *e. g.* in the Ruminants. Besides these, however, the lower jaw in many Rodentia is partly raised and partly carried forwards by a muscle extended to it from the superior Maxillary Bone, and particularly its zygomatic process,—as was first shewn by MECKEL. As in Man, also, the lower jaw is depressed by certain muscles from the Hyoid Bone; but more particularly by a muscle corresponding to the Digastric, which, however, actually consists of two bellies in but few instances, *e. g.* in Apes; and, according to CUVIER, is altogether wanting in Ant-Eaters and Armadilloes.

§. 505. We next come to the description of the lingual bone, for the form of which that of Man may well serve as a type. It so far approaches, however, to the earlier formations, that the anterior, and in Man smaller, cornua, in many Mammalia, *e. g.* Ruminants, Solipeda, Swine, are either longer than the posterior, or are composed of two parts, or are attached to the base of the Cranium by means of a long and flat bone, not as in Man by a ligament reaching to the Styloid Process. These flat bones appear particularly to represent the great cornua of the lingual bone in Fishes and Amphibia, whilst the greater or posterior cornua rather correspond to those of Birds, as is evident in the Os Hyoides of the Hare. (Tab. XX. fig. I. and Tab. XVI. fig. II.) In the Carnivora the anterior cornua, as well as the bones (Styloid Bones of CUVIER) connecting them to the Cranium, are distinguished for their slender and cylindrical shape.\*

\* In the *Echidna hysrix* the body of the Os Hyoides is formed by a flat straight branch: the extremities of its anterior edge support the anterior cornua; which are cylindrical, directed forwards, and each composed of a single piece: the styloid bone descends almost perpendicularly on each side

§. 506. The body of the bone differs from its earlier forms chiefly in the absence of the posterior pointed process so generally found in Birds, Amphibia, and Fishes; and also in the deficiency of an anterior articular surface for the lingual bone or cartilage, which no longer exists; though I find in the Hyoid bone of the Hare and Horse a process projecting anteriorly, and representing that articulation. The body of the Os Hyoides in the Howling Ape (*Simia seniculus*†) is expanded into a large tympanum-like cavity communicating with the larynx, and very accurately representing the laryngeal sac of the Amphibia, (§. 476.) which is in the same manner organized for the reception of air, and for adding to the powers of the voice, though it is unprovided with bony parietes. We shall revert to it in treating of the respiratory and vocal organs.‡ This bone, too, affords the only instance among Mammalia of the solid substance being replaced by cavities for the reception of air, as in the bones of Birds. (§. 209.) In Mammalia, as in Man, the muscles of the lingual bone are tolerably numerous; but as their course in both instances is essentially the same, a precise indication is rendered unnecessary, and I will only mention that the

to meet them. The posterior cornua are arched forwards, large, flat, and articulated to the sides of the body: their extremity, of which the posterior edge is convex, is connected with a second piece on each side, descending parallel to the first until it gets behind the body of the bone, where it unites with the corresponding piece of the opposite side. Two other pieces are connected with these at the point of their junction, and diverge laterally from them. (Cuvier, *Comp. Anat.* iii. 234.)—Translator.

† And also in the *S. Brasiliensis*, according to WOLFF. *De Organo Vocis Mammalium*, præ. RUDOLPHI, 1812, p. 3.

‡ In another point of view it might be compared with the *bullæ osseæ* of the organ of hearing in several Mammalia, (§. 247.) as both serve to increase the sound.

muscle corresponding to the *Stylo-hyoideus* is scarcely ever perforated by the tendon of the *Digastricus*.

§. 507. The tongue of *Mammalia* is distinguished from its condition in the preceding Classes, partly by the softness of its coverings, whereby it is more adapted to the sense of taste, and partly by the absence of bone or cartilage within it, whereby it is rendered less rigid, more flexible, and fleshy. There is no want, however, of approximations to the earlier formations: thus, the thick, fleshy, fatty,\* and but little moveable tongue of the *Cetacea*, which is fixed to the floor of the mouth, and, according to *CUVIER*, is without any evident gustatory papillæ, represents the tongue of *Fishes*: the not uncommon division of the point of the tongue into two parts, (in the *Dromedary*, for instance, but particularly in the *Seal*, Tab. XX. fig. V.) reminds us of the tongue of several *Amphibia*: (§. 477.) and, lastly, the fringed tongue of certain *Birds* (§. 486.) is reproduced in the fimbriated-scolloping of the point of the tongue, as described by *CUVIER*, in the *Opossum*. Farther, the vermiform tongue of the *Ant-Eater* and of the *Echidna* (*Ornithorhynchus* sive *Echidna hystrix*) presents great similarity to the tongue of *Serpents*, (§. 475.) partly as regards its shape and motion, and partly in so far as it appears to serve merely as an organ of ingestion. Lastly, it is not infrequently armed in the manner described in *Fishes*: thus, the prickles with which the tongue of *Cats*, and particularly of the *Lion*, *Tiger*, &c. is furnished, are perfectly similar to the lingual teeth of *Fishes*, consisting like them of sharp, indurated sheaths, directed backwards, and seated over soft lingual papillæ. (See §. 463, and Tab. XX. fig. IV.) The lingual teeth of the *Echidna* (§. 498.) have been already noticed: but besides this

\* It often affords three barrels of oil in the *Whale*. See *OKEN'S Zoologie*, b. ii. s. 667.

animal, we find the tongue of the *Vespertilio caninus* powerfully armed, being covered with sharp dentated scales.\*

§. 508. In other Mammalia the covering of the tongue is usually very similar to that of Man, though the number, size, and position of the papillæ present many varieties. The shape of the tongue itself is commonly distinguished from the human by its narrowness, length, and slenderness. Its motions are ordinarily effected by the same muscular strata as in Man; but it is physiologically interesting to remark that the muscular fibres of the tongue (as an organ belonging to the Vegetative Sphere) differ from those subservient to Locomotion in being softer and more delicate. The mechanism of the motions of the vermiform tongue of the Ant-Eaters and Echidna is very peculiar: according to CUVIER, a long muscle proceeds from the sternum to the tongue, which, like the longitudinal fibres of the arms of

\* BLUMENBACH (*Vergl. Anat.* s. 338. 2e. Auflage, 1815) observes that he is not acquainted with any animal in which the tongue exactly resembles that of Man, for that even in Apes it is distinguished by its narrower and more elongated form, and by the difference of the various kinds of papillæ with which its upper surface is beset. Thus, in the *Simia sylvanus* it is three times longer than it is broad, and has posteriorly only three petiolated papillæ arranged in a triangle; but, on the contrary, upwards of two hundred obtuse papillæ, situated in front of the former, and at the sides of the Tongue. They are most numerous at the front of the organ, and appear like white granules of various sizes, but altogether vary in appearance from the conical papillæ infinitely more than is the case in Man. In the Opossum the middle of the anterior extremity of the organ is beset with sharp and firm papillæ, still stronger than those of the Cat Genus: even in the Herbivora there is a similar disposition, though in a slighter degree, and which is probably of use in grazing. In the Two-toed Ant-Eater, the tongue, though two inches and half long, is scarcely thicker at its base than a Crow-quill, and is cylindrical, with the exception of a superficial groove on its upper surface. At its root are two very small foramina cœca: its muscles are very powerful. (BLUMENBACH, *l. c.* p. 341.)—*Translator.*

the Sepiæ, or of the Feelers of Snails, (§. 110. 136.) is continued into the substance of the organ, and affords the means of retracting it, and giving it lateral motion; whilst, on the other hand, the elongation and other motions of the tongue are effected by circular fibres that form the external stratum of muscle. In the little Ant-Eater (*Myrmecophaga didactyla*) BLUMENBACH found the tongue two inches and half long, though the length of the whole body is only eight inches. It is probable, also, that the motion of the long, flat, and narrow tongue of several Carnivora may be assisted by a round elastic ligament contained within a sheath, and which, from its worm-like shape, was once considered as a worm, and as a cause of Rabies in Dogs. It is best known in the Dog Genus; where it lies in the mesial line pretty close to the under surface of the organ: BLUMENBACH, however, found it also in the Opossum, and I myself met with a perfectly similar ligament, one quarter of an inch long, in the tongue of the Mole. It appears to me to be nothing more than a rudiment of the lingual cartilage usually found in the preceding Classes.†

• *Handbuch der Vergleich Anat.* s. 335.

† In the Echidna the tongue becomes very slender at the point where it is detached from the palate, and appears to consist merely of two small and very stout elongated muscular cones placed side by side. Each cone is composed of two muscles; the one external, and formed of an infinite number of little fibrous bundles, disposed in little rings around the internal muscle, which diminish in size as they approach to the extremity of the tongue. The first of these annular fibres are connected with the Genio-glossus of the same side. The internal muscle is cylindrical and very long. It arises from the upper and front part of the sternum, runs along the front of the neck, and passing first between two layers of the Mylo-glossus, and then between two portions of the Genio-glossus, penetrates the annular muscle. It consists of distinct fasciculi twisted in elongated spiral folds. The outermost of these spiral fasciculi terminate on the first of the rings of the annular muscle:

§. 509. As to the remaining circumstances of the cavities of the mouth and fauces, the most important consists in the more perfect separation of the two by means of a Velum, which generally differs but little from that of Man. Except in Apes, the Uvula is commonly though not invariably wanting, inasmuch as I have found it quite evident, though chiefly membranous, in the Hare. According to CUVIER, the Velum is remarkable in Cetacea, and also in the Elephant. In the former it is a tubular elongation of the posterior aperture of the nares inclosing the pyramidal projecting larynx, and of importance, as well for the purpose of respiring whilst the cavity of the mouth is filled with water, as for spouting out the latter. (§. 354.) In the Elephant, also, the Velum descends below the Epiglottis, which is consolidated with the Arytenoid cartilages, and thereby enables the animal to expire when swallowing fluids, as must necessarily take place when it has previously sucked them up into the trunk. Some years since I also observed in the Horse-shoe Bat (*Vespertilio ferrum equinum*) a mode of formation which partly approximates to that just described, and partly reminds us of the relation between the posterior nasal apertures and the Rima Glottidis of Birds. (§. 485.) In that instance, instead of the Velum the posterior aperture of the nasal canal has attached to it a membranous projecting border, which corresponds with the utmost precision to a similar border surrounding the opening of the Larynx, and elongated anteriorly in the form of an Epiglottis. (Tab. XIX. fig. XIX. b.) Nay, even in the Rodentia we find this hitherto unnoticed the subjacent fasciculi reach the succeeding rings, and so on, the innermost extending to the extremity of the tongue; the diameter of the latter diminishing in proportion as the fasciculi reach the point of their insertion. It will easily be seen how the organ can be shortened and twisted in various directions by the longitudinal muscles, whilst the annular fibres, on the contrary, serve to elongate it. (CUVIER, *Comp. Anat.* iii. 264.)—Translator.

repetition of a simple posterior nasal aperture; thus, in the Rat for example, I observe on the roof of the fauces merely an oval hole leading to the nares without any Velum.\*

§. 510. The Pharynx in this Class is characterized by powerful strata of muscular fibres, the arrangement of which, however, present but few important variations from the structure of the same part in Man. The greatest peculiarity is found in the Cetacea, where it is elongated superiorly into two fleshy tubes serving to conduct the water into the canals and pouches belonging to the nose. In this Class also, as in Amphibia and Fishes, we occasionally find sac-like appendages to the cavity of the mouth, which are chiefly employed as pouches for containing food: but also, in some Bats, the Genus *Nycteris*, according to GEOFFROY,† appear very evidently to serve as receptacles for air: for, as these animals are provided at each side of the mouth with an aperture leading between the skin and the muscles of the body, they are enabled, whilst the nasal

\* In the Camel the Velum Palati descends very low; and instead of Tonsils there are numerous little depressions, containing greenish concretions, probably salivary calculi. In front of the Velum Palati is a peculiar organ, the true nature of which is but little understood: it consists of a depending membrane, eight inches long by four inches wide, apparently formed by two laminae of the mucous membrane connected by cellular substance, and furnished with muscular fibres that are probably capable of voluntary motion: its surface is perforated by the oblique orifices of numerous foveoli. It is stated that during inspiration air penetrates it and distends its cells, though the mode in which this can take place is not very obvious, unless it be by means of a large excavation on each side, described as being capable of admitting the top of the finger. (RICHTER *on the Anatomy of the Camel*. See the *Edinb. Journ. of Med. Science*, vol. i. 221.) The same organ has been noticed by Sir E. HOME, in the life of HUNTER, (*Treatise on Inflammation, &c.*) who describes it as a pouch or bag, and attributes to it the office of moistening the fauces—*Translator*.

† *Annales du Muséum d'Hist. Nat.* vol. xx. p. 15.

canal is closed by a peculiar mechanism, to propel the expired air beneath the skin, so as to expand it and facilitate their flight. As to the true Cheek-pouches, they form, in the Hamster for instance, two spacious sacs about  $2\frac{1}{2}$  inches in diameter, placed beneath the skin at the sides of the joint of the jaw, are lined internally by the membrane of the mouth, and covered externally by a muscular membrane which is connected with the spinous processes of the cervical vertebræ. There are similar cheek-pouches in the Ornithorhynchus, in Baboons, Cynocephali, and Monkeys, (Cercopithecii.) In some degree they perform the same office as the Crop in Birds. Here, also, we must notice the glandular sac which is formed at the posterior part of the palate in the Camel,\* though, like the mucous fossa on the palate of Birds, it appears to serve rather as a secreting organ than as a receptacle.

B. *Of the Œsophagus and Stomach in Mammalia.*

§. 511. The Œsophagus of Mammalia differs from that of the preceding Classes, as well by its smaller size, as by the greater strength of its fleshy parietes. The latter circumstance is more particularly evident in the Œsophagus of the Ruminants, which is susceptible of voluntary motion, and in which the muscular fibres are distinguished by their bright red colour from those of the rest of the alimentary canal. In them, as well as in many other Mammalia, these fibres are for the most part disposed in two spirally contorted and mutually decussating sets, an arrangement by which their powers of action must be increased. The

\* HOME, quoted by BLUMENBACH (*Handbuch*, s. 124).

internal membrane which usually forms longitudinal, and more rarely, transverse folds, is remarkable in many species, *e. g.* Dogs, Moles, and Beavers, for its very great density, and the evident approximation in its properties to the external epidermis, differing in this respect from the human Œsophagus, with which it otherwise corresponds closely, as well in position as in its general form. We may remark, as an unusual structure of the Œsophagus, a peculiar valve, observed by *HOME*, at its commencement in the *Echidna* (*Ornithorhynchus hystrix*), together with numerous papillæ at its termination, pointing upwards, and resembling a similar structure in some *Tortoises*. (§. 479.) In beasts of prey and most *Palmata*, also, it reminds us of the earlier formations by its very considerable width.

§. 512. Among the numerous variations presented by the form of the Stomach in *Mammalia*, it is peculiarly interesting to trace the gradual transition from a simple organization, similar to that of *Fishes* and *Amphibia*, into one of a more complicated kind, such as we have hitherto found only in *Mollusca* and *Insects*. As the Stomach of *Man* is to be classed among the more simple of those found in *Mammalia*, I may state generally that the structure, position, and form, are very similar in those of most of the *Carnivora*, *e. g.* Dogs, Cats, Martins, Moles, Bears, and Hedge-hogs, as well as in those which live on insects, fruits, &c. *e. g.* Apes, Bats, Squirrels, &c.; and only differ from it, either, as in Bears, Lions, by a somewhat more evident contraction and division into two halves, at least during life, and more particularly the period of digestion; or, by a more elongated form, as in the *Martin*; or, lastly, by a more spherical shape, as in several Apes and Bats. The stomach of the amphibious *Mammalia*, *e. g.* the *Seal* and *Manati*, deserves particular notice, in which there is a similarity to that of *Fishes*, dependent on the deficiency

of the left or cardiac pouch of the organ, and the insertion of the Œsophagus at the extreme left margin. (Tab. XX. fig. III.) The Stomach of the Air-Eaters and Armadilloes is likewise simple, but as they have no teeth, like Birds, it is very muscular, and stones are swallowed for the purpose of crushing the food. According to HOME, the stomach of the Ornithorhynchus is proportionally very small and its structure simple: the Œsophagus gradually expands into a sac attached to it, and opens close to the pylorus. The glands secreting the gastric fluid are in general more evident than in Man. The epidermis of the Œsophagus usually terminates at the orifice of the Stomach.

§. 513. The Stomach of several of the Rodentia forms an evident transition to the more complicated formations, partly by the greater development of the glands in the region of the cardiac orifice, which in itself is also an approximation to the cardiac cavity of Birds; and partly by the more strongly marked muscular contraction of a portion of its parietes. The Stomach of the Beaver may serve as a specimen of this kind, in which the epidermis of the Œsophagus terminates abruptly at the cardiac orifice, (Tab. XIX. fig. XV. a.) whilst there is a glandular body external to the same spot, over which the longitudinal fibres of the muscular coat are continued. (Fig. XIV. c.) When these fibres are removed, we find a collection of little mucous pouches, the ducts from which gradually unite together, and ultimately terminate by several apertures of different sizes and closed by semilunar valves. (Fig. XV. b. b.) There is likewise a considerable contraction of the parietes near the Pylorus, giving rise to a second and smaller gastric cavity. (Fig. XIV. f.) According to HOME,\* there is a similar glandular apparatus in the Stomach of the Wombat; and in the Dormouse it even

\* *Lect. on Comp. Anat.* p. 146.

forms a peculiar cavity, covered with glands, and placed at the cardiac orifice. Of this kind are also the Stomachs of Hares and Rabbits, in which it is already easy to recognise the distinct functions of the two portions of the organ, the food contained in the left being merely softened, whilst that in the right is found actually digested. The separation of the two halves of the Stomach is likewise very evident in the Hamster (fig. XVIII.) and the Water-Rat, where the first portion is lined by the epidermis of the Oesophagus, as though it were a Crop, whilst in the Hare, on the contrary, it terminates absolutely at the cardiac orifice.

§. 514. The more complicated form of the Stomach is still farther developed in the herbivorous Mammalia. The three divisions, which are but imperfectly indicated in the common Rat (Tab. XX. fig. VI. a.), present themselves in the Porcupine as three separate cavities, although the cardiac orifice and pylorus are still pretty close together. In the great Kangaroo, the length of the stomach, and its numerous pouch-like appendages, give it the appearance of a portion of the large intestine in Man. The gastric glands are collected into separate roundish masses; the cardiac orifice is at a considerable distance from the pylorus, and the size of the left cul-de-sac is far inferior to that of the larger division to the right: according to HOME,\* also, these animals are capable of ruminating when fed upon hard food. Amongst Bats, the Vampyre (*Vespertilio caninus*), which feeds only on buds and flowers, and not by sucking blood, approaches most to the Kangaroo in the intestine-like shape of its stomach. Amongst hoofed animals, the Solipeda offer a more simple form of stomach; the two portions of which it is composed are, however, distinguished by their lining membranes; that of the left

\* Lect. on Comp. Anat. p. 157.

being continuous with the epidermis of the Oesophagus. In the Pachydermata the stomach is already provided with some considerable appendages. In the Pig, the large base of the stomach is turned to the left side, and furnished with a sac-shaped appendage, whilst there is a fleshy conical process in the pyloric half that may serve occasionally to close the orifice. In the Elephant, the stomach is more cylindrical, and has likewise a conical appendage to the cardiac portion, separated from the rest of the organ by strong transverse folds. These appendages are still more considerable in the Peccari (*Sus tajassac*), and Hippopotamus, in the first of which the cardiac extremity is provided with two, and in the second with three large sac-shaped expansions, which have no claim to be considered as distinct stomachs, inasmuch as the structure of the lining membrane is the same in all. To this series, too, belongs the stomach of the Sloth (*Bradypus*), which, according to DAUBENTON and CUVIER, consists of a large globular cardiac extremity with an extensive appendage, connected to it, and communicating by a canal with the narrow gut-like pyloric portion, which is also enlarged by a small cul-de-sac opening into it.\*

\* In the Kangaroo Rat, the Stomach is divided into two gut-like sacs, united nearly at right angles, and communicating together by a large aperture. The cardia enters at the point of union of the two sacs, but corresponds more particularly to the first; a fold, however, is stretched from the Oesophagus into the second, and probably serves under certain circumstances to guide the food directly into it. The second sac is elongated, and divided into several small sacculi, by the contractions of its parietes. Its right margin, which is thick and short, fixes these sacculi by a muscular band like that of a Colon. A long and narrow gland is stretched along it, and secretes a fluid which enters the stomach by several small orifices on its inner surface. The posterior half of the left sac is disposed in large longitudinal folds, whilst there are merely superficial folds intersecting each other so as leave polygonal interspaces upon the anterior half, and upon the commencement of the right sac, whilst the greater part of the surface of the latter is perfectly smooth;

§. 515. We next come to the description of the stomach in ruminating Mammalia, in which, and in certain

so, that from the difference in their structure the two sacs might, perhaps, with propriety, be considered as distinct stomachs. The muscular membrane forms a decided circle around the Pylorus, and helps to distinguish the Stomach from the Duodenum.

In the great Kangaroo, the Stomach has but a single cavity, forming a long and large cylinder, curved in various directions, and occupying a great part of the abdomen. It has several large muscular bands like those of a Colon, extending through its whole length, and dividing it into sacculi. The part of the cavity which is situated on the left of the Cardia, has two curved appendices crossing it at right angles, and is not more than a sixth part as long as the left division, an inverse proportion to what is observed in the Kangaroo Rat. The left pouch bifurcates into two small cul-de-sacs, of which the outermost is distinguished by its thick and glandular parietes, whilst the inner surface of the other, and of the rest of the left sac, is smooth, whitish, and disposed in small irregular folds. This appearance of the inner membrane is continued around the Cardia, and extends, in the form of three long triangular bands, into the right pouch, whilst the rest of its surface is greyish, semi-transparent, smooth, and not plicated. The Pylorus has a circular fold of muscular fibres, and a corresponding ring of glandular structure on the inner membrane, by which the diameter of the opening is much reduced.

In the Roussette, which is frugivorous, the Œsophagus opens into a rounded sac, separated by a deep groove both from the right and left pouches of the Stomach. The left cul-de-sac is cylindrical, terminates in an obtuse point turned backwards, and is covered by very thick muscular fibres. The right extremity of the organ is  $2\frac{1}{2}$  times as long as the left, forming a large tube with thin parietes, and with several contractions, which give it a sacculated appearance like a Colon. The Pylorus is furnished with a valve closing it so perfectly, that it does not admit the passage of air through it.

In the Unau, or Two-toed Sloth, the Stomach is double. The first cavity is very large and not rounded: it contracts posteriorly, and is elongated into a conical appendage which is twisted from left to right, its cavity being separated from that of the Stomach by a semilunar fold at its base. The Cardia opens quite to the right side of the Stomach, and leaves a vast cul-de-sac to the left: it leads into a canal which at first passes from before backwards along the right side of the first stomach. The right margin of the canal is continued still further in the same direction, expanding considerably, and separates the left pouch of the Stomach from the cavity between

Cetacea, it appears in its most complicated form. In the Ruminants with horns or antlers, as is well known, there are four stomachs, though, as it appears to me, the three first, which are lined by a continuation of the epidermis of the Œsophagus, should be considered merely as separate portions of the left or cardiac extremity; and chiefly, because, like that portion in other animals,—probably, according to HOME's investigations, even in Man,—their operation is that of preparing the food for the digestion which is accomplished in the fourth or pyloric stomach, corresponding to the stomach as it exists in other animals. The different stomachs are arranged in the following order: on the left side, and close to the cardiac orifice, is a large cavity, usually rather globular, frequently divided with distinct pouches,

it and the conical appendage. The canal then bends from left to right, and enters the second Stomach by a very small orifice which corresponds to the extreme right margin of the first Stomach. The inner membrane of the canal is white, tendinous, and arranged in longitudinal folds. The second stomach is shaped like an Intestine, is much smaller than the first, and bends under it from right to left. A semilunar fold divides it into two portions, the first of which has very thin parietes, whilst those of the second are thicker, particularly around the narrow aperture of the Pylorus. The first of the two portions of this second Stomach appears to be again subdivided, by a little fold with a dentated margin, into two parts, of which the first communicates with a little cul-de-sac placed in front of the right extremity of the first, between two similar sacs, opening by a common orifice into the first Stomach. These three little sacs are polygonal, and their parietes apparently glandular. The internal membrane of the two Stomachs is smooth, but not villous, and has even a tendinous appearance in the first two sacs of the great stomach.

In the Ai (Three-toed Sloth), the appendix of the second Stomach is much more elongated, and is divided into three sacs by two longitudinal septa. The existence of a canal, like that in the Stomach of Ruminants, and permitting the passage of food direct from the Œsophagus to the second Stomach, suggests the idea that a kind of rumination takes place in these animals. The contents of these stomachs consist of ligneous matter in the state of plaster. (CUVIER, *Comp. Anat.*, iii. 375, 378, 389.)—Translator.

serving for the first reception of the food, and known by the name of Paunch. (*Κοιλια μεγάλη*; rumen; penula; ingluvies; magnus venter; Pansen or Wanst. *Germ.*; l'Herbier; la Double. *Fr.* Tab. XIX. fig. XIII. b.) It is lined internally with a somewhat rough membrane presenting many flattened papillæ, and is constantly found filled with food in rather a dry state.\* The rotatory motion that takes place within it is proved by the balls of hair or woody fibres, which, when coated over by a firm crust, form concretions consisting of concentric layers. These are known by the name of Bezoar stones, *Ægagropilæ*, &c.; are usually found in this cavity; less frequently in other animals, for instance in the stomach of the Horse; and resemble the rolled masses of indigestible substances ejected from the stomachs of Birds of prey.†

§. 516. This first spacious stomach is succeeded by a second very small one, the internal membrane of which is likewise coarse, beset with little papillæ, and folded into numerous irregular polygonal cells dentated at the edges of their orifices. (Tab. XIX. fig. XIII. c.) It is called the Honeycomb Bag. (*Κεκευφαλος*; reticulum; Garn or Haube. *Germ.*; le Bonnet. *Fr.*) It is placed immediately below the entrance of the *Œsophagus*, and appears to serve more particularly for the reception of fluids, and during rumination for moistening the small portions of food which are successively propelled from it into the mouth.‡

\* HOME found it half full even in an Ox that had fasted 7 days. (*Lect. an Comp. Anat.* p. 174.)

† BLUMENBACH mentions an instance in which a ball of this kind was vomited up by a Cow. (*Handbuch der Vergleich. Anat.* s. 126.)

‡ May we not here refer to many Mollusca and Insects, in which the second stomach, e. g. in the *Aplysia*, (§. 440.) is provided with grinding teeth? Nay, we find something similar even in Birds, in which the food is softened in the Crop, or in the cardiac cavity, and then crushed in the Gizzard.

The third stomach is lined by broad but thin and rather coarse membranous folds, ranged lengthwise, from which circumstance it has obtained the names Many-Plies; *χίονος*; centipellio; erinaceus; Buchs, Psalters, *Germ.*; le Feuillet, *Fr.* (Tab. XIX. fig. XIII. d.) It receives the food after it has been chewed the second time; and it is remarkable, that, according to DAVY and BRANDE, it is distinguished by the evolution of Hydrogen gas within it.\* Lastly, the fourth stomach, which we have compared to the pyloric portion in other animals, is lined by a soft mucous membrane; is of a longitudinal, gut-like shape; is connected with the preceding one by a very narrow orifice; and from the peculiar property which its secretion possesses of coagulating milk, is called the Rennet-bag (the Red); *εντερον*; abomasum, faliscus; Labmagen, Rohm, *Germ.*; la Caillette, *Fr.* (Fig. XIII. e.)

§. 517. The organization of these stomachs is peculiarly remarkable, not merely as it is subservient to rumination, but also as it affords the means of carrying the food after it has been ruminated directly into the third, without passing again through the two first cavities. I have already called attention (§. 511.) to the great strength of the muscular fibres of the Œsophagus in these animals, and have here to add, that the same structure is continued by means of a groove, which may be considered as an elongation of the Œsophagus, into the third stomach, the intermediate space occupied by the second being very inconsiderable. The first and second stomachs are to be considered as appendages going off from this groove; and as its edges can be brought into contact by its muscular power, the morsel of food must necessarily be conveyed at such times into the third stomach. Nay, in young animals, whilst still suckled, when the stomach is distinguished by the incon-

\* HOME, *Lect. on Comp. Anat.*, p. 174.

siderable size of the Paunch,\* the milk appears to pass direct even into the fourth cavity, the laminae of the third still adhering closely together.

§. 518. The organization of the stomach is still more complicated in the Ruminants without horns, *i. e.* in the Camel, Dromedary, and Lama. As to the former, its stomachs, according to DAUBENTON and HOME, are distinguished from the form of the ruminating stomach, as already described, by two cellular appendages to the first cavity, and by a peculiar musculo-cellular structure of the second. The fluids, which these animals take at distant intervals, though in large quantities,† here also pass into the second stomach (Honeycomb Bag): the cells of that cavity are about an inch in diameter, are interwoven with numerous muscular fibres, and thereby acquire the power of contracting and closing their orifices so as to retain water without allowing it to be contaminated by intermixture with the other contents of the stomach, even during the repassage of the ruminated food. A smaller quantity of water passes into the cellular appendages of the Paunch, or first stomach, and serves to moisten the food contained in it as much as is necessary to fit it for being returned to the mouth for rumination. When the morsel is swallowed for the second time, it passes through the second cavity, the cells of which are closed, into the third, which is extremely small, and almost perfectly smooth on its internal surface, and from that into the fourth. The latter is gut-like, is partly beset with numerous longitudinal folds, and apparently divided into two portions, which DAUBENTON considered as similar to the third and fourth stomachs of the horned Ruminants.

\* In a foetal Calf of four or five months I found the cavity of the Paunch filled by a peculiar thickish, gelatinous fluid.

† HOME (*loc. cit.*) mentions that a Camel observed by him drank but once every two days, but then to the amount of 6 or 7½ gallons at once.

§. 519. In the Cetacea, lastly, we meet with a form of stomach very closely connected with its structure in the Ruminants. Thus, in a Bottle-nose Porpoise, eleven feet long, HOME\* found the Œsophagus wide, and furnished with longitudinal plicæ, passing directly into a spacious cardiac cavity, fifteen inches long and nine broad, with strong parietes, and lined internally by a continuation of the epidermis of the Œsophagus. As in the Ruminants, so here, this cavity serves to receive and soften the food; and as these animals live chiefly on fish, &c. we find that not merely is the flesh separated from the bones within this cavity, but that even the earthy matter is dissolved, and the bones themselves converted into a gelatinous mass, probably through the medium of a more powerful secretion supplying the place of rumination.† A canal, three inches in length, leads from the first stomach to the second, in which it terminates by an aperture two inches and half in diameter, at which point the epidermis ceases. The second stomach is seven inches in diameter, globular and cellular, and communicates with the third smaller stomach by an orifice only five-eighths of an inch in diameter. The narrowness of the communications between the stomachs appears chiefly intended to prevent the passage of undissolved bones, &c. into the fourth. This, which communicates with the third by an opening less than three-eighths of an inch across, is cylindrical, is fourteen inches and half long, three broad, smooth internally, and, like the corresponding stomach in Ruminants, the true seat of digestion. Even the pyloric orifice is but a quarter of an inch in diameter. In other species there are frequently one or two additional cavities.

\* *Loc. cit.* p. 253.

† It is a singular fact, affording an unexpected coincidence with this circumstance, that ruminating animals are capable of subsisting on Fish; *e. g.* Oxen in the North of Asia. (See HOME, *Op. citat.*)

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C. *Of the Intestinal Canal in Mammalia.*

§. 520. Various attempts have been made to reduce to some generally applicable principles, the extraordinarily numerous varieties presented by the organization of the intestinal canal in the different species of this Class, either by a reference to modes of life, or a comparison of the length and width of its different portions; but the exceptions have invariably proved too numerous to admit of the establishment of any such rules. If, for instance, it should be assumed as a general principle, that herbivorous Mammalia have a long, and Carnivora a short, intestinal canal, it would be in absolute contradiction to the fact that, in the Sloths, which live wholly on vegetables, and in several Makis, Mice, Shrews, &c. which live chiefly on fruits, &c. the intestine is unusually short, *i. e.* 3 or 4 times the length of the body; whilst, on the contrary, it is found of extraordinary length, (from 11 to 23 times as long as the body,) in many species that live solely on animal food, *e. g.* Seals, Porpoises, &c. So also, in the Lion for instance, where the canal is little more than three times the length of the body, we find it very narrow, instead of being wide as we might expect. In general, it appears to me that the circumstances of the intestinal canal depend chiefly on the situation occupied by the individual in the series of animals; and more particularly that the selection of food must depend on the organization of the alimentary canal, and general structure of the animal, rather than that any peculiar mode of nutrition influences the organization. Thus, shortness of the alimentary canal appears to render rapid assimilation, and consequently highly nutritive, *i. e.* animal, food

necessary: a necessity which is still farther augmented, if the animal should be at the same time distinguished by the energy of its muscular powers. On the other hand, length and a more complicated structure of the alimentary canal, in other words, a decided development of the vegetative organs, appear to determine the subsistence, of the animal on vegetable food.\*

§. 521. The character of the Intestine, nay, even of the entire alimentary canal, in Mammalia being determined principally by their relative positions in the animal series, we shall be enabled to recognise a connection, as regards the structure of those organs, between the animals of the preceding Class and those which approach most closely to them in the present. If, in the first place, we assume, as a standard for comparison, the circumstances of the human

\* Many of the apparent anomalies in the length of the intestinal canal in different species of Mammalia, admit of being explained by the degree of complication of the structure, not only of the Intestine, properly so called, but also of the Stomach and of the Cæca, and similar organs appended to the canal, as well as by the relative diameter of the canal, the absence or presence of the various kinds of teeth, &c. Thus, in the Makies, for instance, which are truly frugivorous, the alimentary canal is comparatively shorter than in Apes, a deficiency more than compensated by the great development of the Cæcum. In the Plantigrada, the deficiency in the Cæcum and large Intestine, together with the uniformity of surface and small diameter of the canal, detract considerably from the effect of its length. In Rodentia, the Cæcum, which is highly developed, and in the Tardigrada, the very complicated structure of the Stomach, place these animals more nearly on a par with other herbivorous species than might at first be supposed. These considerations, however, tend to place in a still stronger light the contrast between the truly carnivorous animals, where every circumstance is combined to accelerate the passage of their highly nutritive food through the intestinal canal, and the Ruminants, &c. the most strictly herbivorous, in which the structure of Teeth, Stomach, and Intestines, reaches the highest degree of complicity, evidently for the purpose of extracting, or rather preparing, the greatest quantity of nutriment from substances least calculated to afford it.—*Translator.*

intestinal canal as regards its length, (which in the adult is to the body as  $5\frac{1}{2}$  to 1, and in the child as 7 or 8 to 1,) its position, and its division into small and large intestine, we shall find the following principal variations in the different species. In the amphibious Mammalia, the relation to Fishes (in which the vegetative organs so remarkably preponderate, and where the abdomen occupies the whole of the body,) displays itself in the peculiar development of the organs subservient to the assimilative processes: here, however, the mode of this development consists in the length of the intestine, and not, as in Fishes, in the breadth of the alimentary canal, and size of the abdomen. In the same manner as we found the stomach extremely complicated in some of these species,\* so also is the intestine distinguished by its remarkable length; being, in the Porpoise, according to CUVIER, 11 times,—in the Bottle-nose Whale, according to HOME, 15 times,—and in the Seal, according to CUVIER, 28 times as long as the body. In the Porpoise, as in the *Squalus maximus*, (§. 472.) there is an expansion of the Duodenum immediately below the Stomach, the diameter of the rest of the intestine being uniform throughout. In the Walrus, also, as in many Fishes, the large intestine and cœcum are but little developed, though somewhat more so in the Seal.

§. 522: In the hoofed animals, among which the Pachydermata, by their unwieldy form, abundance of fat, &c. form evidently an intermediate gradation between the Cetacea and the higher species, the intestinal canal is ordinarily of considerable length. In the Elephant, according to HOME, the small Intestine measures 38 feet, the Colon and Rectum,  $20\frac{1}{2}$  feet, and the Cœcum  $1\frac{1}{2}$ ; at the same time, the canal generally, but more particularly the

\* It almost appears as though these animals bear the same relation in this respect to Fishes as the Aplousie and Cephalopoda to Zoophytes.

Cœcum and Colon, are very capacious. In the Hog the Intestine is about thirteen times the length of the body: the Colon, which, like that of Man, has two longitudinal sets of fibres puckering it into a series of cells, is of considerable length, and forms several spiral convolutions on the left side of the abdomen. In the Ruminants the high developement of the assimilative organs is indicated by the extraordinary length of the intestinal canal, not less than by the organization of the stomach. In the Camel, for instance, the length of the small Intestine is 71 feet, of the Colon and Rectum 56 feet, of the Cœcum 3; the Cœcum and commencement of the Colon being very capacious, then becoming narrower, and forming spiral convolutions. In the Ram, according to CUVIER, the Intestine is 28 times the length of the body: consequently the proportion is the same as in the Seal. In the Solipeda the length of the intestinal canal is somewhat reduced: according to HOME the small Intestine of the Horse measures 56 feet, the Colon and Rectum 21 feet, and the Cœcum  $2\frac{1}{2}$ ; the proportion of the whole to the body being about 10 to 1. In the Zebra the small Intestine is  $36\frac{1}{2}$  feet, the Colon and Rectum  $19\frac{1}{2}$ , the Cœcum  $2\frac{1}{2}$ : the large Intestine, however, is usually of extraordinary width. The Anus in this series of animals invariably forms a distinct orifice behind the sexual and urinary passages: the Vermiform Appendix appears to be wanting in all the species, except, according to DAUBENTON,\* in the fœtus of the Manati (*Trichechus Manatus*), where it is even double, unless indeed one of the two processes be the Cœcum itself.†

\* BUFFON, *Hist. Nat.* t. xiii. pl. 58, fig. 3, 4.

† The relative proportion of the diameter of the intestinal canal to its length has been already alluded to. In the Gibbon the length of the small Intestine is to its circumference as 31 to 1; of the Cœcum as 1 to 4; of the Rectum and Colon as 3 to 1. In the *Meki Mococo*, the length of the small

§. 523. Another series of Mammalia is formed rather on the type of Amphibia and Birds. The Ornithorhynchi, Ant-Eaters, Armadilloes, Gloths, as well as Bats, Rodentia, Shrews, Opossums, &c. have already been noticed as forming intermediate gradations between them and the superior species of Mammalia; and as the comparatively simple organization of the Stomach already presented approximations to those Classes, so also does it happen with the intestinal canal. Consequently, we find it, as in those Classes, of inconsiderable length, not more than about 3 to 6 times as long as the body: a statement, however, to which there is an exception in several Rodentia, *e. g.* Squirrels, Hares, Beavers, and Kangaroos, where the proportion is as much as 8, 12, or even 16 to 1, their relation to the Ruminants\* connecting them with the preceding series. In other instances we find individual portions of the intestinal canal distinguished by peculiarities of structure. First, in the Ornithorhynchus and Echidna it is remarkable, that (as in many Birds, §. 492.) there exists a Vermiform Appendix, which differs from a common Cœcum in not containing

Intestine is to the circumference as 41 to 1; of the very long Cœcum as 2 to 1; and of the Rectum and Colon as 1 to 1. In the *Vespertilio noctula*, where the canal is shorter than in any other of the Mammalia, its length is to its circumference as 28 to 1; in the Brown Bear as 37 to 1; the Hedgehog, 58 to 1; the Mole, 82 to 1; the Aquatic Shrew only 19 to 1. In the Otter the proportion is 64 to 1; in the Martin, 66 to 1; in the Weasel, where the canal is short in proportion to the body, only 25 to 1. In the small Intestine of the Lion the proportion is 80 to 1; in the Cœcum, 5 to 6; in the Colon and Rectum 7 to 1. In the Hyæna, where the canal is much longer than in the other carnivorous Digitigrada, the proportion in the small Intestine is 110 to 1; in the Cœcum 4 to 9; in the Colon and Rectum as 6 to 1. In the Squirrel, the ratio in the small Intestine is as 123 to 1; in the large 20 to 1; in the Cœcum of the Polatouche as 1 to 1; the small Intestine, as 50 to 1; in the Colon and Rectum, as 12 to 1. (Cuvier, *Comp. Anat.* iii. 461.)—Translator.

\* The Kangaroo possesses even the power of Rumination. (§. 514.)

foecal matter, appearing to be rather a secretory organ: we have to notice also the moderate length of the Intestine, the small Intestine in an *Ornithorhynchus*  $17\frac{1}{2}$  inches long measuring  $\frac{1}{4}$  feet 4 inches,—the Colon and Rectum 1 foot 4 inches; also the great uniformity in the structure of the small and large Intestine; and lastly, the common termination of the Rectum, urinary and sexual organs in a Cloaca precisely as in Birds and Amphibia. In the Two-toed Ant-Eater, also, as in many Birds, there are two small Vermiform Appendices (Tab. XIX. fig. XX. m. n.): nay, in the Daman (*Hyrax capensis*), which has recently,\* with great propriety, been classed with the Sloths, there are two long Vermiform Appendices, besides a large stomach-shaped Cœcum† placed above them. The Wombat and Kaola, also; according to HOME, have a single Vermiform Appendage, like the *Ornithorhynchus*.

§. 524. In many species, likewise, *e. g.* Armadilloes, Pangolins, Sloths, Bats, Shrews, in the Hedge-hog, Badger, Bear, Martin, Weasel, and in some Rodentia, as the Dormouse and Rell-mouse, we find, in perfect accordance with the type of the Amphibia (§. 481.), the small and large Intestine scarcely at all separate; at least not by a Cœcum, which is altogether wanting, but merely by an annular valve, and usually remarkably short,—in the Mouse, Aquatic Shrew, and Weasel, for instance, being 3 times, in the Hedge-hog 6 times, and in the Mole 7 times as long as the body. It is only in those species more closely related

\* OKEN'S *Zoologie*, b. ii. s. 1087.

† This fact will serve to prove that the Vermiform Appendix cannot be the point of connection with the Vesicula Umbilicalis; and also, that as Vermiform Appendices are here found considerably below the Cœcum, which is the extremity of the large Intestine, they do not consist merely in prolongations of the large beyond the small Intestine, but are in fact repetitions of the intestinal appendages found in Birds.

to the former series, *e. g.* in the Rodentia belonging to this one, in the herbivorous Vampire (Roussette), and in the larger animals, such as the Bear, that the relative proportion is increased, *e. g.* in the Vampire,  $9\frac{1}{2}$  to 1; in the White Bear, 10 to 1. It is remarkable, that almost all the hibernating animals belong to this series, particularly when we consider how completely hibernation is peculiar to the Amphibia.

§. 525. These forms are connected in various ways, partly with the Carnivora, and partly with the remaining Rodentia. In the former, the Intestine is usually short, (about 3 or 4 times as long as the body); the small and large Intestine more uniform in their structure; the Cæcum for the most part extremely small (Tab. XIX. fig. XXI. b.); though in Dogs, as in Marsupial Animals, it is longer and convoluted on itself. On the contrary, in most Rodentia, *e. g.* Hares, Beavers, Rats, Kanguroos, Squirrels, Hamsters, Marmots, as already (§. 523.) remarked, the intestinal canal is longer, the large Intestine and Cæcum more considerably developed, after the manner of the Ruminants, and, at the same time, frequently furnished internally with numerous glands. The size of the Cæcum is most striking in the Beaver, where it measures almost two feet; in the Rat, (Tab. XX. fig. VI. c.) also, and in the Hamster (Tab. XIX. fig. XVII.) its size is equal to that of the Stomach. Its apex is not infrequently (*e. g.* in the Beaver and Hare) beset with many glands, does not contain any fæces, and resembles the glandular appendices to the Stomach, which are likewise frequently found here. The little cæcal pouch near the valve of the Colon in the Hare, noticed even by WEPFER, appears to me, from its glandular and cellular internal structure, to correspond completely to the Vermiform Appendix, notwithstanding a slight variation in its form. Lastly, the intestinal canal

of Apes, like that of Man, is pretty nearly intermediate between those of the Ruminants and Carnivora. The considerable length of the Cœcum in the Makis is worthy of notice, and likewise the appearance of the Vermiform Appendix to the Cœcum in the Orangs.\*

§. 526. On the termination of the intestinal canal in the Anus, I have to remark, that in all Mammalia it is placed behind, and not, as in Fishes, in front of the sexual and urinary passages. The cloacal structure of the Ornithorhynchi has been before alluded to; but even in the Beaver, the same common termination of the Rectum, urinary, and sexual passages exists: nay, even the sac-shaped dilatations found at the termination of the Rectum in several Carnivora, *e. g.* according to DAUBENTON, in the Hyæna, (Tab. XIX. fig. XVI. a.) and in the Genett-cat, appear to be a repetition of this cloacal expansion; though in those instances the urinary and sexual passages no longer open into it. In very many Mammalia we again find these

\* In the *Vespertilio auritus*, the villi of the Intestine are very numerous, and generally pointed, but occasionally tuberculated or club-shaped. In the Cat they are very long, and terminate in acutely pointed processes. In Swine, they are very numerous, and more or less ramified or subdivided: in the large Intestine, instead of villi there are little eminences, which give nearly a reticulated appearance to the surface of the membrane. In the Ox, the membrane is disposed in little folds in all directions; and is perfectly villous throughout, the villi being very long and apparently pointed. In the Mole, the inner membrane is raised into a great number of superficial transverse folds intersecting each other, so as to form a net-work with interstices of various sizes: as they approach the anus, the folds become smaller, so that the membrane presents merely the appearance of little points. It deserves to be mentioned, that in the various animals of different classes which RUDOLPHI examined for the purpose, he was unable to discover in the healthy state the orifices of the supposed Lieberkuhnian ampullæ. (REIL'S *Archiv.* iv. 63.) In the Rhinoceros, the inner surface of the Intestine is remarkable by being raised into pyramidal tufts or processes, which serve the purpose of Valvulæ conniventes. (THOMAS in *Phil. Trans.* 1801, p. 150.)—Translator.

last mentioned dilatations, as well as the orifice of the anus itself, surrounded by glandular pouches and secretory organs, similar to those existing in the three preceding Classes. These anal glands are peculiarly developed around those dilatations in the Hyæna (Tab. XIX. fig. XVI. e. g.), and also present themselves as tolerably large pouches on each side of the anus, and secreting an oily odoriferous substance, in the Lion, the Cat, and several Rodentia. In the Badger there are several similar, but smaller, glands, opening into a peculiar sac above the Rectum: in the Civet and Skunk,\* on the contrary, this sac is placed between the anus and the opening of the sexual organs. Of the same kind, also, are the glandular bags of the Beaver, which secrete Castor, and open into the Cloaca: and we shall hereafter find repetitions of these in perfectly similar secretions from the sexual organs, &c.

§. 527. In Mammalia, as in the preceding Classes, the attachment of the convolutions of the Intestine is effected by the reflection of the folds of Peritoneum surrounding the canal, *i. e.* by a Mesentery. It is remarkable, however, that here, and even in Man himself, we find elongations of those folds, Omenta, in which there are frequently collections of fat resembling those in the abdomen of Insects. This is particularly the case with the great Omentum of the hibernating animals of this Class, in which the accumulation of fat is very great before the commencement of their torpidity, resembling the fatty mass in the Caterpillar before its metamorphosis or sleep as a Pupa. According to CUVIER, in addition to the usual large Omentum, some hibernating animals, as the Marmot, Dermouse, and Jerboa, have likewise two lateral appendages, pro-

\* It is remarkable how, in this animal, a secretion at the anus forms a means of defence (by its odour), like the black fluid of the Sepia, or the poison of the Scorpion and Bee, although in a different manner.

ceeding from the lumbar-region, and devoted to the same purpose.

§. 528. Before quitting the consideration of the organs employed in the introduction of nutritive materials, it yet remains to solve the question,—how far the human organization in this respect precedes that of other animals? From what has been already stated, it is evident that this precedence can consist neither in the powers of the teeth with which the jaws are provided, nor in the force of the muscles belonging to the jaws, nor in the greater complication of the structure of the stomach, nor in the length and capacity of the Intestine; all of which would have been incompatible with the more elevated character of the human nature. Consequently, the peculiarities of this organization not residing either in the force of its assimilative or muscular power, the higher developement of nervous activity, which constitutes the general characteristic of Man, will be found to form, in this instance also, the sole ground of pre-eminence. That superior developement is most decidedly pronounced at the cephalic extremity of the intestinal canal, where it presents itself as a peculiar dermoid sense, that of Taste; and it is easy to demonstrate that in no other animal is a similar developement of that sense favoured in the same degree, by the delicacy of the organ, as in Man.\* The other circumstance, which might be considered as characteristic of Man in this respect, viz.

\* Physiologically it is not unimportant to remark how completely this higher developement of the sense of Taste in Man corresponds to the more elevated condition of the sense of Touch (§. 344.), which, as a branch of the general cutaneous sense (§. 92. 95.), is parallel to it; and also, that it is the two divisions of the general intestinal sense, i. e. Taste, and the sexual sense, which admit of being elevated to the more animal feeling of voluptuousness. They are the two senses which possess the lowest rank; and have the same relation to Touch and Smell, as Digestion and Generation have to Respiration and Motion.

the structure of the organs just considered, by which they are adapted to the greatest possible diversity of food, is, however, much less strictly peculiar. Among the particularities of organization belonging to this head, I may mention, however, 1st. The position and form of the teeth, which, being intermediate between those of herbivorous and carnivorous animals, are chiefly characterized by forming an uninterrupted range, a circumstance in which Man is equalled, according to CUVIER, by a single species of animals only, and that one fossil and provided with much longer jaws (the *Anoplotherium*). 2d. The proportions of the Oesophagus, Stomach, and Intestinal Canal, already incidentally noticed, presenting themselves as intermediate between those of other Mammalia, the greater simplicity of the Stomach being compensated by the increased development of the Colon, as well as Cæcum, with its Vermiform Appendix. We find, too, a remarkable proof of the accuracy of the principle of a gradually progressive development of organization, in the fact, that the new-born Child, as regards the mode of ingestion of nutritive matter, re-approximates to the inferior Classes of Animals, and wanting teeth receives its nutriment by Suction, like a Polype or a Worm.

CHAP. III. *Of the Organs of Respiration and Secretion.*

§. 529. As the animal is related to the Earth by the necessity for Nutrition, so likewise is it to the Atmosphere by the need for Respiration. Both are equally important conditions to the manifestation of life, inasmuch as both contribute, though in different ways, to maintain the constant change of composition of the bodily frame. It is true that in Digestion, as in Respiration, external materials are taken in, and internal thrown off; but quite in inverse proportion: because, in Respiration rejection and volatilization as much predominate, as do intro-susception and approximation in Digestion. Hence, however simple the animal may be, the unceasing change in the composition of the organic mass must still exist, together with the contrast between ingestion and excretion. But as Respiration must be considered as the first and fundamental Secretion, founded on the relation of the animal to the medium in which it exists, and produced by the previous access of an atmospheric element (Oxygen), the remaining Secretions in the body appear as repetitions of this primary one, and the secretory as Metamorphoses of the respiratory organs,—an idea of which the comparative review of animal formations will afford, and in fact has already (§. 455.) afforded, evident examples.

§. 530. We shall proceed to consider the organs devoted to this purpose in the following order: first of all, we shall

describe the cutaneous excreting surface, with its various transformations, in the animal series, as fundamentally opposed to the internal absorbent intestinal surface; not treating, until afterwards, of the processes developed from the former, sometimes internally, sometimes externally, and which, presenting themselves either as pulmonary cavities, or as laminated Gills resembling the form of the leaf, (which in Plants constitutes the chief organ of Respiration,) perform with greater energy the same functions as the Skin, and form true respiratory organs. We shall then still have to examine the repetitions of these organs in the remaining Systems, the Organs of Secretion, which are as follows: First, the repetition of the respiratory Organs in the Intestinal System, to which belong the Organs of Secretion connected with the Intestinal Canal, and of the utmost importance to Digestion,—the Salivary Glands, Liver, &c.; and secondly, the repetition of the respiratory Organs in the Sexual System,\* with which must also be classed the Urinary Organs.

## I. OF THE DIFFERENT FORMS OF THE CUTANEOUS ORGAN.

### SECTION I. *In Zoophytes.*

§. 531. As we already remarked that in these animals the Intestinal Canal was not yet distinguished from the rest of the animal substance by peculiar parietes, but rather

\* Even the sexual function itself consists properly and essentially in excretion, a fact which may materially assist in explaining the connection so commonly remarked between generation, respiration, and the nourishment of young.

excavated, as it were, cut of the general mass of the body ; so also, in the inferior Orders of this Class, *e. g.* in Polypes, we find that the body is not covered externally by any distinct membrane, but merely by a superficial mucous coating. Already in the Medusæ, on the contrary, and even in Species where the internal substance is altogether homogeneous, there is an investing membrane, interspersed with little granules, and easily removed in detached portions.\* It is peculiarly remarkable, on this account, that the gelatinous fluid which it pours out (perhaps a solution of the substance of the body itself) is, according to SPALLANZANI'S observations,† probably the actual substratum‡ of the phosphorescent light, which has been remarked by so many Naturalists in these gelatinous bodies (Medusa, Beroë), and which occasionally illuminates the whole surface of the ocean.

§. 532. • Though, in the Species above-mentioned, the surface of the body appears merely as a mucous coating, or mucous membrane, which is in many respects analogous to the Epidermis of Plants,|| in others, on the contrary, *e. g.* in Madreporæ, Tubulariæ, &c. we find other materials secreted from the external surface, whence originate the horny and calcareous envelopes before spoken of. (§. 62.) In the larger Zoophytes, also, *e. g.* in the Echini, there is

\* Gäde, *Beytrag. zur Anat. und Physiol. der Medusen.* s. 12.

† He found that water, milk, &c. were rendered luminous by being mixed with this secreted mucus. (See MACARTNEY upon *Luminous Animals* in the *Philos. Trans.* 1810. p. 287.)

‡ I say substratum of the light, because the exciting cause is derived partly from without, and partly from the sensible qualities inherent in animal matter. This Phosphorescence, as well as the power of Stinging, before (§. 60.) mentioned, give rise to many interesting comparisons.

|| *Grundzüge der Anatomie der Pflanzthier,* von KIESEB, jun. 1815. s. 131.

a similar secretion of earthy matter, though, as it appears to me, it is no longer completely external, but, nearly as we shall find it in the superior Testacea, deposited in the form of an ossified rete mucosum between the membrane surrounding the Intestines, (Peritoneum,) and external skin. In the Asterias, the fibrous case of the body has been already noticed (§. 66.) as an organ of motion; but even this is covered externally by a kind of epidermis, and, consequently, its fibrous, and in part calcareous, shell, is in the same manner to be considered only as an ossified rete mucosum, capable of motion by means of cutaneous muscles. Physiologically, not only the composition, but likewise the colour, of the outer surface of the body is important; on which point I may remark that, though the inferior Zoophytes, (Infusoria, many Polypes, &c.) the embryos of the animal kingdom, appear altogether colourless and transparent or white, yet, that in others the body itself, or the shell, present evident and frequently very beautiful colours: thus the *Hydra viridis* is green, the *H. vulgaris* yellow; whilst *Æquorea*, *Beroë*, and *Holothuria*, often present extremely beautiful blue, red, or green colours: of the internal or external shells of Zoophytes, I will mention only red Coral, and the different colours of the Echini and Asterias.\*

\* In Star-fish, e. g. *Asterias aurantiaca*, the external covering is formed in each ray by a considerable number of bone-like masses, decreasing gradually in size from the base to the point of the ray, connected together in such a manner as permits of motion one upon another, and forming collectively a groove or channel, in which the parts contained within the ray are lodged, and which is formed into a perfect canal by a hard firm membrane attached to the edges of the masses in each ray. The number of pieces in each segment of a ray is eight, and the number of segments in each ray about eighty, making altogether from 640 to 700 detached pieces in each, and from 3200 to 3500 in the whole body. (MECKEL *Vergl. Anatomie*, th. ii. abth. i. 25.)—Translator.

SECTION II. *In Mollusca.*

§. 533. Here, also, the skin appears for the most part as a mucous membrane, coinciding very closely with the internal mucous membrane of the Intestinal Canal, and but imperfectly distinguished from the subjacent body: amongst the Acephala, however, the Ascidiæ form a remarkable exception, for in them the gelatinous or leather-like case of the body (§. 122.), which in itself is probably insensible, is frequently connected only by cellular tissue, and occasionally only at the apertures of the mouth and anus, with the muscular bag inclosing the viscera, and of which it appears to be a product. (Tab. II. fig. I. a.) Besides, the external covering of these animals is usually very slimy; nay, in the Pinnæ, Mytili, &c. there is, as has been already remarked, (§. 128.) a peculiar complicated gland on the under surface of the Foot, secreting a tenacious fluid, which, when drawn into threads, affords the means by which the animal attaches itself to rocks, &c. The skin itself in these species is delicate, and frequently possesses considerable elasticity, inasmuch as we find that the Foot, an organ which is capable of considerable elongation, does not present any very large wrinkles when contracting. Here, too, shells appear to be formed over the membranous cloak, first by the coagulation into a thin cuticle of the mucous rete secreted from the external surface of the cloak, which is subsequently indurated from within into a thin stratum of Carbonate of Lime, to which new layers are gradually added from within, the last depo-

sited differing from those which are more external in containing a greater quantity of animal jelly, and, consequently, presenting the nacreous lustre.\*

§. 534. In these respects its organization is the same as that of the skin in the Gasteropoda and Cephalopoda, in which the external surface of the body, when not covered by shells, is found soft and slimy: it is, however, by no means to be considered as a peculiarly delicate organ of touch, inasmuch as the proper seat of cutaneous feeling, the Corpus papillare, rich in nerves, is wanting, the mucous rete and Cuticle being still closely attached to the muscular cloak. (§. 133.) The cuticle appears less elastic than on the Foot of Bivalves, whence the surface is wrinkled when the body is contracted. As to the formation of shell, it is usually effected here, as in the preceding Order, between the cuticle and a mucous† surface, which in Snails with shells (somewhat as in the Echini, §. 532.) is either the Peritoneum itself, which incloses the viscera that are external to the body, (§. 130.) or the edge of the Cloak: there are species, however, in which the shell is covered not merely by the cuticle, but also by a stratum of muscular fibres, *e. g.* in the Sepiæ, Aplysiæ, and Slugs. (§. 129. 133.) The fact remarked by SWAMMERDAM,‡ of the embryo of the viviparous Snail, *viz.* that the cuticle covering the external surface of the shell is beset with many little bristly hairs (Tab. III. fig. XII.) is remarkable, inasmuch

\* This deposition of layers is perfectly analogous to the annual deposition of rings of new matter in many plants.

† It has been recently remarked by NASSE (MECKEL'S *Archiv.* b. ii. h. 4), that this mucus, as it is called, is rather an albuminous matter. It is evident that more accurate chemical examinations of such cutaneous secretions, compared with similar analyses of the substance of the body, may be expected to afford many interesting results.

‡ *Bibb. Nat.* p. 75.

as a similar hairy superstratum is found on the Shell in many Acephala, *e. g.* in the *Arca pilosa*.

§. 535. The colour of the surface of the body is very various in this Class, but frequently very vivid, and more commonly so in the marine than in the fresh-water species.\* In the Acephala, the Shells are usually more coloured than the body concealed within them; though occasionally the latter gives out a phosphorescent light,† whilst the Foot which is protruded from the shell frequently alone presents more determinate colours, *e. g.* yellow or red. Such, also, is the case with the Shell-Snails, whilst, on the contrary, Slugs occasionally present more vivid colours, yellowish-red, brown, grey, spotted, &c. The Cephalopoda are but faintly coloured,—reddish, violet, &c. Invariably, however, the seat of colour is in the rete mucosum, or shell produced from it, the external skin being colourless. The symmetrical markings of Snail-Shells may be explained by the gradual increase of the shell, in accordance with the corresponding increase of the subjacent secreting cutaneous surface, variously organized in different parts.

### SECTION III. *In the Articulata, †*

§. 536. In the inferior Orders of this Class, the principal circumstances of the skin are essentially the same as in the

\* Von GÖTTE zur *Farbenlehre*. b. i. s. 236.—It is remarkable, also, that phosphorescence is most common in marine animals.

† In the Pholades for instance.

‡ We shall treat more fully hereafter on the change of Skin, which frequently takes place in this and some of the succeeding Classes.

uncovered Mollusca. Such is the case in the colourless Intestinal Worms, in which the cutaneous differs so little from the intestinal surface, that the skin itself forms an extremely active organ of absorption. (§. 443.) The organization of the skin is similar in the Earth and in Aquatic Worms, as well as in many Larvæ of the higher Insects, particularly Maggots. In the Crustacea, the skin resembles that of the Testacea. But even in Worms the external skin is more distinct from the body: it separates very readily, in the Dew-worm for instance, and then more nearly resembles the human epidermis; nay, beneath this superficial skin is another which is more closely connected with the fibrous stratum, but, nevertheless, forms a new epidermis when the external one is detached. The case is similar with the skin of the Larvæ of Insects, and even with the Crustacea: here, as in the testaceous Mollusca, the external skin formed by the solidification of gelatine is combined with the ossified, or rather petrified, rete mucosum, so as to form an earthy Shell: with this difference, however, that though in both instances the shell once formed is no longer nourished by vessels, (an invariable point of distinction between bone and shell,) no new layers are here deposited internally, as on the shells of Bivalves, but that the succeeding newly-formed stratum forms both skin and shell after the old one has been thrown off, nearly in the same manner that a permanent displaces a milk tooth.

§. 537. One kind of productions from the surface of the skin which arrives at a high degree of developement in the Articulata is peculiarly remarkable, but first presents itself in the vegetable kingdom, viz. Hair. In Plants where the external surface is chiefly devoted to respiration, the Hairs appear partly subservient to this purpose, and partly agents in various secretions.\* In animals we find these organs

\* KIESER, *Anatomie der Pflanz.* s. 160.

present themselves when the external skin begins to be more definitely developed as a peculiar structure, and when at the same time respiration becomes more absolutely distinct. This is already noticeable in the Mollusca, (§. 534.) but still more in Worms: to this head belong the small bristles of the Dew-Worm, (§. 139.) serving partly as organs of motion; the larger ones, both soft and bristly, of the Nereides, &c.; and particularly the glittering ones of the Aphrodita. Even in the Crustacea, notwithstanding the petrified surface of the skin, the hairs do not altogether disappear; as we find them very evident on the edges of the scuta; on the legs, where they appear to protrude from the pores of the shell; and, above all, on the outermost pair of Maxillæ in the Cray-Fish; and usually disposed in tufts,† as in those of Worms. They are found likewise in very many Larvæ of Insects; in which, as soon as the outer skin varies from the state of the gelatinous surface of the Mollusca, and becomes more horny, we find these productions presenting themselves in greater number and perfection. Thus, for instance, in the Larvæ of Gnats, of the Myrmeleon, and Cæstrus, there are only a few faintly coloured bristles disposed in tufts; in Caterpillars, on the contrary, there are hairs of various colours, either very long, or subdivided, and of different degrees of firmness. In microscopical examinations of single hairs of Caterpillars, as well as of Cray-Fish's bristles, I have always found them forming an uninterrupted canal, nearly as the hairs of Man.\*

† We may in some respects consider hairs as Zoophytes placed upon other animals, the bundle-like manner in which they almost invariably at first appear, corresponding to the manner in which Polypes are disposed in bundles or tufts.

\* In the Aphrodite *aculeata* the bristles are arranged along the whole of the lateral surfaces of the body in about 35 transverse rows. They decrease

§. 538. Lastly, in perfect Insects we again find the cutaneous coverings in the inferior species receding nearer to Vermes and Crustacea; in others, on the contrary, particularly as regards the structures produced from them, advancing to an extraordinary degree of developement. Of the former kind are, the Gnathaptera and Aptera; where the skin is formed in layers nearly as in the Larvæ of Insects, the inferior layer throwing off the upper, and each layer being essentially similar to the other. The tendency to induration of the cutaneous organ is still, however, occasionally evident, as is proved by the shells of the Scorpion; in others, on the contrary, inconsiderable, *e. g.* in Spiders, where the thin cuticle allows the colour of the subjacent rete mucosum to shine through. The Hemiptera, Coleoptera, Diptera, Hymenoptera, and Neuroptera, also present, at least on the body and legs, the same horny condition of the skin, though usually of more brilliant colours, and frequently decorated with a true metallic lustre. The skin on the wings is here extraordinarily delicate, and very similar to the human epidermis; with the exception, however, of the Coleoptera, where the upper

in number, size, and hardness, as they proceed from the middle of the body, either forwards or backwards, the posterior in particular being very inconsiderable. The inferior differ from the upper in being situated upon the point of a projecting conical tubercle, which is itself subdivided into three papillæ: each of these papillæ has bristles attached to it, which are thus arranged in three rows, *viz.* from 4 to 5 in the lower, and 2 in each of the upper papillæ. The superior bristles are placed in a row, and not upon tubercles, being larger and stronger than the lower ones, and the number in the middle rows about 14. On an average of 16 bristles of both kinds in each of the 35 rows or bundles, the total number on each side will amount to nearly 600. At the lower part of the row of superior bristles are numerous long but weak hairs, with a glittering metallic lustre, together with a felt-like texture, which steadies those bristles, and extends over the whole of the back of the animal, but not to the tubercles upon which the inferior range of bristles is fixed. (MECKEL, *Vergl. Anatomie*, th. ii. 2<sup>th</sup> ed. 4. 46.)—Translator.

wings (elytra) present themselves as moveable horny laminae, (opercula, §. 150.) In each of these Sub-Orders likewise there are hairs; which, either separated, though in great numbers, cover the whole of the tender body, as in many Spiders, Flies, Humble-Bees, (in which those of the back are feathered,) and Gnats; or again, project in tufts from the firm crusts, as in many Coleoptera. Lastly, in the Lepidoptera, the cutaneous organ is developed into the most brilliant glittering colours, as well as most numerous and delicate productions: not only is the rete mucosum, which in the Articulata continues to form the first basis of the skin, consolidated into a softer kind of horny crust, (which again may be viewed as a dense intertexture of single hairs,) but also there appear on its upper surface either single satin-like hairs, or ramified hairs (feathers), or little horny scales fixed to stalks, and representing various forms of the leaves of Plants, (Tab. VII. fig. XXV.) covering the delicate membranes of the wings, and forming the coloured powder which constitutes the most ornamental variety in the markings of these (almost flower-like) animals.

§. 539. If, before passing to the higher animals, we take a retrospect of the order of succession in the development of the cutaneous organ, we find in the Zoophyte the mucus secreted from the external surface of the body first consolidated into a coarse earthy mass, or a mere cuticle; in the Mollusca the skin altogether corresponding to a mucous membrane, and the earthy shells, when they exist, covered by a distinct cuticle; the animal in this, as in the preceding Class, but little coloured, and thence more fitted in general for radiating phosphorescent light. In the Articulata, lastly, where even the name indicates the greater development of the external form, Vermes and Crustacea offer repetitions of the Mollusca, whilst in Insects we meet with the highest point of perfection of the colour and

structure of the skin in the first division of the animal kingdom.\* The skin itself here imitates the hairs, the respiratory organs of Plants, nay even (in its coloured scales) the leaves in the most perfect manner; and when the hairs by their ramification appear as feathers, for instance, on the wings of Moths and the bodies of Bees, it must be considered as a repetition of a form of the respiratory organs to be hereafter described—Gills.

§. 540. Lastly, we have to remark that the Articulata also have the power of producing a phosphorescent light, which, according to MACARTNEY,† is probably produced in this as well as the preceding Classes by peculiar secretions. Phosphorescent species are most common in the Genera Cancer, Limulus, and Lynceus, among Crustacea; Nereis, among Vermes; and among Insects, in Scolopendra, Lampyrus, Elater, Fulgora, and Paussus. In phosphorescent Insects the light is produced, according to MACARTNEY, from a yellowish matter secreted by peculiar bladder-like organs, (Tab. VII. fig. XVIII.) and placed behind a transparent spot of the horny covering, without any appearance, however, of a peculiar nervous or tracheal apparatus. The situation of the light is by no means the same in all cases; a fact which makes it improbable that it has any fixed relation to other organs,\* *e. g.* to the Nervous System: thus

\* It is remarkable to observe that in this as well as in the next series of animals, the colouring of the dorsal is always more brilliant and distinct than that of the abdominal surface, the one being exposed to the light, the other to the ground. In this respect, as well as in the brighter colours of the animals of warm climates, we again clearly find that light serves not only to display, but also to produce colours.

† *Phil. Transact.* 1810. *On Luminous Animals.*

‡ TREVIRANUS, in his *Vermischte Schriften*, b. i. 1816, has imputed several errors to the observations of MACARTNEY, and conceives that he has detected the little phosphorescent sacs on the abdomen to be air-bags; and

the Glow-Worm shines on the middle rings of the abdomen, the Lantern-Fly (*Fulgora laternaria*) on the hollow projection from the head, and the *Elater noctilucus* on the Thorax. In the higher Classes we find this phosphorescence of the surface of the body probably in only a few Fishes, though even here there may be some delusion,—Fishes being considered as phosphorescent merely from being covered by small phosphorescent Zoophytes.

#### SECTION IV. *Of the Skin in Fishes.*

§. 541. In most species of this Class the structure of the skin is more complicated than in the preceding. In immediate contact with the muscles, and closely adhering to them, we find a kind of corium, so thin that it can usually be raised in but small pieces. From it arise the scales, surrounded by rete mucosum, and overlapping each other like tiles: they consist of horny or bony laminae, which we may consider as little shells of Bivalves or Snails, partly because they are produced from the same situation, and partly because, like them, they increase by the deposition of new layers and circles. Here, too, pretty nearly as in the more perfect Zoophytes, (§. 532.) the rete mucosum is the seat of the colours, which are frequently very vivid.

farther, that the genital organs are the true source of the light. Still, according to this opinion, it is scarcely intelligible how the light should appear at other points, *e. g.* the Head and Thorax. As I have not hitherto had any opportunities of fully examining these points for myself, I did not feel myself justified in giving an exclusive preference to the views of either of these writers.

Lastly, the external stratum of the skin is formed by a thin cuticle, formed by the superficial consolidation of the rete mucosum, and constantly lubricated, as in the Mollusca, by an albuminous slime.\*

§. 542. The structure of the scales in this Class presents many varieties.† In the vermiform Fishes, *e. g.* Eels, they are extremely small, and scarcely visible, the skin, as in many Vermes and Mollusca, being little else than a mucous membrane: sometimes they are placed one over another as semilunar horny laminæ, rarely of a very large size, the uncovered portion alone of the scale displaying its colours through the albuminous coating. We must not omit to notice, with regard to those colours, that they are here again darker on the dorsal than on the abdominal surface; and that, even in the Pleurónectes, the lateral half of the body which is exposed to the light is darker than the corresponding one averted from it. Not infrequently we find the scales actually ossified, and provided with projecting spines or points,—as in the Sturgeon, Stickleback, Diodon, and Spinous Ray. In the Cartilaginous Fishes these indurations of the rete mucosum gradually disappear altogether, and at the same time with them the various glittering colours of the surface. In Lampreys we find only a tolerably dense corium, firmly attached to the muscles, and covered externally by a granular cuticle. In the Electric Ray the skin is softer, and less closely attached to the muscles; in other Rays, on the contrary, and also in most Sharks, rough, and furnished with coarse granules; on which account they are commonly employed in polishing.

\* The blue colour of Fishes when boiled, or digested in alcohol and acids, depends on the coagulation of this Albumen.

† It is physiologically important that almost all the organs of the skin of animals,—Hair, Feathers, Bristles, &c.—exist also in Plants. As to scales, we find them evidently represented by those of many roots.

The mucus which lubricates the surface of the body in Fishes is secreted by reddish glandular bodies usually arranged along the lateral line, and poured out by peculiar excretory ducts, which not infrequently perforate the scales. In the Rays and Sharks these ducts are peculiarly large; and in the Lampreys their apertures present themselves as distinct points, particularly about the head.

SECTION V. *Of the Skin in the Amphibia.*

§. 543. In Frogs and Salamanders the structure of the skin approaches to that noticed in several cartilaginous Fishes, consisting in a tolerably dense though not very strong corium, which is covered externally by a rete mucosum, ordinarily of no very brilliant colours; and that again by a very delicate mucous cuticle. It is remarkable in Frogs, that the skin, almost like that of the *Ascidia*, loosely surrounds the muscles, being attached merely by vessels, nerves, and some cutaneous muscles; of which the latter only appear when the skin and the muscles of the body are but little connected, and consequently are wanting in the inferior animals, where the muscles themselves are at one and the same time muscular membranes, and cutaneous muscles. The slimy, slippery skin, as in Fishes, still appears as a mucous membrane, and has many glands distributed throughout it. This is particularly evident in the Salamander (*Lacerta Salamandra*), which has a double range of them along the spine, and two large ones at the joint of the jaw perforated by many openings. By means

surface being covered with separate scales. The skin of these Amphibia differs from that of Fishes, partly in being less firmly connected with the muscles, and partly because the Cuticle is less slimy and more solid than in Frogs and Tortoises; whence, as soon as a new stratum is formed by the rete mucosum, the outer old one is thrown off in a single piece, and that, without the scales, though their impression is very evident on the rejected slough. The claws of the toes in Lizards may be noticed as new productions of the skin in this Class, which, growing from the rete mucosum in the form of strong scales, are fixed round the last bony phalanges of the toes. The colours of the rete mucosum in these animals again appear to attain peculiar brilliancy; and probably, also, the organization of that stratum may form the true cause of the well-known, though frequently exaggerated, change of colour in the Chameleon, which, like blushing in Man, appears to be dependent on the temporary fulness of its vessels. Lastly, the papillary structure, the proper seat of the cutaneous sense, of which there were not any traces in the preceding Classes, appears in this, and particularly on the soles of the feet in Frogs, the Salamander, and Lizards, but more especially, according to CUVIER, in the Chameleon, where the little papillæ present themselves in a nipple-like form. Cutaneous glands, though not wanting, are but little developed in Lizards and Serpents: in some of the latter they communicate a musky smell to the animal. Among the most remarkable cutaneous secretions are, the highly viscid fluid on the foliated toes of the Gecko; the musky secretion produced by a gland on the lower jaw of the Crocodile; and lastly, that from the chain of glands on the thighs of several Lizards.

SECTION VI. *Of the Skin in Birds.*

§. 546. Birds are as much distinguished among vertebral animals by the high degree of developement in the organization of the skin as Insects among invertebral. As to the skin itself, it is circumstanced almost completely as in the preceding Classes; being even scaly on some parts, *e. g.* the feet; or altogether naked, as in the neck of many Vultures; or attached to the bones, as on the bill. Here, as in Amphibia, we can distinguish the three usual layers of the skin, and even the papillary structure on the surface of the feet, as in some Lizards, *e. g.* in climbing and swimming Birds. The true skin, as in the preceding Classes, is thin, and, together with the feathers inserted into it, moved by cutaneous muscles, and connected to the subjacent parts by a cellular structure, which differs from that of the preceding Classes by its great tendency to the deposition of fat. The rete mucosum is colourless in the parts covered by feathers, and allows the blood to shine through it; whence the surface of the skin appears white, reddish, and occasionally even somewhat grey. In the parts that are exposed, the legs, combs, ceres, &c. its colour is very variable,—yellow, red, blue, black, &c. as Natural History indicates. The scales of the legs, the claws of the toes, and occasionally also of the thumb on the wing, are not essentially different from those of Lizards. The substance of the projections occasionally found on the head, *e. g.* in the Cassowary, is pretty similar to the covering of the Bill.

§. 547. The most remarkable point, however, in the organization of the skin in Birds is the production of Feathers

In order to trace the transition from earlier structures to this, we must refer to the ramification of Hairs in many Insects,\* but more particularly to their tuft-like projection in others, and even in Worms. In the young Bird we first find that tufts of soft hairs, instead of feathers, project from the pores of the skin in a quincunx order: these hairs are, as it were, only the summit of the true feather, whilst the sheath or bulb from which they project forms its first covering, and subsequently the hollow quill. In this sheath, which is originally closed, the shaft of the feather is formed, nearly like the leaf folded within a bud: this shaft may be compared to a strong hair, (it rarely happening that two shafts arise from a single stem,) and, like the hair of Plants,† consists inferiorly of cells, and terminates superiorly in a solid point. Round this point is twisted a blackish‡ slimy tissue, which, when unfolded, dry and divided, forms the vane of the feather. The quill, or sheath of the feather, is connected with the skin by a fossa or umbilicus, almost like the prickles of the Echinus, and contains pretty large vessels for the cellular body of the shaft, which still remain visible when the feather has attained a considerable size; at least, in a young Crow, in which the pinion-feathers were five or six inches long, I could easily inject the whole quill with quicksilver from the Brachial Artery.

§. 548. When the sheath of the feather (the quill)

\* The hairs of Bees are perfect feathers, except that their vanes are widely separated: the coloured scales of Butterflies are feathers with laminar but not ramified vanes.

† KRESER's *Anatomic der Pflanzen*, s. 160. "The hairs of the Epidermis consist of isolated rows of cells, simple or compound."

‡ This primitive black colour of the vane of the feather, with which the original grey colour of white Birds, e. g. the Goose, Swan, &c. agrees, serves as an additional fact in proof of the increased excretion of Carbon which attends on the highly advanced state of Respiration in this Class. (See §. 392.)

has arrived at a certain size, it opens, the shaft protruding through it, though still covered by a horny elongation of the quill upon its upper surface. The hairs now fall out, (though in some accipitrine Birds they remain at the extremity of the feather,) and are succeeded by the fibres of the vane developed from the blackish mucous texture already noticed: these, again, may be considered as smaller feathers, being themselves furnished with lateral fibres, which are peculiarly evident in those instances in which the fibres of the vane are remote from each other, *e. g.* in the tail-feathers of the Peacock; and, likewise, almost always on Down. When the feather is at last completely formed, the vessels, as well as the membranous cells of the root of the shaft, dry up; and on opening the quill we find only a husky, cellular tube, known as the pith. The quill likewise receives air, though not from the respiratory organs, but by means of a small opening at its superior extremity. The feather thus formed remains for one year, and is then (like a milk by a permanent tooth) replaced by a new one; which, however, is produced without any previous development of hair.

§. 549. It is needless to say much of the form, colour, and position of the feathers, as these are objects of Natural History; but it is remarkable that we can trace a transition from feathers to hairs or bristles. We find it, for instance, in the Cassowary; where, except on the wings, the feathers are to be viewed merely as weak shafts without vanes: and evidently, also, in the tuft of black bristles found on the breast of the Turkey, and representing an original tuft of hair; which, instead of being supplanted by a feather, increases to a considerable size, and is even covered by a thin epidermis;\* lastly, there are also actual hairs on dif-

\* The cuticle appears to be carried forwards with the feathers, though it soon dries and falls off, producing the mealy powder between them.

ferent parts of the body, as in the Vulture, Raven, &c. But even of true feathers the structure is very various; soft downy feathers, in particular, varying from others in this respect, that, according to NITZSCH,\* there are little swellings on the lateral fibrils of the laminæ of the vane; thus resembling the structure of the stalk of many Plants. The structure of the individual laminæ of the vane in the larger feathers is likewise remarkable, inasmuch as the superior edge of each is locked into the inferior edge of the next following by a peculiar mechanism, each lamina being furnished on its upper edge with laterally ramified fibres, and on the lower with small simple fibres: nay, on the extremity of these fibres next the shaft, I see, in the Goose-quill, for instance, merely a little ribband-like membrane on each side of the laminæ of the vane. By this mechanism the laminæ of the vanes shut so close into each other, that the feather appears to form but one surface; and, consequently, it is found peculiarly perfect in the feathers of the wings and tail which serve for flight.

§. 550. Feathers are also distinguished by their degrees of softness, by the more or less close connection of the laminæ of the vane, &c.; thus, in the wings of the Penguin, where we found the wing-bones broad and fin-like, (§. 229.) the feathers are short, stiff, dense, and altogether perfectly scale-like. Feathers vary, however, most materially in their colour; which, being most brilliant in those parts of Birds that are most exposed,—on the dorsal surface, and particularly in diurnal Birds, and those of hot climates, forms another instance of the great influence of light on the production of colour. There is much, also, that is deserving of notice in the change of plumage according to age and sex, and more particularly the observation made by BLUMENBACH, (*Manual of Comp. Anat.*) that the aged

\* VOIGT's *Neueste Magazin f. Naturkunde*, b. ii. st. 5.

females of several species, when the sexual functions have ceased, assume the plumage of the male. Generally, colour among vertebral animals reaches its highest point in Birds, as in Insects among the invertebral, or flowers in the vegetable world. Lastly, the aptness of feathers for receiving an electric tension is remarkable,\* as it is not improbable that the prescience of weather may be connected with the modifications of the electric state of the plumage produced by atmospheric changes. We must mention, too, the glands in the skin of Birds for the secretion of oil, as being important for the support of the feathers. Besides that each feather appears to be supplied with oily matter from the point of the skin where it is inserted, the quantity of oil necessary for rendering them impenetrable to water is furnished by oil-glands upon the Sacrum; which are particularly large in Wading and Aquatic Birds, and pour out their oil by two fissure-like openings.

#### SECTION VII. *Of the Skin in Mammalia.*

§. 551. In the structure of the cutaneous organ the Mammalia also present approximations to the earlier Classes of Animals; the naked, slimy, or oily skin of the Cetacea reminding us of that of Sharks and Rays; the scaly, armour-like skin of Armadilloes and Manis, of that of the Amphibia; and the skin of Porcupines and Hedgehogs, beset with quill-like bristles, of that of Birds. As to the different strata of the skin, we may remark that the true

\* TIEDEMANN'S *Zoologie*, b. ii. s. 155.

cutis is distinguished from that of the preceding Classes by its much more considerable thickness, partly on the back alone, and likewise in every part of certain animals, *e. g.* the Elephant, Rhinoceros, Buffalo, &c. The cutaneous muscles by which the bristling of hair, manes, &c. and the corrugation of the skin, are produced, are usually extraordinarily developed, and particularly so in the Hedgehog, where these muscular fibres are the chief agents in the rolling up of the body. As to the character of the cutaneous muscles, we cannot avoid finding in them a repetition of the muscular membrane, or sac, which we frequently met forming the sole organ of motion in invertebral animals. (§. 131.) The rete mucosum, which is ordinarily but little coloured, and the cuticle, have the same relations as the corresponding parts in the earlier Classes; except that the change of the cuticle here, as in Birds, is less evident, and is confined rather to the change of the structures proceeding from it, *i. e.* Hair. As in Man, the papillary texture is most perfect in the organs of Touch, and is altogether wanting in the Cetacea, as it was in Fishes. The most strongly marked colours of the rete mucosum in this Class are found in the blue or red callosities of the buttocks in several Baboons.

§. 552. The connection of the skin with the subjacent muscles is effected by a cellular texture, which is peculiarly distinguished by an extraordinary accumulation of fat in the Palmata, in Swine, and in hybernating animals in autumn: in some Bats, on the contrary, it admits air (§. 430.); and in the Honey-Bear from the Cape, (*Ursus mellivorus*,) according to SPARMANN, quoted by CUVIER, connects the skin but very little to the muscles. The glandular apparatus of the skin appears to be wanting in the Cetacea,\* where, however, the deficiency is supplied

\* Such must likewise be the case with Pangolins (*Manis*) and Armadillos.

by the exudation of an oily mucus: in the other Orders it is essentially the same as in Man, where, as is well known, the sebaceous glands secrete different matters in different parts of the skin. We occasionally, however, find these organs farther developed; in which case we can usually discover in them repetitions of earlier formations. This has been already remarked of the superior maxillary glands of Sheep, Deer, Bats, &c. and of the anal glands: we have also to notice similar glands in the sexual organs; along the lateral line of the body, as in Fishes, (§. 542.); on the Sacrum, like the oil-glands of Birds, (§. 550.); or between the claws, representing the secretion from the toes in many Amphibia, (§. 545.) The first, according to GEOFFROY,\* is particularly the case in Shrews, and in a less degree in Moles and some Rodentia, where we find a gland on each side of the body, the secretion from which is discharged upon the hair, and not by distinct ducts; and, like most similar products, has a powerful odour. The sacral gland is found in the Peccary (*Sus Tajassu*), where, according to DAUBENTON,† it is as large as a Goose's egg. The glands of the toes are found in particular in some animals with divided hoofs, *e. g.* the Sheep, the Pigmy Musk, and the Reindeer, and for the most part on the hind feet: the excretory duct opens between the spurious claws or hoofs.

§. 553. Hair, as is well known, is as commonly the covering of the skin in this Class, as Feathers in the preceding one; and where it is wanting, as in the Cetacea, the structure of the skin again approaches to that of Fishes and Amphibia. The varieties of Hair, in structure as well as in colour, are extraordinarily great, and must partly be left to the province of Natural History. The plumage of the preceding Class is most closely imitated by the hairs or

\* *Mémoires du Mus. d'Hist. Nat.* vol. i. p. 301.

† BUFFON, *Hist. Nat.* vol. x.

prickles of the Porcupine, which we may consider as Feathers consisting of a Quill and Shaft, but without a Vane, and covered by a firm horny layer. The scales, too, of the Armadillo, which terminate in a projecting edge, instead of lying flat like the scales of Fishes and Serpents, appear to resemble hairs connected together in laminae, and remind us of the scale-like feathers of the Penguin. The small prickles of the Hedge-hog, or the Echidna, form a transition from the stronger ones of Porcupines to the coarse hairs or bristles which occur in the Pachydermata.\* The bristles of the Hog, by the double internal canal which they possess, and the peculiar division of their points, remind us of the tufts of hair of many inferior Orders of Animals, here as it were inclosed within a cylinder. The ordinary Hair of Mammalia is essentially the same as that of Man: the finer kind of Hair, on the contrary, viz. Wool, approaches more nearly to soft feathers or Down, for, according to NITZSCH, there are here the same little tubercles as in that case (§. 549.); which even form the cause of the grey colour of the hair in many animals, *e. g.* the Mouse, inasmuch as under the Microscope the little tubercles appear black, and the interspaces white.† Hair, like Feathers, grows from its roots; and like them, when perfectly formed, is no longer nourished, but falls out and is replaced by others.

§. 554. The colour of the hair in Mammalia is ordinarily less brilliant and less varied than that of the plumage of Birds, which is in fact hair at its highest pitch of development. But here, as in the preceding Classes, we find that

\* According to CURRIER the hair of the tail in the Hippopotamus, as well as in the *Myrmecophaga jubata*, is flattened: such, also, according to BLUMENBACH, is the case with the hair on the toes of the Porcupine and Ornithorynchus.

† As BLUMENBACH mentions, the mustaches of the Seal are also tuberculated or jointed.

the dorsal surface, exposed to the light, always presents the most decided colours, whilst, on the contrary, the hair of the abdominal surface almost always appears white: nay, even the structure of the hair is more perfect on the dorsal than on the abdominal surface; thus, Prickles are found only on the back, &c. The powerful electricity of the hair in several animals, *e. g.* Cats, has been already mentioned. (§. 407.) Lastly, the variation in the situation of the hair, occasionally even in different sexes, is remarkable; thus, for instance, that the feet in so many Mammalia are either naked or covered only with short hair, in the same manner that the feathers in Birds do not ordinarily extend to the feet: or that the tail of others, *e. g.* Rats, Opossums, and Beavers, is covered with scales instead of hairs, in which we recognize the incomplete conversion from the Fish or Amphibium into the mammiferous animal: lastly, the greater developement of hairs in particular situations, *e. g.* on the snout, where they serve as organs of touch (§. 343.); about the Eyes; on the neck, forming the mane, which is wanting in the female of Lions; on the tail, where, as in the horse, they differ so much from that covering the rest of the body; &c.

§. 555. As to the other cutaneous productions of this Class, the shields of the Armadilloes may be pretty accurately compared to the shells of Tortoises, as they are to be considered as formed by several separate but closely connected ossifications of the rete mucosum covered by cuticle. The scales of the Manis have been already noticed as laminæ of closely compacted hairs, (nail.) The scales of the tail in Mammalia have been correctly compared by CUVIER to those of the legs in Birds: in the smaller animals, however, they are already very delicate, and thus form a transition to the regularly grooved epidermis on the feet of so many Mammalia, and even on the hand of

Man. Nails agree with Hair in their chemical composition, and in the mode of their growth. In the Carnivora, Rodentia, and Bats,\* they resemble those of Birds and Lizards, *i. e.* they are placed as pointed, cutting, horny sheaths, over the extremity of the last phalanx. Broad, blunt nails, inclosing the last phalanges, are called Hoofs; and of these we may remark that the nail or hoof is larger in proportion as there are fewer toes visible, of which we have instances in the Solipeda, and in the proportionally enormous claws of the fore feet in the Two-toed Ant-Eater. The hair-like structure is peculiarly evident in hoofs.

§. 556. It only remains to add something as to the structure of Horns, of which we find three kinds in Mammalia. The horns of the Rhinoceros come nearest to the structures just noticed; for in them, the mode of composition by the congregation of single, firm hairs, is so little doubtful, that similar, though shorter, hairs, surround the root of the horn, and that a transverse section of it evidently displays the separate cylinders of hair. (See DAUBENTON'S representation of it in BUFFON, *Hist. Nat.* vol. xi. pl. VIII.) A second kind of horns is formed by bony processes or cones, which arise after birth from the frontal bone (§. 252.), over which a cuticular stratum is extended, becoming callous and horny, and ultimately forming a solid horny sheath, in the texture of which it is easy to discover the individual hair-like fibres. Such are the Horns of Sheep, Goats, and Oxen. The third kind of Horns is found in the Antlers of Deer, in which we have already noticed the intimate mixture of horny and bony substance, as well as the remarkable sympathy between them and the male sexual organs. (§. 251.)

§. 557. If we review the history of the development of the skin, in order to discover how far this structure i

\* Here, as in Birds, the flying extremities have a nail on the Thumbalon

distinguished in Man, we shall find that in the lowest stages the cuticle is as yet similar to the intestinal membrane; that as a secreting mucous membrane, it is little calculated for forming the seat of an acute sense of touch; and farther, that it is in part concealed either by earthy shells, or in superior animals by scales and shields: subsequently, when respiration exists more perfectly throughout the whole body, we find the productions of the skin, hairs, bristles, and feathers, so copiously developed, that the cutaneous sense is impeded as well from this cause, as from the thickness of the skin, the deposition of fat below it, &c. As regards his cutaneous organ, Man is intermediate between the excessive softness of the mucous cuticle of the Mollusca, and the induration of the skin in Insects, or its plumage in Birds: his skin is more delicate and more copiously supplied with Nerves than that of the other Mammalia; and in nearly all parts has only few hairs, and those so soft as not to impede the cutaneous sense. The more copious production of hair on the surface of the scalp appears to me explicable by the remark already so often made, viz. that all the structures belonging to the skin are most perfectly developed on the side turned towards the light (§. 554.): consequently, as by the erect posture peculiar to Man, the cranial surface is that which is most absolutely exposed to light, the hair must be more developed there than in other situations; whence, also, I am farther led to conclude that the hair of the head would in itself afford a most convincing proof that the erect posture is that most suited to Man, even if the grounds for that opinion already pointed out had left any doubt on the matter. The Beard may be viewed as a repetition of the tentacular hairs on the snout of many Mammalia, and its perfect development in the male sex as a consequence of the intensity of the development of Respiration and of the extremities, which in

brutes coincide in the same manner with the perfection of hairs and feathers. The hair of the Pudenda and Axillæ, lastly, appear to be consequences of the more copious glandular secretion in those situations, which in other animals we found frequently connected with a greater developement of hair. (§. 552.)

§. 558. The Nails, the only horny processes of the skin that remain in Man, are in him comparable rather to scales than to claws or hoofs, and instead of blunting the fine feeling of the organs of Touch, appear rather to contribute to render it more acute. In Man, too, the skin is no longer so moveable as in other Mammalia, in which that mobility reminds us of the muscular cloak of Mollusca and Worms, whilst its diminution appears favourable to sensibility. As to colour, we found that it reached its highest point in the two Classes (Insects and Birds) most distinguished for Respiration and Motion, whilst the other Classes—either did not attain, or again retroceded from, the same stage. The latter is the case in Man, where the skin in the most perfect Races\* is almost colourless, and reddened only by the subjacent blood; a phenomenon, the cause of which has been admirably shewn by GOETHE,† when, in considering the colour of Mammalia, he says, “The variegation of  
 “certain uncovered parts in Apes with elementary colours,  
 “is a proof of the remoteness of such beings from perfection:  
 “for we may venture to assert, that in proportion as any  
 “creature is more perfect, its material elements are more  
 “intimately compounded, and that the more intimately the  
 “surface is related to the interior, the less appearance will  
 “there be of elementary colours upon it; because, where

\* It will be seen, from what follows, how far the less strongly marked colour must indicate the superiority of the Race; and for more information on the topic, GOETHE *zur Farbentheorie*, b. i. s. 247, may be consulted.

† *Loc. cit.* vol. i. p. 245-46.

“all should combine to form a perfect whole, there must not be any local or specific distinctions.” The cutaneous organ in Man is, therefore, distinguished by a higher import in this particular; and farther, inasmuch as by the capability of changes in the state of its colour it offers a reflection of the various conditions of mental feeling, approaches near to the nobler organs of sense, *e. g.* the Eye, which we have already noticed with relation to the same point. (§. 402.)

## II. OF THE VARIOUS FORMS OF THE RESPIRATORY ORGANS.

§. 559. The Respiration of Animals, inasmuch as it consists in the mutual action upon each other of the individual and the element surrounding it, (§. 529.) renders necessary the free and constantly renewed access of that element to the respiratory organs. This element is air, and is applied either immediately, or mediately by means of water, which in that case must itself, as it were, have respired air, and must be thoroughly penetrated by it, (not merely mechanically,) in order to be fitted for supporting the animal respiratory process. But in order that the access of these elements, or rather of the single one, Air, may be permitted to the organs of Respiration, the latter must originally be placed on the surface of the body: nay, the cutaneous surface itself appears at first as the sole respiratory organ; and it is only in a more advanced state of developement of the animal body that peculiar structures, air and water cells, (Lungs, Air-vessels, and Gills,)

appear, which, however, may be considered collectively as processes of the skin, ramifying sometimes internally, sometimes externally. That, we ordinarily find a complete apparatus for motion combined with the respiratory function, or, as is probably the fact, that the first and primitive animal motion is purely respiratory, is a fact, of which we find the cause in the principle that Respiration has the same relation to the Vegetative, as Motion to the Animal Sphere (§. 20.); and that, consequently, the less animal and vegetative life in the inferior gradations of organization are distinct from each other, the more perfectly simultaneous must be the progress of the development of Respiration and Motion on the one side, or on the other of Assimilation and Sensibility, and the more completely must they shew themselves connected in the higher organizations. Instances of the one kind are afforded by the Mollusca with highly developed organs of Digestion and of Sense; and of the other by Insects, in which the respiratory and locomotive organs are developed in the highest possible degree.

#### A. RESPIRATION OF ANIMALS WITHOUT SPINAL MARROW AND BRAIN.

##### SECTION I. *Respiratory Organs of Zoophytes.*

§. 560. What we before remarked of the most imperfect animal formations, viz. that the whole surface must be considered as a respiratory organ, applies to the lowest of these originally water-breathing beings. Of this we find

the proof in the fact, that though there can be no doubt of the actual respiration of these animals, yet we are unable to detect any peculiar respiratory organs in the uniform substance of their bodies. How far the current of fluid in the arms or tentacula of Polypes and other Zoophytes, (§. 59, 66.) or the contraction and extension of the body generally, may be subservient to Respiration, is a point that has been already noticed, (§. 60.) and which, though in many respects probable, has not yet been established on sufficient observations. It is in the Medusæ that more distinct organs for this function appear: in several species we find peculiar sacs on the inferior surface of the body, which, during the expansion of the body, admit water through certain apertures, (Tab. I. fig. IX. A. c. c.) and again expel it during the succeeding contraction: in other instances, as the Physophora and Rhizophysa, there are air-bladders at the upper part of the body, which, though usually viewed rather as helps to locomotion, like swim-bladders, may probably also be connected with the respiratory function. In every process of Respiration there are two distinct phenomena; the one consisting in the access of oxygen to the fluids of the body, the other in the evacuation from them of the volatilized elements of the body, Carbon, Azote, and Hydrogen. We usually find both processes united in a single organ, *e. g.* the Lungs of Man and many other animals; not uncommonly, however, they are more or less separated; and in particular, as we shall find to be the case with the swim-bladder of Fishes, there is frequently an excretion of gaseous matter in certain situations very remote from the Organs of Respiration. The air-vesicles in the animals before mentioned may probably be derived from secretions of such nature, inasmuch as it is unlikely that true respiration of air should occur in such low stages of animal existence.

§. 561. In the Echinodermata, where the surface of the body is frequently covered by leathery or calcareous shells, internal respiratory organs appear to be more necessary; and consequently, according to CUVIER, there is in the Holothuriæ a kind of Cloaca (§. 434.) communicating with ramified tubes, which, being fitted for admitting air or water, may be intended for the respiratory process.\* In this, as well as in several other species, consisting exclusively of the lower gradations of organization, we consequently find the intestinal and respiratory functions so little separate, that the respiratory organ appears even to form a part of the intestinal canal. It is remarkable, and, at the same time, perfectly correspondent to what has been already said of the mutual opposition of Digestion and Respiration, 1st, that the digestive cavity (the Stomach) is never a respiratory cavity; and, 2d, that of the two remaining portions of the alimentary canal, the Œsophagus and Intestine, the latter by far the most frequently assumes the respiratory function, with which fact it perfectly agrees, that the latter is in its nature more secretory and excretory; † but in, notwithstanding, we occasionally find the upper portion of the alimentary canal assuming this function, and the respiratory organs in the superior animals ordinarily connected with its oral extremity, we must reflect that the Œsophagus is the first and frequently the sole portion of Intestine, and consequently that it must be originally excretory as well as ingestive. Lastly, it is worthy of notice that the organizations, by means of which intestinal respi-

\* The water that has been respired is expelled from the anus with some force, and forms the means by which the animal moves. (See OKEN'S *Zoologic*, b. i. s. 350.)

† In describing the intestinal canal, we have already frequently indicated the close relation existing between the extremity of the Intestine and the organs of Respiration.

ration takes place, are very frequently indicated or repeated in the superior species; of which we find instances in the various expansions of the intestine already described, and occurring sometimes about the Pharynx and Œsophagus, as Laryngeal sacs, crops, &c.; or in the intestine, as Colon, Cloacæ, &c.

In the Echini and Asterias the Tentacula (§. 66.) appear to absorb water for Respiration: such respiratory Tentacula we may consider as the first indication of Gills, in the same manner as the cavities of the Medusæ of Lungs. Even in the Actinia we already find this ingestion and evacuation of water in the Tentacula, which here are placed about the mouth. (Tab. I. fig. X. A. 5.)

## SECTION II. *Respiratory Organs of the Mollusca.*

### (A.) ACEPHALA.

§. 562. We find more decidedly expressed in this, as well as in several of the succeeding Classes, the fundamental distinction already indicated in the preceding Class between the different forms of the respiratory organs, viz. between Gills, articular, and cavities, intestinal Organs for Respiration. Among the exclusively water-breathing Acephala, we find in the Ascidiæ, where the leather-like case inclosing the body appears to render internal respiration necessary, a large respiratory cavity, (Tab. II. fig. II. d.) which being longitudinally folded, forms the innermost, and at the same

time most delicate, of the three sacs (§. 70.) of which the animal appears at first sight to be solely composed: from its lowest part the Œsophagus, as already mentioned, (§. 435.) arises. In a large species, very closely connected with the *Ascidia microcosmus*, lately examined by CUVIER, and which I had an opportunity of dissecting in 1815,\* I found that this sac, which commences by a trumpet-shaped dilated mouth-piece, (Tab. II. fig. II. a.) and is furnished at its entrance (c.) with a valve and a circle of laminæ, also presents, in addition to its opening into the Œsophagus, a lateral opening furnished with valves, and hitherto unnoticed by any anatomists. (Fig. 2, a. 2, b.) The fact was the more interesting to me, as it afforded the means of explaining the phenomenon described by several writers, and noticed,† though discredited, by CUVIER, viz. that this animal has the power of rejecting the respired water not only through the mouth but also through the anus. These remarkable beings must receive their nutriment from the animal substances taken in with the inspired water; for even in a very small individual I found the Gill-sac occupied by a Pungier (*Cancer pagurus*) scarcely less than half its own size. There is much that is peculiar in the development of this respiratory cavity; for in the young animal it can be distinctly recognized as an integral part of the intestinal canal, and as the body increases this originally crop-like dilated part (Tab. II. fig. IV. b.) gradually attains a more considerable extent, and varies in structure from the intestinal canal in having exceedingly delicate and

\* An investigation, during which it was not possible that I could be acquainted with CUVIER's Monograph on this Animal, (*Mem. du Mus. d'Hist. Nat.* 1815, and which was subsequently published in MICKEL's *Archiv.* b. ii. h. 4.

† *Loc. cit.* p. 10. RONDELET long since depicted the animal ejecting water from both openings.

transparent parietes,—in a word, diverges more and more from the Intestine.\* †

§. 563. In most other Acephalæ, and particularly those provided with shells, we find the respiratory organs with the structure of Gills, though with infinite variety of form. The internal cavity of the Salpæ, furnished with a single branchial lamina, appears to constitute the transition from the Ascidiæ to the Tereidines, where there are two elongated branchial laminae above the Intestine and within the tubular cloak, to which the water has access and egress by means of two tubes placed at the posterior extremity of the body. (Tab. II. fig. XV. i. i.) In Bivalves there are ordinarily four large branchial laminae protected by the branchial membrane (cloak,) and operculum (shells), and also in many instances some small gill-like laminae about the mouth. In the Fresh-water Muscle, (*Unio pictorum*,) for instance, there are four small gill or lip-like laminae about the mouth, (Tab. II. fig. VII. b. b.) besides the two large pairs of laminae extending from the dorsal surface of the animal, partly at each side, and partly behind the foot. (Tab. II.

\* See a fuller account of this developement, unnoticed by CUVIER as well as by earlier writers, in the above-quoted Essay in MECKEL'S *Archiv. f. Physiol.* b. ii. h. 4.

† CUVIER describes the opening at the bottom of the branchial sac as being the mouth of the animal, the respiratory cavity being situated in front of it. In general its surface is uniform, but in certain species is disposed in deep and regular folds, forming the first indication of the four branchial laminae of the Bivalves. The structure of the membrane is also peculiar, and evidently connected with its function as a respiratory organ, consisting in an infinity of small vessels crossing each other at right angles, and forming quadrangular interspaces; which, under the microscope, are seen to be still more minutely subdivided in the same manner. The little vertical vessels are seen to arise from transverse branches, which, in their turn, communicate by each extremity with two vertical trunks, placed at opposite sides of the sac, and supposed respectively to represent the branchial artery and vein. (*Mémoire sur les Ascidies*, p. 11.)—Translator.

fig. VII. d. d.\* fig. VIII. e. d.) The latter laminae are united superiorly, and form a septum between the lower space, which receives the water through the great aperture of the cloak, (fig. VI. g.) and contains the gills themselves, and the superior passage opening into the anal tube of the cloaks, (shewn by the probe in fig. VIII.) In a living Bivalve it is easy to observe that the water gains access to the branchial laminae by the fissure in the cloak, (§. 126.) and escapes by the anal tube, which serves also to evacuate excrement and ova. It has not, however, been hitherto noticed, that this current is uninterrupted, and that thus these animals, when not too deeply immersed, form an eddy on the surface of the water. But, as in almost all other animals, the influx of air or water to the respiratory organs is intermittent, the simultaneous and continuous current into the fissure of the cloak and out of its tube, of which I have satisfied myself by numerous observations, must depend on a very peculiar mechanism, which consists chiefly in the muscularity of the cloak, but partly, also, in the mobility of the gills themselves; and may be compared to the mechanism of certain bellows, which produce an uninterrupted current of air by means of double bags.

§. 564. It is to be remarked, farther, of the large branchial laminae of the Fresh-water Muscle, that both pairs consist of an intertexture of vessels arranged in a rectangular lattice-work, and covered by a delicate membrane, whilst the two external are distinguished by a structure which merits a particular description. Above each external lamina of the gills is a duct proceeding from the posterior part of the foot towards the anal tube, long ago described as an oviduct by OKEN,† and having on its lower surface a long row of openings placed transversely, (Tab.

† Götting. gel. Anzeigen, 1806.

II. fig. XI. q.\*) and forming the entrances to the cells or compartments of the gills themselves. These compartments are all arranged vertically in the gill, and separated from each other by partitions: they appear as though they originated from the mutual recession of the two membranous surfaces of the gill, which remain connected only by the vertically disposed vessels that give rise to the septa: they serve for the reception of the ova, which, coming from the ovary placed within the foot, and not by any means formed in the gill itself, are, however, lodged there, and there receive their farther developement, as in a Uterus. This is a remarkable instance of the connection between the sexual and respiratory functions, of which we shall subsequently meet with many others.

§. 565. Of the various forms of the gills in other Bivalves I will here only mention, that in some they are not laminar; but consist of separate fibres or vessels, *e. g.* in the Genus *Lingula*; where also the little branchial or labial laminæ of the mouth are developed, so as to form two rolled and ciliated arms. More peculiarly remarkable, however, are a kind of branchial skeleton found in the *Terebratulæ*;† and on account of its coincidence with the situation of the gills in the Crab,—the position of the same part in the Barnacle (*Lepas anatifera*), where we find two small pyramidal branchial laminæ at the root of the first of the six pairs of horny tentacula.‡

† OKEN'S *Zoologie*, b. i. s. 250.

‡ See CUVIER in the *Mém. du Mus. d'Hist. Nat.* t. ii.

## B. GASTEROPODA.

§. 566. The variety of the respiratory organs in this Order is considerably greater than in the preceding, particularly as many of the Genera belonging to it breathe air. Gills, the organization which approaches most closely to that of the preceding Order, are found in by far the greater number of the Gasteropoda, and assume, particularly in the marine species, the most diversified forms. Thus, for instance, in the *Clio* we find laminar gills, reminding us of the labial branchial laminae of the Bivalves, placed about the mouth, and which, here as well as in several other species, serve as external organs of motion. (§. 132.) In the *Glaucus*, also, we meet with fin-like gills cut out like a fan, and three in number on each side, the anterior ones being largest. In the *Thetis* the gills appear as fourteen distinct tufts on each side of the back; in the *Tritonia* they run in a circle around the edge of the body; in the *Doris* they are placed as a range of tufts around the anus; and in the *Aplysia*, as well as many other Genera,\* we observe that the gills are placed close to the anus, in the same manner that in the *Acephala* we commonly saw the water that had been respired ejected through the anal tube. We do not observe, however, any peculiar mechanism for the motion of these gills, and respiration appears to be effected merely by their floating in the water.†

\* The different forms of these respiratory organs are well described by CUVIER, in the admirable series of Essays on the Anatomy of the Gasteropoda, which he has given in the *Annales du Mus. d'Hist. Nat.*

† In the *Clio borealis* the branchiae consist in the oval wing-like processes below the head, as is proved by the minute ramification of vessels upon them, and by the connection of those vessels with the heart and internal vascular system. In the *Pneumo-dermis*, though there are similar wing-like organs,

§. 567. In the *Aplysia camelus* these branchial tufts already recede under a small membranous cloak, and are even covered by an incomplete operculum, (§. 129.) a remnant of the shell of the Bivalves,—thus forming a transition to the testaceous Gasteropoda, *e. g.* Buccinum, Strombus, Murex, Cyclostoma; where we find a capacious cavity formed by the cloak, and concealed within the shell, generally having the gills projecting into it in a pectinate form. In the *Cyclostoma viviparum*, (*Helix vivipara*, L.) the gills form three rows of fibres arranged in a pectinate manner, (Tab. III. fig. X. XI. e.) with their extremities projecting but little below the edge of the cloak, and having in their vicinity the rectum, the duct for the discharge of mucus, and the female sexual organs. In the other Genera, *e. g.* Murex and Strombus, the edge of the cloak, nearly, as in many Bivalves, (§. 563.) is elongated into a tube conducting the water to the branchial cavity; and which, though merely indicated in the Cyclostomata by a fissure, is here lodged in a peculiar groove of the shell. The pectiniform gills are here usually double, but in such a manner, that one, according to MECKEL,† is twelve times smaller than the other, and appears only as an insignificant rudiment.

§. 568. Lastly, we find the gills totally disappearing from these cavities, the vessels which contain the fluids that are to be exposed to the influence of the air being expanded in the form of a delicate net-work upon the inner surface of the respiratory cavity; and water no longer sufficing for the exercise of the respiratory process, the animal

there is not a corresponding vascular net-work, and the branchiæ are formed by an elliptical cord placed vertically, and consisting of a number of little laminae. (CUVIER, *Mémoires sur les Mollusques*. Paris, 1817, 4to.)—*Translator.*

† Notes to his translation of CUVIER'S *Comp. Anat.* vol. iv. 269.

requires air itself. Nevertheless, several of these animals, *e. g.* *Lymnæa sive Helix stagnalis*, *Bullinus*, *Planorbis*, &c. live in water, and, consequently, must come frequently to the surface in order to procure air: they appear, also, to employ the respiratory cavity filled with air as a Swim-bladder to facilitate their swimming, thus reminding us of the air-bladders of many Zoophytes (§. 560.) Others, on the contrary, (*Helix* and *Limax*,) live altogether in air. The Cloak in all those which breathe air, by its connection with the neck, forms a kind of collar. (Tab. III. fig. I. e. e.) On the right side of it is a foramen (f.), on the edge of which open the anus and canal for the discharge of mucus, and which can be closed, or expanded by means of circular muscular fibres, so as to favour the ingress or egress of air to and from the respiratory cavity (Lungs). The cavity itself (fig. II. h. l.) is lined with a blackish mucus, and from the minute ramification of vessels upon its parietes, (fig. III. h. g.) presents a very beautiful spectacle. In Slugs, the respiratory cavity is placed on the right side of the back of the animal, is arched over by a horny Operculum (§. 129.), terminates in a contractile orifice, and altogether agrees essentially with that of Snails.

(C.) CEPHALOPODA.

§. 569. Although some *Sepiæ* are capable of living in air for some days,\* yet water must be considered as the proper element of the whole Order; and accordingly, we here again find Gills forming the proper respiratory organs.†

\* OKEN'S *Zoologic*, b. i. s. 343.

† How animals with Gills should also be able to breathe in air becomes less obscure in proportion as the supposed distinction between the Respira-

In the Sepiæ there are two such, (Tab. IV. fig. I. h. h.) one on each side of the peritoneal sac (n.) surrounding the viscera. Each Gill is formed by the Branchial Artery and Vein placed at its edges, and which are connected by numerous detached transverse vessels. The transverse vessels are finer and more numerous in the *S. officinalis*; in the *S. octopodia* fewer, but larger, and with flocculent edges; but invariably connected to the inner surface of the Cloak by means of a membranous ligament. (Tab. IV. fig. II. v.) This Cloak, as well as the Infundibulum, as it is called (anal tube, §. 442.), promote the ingress and egress of the water to and from the floating Gills, and in fact form the respiratory mechanism. The Cloak (fig. I. i. i.) which, as already observed (§. 134.), surrounds the abdominal viscera in the form of a fleshy sac open above, appears by its dilatation to permit the current of water to the Gills, and by its contraction to expel it through the Infundibulum (fig. I. a.); whence it will be seen that the respiratory motion is very similar to that of the Bivalves, where the water in the same manner enters through a fissure in the Cloak, and escapes through the anal tube. In the *S. octopodia* I find, moreover, a fleshy septum in the cavity of the Cloak, arising from the anterior side of that muscular sac, and connected posteriorly, (where it incloses the Rectum,) to the upper part of its dorsal portion, and of the peritoneal sac, so that, consequently, there remains inferiorly a free communication between the two halves of the cavity of the Cloak. (Fig. I. g. fig. II.\*.) This Septum must evidently contribute to produce a more efficient contraction of the cavity of the Cloak.

§. 570. I must not omit to mention that several observations appear to prove that there are also collections of  
 tion of the inferior and superior animals disappears. (See NASSE on Respiration, in the 2d vol. of MECKEL's *Archiv.*)

air, more particularly in the peritoneal sac of the Sepiæ: to this head belong the rapid ascent of the Sepiæ in the water, observed by TILÆSIUS\* to be accompanied by a swelling of the body; the escape of bubbles of air when the animal dies or is opened; and lastly, the porous structure of the Os Sepiæ, † (§. 133.) which contains air within its cells. These collections of air, however, can as little be admitted as proofs of actual respiration of air as those in certain Zoophytes, but rather as dependent on the separation of aëriform matter from the blood, as expirations.

### SECTION III. *Respiratory Organs of the Articulata.*

#### (A.) VERMES.

§. 571. Although Respiration in this Class gradually arrives at the greatest possible degree of development, yet, in the first order, we find whole series of Genera in which there is no peculiar organ assigned to that function, nay, in which it is still even doubtful whether Respiration is performed in any way: this is particularly the case with the Intestinal Worms. Whoever considers, however, that it is scarcely possible to conceive that any animal organization can be perfectly excluded from a mutual influence on

\* *De Respiratione Sepiæ Offic.* p. 64. 68: observations which, as he mentions, have been made also by RONDELET, LE CAT, and MONRO.

† Hence the Os Sepiæ, as SWAMMERDAM states, is so light, immediately after it is taken out of the animal, as to float upon water.

and by the atmosphere, will find a difficulty in admitting this supposed perfect absence of Respiration, and will rather be inclined to think that these beings, formed and living with other animals, are related with the atmosphere, *i. e.* breathe by the intermedium of the bodies in which (as in their proper soil) they are rooted.\* Consequently, as these animals are nourished only as individual parts of the body in other instances (*e. g.* a piece of Intestine, a Vessel, &c.), so also, they breathe in the same manner as such individual parts, *viz.* in consequence of being penetrated by the fluids of the greater organism which has itself respired. Hence, the same thing appears to me to take place here as in the water-breathing animals, which also do not ordinarily come in contact with the atmospheric air as such, but perform the respiratory function by the intermedium of water through which air is diffused.

§. 572. The respiratory organs, on the contrary, are more distinct in most of the extraneous Vermes, and particularly in those with red blood: we there, as in the Gasteropoda, find both kinds of respiratory organs, *viz.* cavities, or Bladders, and Gills. The former is the case in the Dew-Worm and Leech. In the Dew-Worm (*Lumbricus terrestris*), we find, as was described even by WILLIS, a row of apertures, one of which is always visible, placed along the back at the anterior edge of each segment of the body. In the middle of the body, I find these apertures (Stigmata) particularly distinct, (Tab. V. fig. IV. b.) whilst they seem gradually to disappear towards the head. The internal respiratory vesicles are placed as pairs of whitish sacs between the skin and Intestine through the whole length of the body, are peculiarly developed in the central and posterior portions of the body, (Tab. V. fig.

\* RUDOLPH, (*Entozoorum Historia Nat.* vol. i. p. 243.) also, decides in favour of the respiration of these animals.

III. B. e. C. e.) but become smaller towards the head, until about the space between the Pharynx, Head, and Stomach, where they suddenly undergo a considerable increase of size, no longer appearing in the character of respiratory but of sexual organs; of which more hereafter. To these last appear likewise to correspond from three to four pairs of abdominal-stigmata, which, also, should be considered rather as sexual than respiratory apertures.

§. 573. In the Leech (*Hirudo medicinalis*), we find, in the same manner, on each side of the abdominal surface, a row of minute Stigmata forming the entrance to the whitish, roundish, respiratory vesicles, which are lined internally by a vascular mucous membrane, and situated between the Skin and Intestine on each side. (Tab. V. fig. VIII. h. fig. X. b.) We find Gills as respiratory organs in many marine Worms, and presenting great varieties in form and number. Sometimes, for instance, they are placed at each side of the mouth, almost like the Arms of Polypes, as fans or feathers, occasionally of a spiral shape: so, for instance, in the Worms living in calcareous tubes, *e. g.* *Serpula*, *Spirillum*. Sometimes, as in several Gasteropoda (*Tritonia*, *Thetis*, &c.) they are placed as tufts at each side of the body; as, for instance, in the Lob-worm (*Lumbricus marinus*), which has a row of sixteen branchial tufts at each side of the body. Lastly, in the Aphrodite *aculeata*, we have a peculiar form of respiratory organ; for here, a matted covering of hair, open posteriorly, protects the back, the water pouring in below it, and serving for respiration by being thrown upon the projecting lateral cœca, or rather arcades of the intestinal canal, (see §. 445.) in the same manner that in *Holothuriæ*, *Ascidia*, &c. we found a portion of the alimentary canal assuming the respiratory function.

## (B.) CRUSTACEA.

§. 574. Here again we find the respiratory organs as Gills only; but, as in several Gasteropoda, so far different, that in some Genera they are placed externally, in others are withdrawn more towards the internal part of the body. The former is the case in the Genera Squilla, Apus, and Branchiopus, which, in this as well as other respects, approach to the Worms with external respiratory organs. The Gills are here placed, and occasionally in great numbers, as external extremities, or swimming fins, (§. 142.) on the posterior part of the body, or tail, which is articulated completely in the manner of worms. In the Squillæ, they are formed by the Gills which consist of depending fibres inclosed between two larger laminæ: in the Squilla *mantis*, for instance, there are five such pairs of fins.

§. 575. On the contrary, there are internal Gills in the true Crabs and Cray-fish. In the common Cray-fish the Gills compose thick, upright bundles of fibres, turning somewhat backwards, and attached to a branchial lamina at the roots of the legs, nearly in the same way that in the *Lepas* the Gills were attached to the roots of the large articulated Tentacula. (§. 565.) These branchial tufts (Tab. VI. fig. VIII. b. c. d.) are separated from the cavity of the abdomen by a horny, flexible, white, and transparent septum (fig. IV. q.), which consists of separate laminæ like Ribs. These proceed from the abdominal surface, where there is a kind of vertebral column, in which the anterior part of the chain of Ganglia is contained like a Spinal Marrow, (see fig. I.); they terminate, however, without being attached, under the thoracic plate, the lateral portions

on the abdominal surface above a little transverse fold, and on each side of the sexual organs; which, nearly as in the Scorpion, leads to a branchial cavity, the gills of which are white, mucous, and composed of several laminae. (Fig. VI. B.)\*

§. 578. The respiratory organs are altogether different in the remaining Orders. In them we find the body calculated for respiring air alone, which is effected by means of respiratory tubes penetrating every part in the form of extremely minute ramified vessels carrying the included air to all the organs. Even where these Insects live in water they respire air, which generally adheres all round their bodies, (as, for instance, in Water-beetles, and also Water-spiders,) probably by means of the little bristly hairs, which by their oily nature prevent the access of the water. Such Insects, therefore, always swim in the centre of a bubble of air,† and therefore with the more facility,—Respiration, consequently, here serving to facilitate Motion, as Motion

\* M. MARCEL DE SERRES (*Mémoires du Muséum*, vol. v. p. 94) describes the respiratory organs of true Spiders more precisely as being composed of two oval pulmonary sacs, each having a single Stigma opening at the inner side of the lower part. These sacs are formed of a thick, white, and flexible membrane, from the surface of which project several parallel transverse folds or laminae. In the Genus *Phalangium*, on the contrary, respiration is performed by Tracheae, of which there are three principal trunks, viz. two superior, which communicate directly with the two Stigmata at the sides of the Corslet, and with the common central trunk. In the parasitic Insects, *Pediculus* and *Ricinus*, there are two orders of Tracheae, the one arterial, or ramified; the other pulmonary or vesicular, and serving as reservoirs of air. The former are regularly arranged at some distance from each other on the lower parts of the body, communicating with the Stigmata by transverse branches, and also with the vesicular tracheae. (DE SERRES, *Mémoires du Muséum*, vol. v. 126.)—Translator.

† It is remarkable how, according to NITZSCH, (*On the Respiration of the Hydrophila*, in REIL's *Archiv.* b. x. s. 440.) they renew the air in this bubble by alternately elevating and depressing the Antennae.

in so many other instances promotes Respiration. Insects which live in water without having an air-bubble of this kind about them, as, for instance, the Nepa, have respiratory tubes at the anus in the form of long bristles, by means of which they procure air from the surface. In all these Insects, the air penetrates the body by peculiar openings (Stigmata), and is diffused through it by means of air-vessels. These statements apply, however, to the perfectly formed Insect only; for in the Larva the respiratory organs are very generally formed after an inferior type, either respiring water as Gills, the Stigmata being consequently wanting, or else the animal being altogether without any air-vessels.

§. 579. We have next to examine somewhat more precisely the ordinary structure of the respiratory tubes and stigmata. The latter, as in Vermes and the Gnathoptera, are usually found on each side of the body, and though in very various numbers, commonly more developed on the thoracic than on the posterior part of the body, and always in pairs, *i. e.* one on each side of each segment of the body. Their form most closely corresponds to that of the fissure-like openings by means of which Plants, and particularly the leaves of Plants, breathe.\* These Stigmata are also usually found as fissures, so that we observe two lips, an anterior and a posterior, (*e. g.* on the abdomen of Grasshoppers,—Tab. VII. fig. XXI. C.—and also in Libellulæ, several Pupæ, Caterpillars, and perfect Butterflies,) which, being surrounded by delicate muscular fibres, probably, as in the Iris, (§. 398-99.) partly radiated and partly circular, afford the means of closing or expanding the opening. According to SPRENGEL,† this structure is

\* KIESER, *Anat. d. Pflanzen*, s. 154.

† *Commentarius de Partibus quibus Insecta Spiritus ducunt*. Lips. 1815. p. 7.

more complicated in several Water-beetles, one valve being beset with little feathers, thus resembling the branchial structure. Besides these, however, there are also circular Stigmata, *e. g.* in the Willow-Caterpillar, (Tab. VII. fig. XVIII. A.) and the Thorax of the Grasshopper, (fig. XXI. B. X.) where they are peculiarly distinguished by the presence, within this round opening, of a fine, white membrane, shaped like an Eyelid, which rises and falls like a valve during the very powerful respiratory motions of these animals. The edges of the Stigmata are occasionally, also, guarded by little bristly hairs, (in the Mole-Cricket, according to SPRENGEL,) or prominent, protruding like nipples; as, for instance, in several aquatic Larvæ. Lastly, the Stigmata are occasionally almost wholly closed by a perforated cribriform membrane, (as in the Larva of the Cockchafer, *Melolontha vulgaris*;) which has lately given rise to the erroneous idea that no air penetrates the air-tubes.\*

§. 580. As to the air-tubes (Tracheæ), we find them uniformly arising from Stigmata, (rarely from Gills,) extending in two principal trunks along the sides of the body, or radiating in a tuft-like manner from each stigma: they always, however, ultimately divide into smaller ramifications, which not uncommonly present bladder-like dilations, and are ultimately distributed as extremely minute branches to all the organs of the body, somewhat like the Arteries in Man. The Tracheæ themselves are formed by two membranes, between which, though nearest to the innermost of the two,† are placed certain elastic, spirally convoluted fibres, (Tab. VII. fig. XVIII. B.) which, by their delicacy and density, give to the air-vessels that beautiful, silvery, lustrous appearance which present such a

\* See SPRENGEL's refutation of this idea of MOLDENHAWER's, *loc. cit.* p. 9.

† SPRENGEL, *l. c.* p. 14.

striking spectacle in the dissection of Insects. It is interesting, also, to find that the Vegetable Kingdom affords prototypes, not only of the Stigmata, but also of the Tracheæ, viz. the Spiral Vessels. It is certain, however, that considerable differences have been pointed out between them, *e. g.* that the connection of the Spiral Vessels with the fissure-like openings (of Plants) cannot be discovered, that they do not ramify in the same manner, &c.;\* nay, it is even possible that the Spiral Vessels may have more of the character of the Nervous System in Animals. It may, nevertheless, be asked, if it be not probable that Respiration is to Plants what the Nervous action is to Animals, and, consequently, whether the most perfectly developed animal respiratory System may not be a repetition of the type of the Spiral Vessels? This at least is certain, that there is more of similarity than of dissimilarity between the Tracheæ and those Vessels.

§. 581. As to the individual Families of Insects, we will here first briefly notice the most important differences that have been discovered, as well in that respect, as with regard to the changes which the respiratory organs experience from their metamorphosis. The Gnathaptera, *e. g.* the Scolopendræ, breathing by means of Stigmata, approximate to Worms by the great number of those organs.† The true Aptera, also, have a row of Stigmata at the sides of the body.‡ In the Neuroptera, where the Tracheæ commonly form vesicular dilatations, the Stigmata are peculiarly developed in the thoracic region, a fact which, being common to so many Insects, coincides perfectly with the circumstance that the moving extremities are attached

\* Id. p. 12. 16.

† NITZSCH (*Commentatio de Respiratione Animalium*, p. 26.) found sixty pairs, or even more.

‡ SWAMMERDAM *Bib. Nat.* Tab. I. (of the Louse.)

in the same region, (§. 148. 149.) In the Larvæ of this Order, however, the respiratory organs are formed after an inferior type. Besides that here, as in all Larvæ, the vesicular dilatations of the Tracheæ are wanting, and that, as in nearly all aquatic and intestinal Larvæ, two broad tracheal trunks extend from the head to the anus, giving off only small lateral ramifications; there are, also, in the Larva of the Ephemera six true branchial laminae on each side of the posterior part of the body.\* In the Larvæ of the Libellulæ, on the contrary, there are indeed Gills, but situated in a dilatation of the Rectum (§. 455.): these animals consequently breathe like the Holothuriæ, by the Intestine, and like them swim by forcibly expelling the respired water from the anus. Besides the Gills, however, SPRENGEL† found, also, from 7 to 9 Stigmata at the sides of the body.

§. 582. The respiratory organs of the Diptera, both in the perfect Insect and the Larva, present much similarity to those of the preceding division. In the perfect Insect there are air-bags (dilatations of the Tracheæ), and in addition an air-bag on the Œsophagus, the origin of which will be noticed hereafter. In the Larvæ, on the contrary, when they live in water, there are either external elongations of the two tracheal trunks of the body, (e. g. in the Larvæ of Gnats, † a long respiratory tube at the anus, by means of which they suspend themselves at the surface of the water, and in the Pupa of the same Insect two little respiratory horns on the head,) or tufts of hair instead of Gills, and that even without Tracheæ, e. g. in the *Tipula plumosa*. In Larvæ which live within other animals, e. g. in those of the *Oestrus equi*, frequently present in great

\* SWAMMERDAM, p. 104.

† *Comment. de viis quibus Insect. spiritus ducunt.* p. 3.

‡ SWAMMERDAM, Tab. XXXI.

numbers in the stomach of horses, I find a smooth, oval, brown plate at the posterior part of the body, the lateral halves of which present several parallel lines, which appear like the contracted apertures of Stigmata: when this plate is removed we find tolerably large Stigmata, from which the two thick tracheal trunks proceed towards the head. In Larvæ which live in the air, *e. g.* the Mite, the Larva of the *Musca putris*,\* two little respiratory tubes project from the second, and again from the last segment of the body.

§. 583. In the Hymenoptera, the Tracheæ and Stigmata of the perfect Insect are tolerably similar to those of the preceding divisions: the Larvæ, on the contrary, *e. g.* those of Bees, are more perfect, and have regular Stigmata at the sides of each segment of the body. The Hemiptera again, in their imperfect metamorphosis, by the presence of elongated respiratory tubes, (*e. g.* in the *Nepa*.) accord more closely with the Neuroptera, or even their Larvæ. The Orthoptera, also, approximate to the Neuroptera by their large thoracic Stigmata. It is remarkable that the respiratory motions of the body are more distinctly perceptible in this division than in any other Insects. In the *Locusta verrucivora* particularly, it is easy to distinguish how the abdominal rings, which have smaller abdominal scuta between them inferiorly, are alternately elevated and depressed exactly like Ribs. If we smear the great thoracic Stigma with oil, we find that numerous little bubbles of air escape from it during these motions. The whole is probably connected with the large and elegantly arranged air-sacs of the posterior part of the body (Tab. VII. fig. XXI. A. b.), which are distinguished by the circumstance, that when free from air and collapsed, they appear like broad and usually red-coloured stripes. Lastly, I may mention, that

\* SWAMMERDAM, Tab. XLIII. s. 276.

in dissecting these Insects, particularly when they had been destroyed by obstructing the Stigmata, I always found the dilatation of the Œsophagus and the Crop thereby formed, filled with air; so that, consequently, here, as well as in many other Insects, Respiration can be performed in the Intestine, though chiefly in its anterior part.

§. 584. As regards the Coleoptera, we again find the usual vesicular dilatations of the Tracheæ in the perfect Insect. In the Larva, the ramifications are simply aborescent, proceeding in tufts from the Stigmata. The Stigmata are placed at both sides of the body, as is also the case in Caterpillars, (the Larvæ of the Lepidoptera,) in which the respiratory organs have been most frequently examined. In them there are two long tracheal trunks at the sides of the body, (as was already the case in the Larvæ of the Neuroptera and Diptera,) but connected with each Stigma, from which a radiated tuft always proceeds to the neighbouring parts. (Tab. VII. fig. XI. m. l. k.) In the Butterfly, the vesicular dilatations of the Tracheæ are particularly distinct, usually forming large oval sacs and being placed in the posterior part of the body, in the direction from below upwards. Besides these, there are also little lung-like cellular bodies on the Tracheæ and air-sacs. As MÛCKÉL\* has observed, the air-sacs appear in the Pupa soon after its involution; but I believe that the cause of this appearance must be looked for chiefly in the closure of the Stigmata, particularly the posterior ones.† The air of the Tracheæ appears to be thereby much confined, and

\* Translation of CUVIER's *Comp. Anat.* vol. iv. p. 286.

† DE GÈRE (*Mémoires sur les Insectes*, vol. i. p. 41) remarked, that in the Pupa of a Sphinx the 2 or 3 posterior Stigmata were closed, whilst little bladders of air passed alternately in and out of the anterior ones under water. He considered this as In and Ex-piration, but probably incorrectly, inasmuch as the expired air was taken in again.

its quantity probably increased\* by the disengagement of an additional quantity during the development of the organization; whence, probably, the air thus accumulated may mechanically produce the distension of the tracheæ into air-sacs, and whence, also, we can understand why these vesicles should occur chiefly in the posterior part of the body. Nay, it may even be questioned if the air-sac on the Œsophagus of Butterflies and Gnats, may not be produced in the same manner, inasmuch as the observations on Crickets, before mentioned, as well as the air-bladders of this sac itself, prove that the Œsophagus serves for the reception of air,—for a kind of respiration.

§. 585. The organs of respiratory motion, by means of which the supply of air is renewed, present many points of uncertainty. On the one hand, where large Stigmata are placed opposite to each other, and connected by Tracheæ, it is easy to see that the alternate opening and shutting of their valves may produce a current capable of renewing the supply of air.† It is conceivable, also, how in the Orthoptera, Lepidoptera, and others, the expansion and contraction of the body, and the elasticity of the air-sacs contained in it, may cause the ingress and egress of air. It is less obvious, however, how the same effect is produced in Caterpillars and the Larvæ of Beetles, where a current of air cannot very easily arise from the opposite position of the Stigmata on account of the minute ramification of the Tracheæ; and consequently we must look for some peculiar mechanism, unless we are disposed to admit the stagnation of the air in its vessels. Hence it has been conjectured that the dilatation and contraction of the dorsal vessel, hereafter to be described, contributed to this pur-

\* On opening under water the Pupa (several days old) of the Moth of the Euphobia, I observed the escape of air with some force.

† NITZSCH, *Comment. de Respirat.* p. 39.

pose :\* this, however, appears to be scarcely possible, and it might be asked, on the contrary, if the motions of the body itself, the sliding of its segments upon each other, &c. are not the means of keeping up the constant ingress and egress of air? This, however, is not the place for any more extended investigation of the point.†

## B. RESPIRATION OF ANIMALS WITH SPINAL MARROW AND BRAIN.

### SECTION I. *Respiratory Organs of Fishes.*

§. 586. As we very commonly find in the Animal Kingdom that some species in a given Class or Order are its proper representatives, whilst others are to be considered as intermediate links of connection with superior or inferior formations, so also is it in Fishes; among which the Abdominales appear most decidedly to present in their structure every thing essential to the idea of a Fish; whilst, on the contrary, Rays and Sharks, and Myxines and Lampreys, leave us almost in doubt whether we should not rather arrange the former with Amphibia, and the latter

\* REIMARUS, *Ueber das Athmen.* in REIL's *Archiv.* b. xi. h. 2. 40.

† Under certain circumstances Bees emit a voice, consisting in a shrill sound, independent of the motions of the wings, and which appears to be in some manner connected with the existence of a current of air through the respiratory Tracheæ. At least it was observed, that when the animal was irritated, and immersed in water, the surface, where it was in contact with the orifice of the stigma at the root of the wing, evidently vibrated at the moment the sound was produced. (HUNTER, *Phil. Trans.* 1792, p. 182.)—*Translator.*

with Worms. It is in that Order, also, that we find most definitely expressed the type of formation of the Respiratory Organs peculiar to the Class; consequently we shall first describe those Organs as they appear in it, and then notice the variations which take place in others.

§. 587. In the Abdominales, and also in most Fishes, there are two kinds of respiratory organs; of which one only, like the lungs of Man, performs alternate expiration and inspiration, whilst the second, on the contrary, appears to act merely as a means of excretion. The former, consequently, is the true and uniformly existing respiratory apparatus, whilst the latter is found in the greater number only. The organs of the first kind, as the respiratory instruments of the aquatic animals, which, in the superior division of the Animal Kingdom, present repetitions of the lowest gradations of animal organization, are, as was usual in the Mollusca, Gills; nay, these gills are defended by moveable valves (opercula) precisely in the same manner as those of the Bivalves. The second kind of respiratory apparatus consists in a membranous sac provided with numerous vessels, and comparable to the air-sac of several Medusæ, (§. 560.) the swim-bladder as it is called. The principal element of the air contained in it is usually Azote, (nearly pure in the Carp Genus,) rarely mixed with Carbonic Acid or Hydrogen Gas, and sometimes also containing a proportion of Oxygen Gas, varying even in the same species, but often very considerable, and apparently greater in proportion to the depth at which the animal lives.

§. 588. We will first consider these organs more precisely in some Abdominales, *e. g.* the Carp and Pike. As to the Gills, they are attached to the external convex surface of the four branchial arches, or thoracic ribs, already described, (§. 164, 165.) forming on each of them, (Tab. IX. fig. XIV. i. i. i. i.) nearly as in the viviparous Snail,

(§. 576.) a double pecten of separate dark-red branchial fibres, which float loose in the water. The water enters at the mouth, passes through five fissures on each side of the fauces, and escapes through the branchial openings placed at each side of the head, and covered by the moveable Operculum (§. 178. Tab. VIII. fig. XII. k.) as well as the branchial membrane. (§. 179. Tab. IX. fig. XVIII. c.) The fissures, which are guarded internally against the entrance of food by means of little papillæ or small branchial teeth, have each, in fact, the same character as the Rima Glottidis in Man, in so far as they convey the respirable medium to the respiratory organs. The opening of these fissures is effected partly by peculiar muscles of the thoracic ribs, partly by those of the lingual bone, (§. 179.) of the pharyngeal maxillæ, (§. 170.) and of the belt of bones; (§. 167.) muscles which also contribute to form the fleshy septum by which this entire respiratory apparatus is closed posteriorly. Hence we might be led to compare this septum to the human Diaphragm, were it not that the heart is placed without, and behind or below it, (Tab. VIII. fig. XI. l.) being still separated from the abdomen by a tendinous membrane. The proper respiratory motion is here an elevation and depression of the branchial arches, corresponding pretty closely to the motions of the true ribs in Man; with this difference, that this respiratory apparatus is attached to the basis of the Cranium, and that the true respiratory organ, together with the heart, is not situated within the thorax, but is attached to the ribs externally in the form of branchial fibres, which may be considered as everted and elongated cells of lungs. The branchial membrane, the folds of which, as well as the operculum itself, are moved by peculiar muscles attached to the lingual bone, is attached internally to the operculum, and, inasmuch as it alternately opens and closes the branchial aper-

ture, is circumstanced nearly like the membranous cloak, placed under the shell of Bivalves. (§. 563.)

§. 589. The swim-bladder in the Pike consists of an elongated sac placed within the abdominal cavity immediately beneath the vertebral column and the kidneys, and connected to the spine by several symmetrical tendinous ligaments. When opened, it distinctly presents, in addition to a thin covering which it receives from the peritoneum anteriorly, two membranes, viz. an exterior one, tendinous and very strong, and an internal, vascular and more delicate. There are some dark spots on the posterior or upper surface, and the vessels are more numerous anteriorly than posteriorly. The excretory duct, proceeding from the anterior part in the form of a tolerably wide but short canal, enters the pharynx; not, however, like the human trachea, at its anterior, but, on account of the situation of the bladder, at its posterior part. This air-passage is not surrounded by the tendinous membrane, being merely embraced at its origin by a projecting fold belonging to it. It is scarcely possible to detect any traces of muscular structure in the parietes of the bladder in this Fish; and, consequently, from its length, from its firm attachment by ligaments to the spine and ribs, as well as the width and shortness of its excretory canal, the air it contains is probably evacuated only by the compression of the organ by the lateral muscles of the body.

§. 590. In the Genus *Cyprinus*, on the contrary, the swim-bladder is less closely connected with the vertebral column, and is divided into two parts; of which the posterior and longest is distinguished by its greater vascularity, and by giving origin to the excretory canal. This posterior division is connected with the anterior by a short and rather rather narrow passage, and is covered by a thicker layer of fibres, which appear to me to be muscular. The excre-

tory canal is here very long and narrow. In the superior half of the organ the fibrous stratum is wanting, so that it appears like a hernia of the inner membrane taking place between the fibres at the upper end of the other portion; the inner membrane, however, is lined with a delicate vascular mucous rete, and covered externally by a firm, tendinous, white stratum. It does not appear to have any peculiar action, but merely to repel by the elasticity of its external membrane the air forced into it by the contraction of the lower half.

§. 591. Having in these examples given a general idea of the respiratory organs of Fishes, we shall next proceed to consider the most important of the variations from this form, in doing which we shall have an opportunity of observing more completely the character of these organs. In this respect, the variation which the respiratory organ undergoes in the Chondropterygii is remarkable; for, as in several Mollusca, *e. g.* the Slug, but more particularly in many Articulata, (especially Worms and Insects,) the respiratory organ is concealed within the body, and the respired medium penetrates by one or more openings, generally placed at the sides (stigmata), so, also, is it in these Fishes, and especially in the Gastrobranchi and Lampreys, which approach so closely to Worms. In the former, according to HOME,\* the branchial openings are placed on each side, at the commencement of the Œsophagus, being six pairs, and appearing not as fissures, but as small round foramina. The water is conveyed to these openings partly by the mouth, partly by a very singular external opening of the Œsophagus, probably exclusively peculiar to these animals, and partly by the spouting tube already noticed in the Fresh-water Lamprey, (§. 348.) although this as well as the abdominal opening of the Œsophagus appear to me

\* *Philos. Trans.* 1815.

more calculated for expelling, than receiving it. The water flows from these openings by short canals to six small round respiratory sacs on each side, containing branchial projections: and from these passes by the same number of little canals into a common tube near the gills on each side, terminating by two foramina close to the thoracic orifice of the *C*esophagus.

§. 592. In an animal, which, according to HOME, forms a transition from the Gastrobranchi to the Lampreys, there are also seven lateral openings in the *C*esophagus on each side, leading to tubes which expand in the middle of their course into respiratory bladders, and terminate externally by seven branchial foramina (stigmata). In the Lamprey (*Petromyzon marinus*), the principal difference in structure is, that the openings of the branchial sacs do not arise from the *C*esophagus. A membranous canal (a trachea as it were) ascends in front of the *C*esophagus, in which we observe two lateral rows of seven foramina leading to the branchial sacs. These elongated sacs, provided internally with several branchial laminae, open externally by seven foramina, which are surrounded by several elastic cartilaginous arches, that here supply the place of the branchial arches. (Tab. VIII. fig. IV. 15, 17, 18.) Here, also, the water appears usually to enter the trachea by the mouth, and to pass out again by the branchial openings. The spouting tube, which HOME has incorrectly asserted not to penetrate internally, opens merely into the commencement of the *C*esophagus, and consequently cannot possibly convey water to the gills when the mouth is fixed by suction; (§. 462.) partly because it is too small for the purpose, and partly because there is nothing to contradict the supposition that the water may alternately flow in and out of the branchial foramina, as so commonly happens in other

animals. As to the swim-bladder, it appears to be here altogether wanting.

§. 593. In Rays and Sharks, more as in the first instances, and as in Osseous Fishes in general, there are five internal branchial fissures, which receive the water conveyed by the mouth, or by the temporal holes, and force it out, not through a large opening covered by an operculum, but, nearly as in the Lampreys, by five short\* fissures placed one behind the other. Here, as in the preceding cases, the thorax, as already (§. 164.) noticed, is situated not at the base of the head, but farther backwards. The swim-bladder is wholly wanting.

§. 594. In the Branchiostegi, as well as in the Jugulares, Thoracici, and Apodes, the gills are pretty generally circumstanced as in the instances already given in the Abdominales, although there is no deficiency of individual variations. In the Eel, for instance, the external opening of the cavity that contains the gills is merely a round aperture from one-third to one-fourth of an inch across, and situated under the Operculum; in the Hippocampus, according to CUVIER, the gills form eight tufts attached to cartilaginous laminae; so also, according to TIEDEMANN,† in the Syngnathi, there is merely a grape-shaped gill contained in a branchial cavity opening externally merely by a small opening. In the *Silurus anguillaris*, according to GEOFFROY, in addition to the four gills there are four

\* According to an interesting observation of RUDOLPHI, (OKEN'S *Zool.*, b. i. h. 7, s. 109.) it is probable that Rays and Sharks have originally two gills projecting from these branchial fissures, which are subsequently retracted internally. Hence, in this period, the floating gills of Osseous Fishes are found also in these superior species, differing only in not being covered by Opercula.

† MECKEL'S *Archiv. f. Physiol.* b. ii. h. 1. s. 112.

hollow arborescent lamina, on which the branchial arteries not only ramify, but also effuse blood into them. A more complete examination of individual Genera will present many additional varieties.\*

§. 595. There are many remarkable physiological varieties to be noticed in the structure of the swim-bladder. Besides the Chondropterygii, it is not unfrequently wanting in other instances, *e. g.* in the Genera *Lopidius*, *Pleuronectes*, and in the Mackerel (*Scomber scombrus*), &c. Secondly, even when it exists, the air-duct is occasionally absent, *e. g.* in the *Sciæna umbra*, *Cobitis barbatula* (Loach), and *fossilis*, in the Burbot (*Gadus lota*), and others, mentioned by DE LA ROCHE.† On the contrary, the duct, according to CUVIER, is double in the Cod; and in the Sturgeon opens into the stomach instead of the œsophagus. As to the form and internal structure of the organ, we find the following principal variations from the description given in the Carp and Pike, which is common to many other species: it is occasionally composed of two air-sacs placed close to each other, like the lungs of superior animals; such is the case in the Loach and *Cobitis fossilis*, where the two minute bladders are surrounded in a remarkable manner by bony cases proceeding from the anterior extremity of the vertebral column;‡ and also, according to CUVIER, in

\* The parietes of the organs above described in the *Silurus anguillarum* are stated by CUVIER to possess an arterial character, and present on their internal surface numerous villousities, through which exude the contents of the minutely ramified branchial arteries. The trunks themselves open into the roots of the Aorta at the point where they arise from the branchiæ. According to him, besides their office as respiratory organs, they are also to be considered in the light of hearts seated at the origin of the principal arteries of the body, accelerating the current of blood through them, and thereby increasing the force and activity of the animal. — *Translator.*

† See his *Essay on the Swim-bladder*, in the *Annales du Museum*.

‡ According to CUVIER (*Memoires du Museum d'Hist. Nat.* vol. i. p. 320)

the Bichir, (*Polypterus niloticus*,\* GEOFF.) where one sac is small, the other very large, and both open together into the Oesophagus.

§. 596. The Swim-bladder of the *Sciæna umbra* is distinguished, according to CUVIER,\* by having a great number of blind, and sometimes arborescent, appendices or diverticula attached to its edges, and also by the presence of some almost glandular bodies,† as well upon its circumference as its internal surface. The internal cellular structure of the Swim-bladder in several Fishes is likewise physiologically important, in so far as it forms a transition to the form of Lungs of the superior Classes. Such is the case, according to several observers, in the Sword-fish, (*Xiphias gladius*,) in some species of *Silurus*, *Tetrodon*, and *Diodon*. Lastly, the Swim-bladder of the Sturgeon and Beluga (*Accipenser sturio* and *huso*), is distinguished for its size, and for being the material that furnishes Isinglass.‡

§. 597. It remains to say a few words on the character of this part, that of the Gills being already sufficiently clear as the proper and most essential organ of respiration. From the intervention of teleological views, the Swim-bladder has either been considered exclusively as an accessory agent in swimming, or as a true Lung admitting and returning the external air. That however serviceable it may be in the former respect, it is yet by no means indis-

there are similar bony coverings to the Swim-bladder in the *Ophidium imberbe*.

\* *Loc. cit.* p. 18.

† DE LA ROCHE (*l. c.* p. 165.) found these internal red bodies in the Swim-bladder whenever the air-duct was wanting: according to CUVIER, there are similar organs, probably for the secretion of air, in Fishes which possess such ducts, *e. g.* in the *Muraena*.

‡ See FISCHER *Ueber d. Schwimmblase der Fische.* Leipz. 1795.

pensable, is proved by those Fishes which swim perfectly well without it. That its office is not of the second kind is established by the numerous instances in which the air-canal is wanting, and by the permanent continuance of many Fishes at extraordinary depths of the sea, though in them the proportion of Oxygen Gas in the bladder is greater than in those which approach nearer to the surface, nay, in which the alteration in the pressure of the column of water has such a powerful effect, that, according to BIOT, when suddenly taken from these depths, the rapid expansion of the contents of the bladder is so great as to burst it.\* Hence it is most probable that the swim-bladder is employed in performing a part of the expiratory functions of the Lungs of the superior Classes, not only separating excrementitious Azote and the superabundant quantity of Oxygen from the blood, but also actually evacuating them in those cases where there is an air-duct.†

§. 598. We might here quit the respiratory organ of Fishes, were it not necessary to notice some other structures, which in that Class appear occasionally to have some,

\* CONFIGLIACHI on the Analysis of Air from the Swim-bladder of Fishes, in SCHWEIGGER's *Journal f. Chemie*; and BIOT's Essay on the same subject in GILBERT's *Annalen*. 1807, No. 6.

† The communication of the Swim-bladder, in certain Fishes with the internal ear tends to confirm, instead of contradicting, the character assigned to that organ as an imitation or rudiment of the lungs of the superior animals. Where the Eustachian tube exists, it forms in the same manner a communication between the cavity of the ear and the respiratory organs. On the other hand, the lungs in the Proteus form merely two membranous sacs without any cells, whilst in certain Serpents the structure is still farther simplified by the exclusive developement of one lung, the other remaining permanently in a rudimentary state. In the Proteus, again, the closed state of the swim-bladder in other Fishes is very nearly imitated, the bronchi into which the Trachea divides before it enters the lungs being so small that the action of alcohol is sufficient to render them totally impervious to the passage of air. (WEBER, *De Aure et Auditu*, p. 89.)—Translator.

and sometimes a very considerable, share in the respiratory process. Of this nature is the Intestinal Canal; which appears in all Fishes, except the Lampreys, to be closely connected at its anterior extremity with the respiratory organ, inasmuch as it admits water, and has the gills placed on each side of it; of which, too, it has been proved, as regards the *Cobitis fossilis*, by the interesting experiments of ERMAN,\* that it is in itself a respiratory organ, and even that this respiration is indispensable to the support of life. In some experiments of my own I had particularly occasion to remark the thinness and vascularity of the intestine which runs almost direct from the stomach to the anus, and differs materially in its structure from the stomach, and from the generally thick-coated intestine of other Fishes. I found it also almost completely empty of food; and, as is well known, these animals may be long kept in glasses with sand and water, without any other nourishment. It is needless to point out how closely this intestinal respiration resembles that of the Holothuriæ, (§. 561.) Libellulæ, and Larvæ of the Cæstrus. (§. 580, 581.) It is probable, also, that a similar kind of respiration, as MECKEL suspects, may take place in other Fishes; though it is scarcely possible in those instances in which the membranes of the intestine are unusually thick, or even cartilaginous, as in the Pike.

§. 599. Another organ which has appeared to me to contribute in some Fishes to the respiratory process consists in the Peritoneum, Mesentery, and external membrane of the Intestine. In the Chondropterygii, as already observed, (§. 472.) there is a fissure on each side of the anus, by means of which the water can enter the abdomen, and come in contact with its included organs. These remarkable openings may probably derive their primary

\* See his Essay in GILBERT'S *Annalen*, b. xxx.

importance from the sexual organs, as we shall find when we come to consider those parts; but may still, also, in Rays and Sharks, have relation to the respiratory process, from the frequency of the existence of an intimate connection between the sexual and respiratory organs. This form of Respiration reminds us, likewise, of a similar one in the earlier formations; where, as, for instance, in the Medusæ, the respiratory sacs lie immediately below the stomach; or, as in the Aphrodite, the *coeca* are bathed in the surrounding water.

SECTION II. *Respiratory and Vocal Organs of the Amphibia.*

§. 600. As in this Class there is a gradual developement of the animal formation from an aqueous to an aërial being, so also is the aqueous gradually converted into aërial respiration; and the respiratory organ represents that form which was proper to those of the preceding Classes, in which there was respiration, or even expiration, of air. Of that kind are the air or swim bladders of Zoophytes, the respiratory cavities of many Snails, the tracheæ and air-vesicles of Insects, and the swim-bladder of Fishes. But, as in those Fishes where the true respiratory, *i. e.* branchial, apparatus is most completely separated from the intestine, (*e. g.* in the Lamprey, §. 592.) it is placed below or in front of the *Œsophagus*; so, also, is it as regards the apparatus for respiring air in Amphibia, Birds, and Mammalia, where it receives the name of Lungs, whilst, on the contrary, the intestine appears scarcely to take any part in the respiratory process. By the name of lungs are

distinguished cellular sacs for the reception of air, more or less closely compacted, communicating with the mouth or fauces by an air-tube (trachea), more or less long, sometimes merely membranous, at others provided with cartilaginous rings, and thus reminding us of the tracheæ of Insects. In this and the following Classes it is important not only as a part of the respiratory mechanism, but also, by the addition of peculiar organs of motion, and in connection with modifications of the mouth, nose, tongue, and lips, as a vocal organ.

§. 601. Organs for the formation of true Voice are altogether wanting in the four preceding Classes, though many animals belonging to them have the power of producing some sound or single tones, but not so much by peculiar vocal organs as by other parts, which however generally belong more or less immediately to the respiratory apparatus. Snails, for instance, occasionally emit a certain sound by suddenly opening or shutting the orifice leading to the respiratory cavity; so, also, many Insects\* produce sounds for the most part by means of the wings, which is physiologically not unimportant, when we consider with how much propriety the wings of Insects have been already viewed as gills dried up. (§. 150.) Lastly, there are many Fishes which, in a manner as yet but imperfectly understood, emit a murmuring noise, *e. g.* the *Cobitis fossilis* and the Trout. In the former the distension of the Intestine with air is probably the principal cause of this sound; and, consequently, it is comparable rather to the rumbling in the

\* *E. g.* the *Grylli*, by rubbing the upper dry wings against each other; Gnats and Flies by the friction of the roots of the wings in their articular cavities, the Poisers (Hañeres), according to OKEN, (*Zoologie*, b. i. s. 466.) not contributing. The latter species consequently produce a buzzing whilst flying only, as we observe also in Beetles, from the motion of the wings and elytra; whilst in the former it is heard when they are at rest.

intestinal canal of the superior animals than to a pulmonary Voice.

(A.) BATRACHIA.

§. 602. As regards its respiratory organism, this first Order approximates in a very remarkable manner to the preceding; partly, inasmuch as the larvæ of the animals it contains breathe precisely as Fishes, by means of gills, and partly because there are a few larva-like species in which the gills appear to be permanent during the whole term of existence. We shall first proceed to examine the latter, including the Genera Proteus and Siren, and the Acholotl, (*Gyrinus mexicanus*)\* In all of them we find branchial arches, which, precisely similar as in Fishes, are connected with the lingual bone, and fixed immediately behind the head. In the Proteus there are three, and in the other species four, such pairs, to which the gills are attached, the water entering through the mouth, and escaping through the fissures between the arches, exactly as in Fishes. The gills themselves hang from the upper part of the branchial arches in the form of feathered twigs, and project considerably out of the branchial apertures. In the Proteus which lives in the subterraneous lakes of Carniola, they are usually of a pale red colour, but I found that on exposure to a brighter light they soon became darker. Besides the branchiæ there are also pulmonary sacs, which coincide very closely with the swim-bladder of Fishes, and, according to HUNTER,† extend almost to the anus: they are mem-

\* Which, however, may yet be the larva of a Triton. See CUVIER, *Recherches Anatomiques sur les Reptiles regardés encore comme douteux par les Naturalistes*. Paris, 1807, 4to.

† *Philosoph. Trans.* 1766, p. 307.

branous, and in the Siren particularly long, reaching to the extremity of the abdomen. The excretory passages (bronchi) of these lungs are also membranous; and it is only in the Siren and Acholotl that they present the rudiment of a cartilaginous larynx where they open near the tongue. In the Proteus, according to SCHREIBERS,\* instead of a larynx there is a membranous cavity, which opens by means of a small fissure into the pharynx, and is continued posteriorly into two long membranous canals, which ultimately terminate in the pulmonary vesicles.†

§. 603. As to Frogs and Salamanders themselves, we find in their larvæ precisely the same structure of the respiratory organs as in the preceding species. Floating gills\* originally project at each side of the head, become subsequently gradually smaller, and as soon as the animal begins to take in bubbles of air by the mouth, leave merely an opening at the left side of the head, (a branchial opening like that of the Cartilaginous Fishes, except that it is here on one side only,) through which the water escapes, until at length this also disappears, and the animal is limited to pulmonary or aerial respiration. It is remarkable, however, that even subsequently, when the perfect animal respire by lungs alone, the laryngeal region and the lin-

\* *Philosoph. Trans.* 1801, p. 255.

† In the Proteus and Acholotl the branchiæ form long and delicately fimbriated plumes, or tufts, the roots of which are attached to a corresponding member of cartilaginous arches like those of Fishes. In the Siren *lacertina* the tufts are shorter, less divided, and fixed to the branchial arches by a fleshy pedicle. In the Tadpole of Frogs they are more numerous, but shorter, less complicated, and arranged along the branchial arches, which are four in number, and merely membranous. (CUVIER, *Comp. Anat.* iv. 349.)—*Translator.*

† Probably a repetition of the originally floating gills of Sharks. See Remark to §. 593.

gual bone are the agents of the proper respiratory mechanism. This part of the body consequently not only acts in the larva as a true thorax like that of Fishes, (§. 164.) but even subsequently assumes the function of a thorax: hence, too, we are enabled to understand why a thorax formed by true ribs is wanting in this species of Amphibia; (§. 182.) because their thoracic ribs originally forming branchial arches, as in Fishes, none others can be developed on the lower vertebræ, and when those arches disappear, there can of course be no thoracic ribs remaining.

§. 604. As to the lungs themselves, their membranous, vesicular, and loosely cellular structure, still presents a certain similarity to swim-bladders: (Tab. XIII. fig. VI. b. c.) they form two sacs placed at the sides of the trunk, extending low down into the cavity of the abdomen, which is not distinct from that of the thorax, the right being somewhat larger than the left, and both, when empty, contracting into a very small space. In the Pipa the parietes of the lungs are more substantial; they have numerous septa internally; and, as regards their external form, are broader and shorter in the male, in the female longer, but narrow.\* There are scarcely any bronchi in Frogs and Salamanders, the lungs appearing to be attached to the larynx almost immediately, and without any trace of a true trachea. The larynx, on the contrary, is of considerable width in the Frog, opening into the mouth by a rima glottidis without any epiglottis, though the tongue may in some degree serve the purpose. (§. 477.) It is provided also with two strong vocal ligaments on each side, (Tab. XIII. fig. VI. d.) by means of which, as well as from the mobility of the rima, it forms a very powerful, and the first pulmonary, vocal organ. The following is the mechanism of respiration, as described particularly by

\* BREYER, *Observat. Anat. circa fabricam Ranae Pipæ*, p. 15.

TOWNSON,\* though before noticed by SWAMMERDAM and MALFIGHI. When the broad lingual bone (§. 476. Tab. XIII. fig. VI. a.) which forms the floor of the mouth is drawn down from the palate by its muscles, the air of the mouth is rarefied, and an additional quantity enters by the nasal apertures,† which admit of being closed by valves. The lingual bone is then raised, the nasal apertures are closed, and the air is forced, or rather swallowed, through the rima glottidis into the pulmonary sacs, and can also fill the laryngeal pouches (§. 478.) which open into the mouth. We thus see why the lungs of these animals may still be distended when the cavity of the trunk is laid open; which appeared strange to many physiologists, who looked only to the respiratory mechanism in Man. We find also a confirmation of what has been already mentioned, viz. that the respiratory motions of these animals, like those of Fishes, are performed by the pharynx. The contraction of the lungs is produced partly by the pressure of the abdominal muscles, and partly by the peculiar muscular power of their own parietes.

§. 605. In the Pipa, the air-tubes, as well as the Larynx, differ considerably from those of Frogs and Salamanders. There is indeed no proper Trachea, but the Bronchi are longer, particularly in females, (in which the Lungs are on that account smaller,) and are even furnished with minute cartilaginous rings, which are otherwise wanting in this Order. As to the character of these cartilaginous rings of the air-tubes, which here for the first time present themselves, they may be considered partly as repe-

\* *Tracts and Observations in Natural History*, &c. London, 1799.

† The motion of the nasal apertures, nay, even of the glottis itself, is a repetition of the opening and shutting of the stigmata of the lower animals.

titions of the cartilaginous branchial arches of Fishes, which become at once smaller and more numerous, and partly as repetitions of the circular fibres of the Tracheæ of Insects. The latter analogy is probably the most correct, for, if the first actually existed, the branchial arches in the Amphibia that undergo metamorphosis should be converted into the tracheal rings, which is not the case.\*

(B.) CHELONIA.

§. 606. The respiratory organs of these animals have in general been but little investigated, and are by no means perfectly known, though they approach closely to those of the preceding Order, the moveable Thorax being wanting

\* RUDOLPHI (*Obs. Anat. circa fabric. Ranæ pipæ.* Berol. 1811. 4to.) has given a description of the organ which, in that animal, forms at once Trachea and Larynx. It is compressed from above downwards: in the male is about 10 lines in length,  $7\frac{1}{2}$  broad at the basis,  $6\frac{1}{2}$  in the middle, 2 lines thick, and composed of two laminae of bone; in the female it is smaller, and is cartilaginous, with the exception of two longitudinal ridges of bone. The two Bronchi arise immediately from this organ without the interposition of a Trachea, being very short in the male, but, on the contrary, very long in the female.

As regards the character or signification of the rings of the Trachea in general, GEOFFROY St. HILAIRE considers them as constituting a repetition of the Sternum with its Ribs. However fanciful such an idea may appear, RUDOLPHI (*Physiologie*, b. i. s. 390.) has recorded a variety of formation observed by him in the Trachea of a young Lion, that appears to corroborate it. The first ring of the Trachea was regularly formed, but was pushed up under the Cricoid Cartilage, its extremities overlapping each other posteriorly. The six following Rings were divided in front by the interposition of a long, narrow slip, common to all of them, and having the same relation to them as a Sternum to its Ribs. Consequently, instead of six perfect Rings, there were 13 separate pieces, viz. 12 lateral ones, and a middle one common to all.—*Translator.*

also in this case. In the Lungs, of the Mud-Tortoise, I find two very large sacs of cellular structure, more dense above than below, placed under the Spine, and extending considerably downwards. The Bronchi in some species, and particularly in the Land-Tortoise,\* are of very considerable length: in the Mud-Tortoise, on the contrary, they are but short.† The Bronchi, as well as the Trachea, have usually circular cartilaginous rings around them,—the length of the Trachea being in an inverse ratio to that of the Bronchi, and, consequently, very inconsiderable in the Land-Tortoise: in the Hawk's-bill Turtle (*T. imbricata*), on the contrary, it has 38 complete cartilaginous rings, and each Bronchus only 27. It is remarkable that in some species the branches of the air-tubes extend very far into the Lungs, communicating with the lobes only by detached large apertures. The Larynx is without Vocal Ligaments, and, consequently, is incapable of producing sounds. The respiratory mechanism appears to depend partly, as in Frogs, on the parts about the throat, and partly, (particularly according to the researches of TOWNSON,) on muscles of the trunk analogous to the oblique abdominal muscles. That the action of the latter is here the most important, appears probable to me, from the absence of branchial arches in the young animal. (See §. 603. 604.)

\* According to PARSONS, (*Philosoph. Trans.* 1766. p 213.) the Bronchi were 6 inches long in a large Land-Tortoise from Coromandel. He gives, also, a representation from BLASIVS of the air-passages of a Land-Tortoise, where the Bronchi each bend outwards so as to form a loop.

† So, also, according to TOWNSON, (*l. c.* p. 99,) in the *T. orbicularis*.

## (C.) OPHIDIA.

§. 607. As the double pulmonary vesicles of Frogs and Salamanders represented the double Swim-bladder of the Polypterus *niloticus* and other Fishes, so, on the other hand, we may compare the single bag-like pulmonary sac of Serpents, which extends beneath the Spine a considerable distance towards the caudal extremity, with the single bag-like Swim-bladder attached to the Spine in many other Fishes, e. g. the Pike or Burbot. In most Serpents, (probably in all those where the tongue can be protruded to a considerable extent,) the Trachea commences almost immediately below the internal nasal openings, by a rounded projection above the sheath of the Tongue, with a narrow longitudinal fissure in it, serving as Rima Glottidis and entrance to the Trachea. The latter is from 2 to 4 times as long as the head, and like that of Tortoisés, is formed by delicate cartilaginous rings, of which the upper alone are perfectly circular, a few of the most completely developed forming a kind of Larynx: the inferior rings, on the contrary, like the cartilages of the human Trachea, surround only its anterior part. (Tab. XIII. fig. VII. a.) On the posterior side is a fine vascular membrane, which, gradually expanding, is extended into the right pulmonary sac, in which the Trachea loses itself by a pointed termination. The very imperfect Larynx has no Vocal Ligaments, and, consequently, there is no Voice, but merely Hissing.\*

\* In a species of Water Serpent, *Hydrus bicolor*, RUDOLPHI (*Physiologic*, i. 362.) has described a peculiar provision, by means of which the animal is enabled to breathe without interruption, when scarcely more than the anterior extremity of the head appears above the surface of the water. It con-

§. 608. Before the termination of this Trachea, I find both in the *Coluber natrix* and *thuringicus*, a small blind depression, which, as was first remarked by NITZSCH,\* is to be considered as a rudiment of the left Lung. The right, and, in this case, sole pulmonary sac is placed immediately below the Spine, extends posteriorly as far as the region of the Kidneys, and in the *Coluber natrix* is from 5 to 7 inches long, and from  $\frac{1}{2}$  to  $\frac{3}{4}$  of an inch broad. Its parietes are thickest at the point where the rings of the Trachea cease; it is covered externally by a fibrous layer, and lined internally by a fine lattice-like net-work of vessels. (Tab. XIII. fig. VII. b.) More posteriorly the parietes become gradually thinner, and at last are merely membranous, giving to the whole organ still more of the appearance of a Swim-bladder. In the Slow-Worm (*Anguis fragilis*), there are two Lungs, nearly as in the Salamander, though the left is still considerably smaller than the right.† The respiratory motion here, as in the other Amphibia, is unassisted by a Diaphragm, and is effected by the Ribs and abdominal muscles.

sists in the ascent of the Trachea to the anterior angle or symphysis of the lower jaw, the opening of the Glottis being scarcely more than a line distant from the point of the tongue.—Translator.

\* *Comment. de Respirat. Animal.* p. 13.

† It is extremely remarkable that, even in Snails, the respiratory organs are chiefly developed on the right side; that this is again the case in Amphibia; and is observed, also, in Man, (See SOEMMERING *vom Baue d. mensch. Körper*. b. v. th. 2. s. 14.); particularly when we consider the predominance of the power of the extremities of the right side, (for, as is stated in the *Jena Literary Gazette*, June, 1817. p. 452, even Spiders employ the right hind-leg by preference in spinning their thread,) and the relation existing in so many points between Respiration and Motion; whilst, on the contrary, the usual situation of the most important assimilative organs is on the left side, as we have already seen as regards the Stomach, and as is likewise the case with the Heart in the most perfect organism.

## (D.) SAURIA.

§. 609. The respiratory organs are here generally formed pretty nearly as in Tortoises. The Larynx is tolerably simple, without vocal ligaments, and in the Chameleon is furnished with a small sac-shaped appendage: in most Lizards, *e. g.* the Crocodile, it opens by a longitudinal fissure; but in the Chameleon by a transverse one. This opening is always unconnected, being placed far back, and somewhat covered by the posterior edge of the tongue in the Crocodile, but in other species lying more forwards. Many of the species belonging to this Order have the power of emitting a sound by the voluntary tension of the Rima and Glottidis, as is known to be particularly the case in the Geckoes, where the tongue, which can be thrown back like that of the Frog, appears to me to serve as an Epiglottis. In the Larynx we already find, particularly in the Crocodile, a large pointed anterior cartilaginous lamina as a rudiment of the Thyroid Cartilage. (Tab. XII. fig. XIX. a.) The Trachea and Bronchi are nearly the same as in Tortoises, *i. e.* composed of almost completely circular cartilaginous rings. In the Gecko, I find the Trachea particularly wide and somewhat flattened. The Lungs likewise form double cellular sacs; they are almost the same in the Gecko as in the Salamander, extending downwards far behind the Liver; whilst in the Crocodile, on the contrary, at least as I observed in a young one, they remain above the Liver, and, consequently, more in the Thorax. (Tab. XII. fig. XIX. l.) In the Chameleon, the Lungs have been found furnished inferiorly with peculiar finger-shaped appendages. The respiratory mechanism is effected by the thoracic Ribs and their muscles, without

muscles proceeding from the Sternum and Fork-bone, and of being shortened by the elasticity of the tendinous fibres connecting the rings. • This elongation and shortening, as well as the length and bony nature of the Trachea, but, above all, the extended diffusion of air through the spacious cavities of the body, to be hereafter noticed, contribute materially to strengthen and modify the Voice of these Animals.

§. 612. The next point to be noticed is the second or inferior Larynx, (*Larynx bronchialis*,) placed at the lower extremity of the Trachea, which is peculiar to this Class exclusively, existing in most of the species,\* and particularly important as a most essential vocal organ.† It is formed in the following manner: a little before the division of the Trachea there is a strong and solid ring, which is divided from before backwards by two connected bony processes, thus presenting a double aperture corresponding to the right and left Bronchus, each containing a vocal fissure formed by a duplicature of the lining membrane of the Trachea.‡ The Bronchi themselves consist of semi-elliptical rings connected by elastic fibres, the uppermost being broadest and generally ossified, whilst the lower are narrow and cartilaginous. Over the inner surface of the Bronchi is stretched a thin transparent membrane, the vibration of which contributes to the modification of the Voice, and whence it may be called *Membrana tympaniformis*. The branches of the Trachea are never of very

\* According to CUVIER, it appears to be wanting in the *Vultur papa* only.

† There are experiments to prove, that even when the Trachea is divided, Birds can emit their peculiar cry by the bronchial Larynx, though in a weaker tone.

‡ In the Parrot, however, I have myself found that there is but a single aperture, as the lowest ring of the Trachea is not divided.

considerable length, usually contain from 11 to 18 rings, and when cut from the lungs rapidly shorten themselves by their own elasticity. Where they enter the lungs they suddenly lose their cartilaginous rings; whilst, on the contrary, their elastic or muscular fibres are continued for some distance along the ramifications of the trachea.\*

§. 613. The whole of this remarkable elastic apparatus is moved by several muscles (3 to 5 pairs) in those Birds which are distinguished for the modulations of their voice, and for the power of imitating other tones, and even human language, *e. g.* in Singing Birds and Parrots; and is thus adapted, by the shortening or elongation of the branches of the trachea, tension or relaxation of the two rimæ glottidis, and of the membrane of the bronchi, for the production of the voice; which is again modified by the elongation or shortening of the trachea itself, and by the contraction and expansion of the glottis.† There are many other species which have only a single muscle at the lower larynx, the insertion of which is by no means the same in all cases. Of this kind are, according to TIEDEMANN,‡ the Eagle, Falcons, Owls, the Cuckoo, many wading and some aquatic Birds, in which the voice is inflexible and unvarying. Lastly, the muscles of this larynx are sometimes altogether wanting, as is the case in the Gallinæ, and in most Aquatic Birds, though in some of the latter, *e. g.* Anas and Mergus, the males are distinguished by lateral,

\* CUVIER has remarked these muscular fibres, particularly in the Ostrich and Cassowary.

† HALLER says, in his *Elem. Phys.* t. iii. p. 450, "His collectis adparet, glottidem superiorem tendi non posse, sed arctari: Glottidem inferiorem arctari non posse, sed tendi: videri ergo ad variandos tonos, et in tensione organi sonori, et in angustia ostii sonum edentis, varietatem locum habere."

‡ *On the Vocal Organs of Birds*, in his *Zoology*, vol. ii.

though rarely symmetrical, dilatations of the inferior larynx, sometimes membranous and sometimes bony. (Tab. XVI. fig. XII.)

§. 614. The lungs are here chiefly distinguished from those of all other kinds of animals in this respect, that they do not hang in the cavity of the trunk as unattached sacs, but are attached in the form of two flattened masses of spongy bright-red cellular texture to the posterior side of a thorax, reaching to the pelvis. (§. 215.) They are smooth anteriorly, furrowed posteriorly by the projecting ribs between which they are lodged, and divided from each other by the bodies or anterior spinous processes of the dorsal vertebræ. (§. 213.) It is farther peculiar to the lungs of Birds that they are not completely surrounded by the membrane lining the thorax, and which, in animals without a diaphragm, combines the characters of pleura and peritoneum, but are merely covered by it on their anterior surface, being immediately connected on the dorsal side to the parietes of the thorax by short dense cellular structure.\* Lastly, it is most remarkable that they are not closed upon their surface, but communicate by several apertures with the neighbouring regions, so that the air escapes not only into the cavities of the trunk, but also into those of the bones. (See the Section on the Skeleton of Birds.)

§. 615. In the same manner that in Serpents we saw the upper part of the lung with its thick sides terminating inferiorly in a mere membranous sac, so also here various processes of the internal membrane lining the common cavity of the trunk form a series of cells, which, surrounding the other viscera, may be compared to that membranous appendage of the lung of Serpents; and whence, also, we might in this respect say, that in Birds the other viscera

\* Strictly speaking, the human lungs are without the pleura, which is here, however, still more evidently the case.

are contained within the lungs. The openings of the lungs are situated at their lower extremity, and vary in number from five to seven. Even the greater membranous cells are not always similar;\* we may assume it as a general rule, however, that every important viscus is surrounded by one large, or even by two, cells; thus, for instance, there are an anterior and posterior cell to the heart, two great lateral cells which surround the liver, and two particularly spacious abdominal cells which inclose the intestinal and sexual organs, &c. Distinct cells extend also to the surface of the trunk, and convey the air to the clavicles, scapulæ, humeri, femora, and cervical vertebræ; whilst, on the contrary, the other bones of the trunk are furnished with air direct from its cells. All these cavities are so intimately connected together, that it is easy to inflate the whole body from any one of them, or that (as VROLIK and ALBERS proved by experiment) respiration can be kept up in an inverted direction by them; and, lastly, that the injury of any one of them is sufficient to permit the escape of the heated and rarefied air out of the body of the Bird, and render it unable to fly.

§. 616. The respiratory motion of Birds is performed, as in Lizards, though in a somewhat different manner, by the ribs and sternum, and partly, also, by muscles, which may in some respects be compared to a Diaphragm. These muscles proceed obliquely upwards in the form of flat bundles of fibres from the middle of the lower ribs to the under part of the lungs, where they are lost in the pleura covering them; and thus by their contraction depress the lungs themselves, expand their cells, and facilitate the ingress of air into them. I have found them particularly developed in the Parrot. The other and more important respiratory

\* Very closely investigated by MERREM, in an Essay on the Respiratory Organs of Birds, in the *Leipzig. Magazin f. Naturk.* 1783.

motion is performed by the muscles of the thorax, the broad shield-shaped sternum, the ribs, consisting of two articulated portions, and the immoveable range of dorsal vertebræ; (§. 215, 216.) all contributing to dilate and narrow the thorax in the manner of a bellows, or of the branchial apparatus of Fishes. When the sternum is removed from the vertebral column, the angle formed by the separate pieces of the ribs must be increased, and the cavity of the trunk so much expanded, as to cause the entrance of air, not merely into the lungs, but also through them into the membranous cells of the trunk and its bones;\* and in greater quantity than in other vertebral animals, in order to constitute an extended respiration not confined to the lungs alone: on the other hand, the air is expelled from the lungs by the contraction of the parietes of the thorax, combined with the elasticity of the cells of the lungs. It is remarkable that the air contained in the different cells of the body, and so important for the locomotion of the Bird, (§. 423.) is properly expired air, (*i. e.* has already passed through the lungs, though it has by no means lost the whole of its oxygen,) in this respect resembling the air of the swim-bladder of Fishes. (§. 559. 609.) This is the more interesting from the known fact that atmospheric air becomes lighter in proportion as it parts with its oxygen, and as nitrogen predominates, the weight of the latter being to that of the former as 44 to 50. If we take into account that this air is farther considerably rarefied by the heat of the body, we may understand the facility of flight thus acquired by a consideration of the cause of the ascent of balloons.

\* It has been already mentioned (§. 219. 225.) that the air-cells of the bones of the head are supplied with air by the nasal cavities and eustachian tube.

## IV. RESPIRATORY AND VOCAL ORGANS OF MAMMALIA.

§. 617. In common with Man, the whole Class possesses a simple *superior* larynx, a trachea divided into bronchi and furnished with cartilaginous rings, two perfectly closed lungs, and a thorax separated from the abdomen by a diaphragm. As we may suppose the human type of these organs to be known, we have here only to notice the particular deviations from it, and may easily trace the approximations to inferior formations. \* In this as in the two preceding Classes, the air is taken in principally through the nasal passages; but whilst we found that in Amphibia and Birds the apertures of these canals (anterior and posterior nasal foramina) could generally be completely closed by peculiar muscular fibres, the same mechanism is here limited to the occurrence of a contraction either by the circular fibres of the external nares, or by the velum palati, or parts which supply its place. The Amphibious Mammalia, however, as well as the Cetacea, form an exception in this particular, as in them the perfect occlusion becomes again possible, partly by means of the fissures of the external apertures of the nares, and partly by means of valves within the nasal canals themselves. (See the Section on the Olfactory Organs of Mammalia.)

§. 618. In proportion as the nasal canals in Mammalia can be less perfectly closed than in the preceding Classes must the aperture of the trachea itself be covered with more precision,—an object effected by the epiglottis peculiar to this Class, which we may consider merely as a repetition

of the retroverted tongue of many Amphibia, *e. g.* Frogs. As far as is known, it exists in all Mammalia,\* though exceedingly diversified in its form. In Whales and Porpoises, the larynx of which has been so often noticed as projecting far upwards in the fauces, it is small, with its edges attached to the larynx, and the aperture of the latter, consequently, more in the form of a transverse fissure. In other Mammalia its circumstances approximate more and more to the human model, though in many it is proportionally much larger, pointing directly upwards; in some cases even so far as to extend behind the velum palati,† thus rendering the passage for air more complete, and in most of the larger animals, is moved forwards by a peculiar muscle (*hyo-epiglotticus*). The epiglottis is frequently divided at its superior extremity, *e. g.* in the Seal, (Tab. XX. fig. V. a.) Ant-Eater, and Hare; in this respect reminding us of the divided point of the tongue in Amphibia.

§. 619. The larynx itself in the Mammalia in general consists of the same number of larger cartilages as in Man; whilst of the smaller cartilages of SANTORINI and WRISBERG, the former, according to WOLFF,‡ are wanting in Hyenas, Lions, Cats, Otters, Seals, Sloths, and others, whilst the latter exist in Apes only. The larynx is most singular in the Cetacea, presenting a pyramidal cavity without vocal ligaments, whence these animals, if not dumb, are at least incapable of making any thing more than an inarticulate murmur. The larynx of Opossums and Rodentia presents an evident affinity in many points to that of

\* Its existence has been incorrectly denied in the Mole by JACOBS, (*Talpa Europ. Anatome*, Jenæ, 1815.)

† This has been observed in the Elephant, but I find it also in the *Calitrix rosalia*.

‡ *De Organo Vocis Mammalium*. Berol. 1812, p. 42.

Birds. Thus, in the Kangaroo, according to CUVIER, the arytenoid cartilages form two-thirds of the ligaments of the glottis, whilst the vocal ligaments are nearly, and the ventricles of the larynx altogether, wanting. So, also, the vocal ligaments and ventricles are wanting in the Porcupine and many other Rodentia, but both exist in the Rabbit. The larynx of Sloths and Armadilloes, likewise, is ill fitted for the production of voice, in consequence of the imperfect formation of the vocal ligaments and ventricles.

§. 620. Among the Pachydermata the vocal ligaments and the ventricles are wanting, according to CUVIER, in the Hippopotamus. In the Elephant there is merely an imperfect rudiment of the ventricles. In the Pig, too, they are but inconsiderable, but lead to two spacious cavities, which appear to contribute to the production of the grunting voice of this animal. The larynx of the Ruminants is tolerably simple, and, except in the Camel, is usually without the superior ligaments of the glottis and the laryngeal ventricles. In several Antilopes there is a remarkable membranous cavity between the epiglottis and the thyroid cartilage; which in the Rein-Deer, according to CAMPER,\* is dilated into a considerable membranous pouch. It resembles the laryngeal sac of the Amphibia, and is probably connected with the necessity for a greater supply of air in these swift-footed animals. The Solipeda are distinguished by very spacious vocal sacs, and have besides, like the Antilopes, a membranous cavity situated above the upper edge of the thyroid cartilage. In the Horse the vocal ligaments, as described by WOLFF,† are broad and strong, and present on each side a large oval aperture, leading to spacious cavities. These ligaments are also covered by a delicate semilunar fold of membrane, the vibrations of which produce the peculiar neighing of this animal. The

\* *Naturgeschichte des Orang-Utang*, Tab. VIII. † *Loc. cit.* p. 36.

entrances to the anterior and lateral cavities are smaller in the Ass.

§. 621. Among Carnivora the Lion is particularly remarkable for the very considerable extent of the larynx, corresponding to the powerful roar of that animal. In this case the anterior contribute more than the posterior vocal ligaments to the formation of the voice, and there are not any vocal cavities: such, also, is the case in the remaining species of the Cat Genus. In the Dog, on the other hand, the vocal cavities are considerable, and the inferior ligaments strong: the extent of the cavities is considerable in the Wolf also. In the Bear Genus, on the contrary, according to the examinations of CUVIER, the anterior and posterior vocal ligaments are on the same level. The most human-like formation of the larynx is found in Apes; but, notwithstanding, the finer and more important modulations of voice are impeded by the presence of sac-shaped dilatations or appendages, which interrupt and obscure the sound, though VICQ. D'AZYR and LORDAT\* have rendered it very improbable that the incapability of speech is to be attributed solely to these sacs. In the Orang-Utang, where they have been described by CAMPER, they present themselves as two oblong sacs, not always symmetrical, between the body of the hyoid bone and thyroid cartilage, opening into the upper part of the ventricles of the larynx, and appearing like a hernial dilatation of them.†

§. 622. LUDWIG‡ found two such unsymmetrical sacs in the Magot (*Simia inuus*), and I myself observe one such in the Lion Ape (*S. rosalia*), though not between the

\* *Observations sur quelques Points de l'Anatomie du Singe Vert.* Paris, 1804.

† It would be important to examine the mode of origin of these sacs, and to ascertain if they may not actually be produced by respiration after birth.

‡ *Grundriss der Naturgesch. d. Mensch.* Tab. I. II.

Cricoid and Thyroid Cartilages as described by CUVIER,\* but between the Hyoid Bone and Thyroid Cartilage. It is found in the same situation, according to WOLFF,† in the *Simia saba*; and, also, according to CAMPER and CUVIER, in many others, *e. g.* Maimon, Marmon, Sphinx, Cynomolgus, Veter. In other species, on the contrary, the sacs are altogether wanting, *e. g.* in the *S. hamadryas, rubra, and sinica*. The tympanum-like cavity before noticed (§. 506.) in the body of the Hyoid Bone of the *S. seniculus* is particularly remarkable, and is occupied by two unsymmetrical‡ sacs which open into the ventricles of the Larynx. In this case the cavity by its resonance contributes much to strengthen the voice. A similar effect is produced by a membranous dilatation between the Cricoid Cartilage and Trachea, described by CUVIER, in the Coaita (*S. paniscus*). As to the general character of these laryngeal sacs, we need only repeat what has been said with regard to those of the Ruminants (§. 620.), remembering only that in the Chameleon there exists a similar expansion of the Larynx. Here, also, we must notice the structure of the Larynx as described in some American Apes (*S. apella* and *capucina*) by CUVIER, in which the air passing between the vocal ligaments takes a curved direction between cushions of fat, thus resembling the structure of a flute, and explaining the flute-like voice of these animals.

§. 623. As to the form of the Cartilages of the Larynx,

\* Is it not possible that the origin and extent of these sacs, or even their situation, may vary in different individuals of a species?

† *Loc. cit.* p. 1.

‡ Here, as well as in the *S. inuus*, according to LUDWIG, and the *S. silvanus*, according to BLUMENBACH, the right sac is larger than the left, being another proof in favour of what has been already said of the predominance of Respiration on the right side. Is it not probable, too, that this cavity in the Hyoid Bone is formed after birth?

that of the largest, the Thyroid, is subject to many varieties, of which the following are the most essential according to WOLFF and RUDOLPHI: the angle at which its sides meet is usually obtuse as in Man, but more acute in the Guinea-Pig, Sheep, and Horse;—2d, the notch in its upper margin is usually wanting, except in the Badger and the Ruminants, its situation being commonly occupied by a larger or smaller process;—3d, its inferior margin in most species of Mammalia presents a much deeper excavation than in Man, *e. g.* in the Hyæna, Weasel, &c. but more particularly in the Bear and Seal, where the two lateral halves are connected in but a small part of their extent;—4th, of the Cornua, the inferior are generally largest, but the superior in the Stag, Roe, and Lynx;—5th. In some Ruminants, particularly the Antelope *gutturosa*, the anterior surface of the Thyroid Cartilage forms a considerable projection. The form of the Cricoid Cartilage, also, presents many peculiarities in different species: in the Roe, for instance, it has a projecting sharp ridge on its anterior side; in the Bear is divided anteriorly into two halves connected only by tendinous fibres; in the Hyæna it ascends high on the dorsal side of the Trachea; &c. whilst in the Dog and Badger it is very similar to that of Man. The varieties in the form of the Arytenoid Cartilages are equally great: they are proportionally large in the Bear, Hyæna, Weasel, Otter, Beaver, and Mouse; whilst, on the other hand, they are small in Apes, the Badger, Hedgehog, Dog, and particularly the Wolf.

§. 624. In the Trachea of Mammalia, though essentially corresponding to the human type, we find many approximations to earlier formations. Of this kind are the complete rings of cartilage which are found precisely in those species most nearly related to Birds, *e. g.* in some Rodentia, Maki's, and Chiroptera. Such, also, is the case

in the Phalanger, the Galeopithecii, the Mococo (*Lemur catta*), and the Beaver. Besides these, perfect rings have been found in several amphibious Mammalia, *e. g.* the Seal, (at least the 12 upper rings,) the Manati, and Porpoise, analogous to the perfect rings of the same part in many Amphibia, *e. g.* Tortoises. A second remarkable recurrence of formations, already noticed, occurs in the description given by DAUBENTON and WOLFF of the course of the Trachea in the Thorax of the Sloth (*Bradypus tridactylus*), in which it descends on the dorsal parietes of the chest between the Lungs, and then turning forwards reascends in order to divide into two Bronchi. (Tab. XX. fig. VIII.) The extremities of the cartilaginous rings are here in immediate contact, and it may be stated generally, that in many species, particularly such as are related to those which have already been described as possessing perfect rings, the membranous interval between the extremities of the cartilages of the Trachea on the dorsal side is exceedingly small, as, for instance, in most Quadrumana and Rodentia, several Canivora, Ruminants, &c.\* †

§. 625. The length of the Trachea is regulated chiefly by that of the neck, though without any proportion between

\* This is the case, also, in the Mole, though its Trachea is farther distinguished by the distance at which the rings are placed from each other, several of them, also, being divided, and others extending only half way round the tube.

† In the White-throated Sai and Alouatte, the rings of the Trachea present two very opposite conditions. In the former they are very complete towards the lower part, overlapping each other in such a manner as not to leave any membranous interspace. In the Alouatte, they scarcely extend round half the circumference of the tube, and still less so in the bronchi: in the former, they are narrow and remote from each other; and in the bronchi, disappear as the tubes enter the Lungs. This structure must evidently render these canals capable of great changes in length and diameter, and must materially modify the voice of the animal. (CUVIER, *Comp. Anat.* iv. 311.)—*Translator.*

it and the number of its rings, of which there are, for instance, 53 in the Stag, and 78 in the Seal. In most others the number of rings is smaller, though generally more considerable than in Man. The division of the Trachea into the Bronchi is usually simple, without any trace of a second Larynx, and it is only in the Lemur *macaco* that DAUBENTON\* observed a tympanum-like dilatation of the two short Bronchi. A triple division, however, has been observed by many anatomists in Ruminants, (*e. g.* the Stag, Roe, Ox, Sheep, Camel, &c.) and Swine, (the common Pig and Peccari.) WOLFF and RUDOLPHI found this third division given off between the 43d and 44th rings of the Trachea in the Ox and Sheep. In the Goat I reckoned 8 rings between this lateral branch and the division into the Bronchi. It is always found on the right side, and, as MECKEL† has remarked, corresponds to the more considerable size of the right Lung. The rings of the branches of the Trachea in Mammalia generally disappear gradually, as those canals ramify in the substance of the Lungs: in some Opossums, on the contrary, they terminate very abruptly, according to CUVIER, in the same manner as in Birds. The muscular fibres of the Trachea of Mammalia appear to be confined exclusively to the dorsal membranous part.‡

\* BUFFON, *Hist. Nat.* t. xiii. p. 207.

† Translation of CUVIER's *Comp. Anat.* vol. iv. p. 154.

‡ In Man, the Trachea has from 17 to 20 rings; in the Camel, 74; the Stag, 53; Mouse, 14; Hedgehog, 18; Phascolome, 20; Rat, 21; Beaver, 22; *Simia sabæa*, 24; Bear, 28; Hyæna, 36; Lion, Cat, Dog, Rabbit, 38; Pig, 38 to 40; Lynx, Guinea-pig, 40; Hare, 44; Wolf, Sea-Otter, Sheep, 50; Roe, 53; Pole-cat, 67; Seal, 78. In the *Simia seniculus*, Lion, and Bear, the space between the extremities of the Rings is very great, so as to permit of a considerable reduction of the diameter of the tube they form. (RUDOLPHI, *Physiologic*, i. 383.)—Translator.

§. 626. In considering the Lungs themselves, we find a structure which is generally very closely related to that of Man; but, at the same time also, meet with a remarkable approximation to the sac-shaped simple Lungs of the Amphibia, viz. in the amphibious and fish-like\* Mammalia. In these species, and more particularly in the Cetacea, the Lungs are not perfectly divided into several lobes as in Man, and are continued in the form of narrow elongated sacs low on the Spine, a disposition favoured by the form of the Thorax to be hereafter noticed: they are farther distinguished by the very small size of the cells, which, however, communicate very freely together, so that air impelled into a small ramification of the Trachea distends the whole lung; nay, the pulmonary cells, here, as in Amphibia, have an extraordinary degree of contractility, and so completely empty themselves of air, that from its solidity and appearance, HUNTER† compares the pulmonary substance to the Spleen of an Ox. The Lungs are almost precisely similar in some Amphibious Mammalia, whilst in others, on the contrary, they more nearly resemble those of the other animals of the Class. Of the former kind, according to DAUBENTON,‡ is the Manati, in the foetus of which he found the Lungs forming long flat sacs, separated from the Sternum by the large heart, descending below the Liver and Stomach, and penetrated at their upper extremity by the Bronchi: of the latter description is the Seal, in the Lungs of which fissures (lobular) have been observed by several anatomists.||

\* They here again serve as Swim-bladders. (See §. 430.)

† Observations on the Structure and Economy of Whales, in the *Philos. Trans.* 1781. p. 419.

‡ BUFFON, *Hist. Nat.* t. xiii. p. 429.

|| The Lungs of the Dugong are very elastic, and the air-cells near the surface double the size of those in other parts. The cartilaginous rings sur-

§. 627. The parenchyma of the Lungs, in other Mammalia, is not essentially different from that of Man, though it must be regarded as a very distinguishing character in their structure, that, according to DAUBENTON, both Lungs in the *Sus tajassu* present considerable vesicular appendages on the dorsal surface, which, however, may very possibly have been the result of disease. The varieties in the number of the lobes in the different species are, however, exceedingly numerous. We may remark generally, that the number is usually greater than in Man, and greater in the right than the left Lung, a point on which CUVIER has given a copious Table, the general result of which is, that in most species the right Lung has from 3 to 4, and the left from 2 to 3, rarely 4, lobes. Less frequently still each Lung is undivided, *e. g.* in the Elephant, Rhinoceros, Horse, and Lama, (resembling the amphibious species,) or the Bat and Flying Maki, (where it is analogous to the single lungs of Birds.) Farther, in the whole Class we usually (as in many Amphibia and in Man) find the right Lung larger than the left, though, as we shall hereafter see, the Heart is ordinarily placed in the middle of the Thorax: on this account, a distinct lobe of the right Lung is situated between the Diaphragm and the Heart, which is at some distance from it. Hence, I was the more surprised to find that in the Mole, where the Heart is turned to the left side, the right Lung exceeds the left for the same reason as in Man, and even in a still greater degree.

§. 628. As to the mechanism of Respiration in this Class, we here first meet with a perfect muscular septum (Diaphragm) between the cavities of the trunk which con-

rounding the bronchi present a certain degree of analogy to the prietes of the Tracheae of Insects, being arranged around the tube in oval spiral convolutions. (HOME, *Phil. Trans.* 1820. p. 2.)—Translator.

tain the Lungs and the abdominal viscera. It here, consequently, represents the muscular septum dividing the branchial apparatus (Thorax) from the Abdomen of Fishes, with this difference, that, in this instance, the Heart is included within the cavity containing the respiratory organs, the Diaphragm farther offering an analogy to the tendinous membrane moved by muscles, which connects the Lungs of Birds to the dorsal side of the Thorax. The Diaphragm of amphibious and cetaceous Mammalia approximates to these earlier types of formation. In the latter, the very strong and fleshy Diaphragm is attached to the dorsal side of the cavity of the trunk so low down, that it ascends considerably in order to be connected in a peculiar manner with the upper and anterior extremity of the abdominal muscles. The Thorax is, consequently, very long at the back part, the space being occupied by the elongated Lungs; whilst the anterior part is very short, and almost exclusively occupied by the Heart. The Lungs, therefore, (in the same manner in Birds,) may be said to lay behind, rather than above, the Diaphragm: the latter organ, which, from its connection with the abdominal muscles, as well as its own strength, is capable of exerting much force, acting in the same manner as in Man, forms the principal agent in Inspiration, which is rendered difficult by the aqueous medium in which the animal is placed; whilst, on the contrary, Expiration is effected by the elasticity of the cells of the Lungs. The respiratory motions of the amphibious Mammalia agree pretty closely with the above description, and in them, also, particularly the larger kinds, we evidently observe a very considerable exertion of force in breathing. The species of both Orders, and particularly the first, can, as is well known, dispense with respiration for a considerable interval.

In the remaining Mammalia, the structure of the Dia-

phragm, as well as the respiratory motions, have so few peculiarities, that it would be needless to enter into a detailed description of either,—the more so, as we are enabled to refer to these points in the human body as a general model.

§. 629. Having thus considered the whole series of the very varied forms of the respiratory apparatus, it only remains to remark upon the peculiarities which distinguish that of Man. As we already found that in the Systems of the Vegetative Sphere for the ingestion of materials, the human peculiarities were observable in so far only as related to the sensibility of those organs, so are we led to a similar conclusion as regards these organs employed in the volatilization of organic matter. We have found that Man is not distinguished beyond other animals either by the force or extent of his Respiration; nay, that he is exceeded in both particulars by many; and, consequently, that we do not discover the superiority of the human type in the respiratory organs, considered merely as such. If, on the other hand, we view the respiratory organs as an index of the conditions of the mind and of its feelings, what animal is there that can be compared with Man? It is true, that the animal when it possesses Voice employs its tones, or even the sound (without Voice) produced by other parts, to express various affections;\* but as thought is produced in the Head of Man as the crown of a completely independent and harmonic organization, so, also, does Speech receive its full perfection in the mouth of Man, as compared with its rude and imperfectly articulate

\* It deserves to be remarked, too, how Respiration, which is in the Vegetative what Motion is in the Animal Sphere, serves like it to convey the influence of internal conditions to external objects; more particularly, as Vocal organs are formed by the combination of Organs of Motion and Respiration.

tones in the animal world. Nay, Tone alone, without any reference to the expression of ideas, has the power of indicating the minutest shades of passion and mental emotion (Singing); and, as such, is to the Feelings what Speech is to the Intellect.

Lastly, I may here remark, that the greater strength and ability of the right upper extremity in Man evidently coincides with the greater size of the right Lung, and the predominance of Respiration on the right side; and that they cannot by any means be considered as the result of habit alone.



### III. OF THE DIFFERENT FORMS OF REPETITION OF THE RESPIRATORY ORGANS; OR, OF THE SECRETORY ORGANS.

A. *Repetition of the Respiratory Organs in the Digestive System; or, Of the peculiar Organs of Secretion belonging to the Intestinal Canal.*

§. 630. In order that the nutritive matter taken into the Intestinal Canal may be truly assimilated to the body, it is necessary that its individuality should be previously destroyed; for we cannot conceive how a body, so long as it in itself forms an independent and complete whole, should

become an integral part of another Organism. We hence understand, not only why animals which live on others ordinarily destroy their prey previous to swallowing it, but also, the object of the bruising of animal and vegetable matter by teeth, or by parts supplying their place: such, also, is the object of the intermixture of peculiar fluids, which, by their chemical or dynamic qualities, act upon the alimentary matter, destroying or dissolving it, and annihilating its individuality. The same effect is produced when Man, by various artificial processes and mixtures, changes, or almost wholly destroys, the peculiar nature of his food previous to swallowing it. We have already considered the various provisions for taking and dividing the food, and next proceed to the structures which effuse various secretions into the Intestinal Canal, thereby shewing that the secretory nature of the cutaneous surface is repeated in the Intestinal Canal, in the same manner that, on the other hand, the skin in many animals presents itself as an absorbent surface. It must be observed, however, that these secretions, in correspondence with the assimilative character of the Digestive System, are not, like others, lost to the body, (*e. g.* Urine, Perspiration, &c.); but, on the contrary, contribute essentially to the digestive process. Of the Organs belonging to this Class, we must first consider those which, being placed at the entrance of the Intestinal Canal, serve to prepare the fluids that first act on the nutritive matter, and that frequently even like actual poisons.

SECTION I. *Salivary Organs.*1. *Zoophytes.*

§. 631. Distinct organs are usually wanting for the secretion of Saliva, as well as for so many other functions in this Class; particularly as the cavities of the mouth and stomach are so far identical that they appear but as one, in which we are unable to distinguish the saliva from the gastric fluid. But, that these fluids here act powerfully in destroying the individuality of the alimentary materials, and even as chemical solvents, is proved by the *Medusæ*, which, as already noticed (§. 433.), are capable of dissolving and digesting very solid substances. CUVIER found distinct salivary organs only in some of the *Holothuriæ*, in the *H. tremula*, consisting of twenty little irregular blind sacs around the mouth, and in the *H. pentactes*, as two similar, but larger ones.

2. *Salivary Organs in the Mollusca.*

§. 632. In the *Acephala*, where, as in many *Zoophytes*, the *Œsophagus* is so short that the mouth frequently appears to be the orifice of the Stomach, proper salivary organs are in most instances wanting. I have not been able to discover them either in the Fresh-water Muscle nor in *Ascidia*: in the *Terebâ*, however, HOME found two considerable glands on the *Œsophagus*, which, by the secretion of solvent fluids,

appear to facilitate the boring of these animals into the wood-work of Ships and Dams.

§. 633. These organs are much more developed in the Gasteropoda, where they are ordinarily attached to the Œsophagus as a pair of Glands of considerable length, being surrounded (either themselves or their excretory ducts) by the nervous circle of the neck. In the *Helix pomatia*, they are expanded over the anterior part of the Stomach, and empty themselves by two ducts into the cavity of the Pharynx. (Tab. III. fig. III. d. d. fig. V. i.) In the viviparous Snail, they are shorter and more compressed, (fig. X. v.); in the *Aplysia*, on the contrary, they are longer, (fig. VII. u. u.) In the Genus *Doris*, there is, moreover, an accessory salivary gland.

§. 634. Lastly, the salivary organs are usually still more developed in the Cephalopoda, where we generally find two pairs of them.\* In the *Sepia octopodia*, I find a smaller upper pair close to the pharynx (Tab. IV. fig. II. c.), and a lower pair somewhat larger, flat, heart-shaped, and near the Œsophagus (d.): the excretory ducts of these last unite into a single canal, ascending upwards and opening near the excretory ducts of the upper glands. The arrangement is similar in the Cuttle-fish, (*S. officinalis*.)

### 3. *Salivary Organs in the Articulata.*

§. 635. All examinations have hitherto failed to discover salivary vessels in Vermes or Crustacea, which may probably

\* We have here a proof that the greater or less, or even deficient, secretion of Saliva is not in any way connected with the mode of life, inasmuch as we find highly developed salivary organs in these and other Mollusca that live in water. Generally the mode of life is regulated by the organization, and not the reverse.

depend upon the shortness of the Œsophagus in the latter (§. 632.), and the close relation of the former to Zoophytes. It may, however, be proposed as a question, whether we do not find the character of salivary glands in two little green bodies placed at each side of the stomach in the Cray-fish, and which, though long ago described and represented by RÖSEL,\* I do not find mentioned by CUVIER. (Tab. VI. fig. IV. h.) At least, they are placed near the Stomach, as was the case in several Mollusca; and it is remarkable, that the Crab's Eyes, as they are called, are formed immediately over them, whence they might be considered as salivary concretions, particularly as it is probable that they are ultimately rejected through the mouth. In Insects, on the contrary, these organs not infrequently exist, though not as true glands, but as vessels terminating in blind extremities. Among the Gnathaptera, they have been observed particularly in Spiders, the venom organs of which, already mentioned, (§. 451. compare with §. 630.) consist of oblong bladders, and terminate by excretory ducts in the points of the mandibulæ. Some Scolopendræ, also, as well as several Coleoptera, and the Aptera, Diptera, and Hemiptera, furnished with organs for stinging and sucking, appear to infuse similar secretions into the injuries they inflict, as is proved by the poisonous effects from the former, and in the latter by the smarting of the wounds and swelling of the skin. RAMDOHR, also, states that the salivary vessels of several Diptera and Hemiptera have been detected terminating either in the sucking proboscis, the pharynx, or the stomach. The *Gryllus verrucivorus* even derives its name from the saliva poured into the mouth, which, when the animal is allowed to bite a Wart, causes it to disappear. The salivary vessels are more precisely known in the

\* *Insectenbelustigungen*, th. iii. b. ii. s. 322.

Willow Caterpillar, where they open by means of excretory ducts into the mouth, and consist of two sacs an inch long placed at the sides of the Oesophagus, and having, much similarity to the salivary vessels of Spiders.

Before quitting the salivary secretions of invertebral animals in general, and Insects in particular, we must devote a few words to the Spinning Organs of Caterpillars, inasmuch as they present a close relation both in form and situation to salivary organs. They consist of thin vessels with a blind termination, one placed on each side of the Intestinal Canal, (Tab. VII. fig. XI. h. l.) and much exceeding the length of the body, being a foot long in the Silk-worm, for instance: they ultimately terminate by delicate excretory ducts in an opening beneath the spinning tubercle on the lower lip, (nearly in the same manner as the Sublingual Glands beneath the Tongue,) where their fluid, becoming condensed by the action of the air, is drawn into threads which are employed in forming webs for the purpose of metamorphosis. As is well known, we are indebted for Silk to the beautiful web of the Caterpillar of the *Phalæna Mori*, where the Cocoon, weighing  $2\frac{1}{2}$  grains, consists of a thread 900 feet long. In point of character, these organs are evidently repetitions of the spinning apparatus at the anus of less perfect Insects, *e. g.* Spiders: and it is interesting to observe, that the web of the Spider is chiefly employed to form a covering for the ova, thus serving to favour the development of the young; whilst in the Caterpillar, the Cocoon is subservient to the metamorphosis and development of the animal itself.

4. *Salivary Organs in Fishes.*

§. 636. The short and capacious Œsophagus almost invariably existing in this Class, as well as the rapidity with which the food is swallowed, (not being detained in the mouth, and rarely masticated,) are the causes which lead to the almost uniform deficiency of proper salivary organs, and consequently to an approximation to Zoophytes in this particular. The deficiency is, indeed, in some degree compensated by a more copious secretion of mucus from the lining membrane of the mouth, where, consequently, we find very evident layers of mucous glands, e. g. in the Carp Genus, and also, according to CUVIER, in Rays and Sharks.

5. *Salivary Organs in Amphibia.*

§. 637. The Batrachian and Chelonian Orders approximate to Fishes in so far as, that instead of single large glands there are rather flat layers of glands (mucous follicles) under the internal membrane of the mouth, and particularly the Tongue, which, secreting a tenacious mucus, supply the deficiency of Saliva. In Serpents and several Lizards, on the contrary, the Salivary Glands are more distinct. In the former, the Venom Glands are particularly remarkable, which, as already mentioned, (§. 474.) discharge themselves by a divided tooth, precisely as the Salivary Vessels in Spiders. These Glands are here of considerable extent, are situated behind the Orbit above the joint of the jaw, and are compressed by a peculiar

muscle. (Tab. XII. fig. III. c.) In those Serpents that are not venomous, two small glandular layers on each side of the margin of the Superior Maxilla appear to be the only remains of these larger Glands; and I was struck to find that in the Coluber *natrix*, and still more in the C. *thuringica*, the Tendon of a muscle placed upon the back part of the neck passes over the joint of the jaw, and divides into several fibres which are inserted into the scales of the upper jaw. It is easy to see how the tightening of this tendon must retract those scales, and so promote the flow of Saliva. In Lizards, CUVIER states that there are sometimes layers of mucous Glands similar to those in the two first Orders; at others, Glands on the margin of the upper jaw, as in the Serpents that are not venomous; and lastly, that they are sometimes altogether wanting.

#### 6. Salivary Organs of Birds.

§. 638. It is in those Birds which live on vegetables that the salivary organs are most strikingly developed,† though the glands themselves in form and position resemble those of the preceding Classes, being placed immediately beneath the internal membrane on the floor of the mouth, each glandular granule pouring its secretion separately into the cavity. Ordinarily, too, the secretion is less properly salivary than mucous, i. e. thick and tenacious. This is particularly the case in the Woodpecker, where it forms a viscid coating to the tongue, which is employed for taking its prey. (§. 484.) The largest pair of these glands is usually placed between the rami of the lower jaw, (glandulæ submaxillares,) and in the Turkey (Tab. XV. fig. X. d. d.)\* is

† TIEDEMANN, *Zoologie*, b. ii. s. 393.

even double. In the Accipitres these glands are smaller than in herbivorous Birds, but at the same time more numerous. In the Sparrow-Hawk, TIEDEMANN has described five sets of them; of which one pair is situated above the articulation of the jaws, corresponding to the poison glands of Serpents, and at the same time to the parotid glands in Man; another pair, on the contrary, is placed on the palate, pouring out their secretion towards the arched tooth-like extremity of the (§. 482.) upper bill† by two ducts running along the roof of the palate; the remaining sets, as in other instances, are placed at the floor of the mouth.

7. *Of the Salivary Organs in Mammalia.*

§. 639. It affords an additional proof of the close connection between the C etacea and Fishes, that, according to all examinations up to this time, the salivary glands are altogether wanting in the former, and that even in the amphibious Mammalia their size is inconsiderable. On the contrary, they are in a corresponding degree more developed in the Rodentia and Bats, approximated as those animals are in so many respects to Birds: the submaxillary glands in them being of extraordinary magnitude as compared with the parotid, sublingual, and buccal glands, possessed by most Mammalia in common with Man. In the Edentata, e. g. the Echidna and Ant-Eater, the parotid glands are wanting; but in the latter a peculiar gland

† As was already the case in Spiders, so also in Serpents, in Birds, and, as we shall find, even in Mammalia, there is a uniform relation between the salivary organs and the instruments employed in mastication, the saliva being generally poured out near the most efficient of the organs employed for that purpose.

opening on the lower lip serves to secrete the viscid mucus, which, when spread over the tongue, (§. 508.) is employed for taking small Insects. Generally, the rule applies to Mammalia as to Birds, that the salivary glands are most developed in the herbivorous species. This has been already mentioned as regards the Rodentia, in which the great power of the cutting teeth is combined with great developement of the salivary glands, which also evacuate themselves chiefly towards the anterior part of the mouth. These glands are likewise very large in the Ruminantia and Solipeda, in which the saliva from the parotid and buccal glands is evacuated near to the molar teeth, as being the most efficient organs of mastication. Nay, in the Ox and Sheep the secretion of the former is increased by a peculiar gland seated in the orbit and zygomatic fossa, and described by NUCK in the Dog, with some variations. According to CUVIER's statements the parotid glands are particularly large in Apes.†

† In the Two-toed Ant-Eater, besides the salivary glands, properly so called, there is another of a different character, which furnishes the viscid fluid with which the tongue is coated for the purpose of securing its prey. It is oval, flattened, and descends in front of the tendon of the Masseter, behind the angle of the lips, and along the margin of the lower lip as far as its middle. Its duct opens into a groove at the commissure of the lips. When the gland is compressed, the orifice of the duct gives issue to a thick, white, and tenacious secretion. (CUVIER, *Comp. Anat.* iii. 216.)—*Translator.*

SECTION II. *Of some other Secretions poured into the Intestinal Canal in the remaining parts of its course, in the higher Classes of Animals.*

§. 640. Under this head must be classed the mucus of the nasal cavities, which is poured into the cavity of the mouth or fauces in all animals in which there are posterior openings to the nares; consequently, in Amphibia, Birds, and Mammalia, the amount of the secretion corresponding to the extent of the nasal cavities. \* The course which these fluids take in order to reach the commencement of the œsophagus having been already noticed when describing the organs of Smell and the Fauces, requires no farther explanation, except as regards the anterior palatine openings, (foramina incisiva sive naso-palatina,) which are found in most Mammalia, and pouring out a portion of the nasal mucus in the region of the superior incisores, remind us, on the one hand, of the palatine glands in certain Birds, (§. 638.) and, on the other, are evidently a repetition of an earlier form of the posterior nasal apertures, which, in Amphibia, frequently open immediately behind the anterior part of the margin of the superior maxilla.

§. 641. These apertures, which had been already remarked by STENO, and the existence or non-existence of which in Man has given rise to much anatomical controversy, have recently been very well described by JACOBSON.\* They are particularly distinct in herbivorous

\* *Bulletin des Sciences de la Soc. Philomatique.* Avril, 1815. See CUVIER's Report on that Essay in the *Annales du Muséum d'Hist. Nat.* t. xviii. p. 412.

Mammalia, *e. g.* in the Ruminantia and several Rodentia; and as in them the connection between the nose and mouth is established by means of tolerably long canals situated in the openings of the bony palate, and provided with peculiar cartilaginous sheaths, and many fibrillæ of nerves, JACOBSON thought himself justified in considering this apparatus as a peculiar organ of sense, the organ of the Instinct which directs the animal in the choice of its food. With this view we, however, cannot coincide, inasmuch as we can by no means consider this and other instincts of animals as residing in any such individual organ; though at the same time without intending to deny that a very free communication of this kind between the organs of Smell and Taste may tend to favour and increase the activity of both. But that these openings are not common to all the Herbivora has been remarked even by JACOBSON, as regards the Horse, in which they are wanting. Such, too, is the case in the Guinea-Pig, in which I find the ducts proceeding in the same manner from the nasal cavities, but terminating by blind extremities in a prominent papilla placed behind the superior cutting-teeth;\* an appearance the more unexpected, as the openings are very large in other Rodentia, where, in the Hare for instance, they present themselves as two oblique fissures behind the superior incisors, and in the Rat as two minute openings placed on a projecting papilla. In Man, too, this connection between the cavities of the nose and mouth, appears to be wanting in the normal state, in which respect we find a repetition of an earlier formation. This opening is altogether wanting in the Cetacea.

§. 642. Besides the mucous cavities of the nares, we find also many smaller secreting organs dispersed over the surface of the membranes of the continuations of the ali-

\* EISENART has remarked the same fact in the Dromedary. *Salzbürg. Med. Zeit.* No. 35. 1817. s. 160.

mentary canal; among these we may class the glands of the œsophagus, of the crop, of the cardiac sac of the stomach in so many animals, and also those which secrete the gastric juice,—a fluid that presents the character of the saliva, though in a much more elevated degree. An extended description of all these parts in the different Classes of Animals will, however, be the less requisite, as, on the one hand, they form an object rather of physiological than of anatomical investigation, and, as on the other, the most important parts have been already noticed in connection with the description of the intestinal canal. The latter remark is likewise applicable to those secreting organs which present themselves in the lower part of the intestinal canal, and with a peculiarly great development at the termination of the Rectum. We may, therefore, next turn our attention to two other and larger secreting organs,—the Liver and Pancreas; of which the former is so absolutely a repetition of the organs of respiration, that we ordinarily find the degree of its development in an inverse ratio to that of those organs themselves. Hepatic organs, too, appear to be so essential to the animal frame, that we invariably find them even in the lower grades of organization, though it is only in the superior forms that they are still farther advanced by the super-addition of another preparatory organ, the Spleen. This is not the case with the Pancreas, which is much more frequently wanting.

SECTION III. *Of the Organs secreting Bile.*A. *In Animals without Vertebrae.*

## 1. IN ZOOPHYTES.

§. 643. Organs which appear to serve the purpose of secreting a biliary fluid have hitherto been observed in but few species, and those only the higher ones, viz. the Echinodermata, which have lately been separated from this Class: in the inferior species; on the contrary, *e. g.* in the Medusæ, there is but a single and simple secretion into the cavity of the stomach, combining in itself the characters at once of saliva, gastric juice, and bile. This primitive identity of these secretions appears to be indicated also in the Echinodermata, and even, as we shall find, in many of the Mollusca, by the fact of the bile being poured immediately into the stomach itself. In the Echinodermata, *e. g.* in the Asterias, the hepatic organ appears to be represented by a double row of little lobes placed in each of the five rays, and from which a canal runs to the stomach. (Tab. I. fig. XI. B.) Of the same nature probably is the flocculent tissue which surrounds the Intestine of the Holothuria.

## 2. IN MOLLUSCA.

§. 644. In the Acephala the liver is placed in the same manner close around the stomach or intestine, and fre-

quently is so little separable from those organs, that they appear as though excavated out of its substance. This, for instance, as already remarked, (§. 437.) is the case with the liver of the Bivalves, the secretions from which are poured into the stomach through several tolerably capacious openings or ducts. (Tab. II. fig. IX. b. a.) Such, likewise, is the disposition of the liver of the Ascidiæ, (Tab. II. fig. II. g. g.) where it surrounds the convolutions of the intestine in the same manner; though, as I had an opportunity of observing in a large species,\* the intestinal canal in young individuals is unattached, and a true liver altogether wanting. In the Terebratulæ and Lingulæ, on the contrary, the liver, according to CUVIER, is more distinct from the stomach, and in an equal degree more closely connected with the intestine.

§. 645. In the Gasteropoda we find the liver of very considerable size, divided into several lobes, and more completely separated from the intestinal canal. Thus, in the *Helix pomatia*, with which most other Shell-Snails agree in this point, the liver occupies all the upper convolutions of the shell, (Tab. III. fig. I. II. s. fig. III. o.) has several turns of the intestinal canal upon its upper surface, and pours its secretion, by means of two ducts, into a cœcal expansion at the extremity of the stomach. In the *Aplysia*, (Tab. III. fig. VII. n.) and nearly in the same manner also in Slugs, it fills a great part of the common muscular abdominal sac, and has several convolutions of the intestinal canal wound about it. In the Genera *Clio* and *Doris*, on the contrary, as is usual in the Acephala, it surrounds the stomach, pouring the bile into it by several openings. It is remarkable, too, that according to CUVIER's observations, a distinct excretory duct proceeds in the *Doris* direct from the liver to the anus, which, taken together

\* MECKEL's *Archiv. f. Physiol.* b. ii. h. 4.

with a similar organization in the Cephalopoda, appears to prove that with such an extraordinary development of the liver the secretion is frequently more copious than is necessary for the purposes of digestion, and, consequently, that the excess must be rejected as excrementitious matter.

§. 646. The Cephalopoda also possess a liver of considerable size: in the *Sepia octopodia* I find it forming an oval yellowish body, placed in the upper and posterior part of the abdominal cavity, enclosed within a continuation of the peritoneum, (Tab. IV. fig. II. r.) and pouring the bile by an excretory duct (n.) into the spiral-shaped cœcum. On its external surface, though still covered by the peritoneum, is the ink-bag before (§. 442.) mentioned; which, though it probably secretes its own contents, and consequently has a different relation to the liver from that of the gall-bladder, in Man for instance, yet being evidently supplied with vessels, and consequently with the materials, for secretion by the liver, must clearly serve the purpose, like the structure already noticed in the *Doris*, (§. 645.) of evacuating a portion of the materials prepared by that organ. It is disposed in the same manner in the Calmar; in the common Cuttle-Fish (*Sepia officinalis*), on the contrary, the liver, called by the old anatomists *Mutis*, is placed higher in the upper part of the body, pretty close behind the infundibulum, (§. 442.) is attached more firmly to the dorsal surface, and provided with two excretory ducts. The ink-bag, as has also been already remarked, is situated at a considerable distance from it in the lower part of the abdomen.

## 3. IN THE ARTICULATA.

§. 647. The developement of the biliary organs, which advanced so much in the preceding Class, recedes in an equal degree in this, where the great object appears to be rather the developement of the external form. In Vermes a biliary organ is either altogether wanting, *e. g.* in the Intestinal Worms, or it presents itself merely as a thin punctiform coating, usually of a yellow or blackish colour, on the external surface of the intestine, without any distinct ducts for the conveyance of bile being perceptible. For instance, there is a yellow layer of this kind around the intestinal canal of the Dew-Worm, (*Lumbricus terrestris*, Tab. V. fig. III. 1.) and also of the Lug-Worm, (*Lumbricus marinus*.) In the Leech, on the contrary, the external surface of the stomach is covered by a blackish mucous tissue. The biliary organs are more distinctly developed in the Crustacea: in Cray-Fish and Crabs we find them as large bunches of yellow cœcal vessels, occupying the greater part of the abdominal cavity, placed near the commencement of the intestine, and pouring a bitter tasted bile into its cavity. (Tab. VI. fig. IV. n. fig. IX. e.) In the Squillæ, on the contrary, according to CUVIER, there is a true liver divided into several lobes, and accompanying the intestine on both sides throughout its course.

§. 648. Lastly, in Insects the organs which analogy leads us to suppose are intended for the preparation of bile, in some degree assume such a diversity in their form as to have created many doubts as to their true character.\* Many

\* The deviation in the evolution of the biliary organs coincides in this instance as perfectly with the extraordinary developement of the respiratory organs, as the perfect formation of the liver in the Mollusca with their branchial respiration. (§. 642.)

contradictions, however, may be reconciled by the following view. The function of the liver as a secreting organ differs from the secretory action of the lungs in this respect, that the latter expels carbonaceous matter in a gaseous state, and the former a similar matter (though at the same time abounding in hydrogen and azote) in a more solid form. The deposition of fat coincides in many respects with the secretion of bile—a fluid abounding in adipose and resinous elements—from the liver; and if the bile, as an essential requisite to digestion, has a direct influence on nutrition, so also does the fat indirectly contribute to the same end, as a deposit of pure nutritive matter. Hence the deposition of fat and the formation of a liver appear to be less completely separate in the inferior Classes; hence, too, we can more readily understand the bulk of the liver in the Mollusca, inasmuch as in them that organ probably forms at the same time a deposit of nutritive matter: and even in the higher Classes of Animals we shall, for the same reason, find the liver occasionally distinguished by the quantity of fat it contains. These functions and structures necessarily appear more completely separate in Insects, the greater part of which want a true vascular system. In them the secretion of peculiar materials, as has been already noticed with regard to the saliva, venom, the liquids employed in spinning, &c. being performed not by glands, but merely by vessels with closed extremities, it follows that the bile must be prepared in the same manner by similar vessels, and the liver, as a biliary organ, replaced by biliary vessels; whilst, on the contrary, the deposition of pure adipose nutritive matter is connected with another structure,—the liver, in so far as it is a depôt of that kind, being represented by the adipose bodies which have been already noticed (§. 453, 458.); a suggestion by no means weakened, if it should be found that the biliary vessels derive

the materials for their secretion from the adipose bodies, as a general depôt of nutritive matter, from which, also, other parts are supplied with their component elements. It completely coincides, likewise, with this view, that in those Insects which approximate to the Crustacea, and present a true vascular system, the character of liver and of adipose bodies is more perfectly united in a single organ. This appears to be the case in Spiders, where the adipose bodies (Tab. VII. fig. I. d.) adhere so closely to the stomach that it is as impossible to separate them anatomically as to detach the liver from the parietes of the stomach in the Bivalves; and where, also, not only chyle is deposited, but likewise a secretion of bile takes place, as is proved by the brown colour of the excrements\* in the portion of intestine that follows. It is remarkable, however, that here also there are, in addition, peculiar biliary vessels, which pour out their contents about the anus, (fig. I. e. e. e. e.) and, consequently, inasmuch as they appear merely to evacuate superfluous materials, remind us of the similar organization before noticed in some Gasteropoda and Cephalopoda. (§. 645, 646.) There is something similar, also, in the Scorpion, though in it the fatty body is more perfectly distinct from the intestine, and disposed along each side of it; (Tab. VII. fig. IX. g. g.) there are moreover, however, according to TREVIRANUS,† peculiar biliary vessels (f. f.) on each side, which, probably arising from the fatty body, absorb from it the biliary fluid that they pour into the intestine.

§. 649. In the remaining Insects, where it is impossible to detect a true vascular system, the evident relation existing between the fatty bodies and the secretion of bile disappears; the biliary vessels, on the contrary, being much more completely developed than, for instance, in the Scor-

\* *Ueber den Bau der Arachniden*, s. 32.

† *Loc. citat.* p. 6.

pion. They exist as well in the larva as in the perfect Insect, though there are sufficient points of difference corresponding to those different stages of development; thus, in the Caterpillar, in accordance with the extraordinary size of the intestinal canal, the biliary vessels are much more considerable than in the Butterfly. The form, number, and attachments of these biliary vessels, called by the older anatomists *Vasa varicosa*, are extremely various in these animals. As to form, [they are most commonly simple capillary threads, but occasionally also irregular, and beset with little blind pouches, as I have distinctly observed in the Caterpillar of the *Sphinx Euphorbiæ*. (Tab. VII. fig. XII. e. e.) Their length, as CUVIER also states, is usually in an inverse ratio to their number: thus, in the same Caterpillar they are long, (fig. XI. f.) and in the Cockroach, (fig. XX. k.) on the contrary, short. Their number, according to RAMDOHR,\* reaches, and always in even numbers, to as many as 156. They are very numerous in some Neuroptera, e. g. the *Libellulæ*, in the Orthoptera, e. g. the Cockroach, (fig. XX. k.) and in the Mole-Cricket (*Gryllus gryllotalpa*), where they all unite, like a tuft, into one trunk previous to being inserted into the Intestine. In the Coleoptera there are two, in Caterpillars and Butterflies three, on each side, which, uniting into a common trunk, open on each side of the intestine. (Tab. VII. fig. XII.) The mode in which these vessels terminate is yet but imperfectly known, for, according to RAMDOHR, they appear to open between the coats of the intestine without perforating the internal membrane. They usually enter the intestine at its commencement, immediately below the pylorus, though that point varies according to the extent allowed to the stomach: in the *Onisci*, according to CUVIER, they enter close to the œsophagus. According to RAMDOHR,

\* *Ueber die Verdauungswerkzeuge der Insekten.* Halle, 1810.

they are also connected in the Coleoptera and some Caterpillars with the cœcum or rectum: in the Acheta, Locusta, and Buprestis, MECHEL\* states that they penetrate the intestine in two different points; whence we may conclude, that, as in certain Mollusca, a part of their secretion serves to assist in the digestive function, whilst the remainder is a purely excrementitious product.

B: *Biliary Organs in Vertebral Animals.*

§. 650. In all of the four Classes belonging to this division there is a perfectly formed liver, the only essential difference between which and the liver of the Mollusca is, that it does not receive the blood necessary for its secretion, like every other secreting organ, and as in the inferior Classes, from the principal artery of the body only; but that it is farther supplied by a particular venous system, (the Vena Portæ,) hereafter to be considered. There is besides in these Classes another peculiar organ; connected with the liver by the mode in which the blood is distributed, viz. the Spleen; which we may, without any impropriety, consider as taking a part in the secretion of bile, were it only as being the means of converting a greater quantity of arterial into venous blood, and may in consequence examine it at the same time with the liver, as being, like it, a preparatory organ; an opinion with which it perfectly coincides, that we observe the developement of the two organs proceeding in an inverse ratio, the spleen being smaller in proportion as the liver is large and perfectly formed. With regard to the liver itself, it is to be remarked,

\* Translation of CUVIER's *Comp. Anat.* vol. iii. p. 713.

that in the superior Classes it presents a peculiar receptacle for bile, (the gall-bladder,) which may, to a certain extent, be viewed as a repetition of the ink-bag of the Sepiæ, as the fluids subservient to the secretion of the latter organ are furnished to it by the liver, and as also, in certain Mammalia for instance, ducts are found conveying the hepatic bile direct into the body of the gall-bladder: on the other hand, the two organs offer some important differences, inasmuch as the fluids contained in the ink-bag appear to be purely excrementitious, and are probably secreted from the coats of the bag itself; whilst, on the contrary, no such secretion takes place in the gall-bladder, and its contents are evidently important aids to digestion.

### 1. *Biliary Organs in Fishes.*

§. 651. The great extent of the liver in this Class must be considered as a very positive approximation to the organization of the Mollusca, as well as a result of the existence of branchial respiration, the developement of the respiratory organs and of the liver usually proceeding in an inverse ratio: (§. 642.) nor is it less remarkable in another point of view, (§. 648.) that, as BLUMENBACH\* has shewn, the liver of several Fishes, *e. g.* the Ray and Cod, which are otherwise almost wholly without fat, teems with oil. As to the size and shape of the liver, the former is usually so considerable as to occupy a large portion of the abdomen, (Tab. IX. fig. XVHI. g.) several convolutions of the intestine, precisely as in the Mollusca, being frequently

\* *Handbuch der Vergleich. Anat.* s. 184.

enclosed within it, particularly in the Genus *Cyprinus*. The shape presents many varieties in the different Genera: it is usually adapted to the form of the abdomen, presenting a longitudinal mass, convex superiorly, concave inferiorly; (fig. XVIII. XIX.) sometimes, as in Lampreys, the Trout, and Pike, simple and undivided; at others, divided by fissures into several lobes, *e. g.* into three large ones in the Burbot, into very many distinct lobes in the Carp; in the Electric Ray, &c. into two large and almost completely separate halves, each of which is composed of a small and of a large oblong lobe.

§. 652. The colour of the liver is commonly yellowish, reddish, or brownish. The grass-green colour of the liver in the Lampreys (in the *Petromyzon branchialis* I find it orange,) is remarkable, particularly because here, and also, according to CUVIER, in the Nile Perch, Plaice, some *Sciænæ*, &c. the gall-bladder is wanting,\* which otherwise exists almost universally throughout this Class, and in structure as well as position varies but slightly from that of Man. (Fig. XIX. s.) There are usually several biliary ducts, which, as CUVIER has observed, for the most part enter the gall-bladder or its excretory duct at an obtuse angle, thus facilitating the entrance of the usually bright green bile into that organ, whence it is conveyed into the intestine by the cystic duct. In the Turbot (*Pleuronectes maximus*) there is farther a peculiar expansion of that canal before it opens into the intestine; whilst in the Basking-Shark (*Squalus maximus*), according to HOME, its aperture projects in the form of a long papilla into the dilated part of the intestine immediately below the pylorus.†

\* In the Lamprey, however, the deficiency is supplied by a tolerably large dilatation of the biliary duct.

† I find a similar structure at the orifice of the biliary duct in the Sturgeon.

§. 653. The Spleen in Fishes is singularly small as compared with the Liver, and at the same time of a much brighter colour than in Man. Its shape is sometimes globular, (Tab. IX. fig. XVIII. i.); at others, oblong, angular, or irregular: it is situated at the great end of the Stomach in the Shark, and in some other species, *e. g.* the Trout, in which, as well as in the Sturgeon, its size is considerable, that of the Liver being moderate. In other instances, on the contrary, it is placed more in the vicinity of the Intestine, and between the laminae of the Mesentery, *e. g.* in the Burbot. (See Tab. IX.) It appears to me to be altogether wanting in the Lampreys.

## 2. Biliary Organs in the Amphibia.

§. 654. The size of the Liver is also very considerable in this Class, and its colour not much darker than in the preceding Class. In the Salamander, it extends from the Heart, between and in front of the Lungs, as far as the great end of the Stomach, which it almost wholly covers; and is attached, on its anterior surface, by a Ligamentum suspensorium derived from the anterior peritoneal covering of the walls of the abdomen. (Tab. XIII. fig. III. f.) It is bi-lobate at its inferior edge, where, also, on the concave surface we find a Gall-bladder (fig. IV. l.) filled with green Bile, and having its Ducts disposed in the usual manner. The Spleen is small, oblong, of a bright colour, and attached to the left side of the Stomach. (Fig. III. g.) In the Proteus, the entire length of the animal being only from 9 to 13 inches, that of the Liver, which is divided into five lobes, is 5 inches; there is, likewise, a Gall-bladder

of tolerably large size. The disposition of the Liver, Gall-bladder, and Spleen, is pretty nearly similar in Frogs and Toads; except that the former is wider and more absolutely divided into two lobes, having the Heart placed between them in front; the Spleen, on the contrary, is smaller, farther removed from the Stomach; and in an equal degree approximated to the Colon. In Tortoises, the Liver is almost completely divided into two portions; its colour, according to MECKEL'S remark,\* being usually blueish-green, and the right lobe much larger than the left.† The latter point I find confirmed in the Mud-Tortoise, where, however, the colour is usually yellowish-brown.

§. 655. In Serpents, the length of the Liver is very great as compared to its breadth (*e. g.* in the *Coluber natrix*, 32 inches long, its length was  $6\frac{1}{2}$  inches, its breadth about half an inch): it consists, also, like the similarly elongated Lung, of only one lobe.‡ The hepatic duct is very long

\* Translation of CUVIER'S *Comp. Anat.* vol. iii. p. 572.

† This increase of the volume of the right lobe of the Liver, peculiar to so many animals, and even to Man himself, has an evident analogy with the preponderance of respiration on the right side, and the greater size of the right Lung.

‡ Several investigations lead me to think that the formation of the Liver is determined as absolutely by the distribution of the Umbilical Vein, as that of the Pancreas, and probably, also, of the Spleen, by the course of the Omphalo-mesenteric Vein: hence, consequently, the Liver is so long in Serpents because of the extent of the course of the Umbilical Vein from the Umbilicus to the Heart; whilst the Pancreas is so small on account of the short space from the same point to the posterior part of the abdomen. Hence, too, we observe a very long Pancreas in Birds, because the Omphalo-mesenteric Vein runs in the middle of the first long convolution of Intestine, which space is afterwards completely occupied by the Pancreas; whilst, on the contrary, the Liver is wider than it is long, because the course of the Umbilical Vein is here so much shortened. Nay, it is remarkable, how the *Vena Umbilicalis*, belonging chiefly to the almost bronchial Respiration of

and slender, and is connected in the vicinity of the commencement of the Intestinal Canal with the cystic duct, which then perforates the Pancreas. The oval Gall-bladder is at a considerable distance from the Liver, and contains a brownish-green Bile. The Spleen is small, globular, and placed at the upper extremity of the Pancreas. In Lizards, again, the Liver is more similar to that of the Frog and Salamander: in the Gecko I find it elongated, divided by a longitudinal groove into two larger portions, narrow above and broad below, (almost like a J); in the Crocodile, on the contrary, it is more similar to that of Man, (Tab. XII. fig. XIX. l.) and has in the same manner the Gall-bladder placed on its concave surface (n.). According to CUVIER, the hepatic and cystic ducts enter the Intestine, sometimes together, sometimes separately. The Spleen forms a little oblong body at the great end of the Stomach. (g.)

### 3. *Biliary Organs in Birds.*

§. 656. Here, likewise, the Liver is proportionally larger than in Man and Mammalia; at the same time being of a more brilliant red colour, and, like the Liver of several Lizards and Tortoises, divided into two principal lobes, a right larger, and a left smaller, between which the Heart projects from above. (Tab. XV. fig. XI. i. h.) TIEDE-

the Embryo, appears to form the lung-like excretory organ, the Liver; whilst, on the contrary, the Omphalo-mesenteric Vein, belonging to the external organ of nutrition, the Vesicula Umbilicalis, gives rise to the organ which secretes the milk-like Pancreatic Juice. I reserve a more extended investigation and exposition of these points for another opportunity.

MANN† has given an interesting tabular view of the differences of size of the Liver in different Birds, from which it appears that its bulk is greatest in Aquatic and Wading Birds, viz. from  $\frac{1}{10}$  to  $\frac{1}{9}$  of the weight of the body; and smallest in accipitrine Birds, viz. from  $\frac{1}{33}$  to  $\frac{1}{42}$  of the weight of the body. Anteriorly it is covered by the Sternum: the lungs stretch down behind it on the dorsal side, whilst it is retained in its place by the pærietes of the air-cells, and covered by their continuations. There are not any very essential variations in the form of the lobes in the different species. The biliary ducts arise from the under concave surface of the organ, one or more of them usually opening into the fundus of the gall-bladder, which, however, is not uniformly present, I myself having found it wanting in the Parrot and Dove, and others, at least in some instances, in the Guinea-fowl, Grouse, Ostrich, and Peacock. The hepatic as well as the cystic duct, here usually enter the Duodenum at a distance from the Pylorus, (Tab. XV. fig. XII. i. \*) close to the Pancreatic duct, an arrangement dependent on the long loop formed by that Intestine, which almost returns to the Stomach. As to the Spleen, it is extremely small, usually globular, of a dusky colour, and connected rather with the glandular cardiac cavity and left portion of the Liver than with the Gizzard. (Tab. XV. fig. XII.)

† *Zoologie*, b. ii. s. 491. The increased size of the Liver, and its conversion into a fatty substance, in several domesticated birds is very remarkable as an effect of abundant nutrition and limitation of muscular motion.

4. *Biliary Organs in Mammalia.*

§. 657. In the same manner as in the inferior Classes of Animals, the Liver was particularly large in proportion to the Spleen and to the whole body; the Spleen in the Mollusca being even wanting, though the Liver exists in great perfection; so also, in the history of the developement of Mammalia, and even of Man himself, we observe a similar proportion, corresponding to the less perfect degree of developement of the respiratory organs; the mass of the Liver being comparatively much smaller at a subsequent period, when the formation of the body is completed. So, likewise, those Species, *e. g.* the Whale and Porpoise, which approximate in several respects to Fishes and to the foetal state of the more perfect Mammalia, are distinguished by the size of the Liver and the smallness of the Spleen.\* In them the Gall-bladder is wanting, though in point of shape the Liver, according to HUNTER,† is pretty similar to that of Man, being like it divided into a right larger and left smaller lobes, and furnished with a round and suspensory ligaments. The biliary duct is capacious, and enters the commencement of the Duodenum. The small spherical Spleen is sometimes, according to HUNTER, double in the Porpoise; nay, according to TYSON, divided into ten or twelve portions.

§. 658. The Manati approximates to the Cetacea by the very large size of its Liver, which is divided only into

\* *Lacépède Histoire Nat. des Cétacées*, p. 36: "La baleine franche a une foie tres volumineux, une rate peu etendue."

† *Philos. Trans.* 1787. p. 110.

two principal lobes, as well as by the deficiency of the Gall-bladder;† forming in these respects a transition to the hoofed animals, in which the Liver, though somewhat smaller, ordinarily presents the same form, and where also the Gall-bladder is usually wanting, *e. g.* in the Solipeda and Deer, and, according to CUVIER, in the Camel, Pecary, Elephant, Rhinoceros, and Daman. In the Seal, on the contrary, the Liver, though still large, is divided into several lobes,—according to ALBERS, into 7; the Gall-bladder is present, and the same general disposition is common to most of the remaining Mammalia,† particularly the Carnivora and Rodentia. (See the Liver of the Beaver, Tab. XIX. fig. XIV. u.) We are again indebted to TIEDEMANN\* for a tabular view of the size of the Liver in several Carnivora and Rodentia, from which it appears that it is very considerable in those species which burrow or dive. He found it, for instance, in the Dog  $\frac{1}{37}$ , in the Fox  $\frac{1}{33}$ , and in the Hare  $\frac{1}{26}$  of the weight of the body; whilst, on the other hand, it was  $\frac{1}{14}$  in the Field-Mouse, and  $\frac{1}{10}$  in the Marmot and Otter.

§. 659. The Gall-bladder is wanting, however, in several Rodentia, *e. g.* in Mice, in the *Hystrix dorsata*, and in the Hamster. It deserves, however, to be remarked of the hepatic ducts, that when the Gall-bladder is wanting, their common trunk is considerably dilated, thus, *e. g.* in the Elephant and Horse, compensating the deficiency. In the Otter, however, according to DAUBENTON, this dilatation in the vicinity of the Duodenum is coupled with the existence of a gall-bladder. Lastly, the direct

† TIEDEMANN, *Zoologic*, b. i. s. 546.

† HALLER (*Elem. Phys.* t. vi. p. 462.) says, “Animalibus quadrupedibus, quibus divisi sunt pedes, plerisque etiam hepar in multos lobos dividitur.”

\* *Zoologic*, b. ii. s. 522.

hepato-cystic ducts, which are found, for instance, in the Ox and Sheep,\* and which, as was also the case in several Birds, convey the bile immediately from the liver to the fundus of the gall-bladder, are in many respects remarkable; particularly as reminding us of the relation of the ink-bag to the liver in several Mollusca, (§. 644.) in which that bag, though unconnected with the biliary ducts, received all the materials for its secretion from the vascular texture of the liver. The spleen of Cetacea has been already noticed; in other Mammalia it is usually elongated, tongue-shaped, (e. g. in the Beaver, Tab. XIX. fig. XIV. z.) and comparatively much smaller, though at the same time of a brighter colour, than in Man. Its position is invariably at the left side of the great end of the stomach, and when there are several stomachs, at the left side of the first or larger one.†

#### SECTION IV. *Of the Pancreas.*

§. 660. We have already seen some instances among the proper salivary organs of the Mollusca, in which they were partly situated in the region of the stomach; as, for instance, the salivary glands extending into the cavity of the abdomen of the *Aplysiae*, and the second pair of salivary glands in the *Sepiæ*; and, consequently, when we find a peculiar organ in the same situation in the higher Classes resembling the salivary organs, we may to a certain extent

\* See the various observations of HALLER on these hepato-cystic ducts in his *Elem. Physiol.* v. vi. p. 535.

† In the Walrus the bile passing from the liver enters into the upper and lateral part of a large oval cavity with very thick coats, terminating in a canal, which, for some distance before it penetrates the parietes of the intestine, runs behind the duodenum in the form of a thick cylindrical mass. (HOME, *Phil. Trans.* 1824, p. ii. 233.)—Translator.

view it as a repetition of the earlier type. Those deep-seated salivary glands are, however, by no means identical with the pancreas of the higher animals, inasmuch as they pour their fluid into the commencement of the alimentary canal, whilst the secretion of the latter appears to be more intimately connected with the preparation of bile, or at least to act upon the alimentary pulp in combination with the biliary fluid. Hence we must consider those secretions alone as perfectly analogous to the pancreatic fluid of the inferior species of animals which are actually poured into the beginning of the intestine, properly so called, and which, as we have already pointed out, are furnished by certain cœcal pouches around the parietes of the intestine in that situation. Hence, also, the first indication of the existence of true pancreatic organs probably presents itself in the form of a circle of little cœca in the *Holothuriæ*, (§. 434.) similar cœca occurring in the region of the pylorus in the *Aplysiæ*, (§. 440.) *Cephalopoda*, (§. 441, 442.) *Worms*, (§. 445.) and *Insects*, as substitutes for the pancreas; until at length in certain Fishes these cœcal appendages become more numerous, (§. 471.) and finally, as in the *Sturgeon*, are consolidated into a single apparently glandular mass. A genuine pancreas, however, coinciding essentially with the structure of that of Man, appears to exist only in the three superior Classes of Animals.\* †

\* According to CUVIER, indeed, *Sharks* and *Rays* possess a pancreas-like organ of gelatinous consistence, divided into several lobes, and opening by some ducts into the intestine: its true nature, however, requires farther investigation; as is also the case in some other Fishes which are said to possess a pancreas. (See HALLER's *Elem. Physiol.* t. vi. p. 427, 436.)

† In the *Loligo sagittata* there are two glands at the lower and front part of the liver, consisting of numerous lobes of a rose-red colour, and which have sometimes been considered as an ovarium. They surround the two biliary canals in their course from the liver to the spiral stomach, and communicate with them by numerous small ducts. They exist in an equally developed state in both male and female, and have not any organic connections with

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† In the *Loligo sagittata* there are two glands at the lower and front part of the liver, consisting of numerous lobes of a rose-red colour, and which have sometimes been considered as an ovary. They surround the two biliary canals in their course from the liver to the spiral stomach, and communicate with them by numerous small ducts. They exist in an equally developed state in both male and female, and have not any organic connections with

1. *Of the Pancreas in Amphibia.*

§. 661. It usually exists here as a smooth, glandular mass, divided into irregular lobes, and placed between the layers of the mesentery at the first curve of the intestine; so, at least, I find it, for instance, in the Frog, the Mud-Tortoise, where it is of considerable size, and in a young Crocodile. On the contrary, in the Coluber *natrix* and Spotted Viper I find it forming a denser mass, placed more forwards on the intestinal canal, and perforated through its centre by the biliary ducts. In the Crocodile of the Nile COVIER found the excretory ducts double.

2. *Of the Pancreas in Birds.*

§. 662. As this gland in Birds usually occupies the space between the two portions of the first, and generally very long, fold of intestine, its size is commonly larger in proportion than in any other Class of Animals. TIEDEMANN\* found it very large in those Birds that live on vegetables, and, on the contrary, smaller in rapacious Birds; with which my own observations agree. Its form, which is regulated by its position between the two portions of the first fold of intestine, is usually long, narrow, and flat. (See it in the Dove, Tab. XV. fig. XII. k.; and on the probable

the sexual organs. Injections into the alimentary canal pass from the spiral stomach into the ducts, connecting these glands with the biliary canals. Dr. GRANT, by whom they are thus described, considers them as corresponding to the conglomerated pancreas of the Chondropterygious Fishes. (*Edin. Phil. Journ.* xiii. 198.)—Translator.

\* *Zoologie*, b. ii. s. 475. Is it not probable that its size corresponds to the great magnitude of the vesicula umbilicalis in this Class? (Compare the Note to §. 655.)

cause of its form, and of the origin of the organ generally, see the Note to §. 655.) It is generally divided into two perfectly distinct lobes, *e. g.* in the Magpie, Parrot, Goat-sucker, &c.; more rarely—as in the *Ardea pavonica*, and some individuals of other species, in which it is properly single—it is completely double; in which case the additional gland is placed in the second loop of Intestine. The pancreatic ducts in Birds\* are from one to three in number, and not always the same even in the same species, each entering the Intestine separately, and usually before the biliary ducts (fig. XII. 1.): thus, according to a Table given by CUVIER, in the little Owl (*Strix passerina*), the Intestine is first perforated by three pancreatic ducts, then by the hepatic duct, and, lastly, by the cystic duct; in the Parrot the hepatic duct comes first, then the two pancreatic ducts, and, lastly, the cystic duct; in the Ostrich the hepatic opens into the Intestine before the single pancreatic duct.

### 3. *Of the Pancreas in Mammalia.*

§. 663. Though the proper salivary glands are wanting in several species of this Class, such is by no means the case with the Pancreas, which is invariably found, and even in the Cetacea, where, according to HUNTER, it appears as a very long flat body, the left extremity of which is attached to the right end of the first stomach, and also to the Duodenum, its excretory duct opening into the biliary duct near the entrance of the latter into the intestine. In

\* As is well known, (see HALLER'S *Elem. Physiol.* t. vi. p. 434.) this Duct, though already known to GALEN, was discovered by MAUR. HOFFMANN, at Padua, in 1641, in the Turkey; and was then subsequently described in Man by WIRSUNG.

the remaining Mammalia its shape differs only from that of the human Pancreas in being longer, and in being frequently divided into several branches. (See that of the Beaver, Tab. XIX. fig. XIV. k. l. m.) The excretory duct is usually single, though double in the Elephant, and very commonly opens into the Intestine at the same point with the biliary ducts; and particularly in the Ruminantia and most Carnivora.

B. *Repetition of the Respiratory Organs in the Sexual System; or, Of the Urinary Organs.*

§. 664. In the same manner that the Liver, as a secretory organ connected with the intestinal canal, evidently repeated the respiratory function, and consequently, as regarded its developement, stood in an inverse proportion to the respiratory organs, so, also, the urinary organs connected with the sexual system present themselves in several respects as absolute imitations of the respiratory apparatus, and consequently, though they can be distinctly traced only in the four superior Classes of Animals, are usually larger in the inferior than in the superior of them. It is particularly deserving, too, of notice, that from the consideration of the foetal state of the superior Classes, we learn that a part of the urinary apparatus itself, viz. the Bladder, with its continuation, the Allantois, is actually a respiratory organ, inasmuch as the vessels which perform the respiration of the foetus are distributed either immediately upon its

membranes, or upon a membrane (the Chorion), continuous with it. The latter is particularly evident in the embryo of Birds, in which the bladder, (Chorion or Allantois,) continued from the Cloaca appears distinctly branched; whilst, even in the human foetus, it is well known that the Umbilical Arteries extend at the sides of the Bladder and Urachus to the Chorion. Nay, we even find animals where the Allantois (elongated Bladder) does not protrude out of the abdominal cavity, but, nevertheless, attains a considerable size that remains through life, and at the same time continues to receive ramifications of vessels similar to those which are else furnished to the foetus only by the umbilical vessels.

§. 665. These precursory remarks were necessary, in order more clearly to prove, that we are justified in viewing the Kidnies, and Urinary Bladder, as constituting an evident repetition of the relation existing between Gills and a Swimming Bladder; for, as the blood is purified by the former from superfluous carbon, so also are the Kidnies destined for the evacuation of hydrogenous and oxygenous elements: in the same manner, too, that we found that a part of the materials taken in by the Gills (even pure Oxygen, which is present in no inconsiderable quantity in the Swim-bladder of many Fishes)-is carried by the vascular system into the Swim-bladder and accumulated there, so also the fluids poured out from the Kidnies (which, in the former case, were gasiform) are here collected in the Urinary Bladder: and, lastly, in the same manner that we saw that the Swim-bladder did not uniformly occur in connection with the Gills, so here we observe that the Urinary Bladder is occasionally wanting, though the Kidnies are invariably present.

Though we above remarked, that true urinary organs existed only in the higher Classes of Animals, the assertion

must not be taken as though all traces of them were wanting in animals without Brain or Spinal Marrow: on the contrary, in examining the sexual organs, we shall have occasion to observe that various secretory, nay even respiratory, apparatuses are connected with them in the lower gradations of the Animal Kingdom, having in them nearly the same character as the urinary organs of the higher Classes. But since in the four superior Classes, also, peculiar secretions commonly occur about the Sexual Organs, I deem it more advantageous to consider all the organs subservient to such secretions in connection with the sexual system: nay, even the description of the urinary organs might have been deferred to the same opportunity, were it not that they too completely form a distinct whole in themselves, and, in consequence, exert too important an influence on the whole animal œconomy.

#### SECTION I. *Of the Urinary Organs in Fishes.*

§. 666. In the same manner as, from the branchial respiration of these animals, the Liver was of striking extent, so also are the Kidnies, which extend as a single mass along the spine at the posterior part of the abdominal parietes, and occasionally occupy the whole extremity of its cavity, *e. g.* in the Burbot (Tab. IX. fig. XIX. u.): sometimes appearing merely as long narrow masses terminating above and below, in rounded points, without reaching the lower extremity of the abdomen, *e. g.* in the Trout: or, again, are furnished with an appendix on each side,

whence the whole mass appears as an elongated cross, *e. g.* in the Genus *Cyprinus*. They consist of a perfectly uniform mass comparable to that of the Spleen in Man, and we find the branches of the Ureter arising by numerous radicles, nearly in the same manner as those of the biliary ducts from the substance of the Liver. The two Kidnies of Fishes are so closely connected, that we may consider them as forming a single mass, the separation between them being indicated only by the existence of two Ureters and the groove on their surface for lodging the Vena Cava. Even the Ureters not infrequently, *e. g.* in the Trout, unite soon after their commencement into a single trunk, and, consequently, when we view the two halves of the Kidney covered by the Peritoneum, we can scarcely recognise them for any thing else than a single mass. We find the Kidnies, or rather Kidney, of Fishes immediately above or behind the Swim-bladder, which is particularly remarkable in those instances, as the Burbot and Trout, where the latter is closely attached to the vertebral column. In Rays and Sharks, the Species which are in so many respects the highest of this Class, the Kidnies, according to CUVIER, are proportionally smaller, a fact which I also have found confirmed in the Electric Ray.

§. 667. As the Kidnies of Fishes usually extend to, or even beyond, the anus, the Ureters are ordinarily very short, *e. g.* in the Carp, Pike, and Trout; but immediately, as already remarked in the Trout, unite into a single trunk, which then expands into an oblong receptacle that can scarcely be called a Bladder, and terminates in a conical canal opening at the orifice of the sexual organs behind the anus. On the contrary, I find a very considerable true urinary Bladder in the Burbot, (Tab. IX. fig. XIX. m.) which also, according to CUVIER, exists in the *Lophius piscatorius*, *Cyclopterus lumpus*, and some other Cartilaginous

Fishes.\* The Urinary Bladder is wanting in Rays and Sharks, though, according to HOME,† the Ureters open into a dilatation which forms a heart-shaped projection behind the anus, and which, as both semen and ova are there evacuated, is to be considered in the male as a Penis, in the female as a Clitoris. (Tab. X. fig. II. 1.) In the Lampreys, also, I find a similar conical projection corresponding to the openings of the sexual and urinary passages. There are in this Class no traces of Renal Capsules, nor of the perfect internal organization of the Kidnies themselves, which we find in Man, for instance.

## SECTION II. *Of the Urinary Organs in the Amphibia.*

§. 668. In this Class the mass of the Kidnies is more evidently divided into two portions, and their size, though much diminished as compared with Fishes, still very considerable: thus, in the Salamander, they extend through nearly one half, and in the Frog nearly one third, of the length of the cavity of the trunk. According to the different Orders, there are many varieties in their form and position. In the Salamander, they agree very closely with those of Fishes, are elongated, very narrow, extend low

\* A satisfactory idea of the causes on which depends the absence or presence of the Urinary Bladder in Fishes, can only be expected from a more perfect acquaintance with the external organs accessory to the development of the Fœtus in this Class.

† See his *Essay on the Generation of Sharks* in the *Philosophic Transact.* 1810. p. 205.

into the Pelvis, and are thickest at their inferior extremities. (Tab. XIII. fig. III. i.) The shape of the organs described as Kidnies is the same in the Proteus.\* In the Frog, they are placed somewhat higher; are shorter and broader, but still very closely approximated. In the Mud-Tortoise, they are rather oval, and have lobes, which appear upon their surface nearly like cerebral convolutions. In Serpents, particularly the Coluber *natrix* and Spotted Viper, I find them elongated, consisting very evidently of individual sections arranged in a series, tolerably broad above, and extending higher on the right than on the left side. In Lizards, they are nearly the same as in Frogs; though in a young Crocodile, about 18 inches long, I find them divided into lobes similar to, though less distinct than, those of Serpents.† (Tab. XII. fig. XIX. v.)

§. 669. The Ureters, which in Frogs, Salamanders, and Lizards, are short, in Serpents, on the contrary, of considerable length, arise here, as in the preceding Class, by minute radicles from the substance of the Kidney, which unite into one trunk, and open into the Cloaca, in Frogs in connection with the seminal vessels. In several Amphibia, however, the Bladder is very remarkable, which in Frogs is but intermediately connected with the Ureters, arising from the front part of the Cloaca, whilst the Ureters open into it posteriorly. There are Bladders of this kind in the two first Orders of this Class, in Frogs, Salamanders, and Tortoises, and of very great extent as compared to the size of the animals. In the Salamander, for instance, the two portions of the Bladder, when distended with air,

\* SCHREIBERS in the *Philosoph. Transact.* 1801, p. 253.

† CUVIER (*Comp. Anat.* vol. iv. p. 636.) thinks that he has observed, that the lobes of the Kidnies are more distinct in old than in young Crocodiles.

equal two-thirds of the size of the trunk: TOWNSON\* observed that in the Tree-Frog the contents of this Bladder equalled one-fourth of the weight of the animal; and quotes PERRAULT, who found it containing more than 12 pints of limpid fluid in a large Land-Tortoise. Its shape is not always the same; but commonly, as in Frogs, the Salamander (Tab. XIII. fig. III. m.), and several Tortoises, it is provided with two lateral cornua rounded at the angles, and which appear to form a repetition of the vesicular dilatation of the Oviduct observed at the same point in Frogs more particularly. Among the remaining Orders, according to CUVIER, the Iguanas, Monitors, Chameleons, Flying Lizards, &c.; and also, according to EMMERT and HOCHSTETTER,† the common Lizard (*L. agilis*) and Slow-worm, though in a less degree, are provided with a similar organ; whilst, on the contrary, it is apparently wanting in the remaining species, and particularly in Serpents.‡

§. 670. I have drawn very interesting conclusions as to the true nature of this organ from the observation of the progress of the development of Frogs and Salamanders, of which I will here mention the most essential only. If we examine the Ovum of the Salamander (*Lacerta salamandra*), we find the foetus unattached within it, and without any umbilical cord; consequently, the parts which in the higher Classes of Animals we consider as external organs for the

\* *Tracts and Observations in Natural History*, p. 65.

† REIL'S *Archiv.* b. x. s. 114.

‡ In Crocodiles, the Ureters are short, capacious, and with very thick coats, penetrating the upper side of the Cloaca at a considerable distance from each other. In the Chelonia, they terminate in the urethra, and, therefore, communicate indirectly only with the bladder, a circumstance which may, perhaps, afford an additional argument in favour of the idea that the function of that organ in these animals is not as a receptacle of urine, (see §. 671.) (CUVIER, *Comp. Anat.* v. 233)—*Translator.*

development of the foetus, must here be included within the embryo itself at a very early period. The Vesicula Umbilicalis is therefore inclosed within the abdomen, as is, also, the Allantois, which, however, appears merely as a urinary Bladder, not being perceptible externally to the embryo; whilst, on the contrary, in the foetus of Lizards and Birds it is extruded with the character of branchiæ, but subsequently fades away, leaving behind a kind of Urachus, which occasionally appears as a small urinary Bladder. We have thus an explanation of the considerable size of this organ; of its purely membranous, or at least very slightly muscular, structure; as well as of the peculiar course of its Veins, which, as I have found by injection in the Salamander, open into the Umbilical Vein, which here remains pervious through life, whilst in Man it forms the round ligament of the Liver. In the Mud-Tortoise, they communicate in the same manner with the two Veins which correspond to the single Umbilical Vein of Man.

§. 671. The function of this part long remained as obscure as its true character, inasmuch as it was considered exclusively as a receptacle for urine, and even poisonous properties ascribed to the fluid which Frogs and Toads eject when pursued. That excellent observer, TOWNSON, was the first who diffused more correct views on the matter, as we have already noticed. He found the fluid invariably quite limpid, even in Toads perfectly tasteless; and remarked how extraordinarily copious must be the secretion from the Kidnies, if these great receptacles were to be viewed merely as urinary Bladders. Hence he farther concluded, that they here form receptacles for the fluids so abundantly absorbed by the skin, and only felt doubtful as to the mode in which the absorbed matter was conveyed to them; an office in which the Veins, the absorbing powers

of which have been rendered so very probable by many modern experiments, may be supposed to perform an important part. The fluid is ejected only in order that the animal may be less burthened in its flight: and hence TOWNSON observed, that it no longer happened when the animal was sufficiently domesticated, and ceased to be alarmed when touched. The observation made by him on the *Testudo orbicularis* is particularly remarkable, from which it would appear that these animals possess the power of taking up water through the anus; inasmuch as he satisfied himself that when the Tortoise was placed in water coloured with Litmus, the fluid subsequently ejected from the bladder had the same qualities.

These phenomena are the more deserving of notice from the very perfect manner in which they agree with what has been said of the repetition of the respiratory function in the urinary secretion: for, as in animals which breathe water, we find air separated from it, and collected in a bladder, so here, in animals that breathe air, water is deposited in another bladder, which water may very possibly contribute to respiration here in the same manner as the air contained in the swim-bladder of Fishes; particularly as the bladder is here to be considered as an allantois, which we know to be truly branchial in the embryo of Lizards and Birds, and as it is established that many Amphibia introduce water into these cavities in the same manner that inferior animals convey it into their branchial cavities. More than this, the excellent experiments of SCHREIBERS\* are enough to prove that the fluid contained in these cavities is in no respect urinary, *i. e.* secreted from the kidneys; by which he has shewn that the urine in these animals is not secreted as a fluid, but in the form of a white friable

\* GILBERT'S *Annalen der Physik*, b. xliii. s. 83.

concretion, which, according to the analysis of SCHOLZ, consists of Uric Acid, 94; Muriate of Ammonia, 2; and Phosphate of Lime, 3.33.

Lastly, true renal capsules have not yet been detected with any certainty in this Class: the organs described as such in Frogs by some anatomists we shall consider in connection with the sexual organs.†

### SECTION III. *Of the Urinary Organs in Birds.*

§. 672. On opening the cavity of the trunk in a Bird, and examining its posterior surface, we find in its upper half on each side, a smooth, spongy, bright red mass, sunk between the projecting bodies of the vertebræ and the ribs, and which we have before learned to consider as lungs: in the lower half, on the contrary, we find the

† Some more recent observations made by Dr. DAVY are inconsistent with the universality at least of the character here assigned to the bladder of the Batrachia, as well as with the supposed qualities of its contents. He states that in the Bull-Frog (*R. tigrina*) and Brown Toad (*B. fuscus*) the ureters open into the rectum upon soft projecting papillæ. The orifice of the bladder upon the anterior surface of the rectum is large, and so situated as to be well adapted for receiving the urine conveyed by the ureters, the escape of which is prevented by the action of the sphincter of the anus. The fluid contained in the bladder in both these animals, Dr. DAVY found to be strictly urinary, *i. e.* containing urea, but in variable proportion; and sometimes, it would seem, so much diluted, that it is perhaps not unreasonable to suppose that a part only of the contents were derived immediately from the kidneys, and the remainder (by which the renal secretion is diluted) from the skin, as suggested by TOWNSON. (*Phil. Trans.* 1821, p. i. 95.)—Translator.

depressions between the bodies of the sacral vertebræ and the rib-like processes of the lateral bony parietes of the pelvis occupied by other smooth and darker coloured masses, which are the kidneys. (Tab. XV. fig. XII. w.) Hence, consequently, even in their position, those organs offer a repetition of the type of the lungs, and by that means indicate the existence of a relation of their function to the sexual actions; similar to that subsisting between motion and the respiratory function. The bulk of the organs is still in this Class proportionally very great, as proved even by the consideration of their extent, but still more so by a reference to their comparative weight; a point on which experiments instituted by TIEDEMANN\* prove that it is very great in Wading and Aquatic Birds, (which are also distinguished by the sizè of the liver,) amounting in the Lapwing to  $\frac{1}{63}$ , in the White Diver to  $\frac{1}{33}$ , of the weight of the body; and, on the contrary, in the Falcon, only to  $\frac{1}{90}$ . The following may be viewed as the causes of this very considerable size; 1st, the predominance of the negative side of the reproductive powers in these animals generally, as instanced in respiration, as well as the secretions which form repetitions of it; 2d, the moderate size of the lungs themselves, as compared to the extent of the respiratory passages; 3d, the diminished perspiration from the skin, which, even in Man, is attended by an increased secretion from the kidneys; 4th, the limited excretion of water by the respiratory passages, for even in the greatest cold Birds do not expire any aqueous vapour.

§. 673. The structure of the kidneys of Birds, as in the preceding Classes, is still very simple; and the Ureters here, also, arise by separate radicles from the individual lobes into which the kidneys are divided, partly by the dis-

\* TIEDEMANN has particularly called attention to the two latter circumstances.

tribution of their vessels, and partly by the disposition of the bones on which they rest, and by which we find them divided more particularly into a smaller upper and larger lower portion. They are surrounded by cellular structure, and, like the lungs, are covered on their anterior surface by the peritoneum. The ureters descend at the posterior part of the pelvis, are evidently muscular, and enter the cloaca at the edge of the rectum. The urine of Birds is very similar to that of Lizards, (§. 671.) and in the same manner contains so much Uric Acid, Carbonate and Phosphate of Lime, that immediately after its secretion it assumes a solid form, and usually covers the excretion from the intestinal canal in the form of a white coating, which, when exposed to the air, speedily hardens into a friable powder. According to CUVIER, the Ostrich and Cassowary alone have the power of evacuating the two excretions separately; but in other species, particularly the Gallinæ, when there is an egg in the oviduct, I have frequently found the termination of the rectum much distended with fœces, though none had entered the cloaca, which contained only some urinary concretions.

§. 674. There is ordinarily no trace of a urinary bladder in Birds, the allantois, which in the Chick is connected with the cloaca by means of the urachus, being here in general perfectly obliterated. In addition to the kidneys, we first meet the Renal Capsule in a sufficiently distinct form in Birds, though, in proportion to the kidneys, much smaller than in Man for instance; (in the same manner that the spleen was small in proportion, or even wanting, in the large-livered Mollusca, and also the renal capsules in relation to the large kidneys of Fishes and Amphibia.) These organs are placed between the superior lobes of the two kidneys, close to the testes or ovaria; are for the most part somewhat lobed, oval, and of a yellowish-red colour.

MECKEL\* observed two substances in them in the Cassowary. According to TIEDEMANN, they are largest at breeding time;† whilst, according to TANNENBERG, a blind process of the seminal duct is lost in their substance.

#### SECTION IV. *Of the Urinary Organs in Mammalia.*

§. 675. Here again we may consider the human type as the general standard for the other species of this Class; and, consequently, ordinarily find a more complicated internal composition, which we are therefore enabled to subdivide into several parts; Papillæ, which secrete the urine; Infundibula, which pour it into a common pelvis; whence it is conducted by the Ureters into the bladder, and thence evacuated by the sexual passages. There is by no means, however, any deficiency of approximations to the preceding formations. The kidneys themselves are distinguished in the Cetacea by their peculiar structure, which most distinctly presents the composition of the organ

\* In his *Abhandlungen aus der mensch. und Vergl. Anatomie.*

† This is not the place for discussing the function and character of these organs: I cannot help remarking, however, that much of the obscurity connected with them disappears, if we allow that a peculiar secretion, or any similar definite function, is not indispensably requisite; and that it is perfectly conceivable that the mere existence of certain organs may have important effects in any given system of organs. Strictly speaking, every part of the body is a secreting organ, inasmuch as it selects and appropriates to itself certain portions of the general mass of fluids. Why, then, may we not suppose that it is the office of the renal capsules to separate superfluous materials from the Urinary and Sexual Systems merely by employing them in their own nutrition?

by little distinct lobes, as in the preceding Classes, and appear rather as common conglomerate glands than as proper compact secretory organs. \* They consist of upwards of two hundred distinct conical-shaped masses, with the broadest end turned outwards, so that HUNTER\* compares the external surface of the whole kidney to a pavement, each presenting a tubular structure internally, and terminating in a papilla surrounded by a membranous infundibulum, the united points of which open into the ureter at the narrow extremity of the kidney. The structure of the kidneys is likewise commonly precisely similar in the Amphibious Mammalia, (see the kidney of the Seal, Tab. XIX. fig. XXII.) and also in the Otter and Bear, although the number of distinct lobes gradually diminishes in them, whilst the infundibula no longer terminate directly in the ureter, but are previously united in a pelvis. The division of the kidney into separate lobes of this kind is much less perfect in most other Mammalia, being chiefly confined to the first periods of existence, in Man for instance; the number of these divisions, which is indicated internally by the number of papillæ, being at last so much reduced that in animals with claws we find but a single papilla remaining; whence, also, the kidney appears smooth externally, and of a more globular form. As to the position of the kidneys, it is to be remarked that in large as well as small quadrupeds the right is invariably placed somewhat higher than the left.†

\* *Philos. Transact.* 1787, p. 413.

† In the Cat Genus the depressions left on the surface of the kidney by its imperfect division into lobes are occupied by from seven to nine principal venous trunks, which increase in size as they converge towards the sinus of the organ in order to empty themselves into the renal vein. They resemble the sinuses of the brain; their canal, when laid open, presenting at the part next the kidney an angle perforated by the orifices of veins coming from the organ. (CUVIER, *Comp. Anat.* v. 229.)—Translator.

§. 676. The remaining part of the course of the ureter is the same in Mammalia as in Man, terminating in a urinary bladder in all the species of this Class except the Ornithorhynchi, which offer a repetition of the structure of the Amphibia, in so far as the Ureters open directly into the common urinary and genital canal, which leads to the Cloaca, and, consequently, are only indirectly connected with the Bladder; an organization which appears to prove that in these animals, as in Amphibia and Birds, the Allantois (the remains of the Urachus of which form the Bladder in Mammalia) arises from the expansion of the Rectum, the Cloaca: whilst, on the contrary, in other quadrupeds it is connected solely with the genital passages. The shape of the Bladder in Mammalia presents no very essential varieties; but its elongated form in several Rodentia, and in young animals, (*e. g.* the Calf,) is worthy of notice, as a proof of the origin of this organ from a portion of the Urachus. It is in general found small, particularly in proportion to the sexual organs (Vesiculæ Seminales, Testes, Ovaria), of which we have instances in the Hedgehog, as well as several Rodentia. (Tab. XX. fig. VI. d.) The assertion, that the Bladder is always larger in herbivorous than in Carnivorous Mammalia has been already contradicted by CUVIER, who observes, that its comparative size is regulated not so much by the kind of food of the animal as by the greater or less degree of muscularity of the organ, the muscular structure in this as in the other parts of the body generally predominating in the Carnivora.

§. 677. The Renal Capsules of Mammalia so far agree with the Kidnies, that, according to CUVIER, they are, in the amphibious Mammalia, divided in the same manner into several little lobes; whilst in the terrestrial species their shape, either bean-like or more triangular, resembles that which the kidnies here most usually present. It is

remarkable, too, that in size there is somewhat of the same proportion as that existing between the Spleen and Liver, viz. that the Capsules are found smaller in proportion as the Kidnies are more perfectly developed: thus, in the Rodentia, they are very large; according to CUVIER, as 1 to 8—5, in the Guinea-Pig; whilst, on the contrary, they are singularly small in the amphibious Mammalia, as 1 to 150 in the Seal, according to CUVIER. He found cavities in them in the Elephant only, though I have sometimes met such a structure in young Pigs and Dogs. The changes which take place in the Renal Capsules in Man occur also in other Mammalia, they being very large in the fœtus, smaller in the adult, and smallest in old age.

C. *Of Secretions in or near the Respiratory Organs themselves.*

§. 678. As in other secretory organs, we remarked that the most important and most essential secretions were frequently accompanied by others less so; of which we have an instance in the secretion of mucus in the urinary bladder, so also do we observe something similar in the respiratory passages; of which kind are the perspiration, as it is called, of aqueous fluid from the skin and lungs, as well the secretion of mucus in the true respiratory passages both of Gills and Lungs. The parts, however, which produce such accessory secretions are so completely integral portions of the greater organs that a precise consideration of them forms an object of Physiology rather than Ana-

tomy, and consequently is unsuited to the present occasion, though it might be in several respects productive of interesting results, were we only, for instance, to compare the expired air loaded with water in Mammalia with that of Birds (§. 672.) which scarcely contains any. Consequently we can here speak only of some glandular organs; which, though not the seat of peculiar secretions any more than the Renal Capsules, yet by their mere growth or decrease (see Remark on §. 674.) may, and even must, have a very important relation to the respiratory function, inasmuch as in different animals, and even in different periods of life, they undergo important changes corresponding to those in the state of the respiratory function. It will be easily seen that the Thymus and Thyroid are here alluded to.

D. *Of the Thymus and Thyroid in the Superior  
Classes of Animals.*

§. 679. When we reflect that the developement of these two organs in Man is chiefly confined to the earlier periods of life, nay, that the Thymus appears to vanish with the increase of age, it must at first view seem contradictory that they should be altogether wanting in the lower Classes of Animals; that they should be found in some only of the Amphibia and Birds; and that they are distinguishable with perfect precision in Mammalia alone. This contradiction, however, in part disappears, if we consider that in the inferior Classes the limited extent of Respiration dependent on the less perfect organization of the

respiratory cavities, or rather on their incomplete distinction from the other parts of the body, may be more easily compensated by the farther advanced development and activity of other organs, particularly the Liver\* and Kidneys; an idea which will enable us to explain the formation of peculiar organs for the purpose of supplying the imperfection of respiration during the early periods of the existence of Mammalia. Nay, even the imperfection of the respiration of the foetus of Mammalia, compared for instance with the embryo of Birds, may render the existence of such organs necessary. In Fishes, consequently, there are no traces either of Thymus or Thyroid; and though it has been lately attempted to draw a comparison (of much interest, it is true) between the Swim-bladder and Thymus, it by no means coincides with it, that a close consideration of the function of the former appears to prove that it performs a part only of the respiratory function; that its activity is undiminished when the animal attains its full development; and that there is not any evidence of any such antagonistic relation between it and the Gills as that found between the Lungs and Thymus.

§. 680. As to the Class Amphibia, I find in Frog's (*Rana esculenta*) two reddish glands (Tab. XIII. fig. VI. d.) on each side of the Os Hyoides, and on the inner side of the laryngeal pouch, which appear to form a Thyroid, and which, by their truly glandular texture and colour, are sufficiently distinguished from the little fatty bodies that form towards winter, and disappear in spring, and which have been described by TREVIRANUS† as a Thyroid or

\* It is in this respect important to observe, how in the Amphibia, and partly also in Birds, the liver extending considerably upwards in front of the Lungs, and inclosing the Heart after the manner of a Thymus, appears to correspond to the position of that organ.

\* *Vermischte Schriften Anatom. und Physiol. Inhalts.* b. i. s. 96. On the

Thymus. Those little bodies can only be so far compared to a Thyroid or Thymus as they are the seat of an excretion of phlogistic matter, which their formation may perhaps tend to consume; but in other respects they present more analogy to the collections of fat common in hibernating animals. I find the Thymus very much developed in the Mud-Tortoise (*T. lutaria*), forming a reddish cordiform body, about half an inch broad, and occupying the space between the two Axillary Arteries arising from the ascending Aorta. In Serpents, an oblong glandular body, lying above the heart, appears to deserve the name of Thyroid or Thymus; and I should probably be justified in considering of the same nature two half fatty, half glandular bodies, which I remarked at each side of the neck in a young Crocodile. (Tab. XII. fig. XIX. e.)

§. 681. In Birds, also, an ambiguous organ of this kind has been discovered, viz. two reddish, oval, minutely granular Glands placed at each side of the Trachea, close to the inferior larynx, consequently at the entrance of the cavity of the Thorax, and to which no excretory duct has yet been detected. MECKEL,† who views it as the Thymus, states that it is chiefly found in young Birds, and in the adults of some diving Birds only. TIEDEMANN,‡ however,

same occasion M. TREVIRANUS asserts that the Ganglia I have described on the Sympathetic of Frogs are merely collections of fat about the Nerve; but a more accurate examination of my delineation of them might have satisfied him that I spoke not of those Ganglia on the front part of the neck, but of the superior large ones placed on the Intervertebral Nerves of the Brain and Spinal Marrow; (see p. 180 of my *Essay on the Nervous System*.) of which WEBER, also, (*Anal. Comparata Nervi Sympathici*, p. 41,) has demonstrated that they belong chiefly to the Sympathetic Nerve.

† In his *Abhandl. a. d. Mensch. u. Vergl. Anat. u. Phys.* Halle, 1806; and the 4th volume of his *Transl. of CUVIER'S Comp. Anat.*

‡ *Zoologie*, b. ii. s. 688. I can so far confirm his suspicion as to the existence of this organ in the Coot, that I have myself there found a glandu-

asserts, on the contrary, that he has found the same organ in other species, (Falcons, Herons, Bustards, Doves, Magpie, Starlings;) whence, and also from its situation in the vicinity of the vocal organs (the inferior larynx), he agrees with BALLANTI in considering it as the Thyroid. It is by no means impossible that here, as well as in Serpents or Crocodiles, a single mass may unite in itself the character of both organs.

§. 682. As already mentioned, it is in Mammalia that we are most precisely able to discover the existence of these two organs. First, of the Thymus: it appears to be almost exclusively peculiar to the foetus in this Class; and in adults, to exist in the natural state, according to the excellent researches of MECKEL,\* in those instances only in which respiration is occasionally interrupted for a shorter or longer period; consequently in those species which dive, burrow, or hibernate; of this kind are the hibernating and burrowing Rodentia, the Weasel, Mole, Hedgehog, Bears, Otters, and probably all the amphibious Mammalia, being distinguished by the permanent, or at least long continued, existence of a Thymus, occasionally of very considerable size, sometimes ascending high in the neck, or divided into several lobes. As to the Thyroid, it appears to be common to the whole Class, inasmuch as CUVIER has found it even in the Cetacea, where its existence was denied by HUNTER. It is remarkable, however, that in the Porpoise as well as the Seal it resembles the lateral glands near the inferior larynx of Birds, in being formed of two perfectly distinct halves,—a separation which exists also in many other Mammalia, *e. g.* the Elephant, Solipeda, Dogs, Cats, Bats, and several Rodentia, at least in the adult

lar organ in the same situation, though smaller, of a more globular form, and a more yellow colour.

\* *Loc. citat.*

animal; for in the foetus, or young animal, the organ is either larger, or forms but a single mass. The two halves, however, are connected, "even in the adult, by one or more transverse portions, in Apes, Bears, several Rodentia, and Man himself; on which point we may remark, that in the latter this organ is proportionally of greater extent than in other Mammalia, which serves as a forcible argument for the opinion of those who think it probable that its function is intimately connected with the formation of the voice.

§. 683. A retrospect of the history of all the secretory organs just considered will readily convince us that in Man we can here no longer discover the same peculiarly perfect developement as in most of the organs before examined. But though in this respect he does not possess the same pre-eminence, yet it merits a particular consideration, that it is precisely in those organs, which, as purely vegetative, are completely opposed to the influence of the Nervous System, that Man is scarcely essentially distinguished from other Animals.

CHAPTER III. *Of the Vascular System.*

§. 684. In what has preceded we have traced through the series of Animals the developement of those organs, by means of which either extraneous materials are taken into the body in order to be assimilated to it, or internal organic materials are either absolutely excreted, or secreted in subservience to particular purposes. In the same manner that the Organs of Sense and of Motion required to be united by the Nervous System, so here the existence of these two functions usually renders necessary an intermediate member,—the Vascular System. Consequently, its divisions or subordinate systems must present themselves in more various forms in proportion to the multiplication of their points of contact with other organs; in other words, in proportion to the increase in the complication and perfection of the animal organization at large. Whilst, for instance, we find in Man a peculiar system (Lymphatic) for the absorption of extraneous and of internal organic materials, as well as a system (Sanguineous) for the uniform distribution of fluids to all parts of the body, which is again subdivided into the Arterial and Venous Systems, and also into a greater system circulating fluids through the body in general, and a lesser system for the circulation of the same fluids through the respiratory organs; in the inferior Classes, on the contrary, these systems are much less variously developed, and more particularly the Animals without Brain or Spinal Marrow differ from the superior

Classes scarcely less in their Vascular System and fluids than in their Nervous System.

A. *Vascular System in Animals without Spinal Marrow and Brain.*

§. 685. The most important peculiarities characterizing the Vascular System of the three inferior Classes of Animals consist, *1st*, as regards its formation, the absorbing vessels not being apparently distinct from those which distribute the fluids; nay, the Respiratory not being distinct from the General Circulation, or the System (Arterial) which distributes the fluids not distinct from the System (Venous) by which they are brought back again: *2d*, as regards the mass of fluids, which, being ordinarily merely lymphatic, and flowing in vessels, or even stagnating in cavities of the body, keeps up the constant interchange of organic elements. We might therefore correctly institute a comparison between the system which in the superior Animals may be called the lowest, viz. the Lymphatic, (so similar in many respects to the system of sap-vessels in Plants,) and that which forms the sole system of the inferior gradations of the Animal Kingdom; nearly in the same manner that a similar comparison was instituted with the Ganglionic System as regards the Nerves. For, as the Ganglionic System has more importance in these than in the higher Classes of Animals, so also is this form of the Lymphatic System more developed in the one than in the other case. It is not merely that the single kind of vessels found in the lowest organizations constitutes at once the agent in absorption

and excretion, (whilst in the Lymphatics of the superior Animals there is ordinarily only a retrograde motion of fluids to the central points,) but also the increase in the perfection of the internal structure of such organizations is accompanied by a division of those vessels into subordinate systems for distributing and for returning the fluids, as well as for exposing them to the influence of Respiration, and by the formation of central organs (hearts); the whole thus approximating more and more closely to the blood-vessel system of the superior Animals, and ultimately differing from it in this respect alone,—that it includes absorption, and ordinarily conveys colourless lymphatic fluids only. Hence, also, we have here again the same state of circumstances as in the Nervous System; where we found that the chain of Ganglia of the inferior Animals presented the relations both of Brain and Spinal Marrow, differing in this respect only,—that it was placed on the abdominal surface, and that there was not any Sympathetic Nerve.

#### SECTION I. *Vascular System in Zoophytes.*

§. 686. Comparative Anatomy has hitherto been as little able to trace the existence of a Vascular as of a Nervous System in the lowest species belonging to this Class. In Infusaria, Polypes, as well as in the inhabitants of Corals and Sponges, the uniform gelatinous (primitive animal) mass alone suffices to keep up the constant change of composition, by its universal impregnation with fluids, produced by mere elective attraction and repulsion depen-

dent on organic laws.\* In the Medusæ and Echinodermata, on the contrary, we discover definite canals for the passage of fluids in the interior parts of the body; the vessels of the Medusæ deserving a particular notice, inasmuch as we shall find their formation subsequently repeated in the Ovum of the superior Animals. From the gastric sac, as from a Receptaculum Chyli or Heart, radiated and considerably ramified vessels (Tab. I. fig. IX. A. c. d.) proceed towards the margin of the body, there to empty themselves into a circular vessel (d.): of which we may observe, that it might be considered as an extremely simple rudiment of the great circulation of superior Animals, in case we view the radiating as chyloferous vessels. In the Echinodermata, also, there are several traces of peculiar vessels for the diffusion of fluids. CUVIER has described vessels, in the Holothuriæ for instance, which are even distinguishable into those that distribute and those that return the fluids.† ‡

\* The part formerly described as a heart in the Wheel-animal is, in fact, the stomach; but if a more complicated structure actually exists in this little animal, (for it is said to have eyes,) we may ask whether it should not be considered as a microscopic species of Mollusca?

† *Comp. Anat.* vol. i. p. 255. In a more recent work (*Le Règne Animal* t. iv. p. 6,) he says of the vessels of the Echinodermata generally, "Une sorte de système vasculaire, qui à la vérité ne s'étend pas à tout le corps, entretient une communication avec diverses parties de l'intestine et avec les organes de la respiration."

‡ In the *Holothuria tubulosa*, where there are three folds of intestine, the middle fold has along one of its sides a vessel, which becomes narrow at each extremity, receiving a great number of short branches from a vessel to be subsequently described, and giving off others from the opposite side, which subdivide considerably, and then unite into a certain number of vessels, which by their junction form another trunk. The net-work produced by this subdivision of the branches of the first vessel before they unite to form the second, is intimately intermixed with the ramifications of an arborescent intestine, opening into the cloaca, and appearing to form a respiratory organ. The first vessel, therefore, is a Pulmonary Artery, receiving the blood from the

SECTION II. *Vascular System in Mollusca.*

## A. ACEPHALA.

§. 687. The very distinct developement of the respiratory organs in this whole Class, and even in the first Order, is accompanied by a corresponding extent of developement of the circulation, which is ordinarily already carried on according to the same laws as in the superior Animals, and even in Man himself. Among the Acephala the Vascular System appears to be least perfectly evolved in those instances in which there is a branchial cavity in part be-

body in order to transmit it to the respiratory organ. The second great trunk is divided into four large branches united by a transverse branch. Two of these branches receive the blood from the respiratory organ, and run parallel to the first trunk, the intermediate space being occupied by the ramification, of the vessels connecting them. These two are a kind of Pulmonary Veins, conveying the aerated blood into the other two branches by means of the transverse canal, and by their extremities, where there is a visible communication. The other two branches, consequently, are aortic, proceeding along the first fold of intestine, and furnishing it with blood by means of numerous little arteries, which penetrate its substance directly. The superior branch having reached a certain height, bifurcates, in order to form a circle around the Oesophagus, which gives off five branches following the direction of the fleshy mass of the mouth, and distributed longitudinally upon the general covering of the body. The blood is returned from this covering by veins situated within the mesentery, and also by a trunk, which appears to form a kind of Vena Cava. The latter is formed by four principal branches connected by a transverse canal: two of those branches, situated along the first fold of intestine, receive its blood, whilst the other two transmit it to the pulmonary vessel by means of the little branches mentioned at the commencement of this description. (CUVIER, *Comp. Anat.* iv. 415.)—*Translator.*

longing to the intestinal canal, *e. g.* in the Ascidiæ; at least in a large species, very similar to the *A. microcosmus*, I observed merely a membranous cavity at the fundus of the muscular sac, (Tab. II. fig. I. o.) which appeared calculated for receiving the fluids of the body by means of some branches from the liver, and to distribute them to other parts by means of a canal running on the dorsal surface. (q.) In the remaining Acephala, possessing branchial laminae, the veins of the body convey the blood into the branchial vessels, whence it is again returned to the heart by means of branchial veins, and thence distributed through the body by one or more arterial trunks. The form and position of the heart, however, vary materially in the different species.

§. 688. In the *Teredo* the Heart, according to HOME,\* is situated on the dorsal side,† and presents two Ventricles, (Tab. II. fig. XV. f. f.) which receive the branchial blood by means of two auricles, (*e. e.*) and evacuate themselves into a dilatation at the commencement of the Aorta. (*g.*) The Brachiopoda, *e. g.* *Lingula*, and also the Genera *Arca* and *Pinna*, have, according to CUVIER, a separate aortal heart for the branchial blood of each half of the body. In the Oyster the heart is placed between the liver and the muscle that closes the shell, and extends from the back forwards towards the gills. In the Acephala, which have two similar (symmetrical) shells, *e. g.* the River Muscle, the heart is situated on the dorsal side below the hinge (*cardo*), within a thin sac, through which it may be clearly seen pulsating in the living animal when taken out of the shell. (Tab. II.

\* *Philosoph. Transact.* 1806, p. 184.

† This position of the Heart on the dorsal surface is altogether peculiar to Animals without Brain and Spinal Marrow; and, together with the situation of the principal nervous cord on the abdominal surface, indicates the preponderance of the vegetative structures.

fig. XI. c.) It is there of an orange-yellow colour, oblong, (fig. XIII. c.) terminating anteriorly and posteriorly in arterial trunks, and possessing powerful muscular fibres. The two auricles, which receive the blood from the gills, are placed on each side of the heart, and composed of very thin membrane. (Fig. XIII. d. d.) I have already (§. 437.) mentioned the remarkable fact in the organization of these Bivalves, that the R<sup>e</sup>ctum passes through the centre of the Heart. It is worthy of notice, also, that the Tere-  
dines, according to HOME, possess red blood, whilst the fluids contained in the vessels of other Mollusca are clear and serous.

#### B. GASTEROPODA.

§. 689. Here, also, there is a double circulation through the body and through the lungs, though the Heart is invariably single: its form and position, however, are different, the latter being regulated by the situation of the respiratory organ. \* We may describe as instances the disposition of the Vascular System in some Species. In the *Helix pomatia*, where the Heart and its principal vessels have been pretty accurately described and depicted by SWAMMERDAM, and which is one among the many Gasteropoda of which the Anatomy has subsequently been so well investigated by CUVIER, in the *Annales du Muséum*, the Heart is placed within a delicate Pericardium to the left side, and behind the pulmonary cavity, between the latter and the Liver.\* (Tab. III. fig. II. m.) The thin blueish milky blood arrives by means of a capacious pulmonary Vein and a

\* A position, consequently, which is precisely the same as that found in the superior Animals.

roundish Auricle (fig. III. i. k.) at the muscular Ventricle (l.), which is rather triangular and provided with Valves : and is thence distributed to the rest of the body by means of an Aorta somewhat dilated at its origin. The blood is brought back by two Venæ Cavæ, a larger one following the concavity (fig. III. f. fig. I. k.), and a smaller one (fig. III. g.) running along the convexity of the convolutions of the body : the two are connected by a canal of communication (h.), from which the Pulmonary Arteries arise, ramifying minutely on the inner surface of the lungs, and ultimately terminating in the Pulmonary Veins.

§. 690. When the Respiration is performed by Gills, the Heart is usually situated immediately behind them, as, for instance, in the Aplysiæ; where, according to CUVIER, the Vascular System in general presents many peculiarities. There are here at the sides of the body two strong and muscular venous (Cavæ) trunks, that open into the cavity of the abdomen by peculiar orifices, which are, probably, absorbing apertures, supplying the deficiency of a distinct Absorbent System. The two trunks unite to form the Branchial Artery, from the extremities of which the Blood is conveyed, by a Branchial Vein, first into the Auricle (Tab. III. fig. VII. x.), then into the Ventricle (y.), and is thence again distributed by a principal trunk dividing into the Hepatic Artery (b.\*), the Gastric Artery (b.), and the Aorta (z.) At the root of the latter is placed a peculiar double Pecten, which is filled by injection from the artery, and again returns its blood to it. In the Viviparous Snail, the Heart is situated in the same manner between the Gills and Liver. (Fig. X. k.)

## C. CEPHALOPODA.

§. 691. The Organs of Circulation in the Sepiæ differ from those of all other Mollusca, in presenting a greater number of central cells or Hearts than any other animal, viz. three: of these, one (the Aortal Heart) corresponds to the single or double heart of other Mollusca, whilst the other two (Pulmonary) serve to propel the general mass of blood into the branchial vessels. In the Cuttle-fish, for instance, (and with slight variations in the other species,) the principal trunk of the Veins of the body descends from the head and divides into two branches distributed to the Gills, presenting in this situation an organization which appears to correspond to that of the Venæ Cavæ in the Aplysiæ; the Veins being provided with numerous glandular appendages which communicate with those vessels, and probably absorb fluids from the cavity of the abdomen. (Tab. IV. fig. XVII. d. d.) The venous trunk on each side terminates by means of an orifice furnished with valves in a Branchial Heart, (b. b.) which propels the merely serous blood through a Branchial Artery into the Gills, whence it passes by the Branchial Vein (c. f.) on each side, (which presents a slight dilatation,) into the Aortal Heart, through an opening furnished with Valves. The Aortal Heart itself is powerfully muscular, is placed transversely in the body (a.), and sends upwards a principal arterial trunk (g.), which has a dilatation at its root, is distributed to the different parts of the body (fig. II. s. t.), and in the Head, forms a Circle, like the Nervous System, around the Œsophagus.

SECTION III. *Vascular System in the Articulata.*

## A. VERMES.

§. 692. As regards the Vascular System, the Intestinal Worms are circumstanced in the same manner as Zoophytes, viz. there are either no traces of any such, as, for instance, in the Hydatids, or, there are some canals in the interior of the body, as in the Tœniæ, which, however, appear to be rather ramifications of the Intestinal Canal than vessels; nay, the extraordinary absorption by the external surface in all these animals, already noticed (§. 443. 444.), appears to be the consequence rather of immediate impregnation by fluids than of the action of peculiar absorbent vessels. It is otherwise in the extraneous Worms, where there is not only a distinct, though in many respects still very imperfectly understood, Vascular System, but also a red-coloured fluid or Blood. In the Leech, for instance, there are two larger, serpentine, and distinctly pulsating lateral vessels, (Tab. V. fig. VIII. h. X. a.) and a smaller, central dorsal Vessel; of which the former, according to CUVIER, appear to be a venous, and the latter of an arterial nature. There is no trace, however, of distinct central organs; nay, according to THOMAS,† the blood does not appear to move in any regular manner, but sometimes backwards, and sometimes forwards, which, however, I am the less inclined to believe, as I have sufficiently ascertained from the observation of living Earth-

† *Mémoire pour servir à l'Histoire des Sangsues.*

worms, how easy it is to make a mistake, and how frequently the motion of the rings of the body may lead us to imagine that the blood moves sometimes backwards and sometimes forwards in the same vessel, though such is by no means really the case. How minute and numerous the ramifications of the vessels are in the Leech, is proved by the multiplicity of the branches surrounding the nervous Ganglia. (Tab. V. fig. XII.)

§. 693. The Vessels already alluded to in the Earth-worm are more distinct than those of the Leech. In it I find three principal Vessels stretching through the body, a superior one, probably arterial, (Tab. V. fig. IV. a.) and two inferior, of which the largest may be considered as a Vena Cava, whilst the other smaller one, placed below it, and of a more brilliant red colour, appears to be the Branchial Vein, which, probably, receives the blood conveyed to the respiratory vesicles by branches of the Aorta, and intermixes it with the rest of the venous blood at the anterior extremity of the body, where the superior and inferior trunks communicate. The connection between the superior and inferior longitudinal vessels is particularly remarkable, from the circumstance that it is effected by means of circles of vessels around the Oesophagus, (again reminding us of the Nervous Circle around the same part,) the circles each presenting several heart-shaped dilatations, (Tab. V. fig. II. m. m. fig. V.) which, however, rather give them the appearance of Lymphatics contracted at the valves and dilated in the interstices, than actually represent the form of the Heart of superior animals. According to CUVIER, there is a similar, though somewhat more complicated, Vascular System in the *Lumbricus marinus*: according to OKEN,\* however, the blood of the Branchial Veins on each side, placed close to the Vena Cava on the abdominal sur-

\* *Isis*, b. i. h. 4. p. 470.

face, is poured at the anterior part of the body into two Auricles, and thence into two Ventricles, which send off Arteries both upwards and downwards, and then unite to form a central longitudinal vessel closed superiorly and inferiorly.\*

## B. CRUSTACEA.

§. 694. It is particularly in the Branchiopodous Crustacea, *e. g.* the Squillæ, that the central organ of Circulation approaches most closely to the elongated Heart lying

\* In the *Lumbricus marinus*, a large vessel is stretched along the back between the branchiæ on each side, diminishing in size at both extremities. It transmits its contents by its anterior end, and receives 15 lateral vessels on each side, viz. one from each of the branchiæ. These vessels correspond to pulmonary veins, and convey the blood from the branchiæ into the great vessel, which becomes distended by the contraction of those organs. A corresponding number of vessels convey the blood to the branchiæ, though all of them do not arise from the same trunk. The nine first are given off from a large trunk situated upon the intestinal canal, immediately below that already described. The others arise from the posterior part of a vessel parallel to the two former, but situated below the intestinal canal. The two great longitudinal trunks, therefore, send the whole of the blood contained in them to the branchiæ *al.c.c.*, performing the office at once of Venæ Cava and Pulmonary Arteries, for such of their branches as do not proceed to the branchiæ are veins which receive the blood from all parts of the body. These branches of the Venæ Cava expand in a very regular manner on the yellow surface of the intestinal canal, with which their purple colour forms a beautiful contrast. They arise primarily from two vessels arranged at the sides of the intestinal canal, performing the office of Aorta, and communicating at the lower part of the Œsophagus with the great Pulmonary Vein first described: at the point of communication is a swelling which presents more distinct motions of dilatation and contraction than the rest of the system, and which may in some respects be considered as a Heart, though its parietes are not thicker than those of the other vessels. (Cuvier, *Comp. Anat.* iv. 411.)—*Translator. ÷*

on the back of the Mollusca, or to the Aorta stretched along the back of Vermes, the Heart itself being here little else than an Aorta extended along the back, receiving its blood from the Branchial Veins and propelling it into the other parts of the body. It is thence collected into a Vena Cava placed on the abdominal surface, and from it passes again into the Gills, the mode of Circulation, consequently, being here the same as in the Mollusca. In the true Crabs, the Heart is more rounded; in the Cray-fish, it is fringed at the margins, is placed immediately below the dorsal shield, (Tab. VI. fig. IX. fig. IV. a.) being distinctly seen to pulsate when it is removed, and sends off several Arteries both forwards and backwards. (Fig. IV. b. c.) The substance of the Heart is distinctly muscular, though still very soft: the Arteries are delicate and perfectly transparent tubes.

### C. INSECTA.

§. 695. It is in those Species only where the respiratory apparatus differs but little from that of the Orders hitherto considered, that we find a distinct Vascular System capable of keeping up a Circulation, *e. g.* in the Arachnida, which approach in so many particulars to the Crustacea. In Spiders, as well as Scorpions, the investigations of CUYIER, MECKEL, and TREVIRANUS, have shewn that the Aorta-like Heart extended along the back, (and of which the pulsations may be seen by the naked eye in those Spiders which are not covered with hair,) gives off several vessels, of which some are constantly connected with the Branchiæ, and others with the (so called) adipose Bodies, (Tab. VII. fig. VII. a. b.) though the actual mode of Circulation cannot be discovered with any certainty on account of the

extreme delicacy of the vessels. If we may trust to analogy, however, it must agree pretty closely with that of the Crustacea.

§. 696. As to other Insects, though some of the older anatomists have supposed that they have observed vessels and a Circulation in particular instances, all the more recent observations agree in denying their existence, and in the supposition that the fluids of the body permeate the internal organs without being contained in vessels, which perfectly accords with the manner in which the Tracheæ convey air to every point of the body, as well as with the peculiar forms of the secretory organs. (§. 648.) One vessel, however, still remains, and by its evident pulsation, as well as by the absence of all communicating canals, has given rise to the most various suppositions. It is placed along the back, in the same situation where a true Aorta-shaped Heart presents itself in the preceding Orders, and even in the Arachnida; and, consequently, has received the name of the Dorsal Vessel. In all the Insects which have been examined with regard to this point, it presents itself as a thin membranous canal of uniform size, except that it is somewhat contracted at its extremities, and that by its pulsations, (greatest, according to LYONNET, at the lower extremity,) it sometimes appears as though it had alternate points of contraction, and was on that account described by MALPIGHI as a series of Hearts. The very minute ramifications of the Tracheæ which surround this canal on each side deserve notice, (Tab. VII. fig. XIII.) as well as its attachment to the back by peculiar bundles of muscular fibres. The Dorsal Vessel is found in all stages of the development of Insects, though, according to the excellent investigations of MARCEL DE SERRES,\* its diameter is less

\* *Magasin Encyclopedique de MILLIN.* Mai. Juin. Sept. 1814. "Observations sur les Usages du Vaisseau Dorsal."

uniform in the perfect Insect than in the Larva. He states, also, that the Muscles and Tracheæ appear to have more influence over its motion than the Nerves; and moreover, that the organ is so little essential to life, that Caterpillars, for instance, when it is removed, or when its contained fluid is coagulated by Muriatic Acid, continue, nevertheless, to live and breathe: whilst, on the contrary, Spiders and Scorpions die when the Heart is removed. It still remains to be determined whether this organ have any, and what, definite function; or whether it should not rather be considered as a remain of an earlier type of formations, gradually losing its functions in these organisms; an idea which is rendered not improbable by the observations above alluded to. I am but little inclined, however, to agree with the suggestion of M. DE SERRES that it is the secretory organ of the Adipose Body, inasmuch as it is contradictory to suppose that a canal should absorb fluids by its parietes, and then exude them in the same manner, but in a different form; besides, that as the character of those bodies is that of chylous masses, it is more probable that they are secreted by exudation through the parietes of the Intestine.

*Remark.* In my *Essay on the Nervous System*, p. 75, I have alluded to the remarkable circumstance, that the embryo of the superior Animals presents, in the same situation as the Dorsal Vessels of Insects, a similar canal, impervious at the extremities, and containing a fluid in which nervous fibres are subsequently deposited, converting it into the Brain and Spinal Marrow; and on the same occasion noticed, that in this view the Dorsal Vessel, the fluid of which appears to be prevented only by the continued pulsation from becoming solid, (which, according to SERRES, it does when acted upon by Muriatic Acid or Galvanism,) may be considered as a prototype of the central Ner-

vous System. But that the Dorsal Vessel is actually in point of function a Brain and Spinal Marrow is as little to be concluded from these propositions as that when, for instance, we viewed the black spot in the compound Eye of Insects as a prototype of the pupil, (§. 117.) we should therefore necessarily conclude that it actually was a pupil. Nor is it hereby rendered less unferable that the Dorsal Vessel should be developed in the series of Animals so as to form the Heart or Aorta, unless we should be content to range the organization of Insects below that of Worms. (Compare MECKEL's *Archiv.* b. i. h. 1, s. 15.)

B. *Vascular System in Animals with Spinal Marrow and Brain.*

§. 697. The Vascular System of the four superior Classes of Animals is distinguished from that of the inferior in the same manner as the Nervous System; viz. partly because being essentially subservient to the successive change of materials, it attains a higher and more absolute degree of centrality, these Classes all agreeing in possessing a single Heart, an organ which presents the highest point of development of the Vascular, as the Brain does of the Nervous System; and which, consequently, exerts the same influence over the system to which it belongs, as the Brain does over the Nerves: partly, because the position of this Heart is regulated nearly as much by the situation of the nervous central organ as by that of the respiratory organs, the Heart corresponding to the former in this respect, that inva-

riably in the lower Classes, and in the foetal state of the higher, it is situated at a point of the anterior surface corresponding to that of the posterior, where the Brain presents itself.\* This whole division of the Animal Kingdom is farther distinguished by the red colour of the blood, and in the two higher Classes by its considerable warmth; and farther, in this respect also, that the Vasular System, in addition to the circulation through the respiratory organs, which existed even in some of the inferior Animals, presents a partial circulation through the Liver, where the venous blood returning from the assimilative organs is again distributed, (precisely as all the venous blood was distributed through the respiratory organs in the Mollusca,) and thence again conveyed into the common Vena Cava. Lastly, we find also a perfectly distinct Lymphatic (absorbent) System, containing a clear fluid representing that in the vessels of the inferior Classes. The general type, however, undergoes many variations and gradual approximations to completeness in the individual Classes, which we shall next proceed to consider.

## SECTION I. *Vasular System in Fishes.*

### (a.) BLOOD-VESSELS.

§. 698. The circulation of the Blood in Fishes may be compared with that of some Worms, e. g. the Earth-worm,

\* Where the Brain bends forward so as to occupy the upper point of the body, the heart is necessarily placed below, rather than in front of it.

(§. 693.) in so far as here, also, the veins are collected on the abdominal side, where they pour their blood into the Heart, from which it is then propelled round the Œsophagus through numerous circles of vessels\* ramified on the branchial arches, and thence again returned to the commencement of the Aorta. Consequently, as the Heart here propels the blood immediately into the Gills, it has often been considered as merely palmonary; but with as little reason as if, when an arterial trunk is tied, and the circulation kept up by collateral branches, we should consider as Arteries those lateral ramifications only which arise above the ligature, and view those which carry the blood into the trunk below as Veins. Consequently, as other anatomists have already remarked, the Heart of Fishes, as is invariably the case when there is but one, is Aortal: it is remarkable, however, that the blood is here oxygenated in ramifications of the Aorta itself. In the Osseous Fishes the Heart is situated in the laryngeal region, immediately below the head, and external to the thorax formed by the branchial arches and their muscles: it is contained within a delicate Pericardium, which forms a duplicature with the Peritoneum inferiorly, by which the Heart is separated from the abdominal viscera, and particularly from the neighbouring Liver. (Tab. IX. fig. XVIII. a.) The size of the Heart is here so inconsiderable, that, according to TIEDEMANN,† it is but from  $\frac{1}{331}$  to  $\frac{1}{768}$  of the weight of the body, whilst in Man it is  $\frac{1}{160}$ ; which, on the one hand, well agrees with the smallness of the Brain, (though the Heart is nevertheless ordinarily much larger than the Brain,—in the Sturgeon more than a hundred times,) and on the other, is

\* These circles of vessels, which in the Amphibia are converted into a single one, remind us of the circles of vessels in the Sepia. (§. 691.)

† *Anatomie des Fisch-~~F~~irzens*. Landshut. 1809, 4to.

connected with the moderate quantity of blood and smaller number of vessels in these cold-blooded animals.

§. 699. The Heart itself consists of an Auricle and a Ventricle; of which the former has but thin parietes, and appears of a dusky colour, receiving the venous blood from the body by several venous trunks collected in this point, and usually situated behind the Ventricle; the latter has thick parietes, and is generally of an oblong shape.\* The return of the blood from the Ventricle to the Auricle is generally prevented by two semilunar valves, (Tab. X. fig. VI. a.) and from the former it is propelled into an aortal trunk dilated at its origin, at which point there are generally two semilunar valves, (fig. VII. a.) but in the Cartilaginous Fishes a greater number; in the Sturgeon, for instance, I have found three rows, each containing three valves. (Fig. IV. h. i. k.) This aortal trunk divides in such a manner that branches go off on each side to the under part of each branchial arch, (Tab. X. fig. V.) and after ramifying through the Gills, re-unite at their upper part, or at the base of the Cranium, in the commencement of the Aorta which runs along the vertebral column. The aortal trunk thus again formed, in the Carp immediately passes through the hole of an inferior spinous process of the Occipital Bone; then, as in most Fishes, runs through the abdomen behind the kidneys, sending off branches to the neighbouring parts; and, lastly, enters the canal formed by the inferior spinous processes of the caudal vertebræ: in the Sturgeon, on the contrary, the membranes of the Aorta are lost under the vertebral column, and the blood passes through a tube formed by the cartilaginous substance of the Spine. There are deviations from this type in the Cartilaginous Fishes, both as regards the Heart, which is

\* A second and perfectly closed Ventricle has lately, but incorrectly, been ascribed to the Heart of Fishes.

generally proportionally larger than in the Osseous Fishes, and the greater number of valves; thus, according to TIEDEMANN, the *Raja rubus*\* has three valves at the venous orifice of the ventricle, and five rows, each containing three valves, at the bulb of the Aorta. The Gills, too, being placed farther backwards, (§. 593.) the Heart is farther removed from the Head, the number of circles of vessels from the Aorta corresponding to the greater number of the Gills, viz. in Rays and Sharks five, in Lampreys seven. The Heart of the Lamprey has many peculiarities, being inclosed within a perfectly cartilaginous Pericardium at the extremity of the elastic branchial apparatus, (Tab. VIII. fig. IV. B. 19.) and connected to it as well by a kind of suspensory ligament as by strong tendinous fibres; a mode of connection which exists also in other Fishes, e. g. the Sea-Wolf and Conger Eel. HALLER† quotes VALSALVA for the existence of glands in the Heart of the Sturgeon pouring a black fluid into the Ventricle, which however I have not met with.

(b.) LYMPHATICS.

§. 700. The absorbent vessels bringing back the fluids from the various parts of the body in Fishes, and first described by HEWSON,‡ are distinguished, according to him, from those of Man in the following particulars: though forming numerous plexuses, they do not present any

\* I find it the same in the Heart of the Sturgeon. (Fig. IV. c.)

† *Element Phys.* t. i. p. 384.

‡ *An Account of the Lymphatic System in Fishes.* *Philos. Trans.* 1769, p. 204.

glands; they have not any valves, so that they can be injected from the trunks, two points in which they evidently appear to approximate to the Vascular System of the inferior Classes; in the Cod, and probably in other species, they form a peculiar beautiful net-work between the muscular and mucous coats of the intestine, into which the absorbed chyle appears to be first carried; they are united in a large Receptaculum Chyli placed on the right side at the upper end of the Stomach, from which the lymph is conveyed by plexuses, and ultimately by a fine orifice into the jugular vein.

## SECTION II. *Vascular System in the Amphibia.*

### (a.) BLOOD-VESSELS.

§. 701. The Class Amphibia, as regards circulation, approximates to the preceding in the following particulars: 1st, in the imperfect oxydation of the blood, though arising from other causes than in Fishes; 2d, in the low temperature of the blood (cold-bloodedness); 3d, in their more scanty and minute blood-vessels,\* and the small quantity of blood that they contain, particularly as compared with the higher Classes, for the body of Fishes is yet more bloodless; and, lastly, the size of the Heart, which, though somewhat larger than in Fishes, is still much smaller than in the

\* BLUMENBACH (*Comp. Anat.* p. 234) found that in the *Lacerta palustris* the weight of the blood was to that of the body as  $2\frac{1}{2}$  to 36; whilst in Man it is as 1 to 5.

higher Classes. In the Frog, for instance, I found the Heart,  $\frac{1}{276}$ , and in the Coluber natrix  $\frac{1}{276}$ , of the weight of the body.

The circulation in Frogs is very remarkably similar to that of Fishes. The Heart, which is situated within its Pericardium, immediately below the Sternum and above the Liver, is here also simple, consisting of a single capacious auricle with thin parietes, and an elongated, red, and muscular ventricle; the arterial trunk immediately after its origin divides into two branches, surrounding the Œsophagus, and which, precisely like the branchial vessels of Fishes, first unite in the lumbar part of the vertebral column in order to form the descending Aorta. (Tab. XIII. fig. VIII.) It is probably from the arterial circle thus formed that the branchial vessels are given off in the Larva, and in those Amphibia which have branchiæ, (precisely as in Fishes,) and from which the Pulmonary Arteries arise as lateral branches in the perfect animal, so that, consequently, a part only of the blood passes through the Lungs. SWAMMERDAM\* farther states that two Carotid-like Arteries ascending from this circle present two grey dilated points, which appear to indicate the situation whence the Branchial Arteries were given off at a former period. The Venous System here presents many peculiarities: in the first place, there are true Pulmonary Veins returning the blood from the Lungs to the Heart, (whilst, on the contrary, the blood of Fishes is conveyed through the respiratory organ, and thence into the Aorta, by Arteries alone;) they empty themselves, however, together with the other Veins, into two caval trunks, which open into the Auricle on each side; secondly, (as is peculiarly evident in Salamanders,) the Umbilical Vein, which in the superior Animals is ordina-

\* *Bib. Nat.* s. 327, t. 49. I, however, as well as MECKEL, find merely a dilatation of each Carotid. (Tab. XIII. fig. VI. B. i.)

rily converted into the round ligament of the Liver, according to an interesting discovery by JACONSON,\* remains pervious through the whole period of existence, receiving the branches of the Epigastric Vein and the Veins of the great urinary Bladder (Allantois): an organization explainable only by a reference to the mode of developement of these Animals, (without an Umbilical Cord or Placenta,) and proving that the surface of the skin in the fœtus here forms a respiratory membrane (Chorion,) and consequently that the Umbilical Vein must arise from that surface as from the Chorion in other cases, the Allantois at the same time not projecting from out of the Abdomen, but remaining permanently as a receptacle for water.

§. 702. The Circulation of the blood is already somewhat more complicated in Tortoises than in the preceding Order. The Heart, situated immediately above the Liver and close behind the abdominal scutum, consists of two Auricles and a Ventricle, the latter being divided into several communicating cells and presenting a broad circular depression, having likewise strong muscular parietes, and being connected at its inferior obtuse extremity by means of a tendinous ligament to the Pericardium, as is the case in many Fishes. The Auricles are extremely capacious, either of them being nearly equal in size to the Ventricle: they are divided by a septum, which, however, is perforated in the *Testudo scorpioides*; and we find that, as in Man, the right receives the blood of the body by means of the Venæ Cavæ, whilst the oxidised blood from the Pulmonary Veins enters the left by a fissure-like valvular orifice. The internal arrangement of the Ventricle varies somewhat in different instances: in some, *e. g.* the *Testudo græca*, it is little more than a simple cavity rendered irregular by the

\* *Bulletin des Sciences de la Soc. Philom.* 1813. Those investigations also show that the urine is in part secreted by inferior Renal Veins.

projecting bundles of fibres of its parietes: in others, on the contrary, *e. g.* the *T. imbricata*, these fibres are so very prominent, and appear to divide the cavity so completely into several cells, that MERY\* was induced to admit the existence of a Ventricle for the Pulmonary Artery and Aorta, in addition to a right and a left Ventricle. Whether the cavity, however, be simple or complicated, the course of the blood through the Heart is always such that the pulmonary blood enters at the left side, is mixed with the blood of the Venæ Cavae rather towards the back part of the Heart, and then passes on the right side into the Aorta, and anteriorly into the Pulmonary Arteries. (See Tab. XIII. fig. V.) The Arteries here again form a circle round the Œsophagus, which we must consider as a repetition of the Branchial Arteries: the Aorta, which in the *T. imbricata* is furnished with two semilunar valves, arises double from the right side of the Heart, a branch ascending from the division to form the Axillary and Carotid Arteries, whilst the two great lateral trunks bend outwards right and left: the left, after giving off some branches to the Intestinal Canal and Liver, unites on the vertebral column with the right and larger branch, forming with it the descending Aorta which supplies the other parts of the body, a vascular circle being thus produced precisely as in the Frog. A second circle, as has been proved by the observations of MECKEL† and MUNNIKS, is formed by the Pulmonary Artery, which, like the Aorta, is furnished with two semilunar valves, and immediately after its origin divided into a right and left branch, each of which enters one of the Lungs, but, at the same time, communicates with the corresponding branch of the Aorta by means of an arterial canal (Ductus Botalli), which, probably, is permanently

\* *Mémoires de l'Académie des Sciences.* 1703.

† Notes to *Translation of CUYER*, vol. iv. p. 130.

pervious. As a consequence of these dispositions, but a small part of the blood is exposed to the action of the atmosphere, and the oxydation of the blood would be even less perfect than in Fishes, where all the blood passes through the Gills, were it not that in the latter the Respiration is merely of water, and that probably in these and other Amphibia there is, in addition to the pulmonary Respiration, a respiration of an aqueous kind performed by the permanently existing Allantois. As to the Veins, it is remarkable that here, according to the investigations of BOJANUS\* and myself, the blood of the whole posterior part of the body, the abdominal coverings, posterior extremities, &c. (with the exception of the venous trunk belonging to the Kidnies and Sexual Organs,) probably in the same manner as in Frogs and Salamanders, is carried into the Liver, and, as I find in the Mud-Tortoise, by two trunks, in order to circulate partly in this organ, and partly, according to JACOBSON, by means of inferior Renal Veins, in the Kidnies, previous to arriving at the Heart. The venous blood of the body, as well as that of the lungs, is collected into a venous receptacle for each close to the Auricles, which it then enters in the manner already described.

§. 703. In Serpents, the Heart is situated towards the middle line of the body, in front of the Lungs and above the Liver; and in the Coluber *natrix*, about 4 inches below the head. Here, also, it is furnished with a left Pulmonary Auricle and a right caval, which is nearly as large again: both open into the simple and fleshy oblong Ventricle, from which arise a double Aorta, the branches of which meet again on the vertebral column, and a single Pulmonary Artery. As to the Veins, in those Serpents where the Lung is single, there is but one pulmonary Vein: there are, also, a Vena abdominalis proceeding to

\* OKEN'S *Isis*, b. 5. p. vii. s. 879.

the Liver, and two Inferior Renal Veins, which last, however, are in this case unconnected with the former.

§ 704. In Lizards, the structure of the Heart again offers a great similarity to that of Tortoises. Hence, consequently, we find two separate Auricles and a single Ventricle, which, however, is generally divided into several cells. In several species, *e. g.* the Crocodile, the Heart is even, as in some Tortoises, attached by a tendinous ligament to the Pericardium. (Tab. XII. fig. XIX. i.) The situation of the Heart is here again usually immediately above the Liver; though, according to CUVIER, in the Iguana at a considerable distance from it, and quite in the front part of the Thorax. Its Auricles (fig. XIX. g. h.) are proportionally smaller than in Tortoises, and separated by a thin septum, which is perforated in the *Lacerta apoda*. The Ventricle, the form of which is tolerably similar to those of the human heart, is divided, in the Crocodile, into three anastomosing cells in such a manner that the blood of the *Vena Cavæ* passes from the right Auricle into the two inferior cells on the right side, from which the pulmonary Artery and left ascending Aorta arise; whilst, on the contrary, the pulmonary venous blood flows from the left Auricle into the left superior cell, which is more distinct from the other two, and which gives origin to the right Aortal, Carotid, and Axillary trunks: the latter vessels, consequently, are not only filled by blood that is more oxydised than that of the left Aorta, but also contain a smaller proportion of venous blood than the Arteries of Tortoises, inasmuch as but little blood penetrates this from the other two cells. The right and left Aorta, the latter of which is reduced in size by giving off several considerable branches, unite on the vertebral column, so as to make the usual vascular circle around the *Œsophagus*, and then form the descending Aorta, the remaining course of which

presents nothing peculiar. The Veins of the body do not appear to differ essentially from the ordinary arrangement found even in Man, except so far as regards the distribution of the Veins of the Liver and Kidnies, already noticed.\*

\* According to Mr. N. M. HENTZ, the American Alligator (*Crocodylus lucius*) presents a much more perfect structure of the Heart than any other of the Amphibia, the two Ventricles not having any immediate communication. From his description the following particulars are derived:—The Vena Cava Superior follows the course of the right Subclavian Artery in its passage through the chest, and descends to the Pericardium to join the Vena Cava Inferior opposite the right Auricle. In its course upwards, the Inferior Cava runs upon the right side of the spine until it reaches a straight channel in the substance and near the edge of the Liver, where it receives four or five *venæ cavæ hepaticæ*. A Vein analogous to the right Subclavian enters the upper part of the right Auricle at its left side. The auriculo-ventricular opening of the right heart is furnished with two valves. The right Ventricle opens into two arterial tubes, of which one is the Pulmonary Artery; the other, at the left and upper part of the Ventricle, is furnished at its base with two semilunar valves, and terminates in the left Aorta. There is not any direct communication between the cavities of the two Ventricles. The left Ventricle, which is rather smaller than the right, and situated behind and somewhat above it, has also two valves at the orifice by which it communicates with the Auricle. Like the right Ventricle, also, it opens into two arterial tubes, of which the first leads into the left Aorta, and is separated from the corresponding orifice of the right Ventricle by a cartilaginous septum only. It is important to observe, that this septum interrupts the immediate communication between the cavities of the two Ventricles, (for they communicate *intermediately* by means of the Artery from each opening into the left Aorta,) and constitutes the most essential variation of the structure of the Heart in this, from what is found in other Saurian Amphibia. This first branch, arising from the left Ventricle, is bordered by a valve at its origin that nearly closes its cavity. The second artery from the left heart divides shortly after its origin into three branches, of which one is the right or systemic Aorta, the second the right Subclavian, and the third the common trunk of the Carotid and left Subclavian Arteries. The left or splanchnic Aorta, previous to dividing among the viscera, gives off a large branch which communicates with the right, descending, or systemic Aorta. The three great Arteries, viz. the Pulmonary, and right and left Aorta, are closely connected together immediately after their origin, and dilate into expansions which are collectively larger than the cavities of the Heart. In the

## (b.) LYMPHATICS.

§. 705. According to HEWSON,\* the Lymphatics of the Amphibia differ from those of Fishes in being provided with Valves, though they are neither so close together nor so strong as in the higher animals, being insufficient to prevent the course of injections from the trunks to the branches. In a Turtle which I examined with respect to this point, there were numerous ramifications of the Lymphatics between the muscular and mucous coats of the Intestine, though rather having the appearance of cells crowded together. The Lymphatics of the whole of the lower part of the body united in a common receptacle, from which there did not proceed any single Thoracic Duct, but a double Plexus connected superiorly with the cervical Plexus, and emptying itself into the Axillary Veins by two branches on the right, and one on the left side.†

common state of circulation the blood passes from the right Ventricle chiefly into the Pulmonary Artery, and partly, also, into the branch arising from it, to enter the left Aorta. The blood of the left Ventricle, on the other hand, is thrown into the right Aorta, right Subclavian and Carotid Arteries, a small quantity only passing into the left Aorta. When the animal is under water, the action of the lungs being interrupted, and the circulation of blood through them suspended, a larger proportion of the contents of the right Ventricle must pass into the branch of communication with the left Aorta, and it is probable, that under such circumstances only does it happen that the blood sent to the various organs is an admixture of arterial and venous blood, as in the Chelonia and other Sauria. (*Edinburgh Journal of Med. Science*, i. 217.)—*Translator*.

\* *An Account of the Lymphatic System in Amphibious Animals*, in *Phil. Trans.* 1769. p. 178.

† In the Crocodile HEWSON found the Chyle white, whilst in Fishes and other Amphibia the contents of the Lymphatics are usually colourless.

SECTION III. *Vascular System of Birds.*

## (a.) BLOOD-VESSELS.

§. 706. The extended Respiration of this Class, and the distinguished developement of its Muscular System, which we have observed in so many particulars, are closely and essentially connected with a corresponding degree of perfection in the formation of the Vascular System. We here, for the first time in the animal series, meet with warm blood, and also perfectly distinct Pulmonary and Aortal Hearts, connected together, however, so as to form a single organ. Hence, consequently, not a part merely, but the whole of the mass of fluids is exposed to the action of the air, and that even in two ways, once in the Lungs, and again in the air-cavities of the other parts of the body. We are enabled, notwithstanding, to trace the transition in the form of the Heart and the distribution of the Vessels from those of the preceding Class, and particularly of Lizards. If, for instance, in the Crocodile, (§. 704.) we suppose the incomplete Septum between the double right and the left Ventricles (Cells) to be perfectly closed,—viewing that branch of the Aorta which gives off the Carotid and Axillary Arteries as the sole Aortal trunk, and instead of the Pulmonary Artery and left Aortal, (which latter is, in fact, merely an accessory branch,) imagine that the former alone arises from the right Heart,—we shall then have a perfect idea of the Heart of Birds, and shall find that here, for the first time, (at least, in the fully

formed animal,) there is not any vascular circle round the Œsophagus. It exists, however, in the Embryo, for, as was remarked by HALLER, the two Pulmonary Arteries enter the Aorta as Arterial Ducts, (the abdominal Aorta being, consequently, formed by three roots, the proper Aorta and the two Arterial Ducts,) and in that way surround the Œsophagus, (Tab. XVI. fig. XIII.); whilst the proper Pulmonary Arteries are sent off laterally as branches, nearly in the same manner that the Pulmonary Arteries of the Frog are given off from the aortal circle.

§. 707. The Heart in Birds is placed within its Pericardium in the middle of the upper part of the Thorax, immediately above the Liver (Tab. XV. fig. XI. e.), between the Lungs,\* behind the Sternum, and with its point a little turned to the right side in those that have powerfully muscular stomachs: in Accipitrine Birds, some Gallæ, and also, as I observe, in the Green Parrot, it is quite in the middle. Its shape is conical, its colour dark red, and its parietes, particularly those of the left Ventricle, extremely strong and powerful. Its bulk deserves particular notice, being greater in proportion to the rest of the body than in any other Class; its weight, according to TIEDEMANN,\* being to that of the body from  $\frac{1}{10}$  to  $\frac{1}{12}$ , and thus forming a remarkable contrast to the proportions found in Fishes and Amphibia. Its internal organization approaches very closely to that of the Heart of Man: it consists of two Ventricles, and two thin, but tolerably muscular, Auricles, of which the right is the largest. The left Auricle receives the blood from the Pulmonary Veins, (its return being prevented by a Valve,) and empties it into the left Ventricle, which may be considered as the principal part of the Heart, the right Ventricle being applied to its side like a shell. The reflux into the Auricle,

\* *Zoologie*, b. ii. s. 562.

is prevented partly by a kind of Sphincter Muscle, and partly by a membranous valve with tendinous fibres attached to it, and corresponding to the Mitral Valve of the human Heart. The left Ventricle elongated, capacious, and distinguished by the strength of its muscular parietes pours the blood into the Aorta, which is furnished with three semilunar Valves at its root, and divides immediately into three branches.

§. 708. The right Heart has, also, an Auricle into which the blood of the body is conveyed by two Venæ Cavæ, of which the upper has one, and the lower two, Valves. It is somewhat more capacious than the left Auricle, and opens into the right Ventricle by an orifice furnished with a peculiar broad and fleshy Valve attached to the side of the cavity. The right Ventricle is shorter and more compressed than the left, and, as already mentioned, is disposed concentrically around its right side. The Pulmonary Artery, provided with three Semilunar Valves, arises completely from its left side, and immediately after its origin divides into two lateral branches, its trunk being narrower than that of the Aorta.\* (See Tab. XVI. fig. XIV.) The Arteries themselves have very thick coats, and their fibrous structure is very distinct. Their course in general is perfectly similar to that described in human Anatomy; though I must mention, that of the three principal divisions at the commencement of the Aorta, the right forms the ascending Aorta, the middle one the right, and the last the left, Subclavian Artery, from which last the Carotid and the large Vertebral Arteries arise on each side, the trunk continuing its course to the wing as the Axillary Artery.

\* In contradiction to this observation of CUVIER's, which agrees with my own experience, TIEDEMANN states, that the injected Pulmonary Artery appears to him larger than the Aorta, which, however, probably depends on the weaker parietes of the former yielding more to the force of the injection.

## (b.) LYMPHATICS.

§. 705. According to HEWSON,\* the Lymphatics of the Amphibia differ from those of Fishes in being provided with Valves, though they are neither so close together nor so strong as in the higher animals, being insufficient to prevent the course of injections from the trunks to the branches. In a Turtle which I examined with respect to this point, there were numerous ramifications of the Lymphatics between the muscular and mucous coats of the Intestine, though rather having the appearance of cells crowded together. The Lymphatics of the whole of the lower part of the body united in a common receptacle, from which there did not proceed any single Thoracic Duct, but a double Plexus connected superiorly with the cervical Plexus, and emptying itself into the Axillary Veins by two branches on the right, and one on the left side.†

common state of circulation the blood passes from the right Ventricle chiefly into the Pulmonary Artery, and partly, also, into the branch arising from it, to enter the left Aorta. The blood of the left Ventricle, on the other hand, is thrown into the right Aorta, right Subclavian and Carotid Arteries, a small quantity only passing into the left Aorta. When the animal is under water, the action of the lungs being interrupted, and the circulation of blood through them suspended, a larger proportion of the contents of the right Ventricle must pass into the branch of communication with the left Aorta, and it is probable, that under such circumstances only does it happen that the blood sent to the various organs is an admixture of arterial and venous blood, as in the Chelonia and other Sauria. (*Edinburgh Journal of Med. Science*, i. 217.)—Translator.

\* *An Account of the Lymphatic System in Amphibious Animals*, in *Phil. Trans.* 1769. p. 178.

† In the Crocodile HEWSON found the Chyle white, whilst in Fishes and other Amphibia the contents of the Lymphatics are usually colourless.

SECTION III. *Vascular System of Birds.*

## (a.) BLOOD-VESSELS.

§. 706. The extended Respiration of this Class, and the distinguished development of its Muscular System, which we have observed in so many particulars, are closely and essentially connected with a corresponding degree of perfection in the formation of the Vascular System. We here, for the first time in the animal series, meet with warm blood, and also perfectly distinct Pulmonary and Aortal Hearts, connected together, however, so as to form a single organ. Hence, consequently, not a part merely, but the whole of the mass of fluids is exposed to the action of the air, and that even in two ways, once in the Lungs, and again in the air-cavities of the other parts of the body. We are enabled, notwithstanding, to trace the transition in the form of the Heart and the distribution of the Vessels from those of the preceding Class, and particularly of Lizards. If, for instance, in the Crocodile, (§. 704.) we suppose the incomplete Septum between the double right and the left Ventricles (Cells) to be perfectly closed,—viewing that branch of the Aorta which gives off the Carotid and Axillary Arteries as the sole Aortal trunk, and instead of the Pulmonary Artery and left Aortal, (which latter is, in fact, merely an accessory branch,) imagine that the former alone arises from the right Heart,—we shall then have a perfect idea of the Heart of Birds, and shall find that here, for the first time, (at least, in the fully

formed animal,) there is not any vascular circle around the Œsophagus. It exists, however, in the Embryo, for, as was remarked by HALLER, the two Pulmonary Arteries enter the Aorta as Arterial Ducts, (the abdominal Aorta being, consequently, formed by three roots, the proper Aorta and the two Arterial Ducts,) and in that way surround the Œsophagus, (Tab. XVI. fig. XIII.); whilst the proper Pulmonary Arteries are sent off laterally as branches, nearly in the same manner that the Pulmonary Arteries of the Frog are given off from the aortal circle.

§. 707. The Heart in Birds is placed within its Pericardium in the middle of the upper part of the Thorax, immediately above the Liver (Tab. XV. fig. XI. e.), between the Lungs, behind the Sternum, and with its point a little turned to the right side in those that have powerfully muscular stomachs: in Accipitrine Birds, some Gallæ, and also, as I observe, in the Green Parrot, it is quite in the middle. Its shape is conical, its colour dark red, and its parietes, particularly those of the left Ventricle, extremely strong and powerful. Its bulk deserves particular notice, being greater in proportion to the rest of the body than in any other Class; its weight, according to TIEDEMANN,\* being to that of the body from  $\frac{1}{15}$  to  $\frac{1}{12}$ , and thus forming a remarkable contrast to the proportions found in Fishes and Amphibia. Its internal organization approaches very closely to that of the Heart of Man: it consists of two Ventricles, and two thin, but tolerably muscular, Auricles, of which the right is the largest. The left Auricle receives the blood from the Pulmonary Veins, (its return being prevented by a Valve,) and empties it into the left Ventricle, which may be considered as the principal part of the Heart, the right Ventricle being applied to its side like a shell. The reflux into the Auricle,

\* *Zoologie*, b. ii. s. 562.

is prevented partly by a kind of Sphincter Muscle, and partly by a membranous valve with tendinous fibres attached to it, and corresponding to the Mitral Valve of the human Heart. The left Ventricle elongated, capacious, and distinguished by the strength of its muscular parietes pours the blood into the Aorta, which is furnished with three semilunar Valves at its root, and divides immediately into three branches.

§. 708. The right Heart has, also, an Auricle into which the blood of the body is conveyed by two Venæ Cavæ, of which the upper has one, and the lower two, Valves. It is somewhat more capacious than the left Auricle, and opens into the right Ventricle by an orifice furnished with a peculiar broad and fleshy Valve attached to the side of the cavity. The right Ventricle is shorter and more compressed than the left, and, as already mentioned, is disposed concentrically around its right side. The Pulmonary Artery, provided with three Semilunar Valves, arises completely from its left side, and immediately after its origin divides into two lateral branches, its trunk being narrower than that of the Aorta.\* (See Tab. XVI. fig. XIV.) The Arteries themselves have very thick coats, and their fibrous structure is very distinct. Their course in general is perfectly similar to that described in human Anatomy; though I must mention, that of the three principal divisions at the commencement of the Aorta, the right forms the ascending Aorta, the middle one the right, and the last the left, Subclavian Artery, from which last the Carotid and the large Vertebral Arteries arise on each side, the trunk continuing its course to the wing as the Axillary Artery.

\* In contradiction to this observation of CUVIER's, which agrees with my own experience, TIEDEMANN states, that the injected Pulmonary Artery appears to him larger than the Aorta, which, however, probably depends on the weaker parietes of the former yielding more to the force of the injection.

The Aorta here does not divide at its lower part as in Man, but gives off a Femoral Artery on each side, and then descends, as an *Arteria sacra media*, to be distributed in the Pelvis. As to the Veins of Birds, their parietes are thicker than in other animals, and their fibrous structure is easily detected in large individuals. As regards their course, the considerable capacity of the three inferior Caval trunks, already noticed, which CUVIER and MECKEL have observed in Diving Birds, is physiologically important in so far as explains the long continued interruption of Respiration to which these Birds are capable of submitting, and reminds us of similar receptacles on the principal venous trunks of Tortoises. (§. 702.) JACOBSON has here, also, discovered the distribution of the greater part of the venous blood of the posterior part of the body partly through the Liver, and partly through the Kidnies.

(b.) LYMPHATICS.

§. 709. The Lymphatics of Birds were first discovered by J. HUNTER, and afterwards more precisely described by HEWSON,\* who found the following peculiarities in them:—1st, A transparent colourless Chyle, which, however, does not coincide with the fact that the blood of Birds often presents an intermixture of a perfectly milky fluid; 2d, an absolute deficiency of glands in the abdomen and about the thoracic duct, a few only being found in the neck; 3d, the frequent varicose dilatations found in them, if, indeed, this be not rather the consequence of domestication and more of a diseased state. The Lymphatic

\* *An Account of the Lymphatic System in Birds.* *Philos. Trans.* 1768. HALLER, indeed, quotes some ancient observations of Lymphatics in Fishes, Amphibia, and Birds, but without attaching any credit to them.

Vessels in Birds are collected into a large Plexus in the region of the Coeliac Artery, thus supplying the deficiency of a receptaculum, and having two thoracic ducts ascending from it to empty themselves into the Subclavian Veins. According to TIEDEMANN, the lymphatic glands of the neck are more developed in Wading and Aquatic than in Land Birds.

#### SECTION IV. *Vascular System in Mammalia.*

##### (a.) BLOOD-VESSELS.

§. 710. Both as regards the distribution of the Vessels and the form of the Heart, the structure of the whole Class so closely corresponds to the human type, that it is necessary to notice only a few peculiarities of individual Species, which present deviations from the ordinary forms, and in the same degree approximate to the inferior formations. In this respect we have to notice particularly the Amphibious and Cetaceous Mammalia: first, on account of the very great quantity of blood, (in which HUNTER\* even suspects the existence of an unusual number of globules,) and also on account of the peculiar structure of the Heart, and the large and very much divided vessels; points in which we again find the predominance of the Vegetative Sphere, as instanced likewise in the length of the intestinal canal, the number of stomachs, collection of fat, &c. HUNTER, for

\* *On the Economy and Structure of Whales.* *Philos. Trans.* 1787, p. 413.

instance, found the Aorta of a White Whale a foot in diameter, and observed also numerous arterial plexuses between the Ribs, about the Vertebrae, &c. which appeared to have the character of mere receptacles of blood. Even at the origins of the Aorta and Pulmonary Artery there are frequently dilatations,\* which, even if they are not to be considered as parts of the normal structure, still appear to be rendered compatible with health by the mode of life and general organization of these Animals; whilst in Man, on the contrary, they form dangerous diseases (Aneurysm). The same remark is also applicable to the dilatation of the venous trunks, to be hereafter noticed, and to the varieties in the structure of the Heart, which in Man produce inconvenience and disease. The very flat and broad shape of the Heart in the Amphibious Mammalia (Tab. XX. fig. VII. a.) is remarkable from its coincidence with the form of the Heart in Tortoises, (§. 702.) as well as in the human embryo. The point of the Heart is double here, in the Manati for instance, the left point projecting on account of the greater length of the left Ventricle, in the same manner that in Birds we found the left longer than the right ventricle. There is not the same difference here between the thickness of the aortal and pulmonary Ventricles as in Man and other Mammalia; and, consequently, the latter is in proportion more muscular. In these species, and also in some other Diving Animals, *e. g.* the Beaver and Sea-Otter, we occasionally find the Foramen Ovale in the Septum of the Auricles open,† and less frequently the ductus arteriosus between the Aorta and Pulmonary Artery: a structure, however, which cannot with constancy or propriety be connected with the mode of life of these

\* MECKEL, Notes to CUVIER'S *Comp. Anat.* vol. iv. p. 77.

† See the various testimonies to this effect collected by MECKEL, *loc. cit.* p. 37.

animals, inasmuch as that here, as well as in other Mammalia, it belongs properly to the period of foetal existence. The position of the Heart of the Whale varies less from that of Man than in other Mammalia, the pericardium, according to HUNTER,\* being attached by a broad surface to the diaphragm. As regards the distribution of the vessels, we may remark that the Aorta, in consequence of the imperfection of the posterior extremities, is contorted, as in Fishes, and even in Birds, below the caudal vertebræ, in the form of an Arteria Sacra Mèdia, having previously given off two branches analogous to the Iliac Arteries. A peculiarity of the inferior Vena Cava in the Porpoise and Seal deserves notice, viz. that it forms a considerable dilatation between the Liver and Diaphragm, thus representing a similar structure in Tortoises and Diving Birds. (§. 708.) A similar dilatation has been found also in the common and Sea Otter.† ‡

§. 711. The Heart and Vessels in other Mammalia agree still more completely with those of Man. The most remarkable peculiarities are, first, as regards the Heart: except in the most anthropomorphous Apes, it does not reach the Diaphragm, its point resting on the Sternum,

\* *Loc. citat.* p. 414.

† It is remarkable that in the *Ornithorhynchus*, which dives admirably, HOME (*Phil. Trans.* 1802, p. 74) could not discover any communication between the right and left Hearts, nor does he notice any venous dilatation of this kind. He says merely that the right Auricle is very capacious.

‡ The Heart of the Dugong is very remarkable for the complete separation of the two Ventricles, which come in contact with each other merely for an inconsiderable extent at the upper part, thereby presenting the real character of the central apparatus of circulation, as being formed by the juxta-position of two actually distinct organs. The structure of the Heart does not, however, vary in any essential particular from that common to other Mammalia. The Foramen Ovale was found perfectly closed in the young animal. (HOME, *Phil. Trans.* 1820, p. 11.)—*Translator.*

besides that it is situated in the middle line of the body, and not, as in Man, turned to the left side. In the latter particular, however, I find a remarkable exception in the Heart of the Mole, which is very much directed to the left side; a position that, taken generally, is probably not without importance, and appears to prove that Assimilation predominates on the left as Respiration on the right side, the Lungs and Heart bearing the same proportion in the Chest as the Liver and Stomach in the Abdomen. According to CUVIER, the Heart in the Elephant is broad and thick, like that of the Porpoise; a proof, with many others, of the relation existing between the Pachydermata and Cetacea.\* As relates to the internal structure of the Heart, we may remark that the right Auricle in many instances, precisely as in Birds, (§. 708.) receives two superior Venæ Cavæ, *c. g.* in the Poreupine, Guinea-Pig, Kangaroo, and, according to HOME, the Ornithorhynchus; also, that the Eustachian Valve, which in Diving Animals, *e. g.* the Seal, is very strong, is wanting in many species, *e. g.* Lions, Bears, and Dogs. The ossifications naturally existing in the Heart of many Ruminants, and of the Pig, are also remarkable, inasmuch as ossification of the same parts is frequently the effect of disease in Man. In the Stag they are cruciform, and are placed at the origin of the Aorta in the Septum of the Ventricles. They appear to be formed from about the third to the fourth year of life, are less perfect in the female, and altogether wanting in the Roe and Fallow-Deer;† In what concerns the remaining vessels, there

\* In this respect the tendency to dilatations of the Aorta in the Peccari is also remarkable, having been described there as the natural state, (DAUBENTON in BUFFON'S *Hist. Nat.* t. x.) particularly as similar dilatations frequently occur in the Cetacea.

† *Diss. in. sistens Observ. nonnullas Zootom. Ox Cordis Cervi, Clavicula filis, &c. spectantes.* Priesz, C. F. J. KIEPMEYER. resp. LUTHELI. Tubing. 1814.

deserve notice several peculiarities in the branches arising from the arch of the Aorta, which occasionally present themselves as varieties in Man; also, and particularly in long-tailed Animals, the continuation of the Aorta below the caudal vertebræ, as in the preceding Classes; and, lastly, several peculiar reticular ramifications of vessels. Of the latter we have an instance in the *Rete Mirabile*, already noticed, (§. 328.) at the base of the Brain. Of the same nature, also, are the plexuses formed by the Arteries for the extremities in the Sloths and Lories; and from which they again emerge to form new trunks, nearly in the same manner that the Aorta in Fishes is formed by the branchial vessels, or the Nerves of the extremities by their Plexuses. The number of these longitudinal branches collected into bundles is very considerable in the Axillary Artery, and is most so in the Three-toed Sloth, where they amount to 34 in the posterior, and 62 in the anterior, extremity. The discoverer\* of this singular structure has correctly deduced from it the power these animals possess of remaining long in one position, as well as the tardiness of their muscular motion. The fact remarked by SAISSY,† of the proportionally greater size of the superficial vessels in hibernating Animals, is so far remarkable, as, in connection with the want of coagulability in their blood, it serves to elucidate their state of torpidity. The most important peculiarities of the Veins have been already noticed, such as the dilations of the inferior, and the existence of two superior, *Venæ Cavæ*: to which we may add several venous Plexuses, *e. g.* the very delicately interwoven venous rete (*rete mirabile venosum*) on the Horse's foot, and also the large and much

\* CARLISLE, *Account of a Peculiarity in the Distribution of the Arteries sent to the Limbs of Slow-moving Animals.* (*Philos. Trans.* 1800 and 1804.)

† *Recherches Experimentales sur la Physique des Animaux Mammiferes Hybernans.* Paris, 1808.

ramified venous trunks on the uterus of several pregnant Animals, *e. g.* the Cow.

(*b.*) LYMPHATICS.

§. 712. It is well known that human is indebted to Comparative Anatomy\* for the discovery of the Lymphatic System, as well as for many others: it is favoured in Mammalia by the distension of the proportionally larger absorbent vessels of the Mesentery with milk-white Chyle, thus rendering them more distinctly perceptible. This greater size of the trunks of the Absorbents is one of the principal points serving to distinguish the system in Mammalia from that of Man, but few variations having been hitherto discovered in the course of the branches. A deviation of that kind, and at the same time an approximation to an inferior type, consists in the smaller number of Lymphatic Glands generally, and of those of the Mesentery in particular; of which last CUVIER remarks, that in Herbivora, with a long intestinal canal, they are more separated, and in the Carnivora more crowded together, and collected in larger masses. The structure observed by ABERNETHY† in the Mesenteric Glands of the Whale deserves particular notice, and above all a repetition of the observations. He states that in these animals after injection there appear not glands but cavities in the Mesentery, into which open not only the Lymphatics of the Intestines but also Arteries and Veins, so that a mixture of the Chyle with secretions from the Arteries, and at the same time the passage of the former direct into the

\* They were seen in the Mesentery of the Goat even by ERACISTRATUS and GALEN.

† *Philosoph. Trans.* 1796, p. 27.

Veins, are rendered possible. As to the Thoracic duct, there are usually two, as in Birds; whilst, on the contrary, in the higher species, and in Man himself, there is but a single one, and that on the left side, as the situation more particularly devoted to the assimilative apparatus.

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It will be seen that there are not any peculiarities of structure that can be pointed out as exclusively belonging to Man in the Vascular System,—the central System of Vegetative Life; on which subject we may again refer to the remarks already made. (§. 683.)

## BOOK II.

DESCRIPTION OF THE ORGANS SUBSERVIENT  
TO THE REPRODUCTION OF THE SPECIES;

AND

ALSO OF THE DEVELOPEMENT OF INDIVIDUAL  
ANIMAL ORGANISMS.



§. 713. In the Vegetable World we find the great object of Nature, the continuation of the Species, effected in two ways: in one, the mother plant throws out from Buds (they may appear also as Tubera or Bulbs), Shoots, which, gradually becoming detached, continue to live as new and perfectly distinct individuals: in the other, two different tendencies existing in the Plant appear definitely fixed in organs of opposite natures, *i. e.* as Stamina, (positive, animal,) on the one hand, and on the other a Pistil, (negative, purely vegetative,) which by their mutual and combined influence communicate to the Bud (Seed), contained within the Pistil (vegetative organ), the power of reproducing in itself the whole Plant. KIESER,\* to whom we are indebted for having thoroughly established the identity of

\* *Grundzuge der Anat. d. Pflanzen*, s. 192.

character of Buds, Bulbs, and Seeds, says of the Seed,  
 "It is the Bud in a state of greater perfection, but at the  
 "same time more compressed within itself, having more of  
 "individuality, and, consequently, an independent exist-  
 "ence. The whole Plant is contained preformed within  
 "the Seed, in the same manner as within the Tuber, Bud,  
 "or Bulb, but, at the same time, so far ideally, that it fre-  
 "quently is scarcely perceptible as a material embryo."  
 The whole of this is repeated most perfectly in the Animal  
 Organism. We shall find Animals in which propagation  
 is effected by the detachment of individual Shoots, (in  
 which a part of the maternal body appears as a material  
 embryo,) or even by the division of the maternal body into  
 several parts: whilst, on the contrary, in other species, dif-  
 ferent kinds of organs, usually placed in distinct bodies,  
 present themselves, being either of a vegetative (female)  
 or of an animal (male) character, and by their combined  
 action impart to a mass of elementary matter, originally  
 proceeding from the vegetative organ, the power of repro-  
 ducing within itself the collective animal organism; *i. e.*  
 give to it the character of an Ovum, in which, as in the  
 Seed of the Plant, and even more so, the embryo exists  
 merely ideally, and is produced materially only by the  
 accession of certain external circumstances. But as the  
 Seed in Plants is not always the product of the combined  
 action of the Stamina and Pistil, being frequently, as in  
 Fungi, Lichens, &c. formed by an organism in which we  
 do not discover this contrast of organs, and which on that  
 account appears more purely vegetative; so, also, in Ani-  
 mals the formation of Ova very commonly occurs as the  
 product of a body in which we cannot detect the distinc-  
 tion of male from female organs, and which, therefore, has  
 more the appearance of being purely female. But, lastly,  
 since Animal as well as Vegetable Organisms are not pro-

duced solely from other similar ones, but also from elementary materials, either primarily, or secondarily by the death or disintegration of other Organisms, we may with propriety arrange the various modes of origin of Animals in the following tabular form.

## §. 714.

ORGANICALLY.	
<p>From primitive Elementary Matter. (I. Creation.)</p>	<p>By the division of the maternal body into several parts, which form new Individuals. (III. Propagation by Division.)</p>
ORGANICALLY.	
<p>From primitive Elementary Matter. (I. Creation.)</p>	<p>By the formation of an Embryo.</p>
<p>Secondarily, by the disintegration of the Elementary Matter of other Organic Bodies. (II. Equivocal Generation.)</p>	<p>Immediately, by an Ovum, which is produced</p>
<p>Without Copulation. (V. Generation in which we have to distinguish</p>	<p>With Copulation. (VI. Sexual Generation; in which we have to distinguish</p>
<p>proceeds from the body of the Mother in the formation of a Bud. without Copulation by Budding.)</p>	<p>Copulation of two Individuals of different Sexes.</p>
<p>Single Hermaphrodites.</p>	<p>Double Hermaphrodites.</p>
<p>Mutual Copulation of two Hermaphrodites.</p>	<p>Mutual Copulation of two Hermaphrodites.</p>

But, as the different modes of developement of Plants are ultimately referrible to one and the same, so, also, are these various modes of Generation of Animals; of which we shall be easily convinced, when we consider that Sexual Generation approaches to Generation without Sexes, inasmuch as in the former case the Germ to be impregnated belongs to the vegetative female organ, and that the Ovum is produced like a Shoot from it; in which way, also, Generation without Sexes approaches to Propagation by Shoots, and this again to Propagation by Division, viz. inasmuch as the Shoot is originally an integral part of the maternal body: whilst, ultimately, the origin of all these modes of Generation is deducible solely from the reproduction of organic elementary matter.

Nevertheless, we shall find these divisions useful in the following considerations, in which we shall again find that the simplest modes of Generation are proper to the lowest Classes, and that in the superior, on the contrary, we meet with sexual Generation, and that again with very various modifications.

This Book we shall again subdivide into two Chapters, considering in the first the Organs destined for the production of new Organisms, (with which the Sexual Sense is connected in the same manner as the Sense of Taste with the Digestive Organs;) and in the second, the developement of those Organisms themselves.

ing in size, until they are sufficiently advanced to be detached and exist permanently distinct. (Tab. I. C. D.) According to SPINX,\* the cavity of the Stomach in the Actiniæ is surrounded by several grape-shaped Ovaries, the ducts of which gradually unite together and terminate by several apertures in the Stomach; the Ova, consequently, like the undigested food, (§. 434.) being expelled through the mouth. (Tab. I. fig. X. A. B.) He states, also, that there are similar globular Ovaries under the lobes of the Liver (§. 643.) in the rays of the Asterias. (Fig. XI. C.) More than this, however, most Polypes, as has been sufficiently proved by the experiments of TREMBLEY, are propagated by division into several parts.

## SECTION II. *Sexual Organs in the Mollusca.*

### (a.) ACEPHALA.

§. 718. In this as well as in the following Order the Sexual Organs, particularly the most essential, the Ovaries, are usually placed in the vicinity of the Liver and Lungs, or Gills, a position which forms an additional instance of the relation existing between the Sexual, Respiratory, and Secretory Organs. In the Acephala, more particularly, as in the higher Species of Zoophytes, there is not any

and is frequently repeated in the superior Classes, even in Man, by the nutrition of the new being, first in the Uterus, and subsequently at the Breasts. It has a reference, also, to the connection of the generative function with the respiratory on the one hand, and the digestive on the other. (§. 715.)<sup>o</sup>

\* *Annales du Muséum d'Hist. Nat.* t. xiii. p. 417.

true Copulation, but merely propagation without Sexes, by means of Ova, or, at most, single Hermaphrodite Copulation, (i. e. by different kinds of genital organs in one individual.) In all the Bivalves, as has been shewn by POLI, there is a large Ovary immediately below the Liver within the Foot, in which the Ova are formed in such a manner, that, as I have frequently observed with the Microscope in the Fresh-water Muscle, (*Unio pictorum*), from 8 to 10 small Ova are contained in larger hulls or cases connected together like grapes,\* (Tab. II. fig. IX. f. fig. XII. C.) in which they continue to grow for a certain time, and then pass into the external laminæ of the Gills, within the cells of which, (§. 564.) as within a Uterus, they are converted into perfect Bivalves. Hence, if we open a pregnant Bivalve, we may take the young from out of the compartments of the Gill to the number of some thousands, and observe them moving briskly when placed on the slide of the Microscope. The transference from the Ovaries to the Gills (which last have even recently been considered as Ovaries) is effected, according to OKEN,† by means of an opening direct from the Ovary on each side into the canal placed above the compartments within each Gill. This statement, however, appears to rest on the authority of a single observation, and is, in my opinion, still doubtful, because, in numerous examinations of pregnant and unimpregnated Bivalves I have never been able to discover this opening; whence, likewise, it seems to me more probable, that the Ova, as in the Medusæ‡ or Actiniæ, (§. 718.)

\* This is remarkable, because, according to CAVOLINI, the Ova of several Zoophytes are similarly massed together in the hulls by which they are surrounded.

† Goetting. gel. Anzeigen. 1806.

‡ In them there was a similar transference of the Ova from an internal to an external organ. (See §. 717.)

enter the Stomach\* by one of the openings hitherto considered as belonging exclusively to the biliary ducts, and are then evacuated through the mouth, and conveyed into the openings of the Gills by the water which flows through the Cloak from before backwards; though it must be mentioned, that a prominence on the Rectum (Tab. II. fig. IX. a. 6.) has much resemblance to an Oviduct. The young animals must ultimately escape by two tubes (vaginæ) (fig. IX. t. t.) running above the compartments of the Gills and opening below the anal tubes. The parts which in these and other Bivalves have occasionally been considered as male organs, are of a very dubious nature.

§. 719. There are many varieties of this organization in the different species of the Order, of which some are but imperfectly known, and others unsuited for extended description in this place. I shall, therefore, only notice the very considerable deviation in the Ascidiæ: in them, an Oviduct (i.) arises from the Ovary, (Tab. II. fig. II. h. h.) which is here, also, placed below the Liver; it conveys the ova either through the anal opening, or through the lateral aperture of the Gill-bag, (§. 562.) to the external surface of the fibrous case, where the young animals remain fixed, and undergo a farther developement.† Opposite to the opening of the Ovary, I remarked the orifice of another glandular organ, (fig. II. k. l.) which apparently possesses the character of a male organ, or serves to furnish the gelatinous covering of the Ova.

\* The crystalline style, before mentioned, (§. 437.) may probably in that case have the same character in these animals as the peculiar dart of Snails. (§. 722.)

† See the Essay before quoted from MECKEL'S *Archiv.* b. ii. h. 4.

## (b.) GASTEROPODA.

§. 720. Instead of the formation of Ova without the existence of Sexes, or the self-copulation of perfect Hermaphrodites, as in the preceding Order, we here, for the first time in the series of animals, find a distinction of Sexes in different individuals, which is the case in those species possessing Gills placed within the cavity of the Cloak: nay, in the higher Species, *i. e.* in those breathing by detached Gills or pulmonary cavities, we find as a repetition of the inferior formations that each individual is furnished with sexual organs of both kinds; in such a manner, that self-copulation is no longer possible, and mutual copulation necessary. We shall examine some species as specimens of each of these organizations, selecting first the Viviparous Snail (*Cyclostoma viviparum*) as an instance of those Gasteropoda in which the Sexes are completely separated. In the female, we find a whitish Ovary between the respiratory cavity and the Liver, with an Oviduct proceeding from it behind the pecten of the Gills, (in the same manner as the Vagina of the Fresh-water Muscle over the laminae of the Gills,) (see Tab. III. fig. X. f.): it here, also, supplies the place of a Uterus, the Ova being detained in it for a considerable time, and there developed into young Snails (like the Bivalves within the Gills), distending the canal in an extraordinary degree. In the male, the Testis (fig. XI. a.) occupies the situation of the Ovary in the female; a contorted seminal duct (z.) proceeds from it to the Penis (y.), which can be protruded through an opening in the right Feeler. In other Species of this kind the Oviduct serves simply as such, and the Ova are developed external to the body of the mother; as,

for instance, in the *Buccinum undatum*: it is remarkable, however, that here, as well as in most Snails, several are evacuated together in a covering common to all,† by which we are reminded of the hulls for the Ova in the Ovary of Bivalves and of similar appearances in Zoophytes. The male of this animal is, also, distinguished by an extraordinarily large Penis, which can at pleasure be protruded at the right side of the neck, or retracted within the pulmonary cavity.

§. 721. Among the Hermaphrodite Gasteropoda, where the Copulation is mutual, we shall consider more particularly the *Helix pomatia*. In each individual there is a moderately large Ovary (Tab. III. fig. III. q.) situated below the upper extremity of the Liver, with a convoluted seminal tube (r.) descending from it, and which, after contracting a little, suddenly expand into a capacious, mucous, plicated Vagina (w.), in which the Ova receive an albuminous coating, and are united into masses. At the orifice of this Vagina terminate several secretory organs, the character of which is as yet but imperfectly understood: of this nature are two vesicles (x. x.) with numerous ramifications, and a bladder with a long neck (v.). The male organs consist of a large Testicle (t.), a seminal canal, at first attached along the Vagina (t.\* u.), and then taking its course to the Penis; and lastly, the Penis itself (a.), moved by a muscle (a."), and provided with a long appendage (a.'). Both Penis and Vagina ultimately terminate in the common sexual cavity, (fig. III. z. fig. IV. a.) opening externally below the right large feeler, (fig. I. c.) and presenting in its blind appendage (fig. IV. b. fig. III. y.) the little pointed calcareous body or dart (fig. IV. \*) attached to a small

† These hulls or cases in the *Buccinum undatum* form masses as large as a fist, and each contain some dozens of dot-like Ova. (See OKEN'S *Zoologie*, b. i. s. 271.)

projection. In the time of mutual copulation the sexual cavity is protruded (like a feeler, §. 98. 110.) through the external opening, the Penis at the same time is protruded as far as up to the insertion of its seminal duct, (see the sexual organs thus protruded, fig. XIII.) and the style or dart comes into view; which, after having served to produce mutual excitement, is cast off and subsequently renewed.\* Nearly the same description will apply to the sexual organs of Slugs (Limax); where, however, the ramified bladders and the sac for the style (dart) are wanting. Lastly, the sexual parts are similarly disposed in most others of the Gasteropoda breathing by detached gills or pulmonary cavities, except that, according to CUVIER, these organs in some species, *e. g.* the *Aplysia* and *Onchidia*, differ in the circumstance that the Penis is placed at a distance from the common sexual aperture, and connected with it only by means of a groove. (See Tab. III. fig. VII.)

§. 722. Before quitting the consideration of the sexual organs of the Gasteropoda, it still remains to notice some secretory organs which appear to be closely connected with the sexual function. In the first place it is remarkable how, in the two first Orders of Mollusca, the respiratory organs stand nearly in the same relation to the sexual organs and rectum as the urinary organs in the superior animals; a circumstance which affords an additional proof of the correctness of the character before assigned to the urinary system as a repetition of the respiratory organs. In addition, there are some peculiar excretory organs, consisting of a tolerably considerable mucous gland, or rather mucous cavity, which, placed in the vicinity of the respiratory cavity, (Tab. III. fig. III. d.) usually empties itself close to the anus by means of a peculiar excretory canal, (fig.

\* According to OKEN, (*Zoologie*, b. i. s. 315.) the dart is to the sexual aperture what the covering (§. 130.) is to the shell.

X. XI. l.) taking its course between the Rectum and Vagina or Penis. In many marine Snails (*Murex strombus* and others, and also the *Aplysia*), we meet with a glandular organ beneath the margin of the cloak, which secretes the purple fluid so celebrated amongst the ancients, and is apparently related to the sexual function.

(c.) CEPHALOPODA.

§. 723. In this Order of Mollusca, the organization of which is in so many respects more perfect than of those that preceded, the sexes are always perfectly distinct, though actual copulation does not appear to take place, the fructification of the Ova being rather (as in dioecious plants) the result of a simultaneous evacuation of ova and semen. The female organs in the common Cuttle-Fish consist of a large ovary, which is contained within a peculiar capsule at the lower part of the peritoneal sac, (Tab. IV. fig. XV. d.) and encloses a great number of ova, of various sizes, and of an oblong pointed shape. (Fig. XVI.) The ova are expelled by means of an oviduct (fig. XV. e.) placed on the left side, so that they pass under the Infundibulum, so often before mentioned, and are here evacuated with the current of expired water, in the same manner as the ova in Bivalves pass through the tube of the cloak. There appear, also, to be other secretions intermixed with the ova, giving to them the albuminous coating by means of which they are united into clusters. As secretory organs of this nature,\* we may notice in particular two large flat oval

\* These and similar glandular secretory organs in some degree supply the deficiency of a Uterus in the inferior animals, and, consequently, it is remark-

bodies, (fig. XV. g. g.) the internal structure of which resembles the tubular substance of the human kidneys; and also a small reddish bladder, (f.) observed between them by SWAMMERDAM. The *Sepia octopodia* and *Calmar sagittatus* differ from this structure in possessing a double oviduct, one opening on each side.†

§. 724. In the male Cuttle-Fish, according to CUVIER, a large, soft, and glandular Testicle occupies the situation of the Ovary in the female: from it arises a seminal canal, which first by its multiplied convolutions forms an epididymis, and then opens into the upper extremity of a spacious cavity, (described by SWAMMERDAM as the Testicle itself,) and containing, in addition to some thick mucus, numerous little, elastic, vermiform tubes, the true nature of which is altogether unknown, though they have been frequently examined, and even mistaken for seminal animalcules. The bag itself appears to be analogous to the glandular organs in the female for the secretion of Albumen, and in this view should be considered as a Prostate. (See note to the last §.) The extremity of the seminal canal, projecting beneath the Infundibulum, and placed above the peritoneal sac, is situated close to the Rectum on the right side; and, though it does not actually serve as an organ for copulation, has received from CUVIER the name of Penis. In two specimens of the *Sepia octopodia*, where I had the opportunity of examining the sexual parts, (though not in a perfectly fresh state,) I observed that a seminal duct proceeded on

able that in the superior animals, and even in Man himself, we find a rudiment of the Uterus in the male in the form of a secretory organ, the Prostate.

The duplication of the sexual organs, wherever it exists, appears to be a result of the union of two kinds of sexual organs (perfect hermaphroditism) in a single individual in the lower Classes.

each side\* from the Testicle, (Tab. IV. fig. II. z.) corresponding to the two oviducts of this species: each seminal duct had a glandular swelling (x.) at its origin, and opened on the Peritoneum close to the Gills. Close to, and in front of, the Testicle were two spacious sacs containing thick mucus, and each opening above the seminal duct by means of a peculiar excretory canal. (Fig. I. l.)

### SECTION III. *Sexual Organs in the Articulata.*

§. 725. It is remarkable that in this Class, where the external form in general is more developed, the Sexes are not only more uniformly distinct, and single copulation the most common, but also that the sex impresses a peculiar character on the entire form of the body, so that the males and females are often very considerably distinguished by differences in the size of the body, of their colours, or even of the formation of the extremities: differences which are pointed out by Natural History as regards Insects, but which also occur in Worms; whilst in the Mollusca, on the contrary, similar contrasts in the sexes of the same species have not been observed, and probably do not exist. As regards their sexual organs, however, many species of Worms

\* As COUVIER has stated that the seminal duct is single in the *S. octopodia*, I at first imagined that I was examining female organs; but, on the one hand, the nature of the testicle-like body, in which there were not any traces of ova, and, on the other, the analogy between the male and female genital organs prevailing through the whole animal kingdom, satisfied me that the view I have taken is the most correct.

approximate by hermaphrodital formations to the preceding Class, and many even to Zoophytes, by the probable occurrence of propagation without sexes.

(a.) VERMES.

§. 726. Among the Intestinal Worms, the Hydatids (*Entozoa cystica*, R.) do not present any traces of sexual parts,\* and consequently, appear to be produced by propagation without sexes. In the Tœniæ, (*Cestoidea* R.) small fossæ with external apertures, and situated in the middle of all, except the anterior smaller, segments of the body, are clearly recognizable as Ovaries, inasmuch as RUDOLPHI observed not only Ova, but also young Tœniæ in them. There are also single canals and penis-like projections, which appear to have the character of male organs; whence we may be allowed to suppose that these Worms are capable both of mutual hermaphrodital and individual hermaphrodital impregnation.† The sexual parts of the Trematoda appear to be hermaphrodital, whilst those of the Acanthocephala are distributed to separate individuals; and in such a manner that, in the *Echinorhynchus* for instance, almost the whole body appears to be an Ovary filled with ova, and emptying itself by a proboscis, whilst in the male, on the contrary, the sexual organ consists in a bladder placed at the farthest extremity of the body. Lastly, in the Nema-toidea, the sexual organs are very distinctly formed. The female is larger and thicker, and in much greater numbers

\* RUDOLPHI, *Hist. Entozoor*, t. i. p. 305.

† L. c. p. 317. The common Tape-Worm, at least according to CARLISLE, is also capable of propagation by division.

than the male: the female sexual aperture is in the vicinity of the cephalic extremity, with a Vagina extending inwards from it, and terminating in two very long (sometimes more than six feet) and extremely contorted tubes, joined at their other extremity, and containing an incalculable number of minute Ovula. In the male there is a small thread-like Penis (bifid, according to RUDOLPHI, in the *Ascaris spiculigera*), protruding at the caudal extremity, which dilates internally into a thick canal (Vesicula Seminalis), two inches long, which, in the last place, has inserted into it a thread-like vessel (Testicle), two feet long, and convoluted around the Intestinal Canal. In the *Cucullanus* the Penis is bifid (Tab. V. fig. VII. B.); the female sexual orifice is more in the middle of the body; the Oviducts more capacious than the Intestinal Canal, usually crowded with living young ones, and occupying nearly the whole of the body. (Fig. VII. A.)

§. 727. The sexual organs of the extraneous Worms are in general but little known, though the hermaphroditical formation (with mutual copulation, as in Snails) appears to be the most common; such is the case in the Leech, where there are two sexual openings on the anterior half of the abdominal surface,—an anterior male, and a posterior female. (Tab. V. fig. IX. a. b.) The former leads to a conical hollow organ, (fig. XI. a.) from the base of which proceeds a thread-like vessel (probably the Penis). The base of this cone is also perforated by the seminal ducts on each side, (fig. XI. c.) proceeding from two large Epididymes, (fig. XI. b. fig. X. e.) the Vasa inferentia of which are given off from a row of separate roundish pairs of Testicles. (Fig. X. d.) The female orifice leads to a capacious Vagina, (fig. X. g. fig. IX. e.) which is connected with the Ovaries (g. g.) by two Oviducts. (Fig. XI. h.) In the Earthworm there do not appear to be any true sexual apertures in the

situation where these animals adhere in the act of copulation, *i. e.* in the region of the circular belt, (fig. I. b. c. d.) but; instead, near the heart-like vascular circle, (§. 693.) a row of Ovaries (fig. III. A. d. d. d.) around the Œsophagus; whilst, on the contrary, I myself, as well as MECKEL\* and MONTEGRE,† have distinctly observed the living young unattached between the cellular parietes around the intestinal canal, corresponding closely to their situation in the Cucullanus. The mode in which they are removed from that situation is not very obvious, though it is probably by means of the longitudinal projection at the back of the intestine, which I find to be a hollow tube.‡ (Fig. III. k.) According to CUVIER, the Ova, or young animals, are similarly situated in the *Lumbricus marinus* and Aphrodite.

(b.) CRUSTACEA.

§. 728. The sexes are here perfectly distinct, but the sexual organs double, (forming, as it were, a repetition of the two kinds of organs so commonly existing in the preceding Order,) so that two male and female sexual openings exist in each individual. In the female of the Cray-Fish there is a tolerably large Ovary upon the Intestinal Canal behind the Liver, (Tab. VI. fig. XI. f.) from which proceed two capacious Oviducts, (fig. XI. g. g.) sur-

\* Translation of CUVIER'S *Comp. Anat.*

† *Mémoires du Muséum d'Hist. Nat.* t. i. p. 242.

‡ It is farther remarkable of the sexual bladders at the cephalic extremity of the Earthworm, that, as already mentioned, (§. 572.) they agree, both in form and situation, with respiratory bladders.

rounding the Intestinal Canal and muscles of the tail, and terminating at the root of the third leg on each side. (Fig. VIII. a.) When the Ova are expelled they are lodged upon the little fin-like laminæ under the tail, (fig. XII.) which is so far remarkable, as it forms another instance of the transference of the Ovum from an internal to an external organ, and as these laminæ are themselves merely repetitions of the branchial laminæ of the Squillæ. In the male there is a tri-lobed Testicle occupying the situation of the Ovary in the female, (fig. X. a.) and from it arise two long, minute, white seminal vessels, (b.) which are very much convoluted, like the seminal vessels of the *Ascaris*, gradually increasing in thickness; they then suddenly become small again, and immediately expand into a Penis half an inch long, and contained within the body, (fig. I. h.) but probably, like the Penis of Snails, protruded at the time of copulation from a tubercle at the root of the last pairs of legs. Close to this tubercle, on the under surface of the tail are two bony, groove-shaped, moveable masses, which are considered by CUVIER as the true Penis, although CAVOLINI\* and others had already described them as being merely excitative organs, because they are so far removed from the opening of the seminal canal that it is impossible they should be intended to conduct the semen to the orifice of the Oviducts.

(c.) INSECTA.

§. 729. In this extensive Order the sexes are invariably perfectly distinct, and frequently the males and females so

\* *On the Generation of Fishes and Crabs, translated by ZIMMERMANN.* Berlin, 1792, p. 121. He found two pairs of such parts in the Pungier.

very different as to appear as though they belonged to different species: individuals without sex are, however, very common among Bees, Wasps, Ants, though more properly to be considered as females in which the sexual parts are undeveloped.\* But though the internal sexual organs are still ordinarily double, the external sexual openings are single, as in the superior Animals. In the latter respect, indeed, Spiders form a remarkable exception, reminding us of the structure in Cray-Fish: in both sexes† the external genitals are situated on the anterior part of the abdominal surface between the branchiæ, presenting in the females two orifices (Tab. VII. fig. VIII. B. a. a.) belonging to the very simply organized pouch-shaped Ovaries, (d. d.) and in the male two openings (fig. VIII. B. a.) belonging to the seminal canals (b.) of the similarly pouch-like testicle. (c.) An evident approximation to the preceding Order consists in the fact, that in the Onisci the Ova pass from the Ovaries between some valves placed on the abdominal surface, in order to be there farther developed;‡ which valves have a great resemblance to those covering the Gills, (§. 577.) and are also situated in the immediate vicinity of the respiratory organs. It is remarkable that this development of the Ova in an external organ is so far imitated even in Spiders, that the female surrounds the Ova as they escape with a web; the bag thus formed being attached to its own body by the *Aranea saccata*, and carried about

\* The influence of the difference of sex on the development of the extremities is very remarkable; for, in the Glow-Worm, for instance, the female, and in Ants those that are without sex, are Apterous.

† Previous to TREVIRANUS it was supposed that the male organs of Spiders consisted in the Antennæ: he has shewn, however, that their knob-like extremities are merely excitative organs. (*Ueber. d. Bau d. Arachnid.* s. 37.)

‡ G. R. TREVIRANUS on the Organization of Apterous Insects, in his *Vermischte Schriften.* b. i. s. 60.

with it. In the Scorpion, TREVIRANUS\* found the external genitals alike in both sexes, (the male being distinguished only by two small penis-like projections,) and consisting of a small opening with a comb-shaped lamina on each side. The internal organs consist, in the female, of three tubes connected by transverse vessels, (in the oviducts of the Scorpion, REDÍ usually found from 26 to 40 young ones,) and in the male, of two testis-like bodies, with vasa inferentia arising from the Liver or adipose body.†

\* *Ueber d. Bau. d. Arachniden*, s. 11.

\* In Woodlice the male organs consist of a Penis placed at the extremity of the abdomen a little above the anus, and communicating with a common spermatic duct arising by two vasa deferentia from the Testicles, which are elongated and formed by a single order of vessels. The female organs consist of a vulva leading to a common Oviduct, which divides into two, and sometimes four, branches or ovaries. These animals are viviparous, the young ones being hatched within the uterus or common oviduct, and when hatched escaping at the lower part of the abdomen in order to be lodged between the legs of the mother until they are capable of independent existence.

In the Phalangides the male organs are composed of two white pyramidal testicles, with two vasa deferentia proceeding from them, and opening into a large common seminal canal, within which is a cylindrical horny projection that probably serves as a Penis. The vesiculae seminales also open into a common seminal canal, and are formed by two cylindrical, capillary, and extremely contorted tubes. In the female there is a common oviduct opening by one extremity at the upper part of the body near the mouth, and at the other communicating with two canals, which dilate into the Ovaries. The most remarkable circumstance, however, is the canal by which the Ovaries again open near the mouth. It is six times as long as the body, and after gradually contracting for a certain space, suddenly expands into a cylindrical tube. It consists of two membranes; of which one is cellular, and surrounds it loosely, whilst the other is composed of spirally convoluted fibres, and is very elastic. The Ova, which are formed in one only of the Ovaries at a time, are found in the part of this canal next the Ovary, the common oviduct first described probably serving rather as a Vagina than as an oviduct properly so called.—(MARCEL DE SERRES, *Mém. du Muséum*, v. 83, 108.)  
—Translator.

§. 730. The organization of the sexual organs in the more perfect Worms without vessels, *e. g.* the *Ascarides*, may serve as a prototype for those of the remaining Insects which breathe through Tracheæ. As in them, so also here the seminal organs as well as the ovaries are merely long, and frequently very much convoluted, tubes; so that there are in fact neither Ovaries nor Testicles properly so called, but merely seminal canals and oviducts; which, however, are usually connected with several secretory organs of various kinds. In the *Gryllus verrucivorus*, among the Orthoptera, we find two large tuft-shaped Ovaries, which consist of numerous tubes placed near each other, and interwoven with extraordinarily large and numerous Tracheæ.\* Both empty themselves by a common Oviduct, which unites with that of the opposite side into a short Vagina, into which opens a little bladder, provided with a peculiar convoluted secretory vessel terminated by a blind extremity. From the Vagina the Ova pass into a laying tube of considerable length, which exists also in several other Insects, *e. g.* Wasps, (reminding us of the evacuation of the Ova through the tube of the Cloak in Mollusca, §. 718. 723.) and here consists of two long, narrow, and pointed laminae closing into each other at the sides. The male organs consist in two yellowish Testicles, (Tab. VII. fig. XXIV. a.) formed by seminal vessels, and penetrated by numerous Tracheæ: the excretory duct by its minute convolutions forms an Epididymis, (fig. XXIV. b.) then receives two tuft-like bundles of coecal vessels, (h. i.) and, lastly, opens together with that of the opposite side into the Penis, which presents a tongue-like body, (e.) surrounded by a circle of skin armed with two little hooks.

\* Is it not probable that the number of these Tracheæ is connected with the very considerable size to which the Ova of these animals attain within the body of the mother?

Among the Hemiptera, the female organs of the Water Scorpion (Nepa), according to SWAMMERDAM, consist of two Ovaries formed of five canals, the Ova being distinguished by a row of bristles at their upper extremity: the male organs are formed by two bladders with two extremely convoluted seminal tubes, and on each of them five seminal vesicles, at the base of each of which is inserted a minute testicle-like convoluted seminal vessel. Among the Neuroptera, I shall notice only in the Libellula the remarkable position of the male organ at the anterior part of the long and narrow abdominal surface, whilst in the female it is at the posterior part of the body, thereby explaining their peculiar mode of copulation.\*

§. 731. Among the Hymenoptera, SWAMMERDAM found in the Queen Bee two large Ovaries consisting of numerous strings of Ova, estimated to amount to ten or twelve thousand: the Vagina is placed at the termination of the common duct of the two Ovaries, and has connected to it a little bladder with two secretory vessels, which here, as well as in other Insects, are supposed to prepare the viscid covering of the Ova. The male organs of Bees consist of two Testicles of tubular structure, two seminal ducts, two bladders, and a Penis, which, like that of Snails, is everted when it is protruded. In the Coleoptera, the female organs are simpler, and more like those of the Water Scorpion: in the Rhinoceros Beetle, for instance, according to SWAMMERDAM,† there are only six tubes on each side, containing but a moderate number of ova; and the Vagina again receives several secretory organs. In the male the two Testicles are divided into six little flat bodies, each sending off a little canal, which, uniting with the rest, assist in forming the common seminal canals, that enlarge as they proceed downwards on each side. Where

\* SWAMMERDAM, *Bibl. Nat.* p. 96. † *L. c.* Tab. XXX. fig. X.

the two seminal ducts unite in the canal of the Penis, there are also two little seminal bladders, into the bottom of which opens a delicate convoluted vessel, about 20 inches long. In the Lepidoptera we may take as an instance the sexual parts of the *Papilio brassicae*, L. lately so well described by HEROLD.\* The female organs consist on each side of four long spirally convoluted tubes, containing a great number of Ova (Tab. VII. fig. XXVI. A. a. a.); both organs unite in a short Vagina, that also receives the orifices of a simple bladder and of a smaller one with two cornua and secretory vessels, (c. d. e.) as well as a larger cavity, (b.) which HEROLD considers as the receptacle of the male semen. The male organs are a red spherical Testicle, composed of two halves (fig. XXVII. A. a.); two long and delicate [seminal canals, (b. b.) each of which receives a long convoluted seminal vessel (c.) before it unites with its fellow to form the common seminal duct. (d.) It is remarkable in the history of the development of these organs, that in the very young Caterpillars the organs of each kind differ but little, and appear as little buds (fig. XXVI. C. female, fig. XXVII. D. male); in the full-grown Caterpillar approach more closely to their subsequent form, (fig. XXVI. B. fig. XXVII. C.) and attain their ultimate perfection in the Pupa.

\* *Entwicklungsgeschichte des Schmetterlings.* Cassel und Marburg. 1815.

B. *Sexual Organs in Animals with Spinal Marrow  
and Brain.*

SECTION I. *Fishes.*

§. 732. In the species of animals reviewed in the preceding paragraphs we found it a general rule, with a few exceptions, (*e. g.* the Cephalopoda,) that the ova are formed in considerable numbers in the organs destined for that purpose, and then simultaneously evacuated to be again simultaneously renewed, (like the yearly production of new fruits on Plants;) if, indeed, the animal be capable of repeated generation, which is not the case in most Insects for instance. In the higher Classes of Animals, on the contrary, it generally happens that the Ova, when they can be detected preformed in the Ovaries, are originally formed in a definite number, but then gradually arrive at maturity, and detach themselves, so that there are constantly Ova in the Ovaries, but of very different sizes. Most Fishes, however, here again form an exception, and approximate to the inferior Classes by the periodical and simultaneous growth, evacuation, and regeneration of large numbers of Ova: nay, there are even some species in which various observations have rendered it probable that the hermaphroditical formation exists, by means of which they are rendered capable of self-impregnation. This is the case, according to CAVOLINI,\* in the *Perca marina* and the *Canna* (*Hiatula Salviani*, L.); and, according to HOME,† in the Lam-

\* *Ueber Erzeugung d. Fische und Krebse*, s. 82.

† *Philosoph. Trans.* 1815.

prey (*Petromyzon marinus*) as possessing both Testes and Ovaria. I confess, however, that though I find the Ovaries very distinctly in the Lampreys, I am still doubtful as to the true character of the Testicle-like<sup>o</sup> body, inasmuch as it is very possible that these animals, which have so much resemblance to Worms, may also approximate to them in the circumstance that the females are found in much greater number than the males.\*

§. 733: The following is the usual state of the sexual organs in the Osseous Fishes:—The Ovaries form two large sacs extending on each side of the Intestinal Canal to the under surface of the Liver, and attached by a kind of Mesentery: they are supplied and fixed by minute blood-vessels, and have processes extending from the inner surface of their parietes, to which the Ova are attached, and in such numbers, that towards spawning time the Ovaries occupy nearly the whole of the cavity of the abdomen, some hundreds of thousands of Ova having been counted in a single Fish. These sacs open by two very short excretory canals, which immediately unite into one, terminating together with the urinary organs immediately behind the anus. (Tab. X. fig. III. A. B.) The Testicles (Tab. IX. fig. XVIII. XIX. h.) present precisely similar sacs, containing, instead of Ova, a whitish, seminal (and, according to FOURCROY and VAUQUELIN, highly phosphorescent) fluid, secreted from their internal parietes, and discharged at the same place as the Ova of the female. Like the Ovaries, also, the Testicles swell at the spawning season, and it is easy to see from this organization, what is also proved by observation, that no copulation, properly so called, can take place. As deviating from this form, I may notice, first, the Ovaries of the Trout, of moderate

\* Among the Ascarides, for instance, the number of males is very inconsiderable.

size and situated high up close to the Liver; in which I do not find the Ova simultaneously developed as in the Carp, Pike, &c. but, on the contrary, of various sizes: nor is there any peculiar Oviduct to be detected, the Ova, which when they have attained their full growth are nearly as large as a pea, detaching themselves and falling into the cavity of the abdomen, which therefore is frequently found quite full of unattached Ova. They are evacuated, however, through the openings, before mentioned (§. 472. 599.), of the abdominal cavity close to the anus, which openings these Fishes, even the Males, possess as well as the Rays, with this difference only, that they here unite into a common external aperture. This circumstance, not before detected by any observer, is remarkable, in so far as it reminds us of the deposition of the Ova within the abdomen of several Worms, and serves to throw a clearer light on the true nature of these mysterious openings into the abdomen; inasmuch as they here serve as uterine apertures, of which they are merely a repetition in the higher Order of Rays and Sharks, and in them stand in relation to the respiratory, connected as it always is, with the sexual function.

§. 734. A remarkable transition to the Cartilaginous Fishes is formed by several Osseous, *e. g.* the *Blennius viviparus*, which bears living young, though we still need a more complete investigation of its sexual organs. As regards the Cartilaginous Fishes, their sexual organs in the *Branchiostegi*, *e. g.* the Sturgeon, agree with the usual form of those of the Osseous Fishes; but there are also viviparous species, *e. g.* the *Syngnathus acus*, of which ARISTOTLE long ago remarked, that the young escaped through an extensive fissure in the abdomen, which again closes after their birth; a fact confirmed also by CAVOLINI, who states, that the young are formed in a sac behind the anus, which opens when they arrive at maturity: a remark-

able phenomenon, which, however, appears to me to agree closely with the mode of expulsion of the Ova of the Trout, and may probably be explained by supposing that the Ova, escaping from the Ovary, are developed in a particular part of the abdominal cavity, and are then expelled through a similar natural (not new-formed) aperture of the abdomen itself, which merely dilates in an extraordinary manner at the period of parturition. Lastly, in the females of Sharks and Rays, there are two small Ovaries situated under the Liver, in which the Ova are developed individually, not simultaneously, as in Osseous Fishes, and two Oviducts, each of which (Tab. X. fig. IX.) receives the Ova from the Ovary by means of a floating\* extremity placed near the Heart and Liver, for the most part containing the young until the period of their full development like a Uterus, and ultimately evacuating them through the pudendum, which is situated behind the anus, and furnished with a penis-like projection (Clitoris). In the *Squalus acanthias*, HOME† always found several Ova surrounded by transparent jelly, and enclosed within a common capsule pointed at the corners (fig. IX. e.); he observed, too, that the young were always completely developed within these eggs, whilst, on the contrary, the *Squalus canicula* is, according to him, merely oviparous. In the male, the testicles are already of a more glandular structure, and occupy the same situation as the Ovaries in the

\* This floating orifice (Fimbriated extremity of the Fallopian Tube in Man) serves to distinguish the Oviducts of the superior from those of the inferior animals, where the Oviduct appears to be merely a continuation of the membrane of the Ovary. Is it not allowable to consider these orifices as the apertures into the cavity of the abdomen (e. g. of the Trout) inverted and elongated into tubes?

† *On the Mode of Breeding of the Cvi-viviparous Shark in the Philos. Transact.* 1810.

female (Tab. X. fig. II. n.): the excretory duct by its numerous convolutions forms a long Epididymis, and then dilates into a kind of Vesicula Seminalis, (p.) which is connected with its fellow, and opens in common with the urinary passages into a heart-shaped cavity with an external projection (Penis). Consequently, there is true copulation, at which time the male grasps the female by the posterior extremities, already noticed (§. 168). In the Lamprey there is a similar conical projection, within which the Ova and Semen are intermixed: two apertures lead to it from the cavity of the abdomen, in which the Ova detached from the Ovary remain until they are transferred into this conical cavity, and thence ultimately expelled.

## SECTION II. *Sexual Organs in Amphibia.*

§. 735. The Sexual Organs in this Class approach most closely to those of Rays and Sharks. In the Frog, the Ovaries are situated in the lumbar region: each is divided into several (sometimes nine) lobes, and consists of thin membranes, in and upon which the Ova are formed, and in such a manner, that, nearly as in Osseous Fishes, an extraordinary number are produced at the spawning season, distending the Ovary until they are deposited. At the upper part of the Ovaries there are also peculiar oblong, finger-shaped, lobes of fat supplied by their own vessels, and which have been occasionally viewed as Renal Capsules, but which, however, particularly as they are already very large in the Larva, appear to me to serve rather as

deposits of nutritive matter subservient to the sexual function, nearly like the fatty bodies in Caterpillars. The Tubes or Oviducts open on each side between the Heart and Liver,\* then descend with many convolutions close upon the vertebral column, each dilating, before its entrance into the Cloaca, into a membranous bladder, in which the Ova are collected, distending the body of the animal in an extraordinary degree, and are then expelled in the form of masses glaed together by jelly; thus reminding us of the clusters of Ova in the Mollusca. As to this gelatinous covering of the ova, it is secreted in the Oviducts towards winter time, and, according to BRANDE,† is intermediate in composition between mucus and albumen, on which account it swells extraordinarily in water, as I have often had occasion to observe.‡ In addition to these internal organs, there are, also, in the Surinam Toad external organs subservient to the formation of the young, and perfectly resembling phenomena before noticed, *e. g.* in Bivalves, &c. The ova are here impregnated by the male on the back of the female, and it is not until that time that the cells on the surface of the back are produced, in which the animal hatches its young; a circumstance that receives

\* From the remoteness of the termination of the Oviduct from the Ovary, the transference of the Ova from the one to the other is very difficult of explanation, and can only be imagined to take place by the existence of a direct attraction between them.

† See HOME's *Essay on the Breeding of the Shark. Philos. Trans.* 1810. p. 205, where this jelly is stated to be similar to that found in the Oviduct of the Shark.

‡ In spring it is common to find near brooks, or after rain, masses of tough mucus with fragments of these Oviducts, which have been ejected by Birds on account of the manner in which they have swollen. They were formerly considered as the jelly of star-shoots, or as a Tremella (*nostoc*); but I have evidently distinguished fragments of the Tubes in such masses.

additional interest from the fact, that it is the cutaneous organ, which, as we have already seen, is the primary respiratory organ that is employed in supporting the young. In the male Frog, there are two oval Testicles of granular substance, provided with two little fatty lobes like those of the Ovaries, and like them increasing very considerably at the breeding season; and also two seminal canals connected with the Ureters, and dilating into Vesiculæ Seminales previous to their entrance into the Cloaca. Here, also, there is not any proper copulation; instead of which, the male grasps the female by means of two thumb-like tubercles, which appear at the spawning season, and pours his semen over the Ova as they issue from her. The female sexual parts of Salamanders are distinguished from those of Frogs as regards the Ovaries, (Tab. XIII. fig. IV. g.) in which the Ova are more permanent, and detached in smaller numbers at once. The Oviducts (d.), also, are each dilated inferiorly, not into a bladder, but into a long canal, within which the Ova are developed precisely as in a double Uterus. The male organs consist of a double Testicle on each side, (Tab. XIII. fig. III. h.) several blackish tube-shaped Vesiculæ Seminales turned towards the Kidnies (k.), and two small triangular folds of the Cloaca, which appear to be rudiments of a double Penis (e. e.). In the Proteus, too, where rudiments only of Ovaries had been admitted, RUDOLPHI\* has discovered not only Ovaries and Oviducts, but also in other individuals Testicles and Seminal ducts.†

\* OKEN's *Isis*, b. i. h. vii. s. 1017.

† That the Aloxoti, or Mexican Proteus, is also a perfect animal, and not merely a Larva, has recently been established by Sir E. HOME, who found in different specimens both male and female organs, not differing in any essential points from those of the Batrachia. (*Philosoph. Trans.* 1824. p. ii. 429.)—*Translator.*

§. 736. In the Mud-Tortoise (*T. lutaria*) I find two large Ovaries at the lower part of the abdomen, to which are attached, by means of pedicles, bright yellow Ova covered by a very vascular membrane which remains as a Calyx, after the expulsion of the Ova, and then withers away. The Oviducts are very long, attached to a vascular Mesentery, and in the individual that I examined contained on the right side six, and on the left three eggs an inch long, and with solid shells. Both Oviducts opened into the Cloaca, with which two empty membranous bladders were connected on the right and left sides: there was, also, an egg in the Cloaca, and a Penis, small, but otherwise precisely like that of Man. In the male, I find two oval yellowish-red Testicles below the Kidnies, with a kind of Epididymis formed by their large and blackish seminal ducts, which last open at the root of a large and tongue-shaped Penis, concealed within the Cloaca, moved by its peculiar muscles, and grooved at its extremity, instead of being perforated like that of Man.\*

§. 737. In Serpents, the Ovaries, forming two elongated bodies furnished with Ova of different sizes, are situated on each side of the Spine above the Kidnies: the Oviducts are of considerable length, and the Ova within them arranged in such a manner, that those lodged within one correspond to an unoccupied space in the other. In the Viper, too, as in the Salamander, the Oviduct serves for hatching the ova. These canals open into the Cloaca close to the Ureters. In the male there is an oblong Testicle on each side with a very much convoluted seminal duct, that with its fellow opens into the Cloaca at the root

\* Hence in these animals there is an ardent and long-continued copulation.

of a double,\* grooved Penis; which, though not capable of being very far protruded, permits of actual copulation. Nearly similar, too, is the disposition of the sexual organs in Lizards, except that the course of the seminal duct being shorter, it forms a more perfect Epidydimis, and that in the Crocodile the Penis is single.

### SECTION III. *Sexual Organs in Birds.*

§. 738. The female sexual organs of Birds are extremely similar to those of Amphibia, particularly Tortoises, except that here, and here only of the higher Classes of Animals, the internal genital organs are single. The Ovary is placed in front of the Aorta, above the Kidnies, and below the Liver (Tab. XV. fig. XII. f. Tab. XVI. fig. XVI. a.); has a clustered shape; and increases considerably in size at certain periods in those Birds that breed periodically: it contains some hundreds of soft Ova of different sizes, surrounded by a vascular membrane, which forms pedicles for their attachment, and as they increase presents a white line in front, (Tab. XVI. fig. XVI. c.) indicating the spot at which the vascular membrane (Calyx) gives way in order to allow the escape of the Ovum, subsequently shrinking away. (d.) The egg is received into the single oviduct,

\* This double Penis corresponds to the cloven Tongue of these Animals, to the double Penis of several Worms, and to the double sexual organs of many of the inferior animals.

which commences by a fine membranous and funnel-like orifice, and gradually assumes nearly the form and structure of a common Intestine,\* except that it is softer and more flattened: it is attached by a mesentery, and making several convolutions (fig. XVI. f.) descends to the Cloaca. The internal membrane of the oviduct varies in different points: it is first precisely like the villous membrane of the Intestine; is then plicated; presents long villi at the point where the egg remains for a considerable time, and where its calcareous shell is secreted; and then again becomes smoother, and plicated longitudinally: this, however, does not form any ground for dividing it into Vagina, Uterus, and Fallopian Tubes, inasmuch as the Ovum is here developed external to the body of the mother, and the whole Oviduct, consequently, is analogous to the Fallopian Tubes in Man. The Oviduct always enters the Cloaca on the left side near the Rectum, (fig. X. b.) where it is furnished with a sphincter muscle: according to PERRAULT, also, the Ostrich and Cassowary present traces of the existence of a little Penis, shaped like that of Man. Lastly, the various stages of developement are very distinctly perceptible in these genital organs, the Ovary and Oviduct being reduced in old Birds nearly to the same inconsiderable size as they originally present in young ones.

§. 739. The male genital organs of Birds approximate still more closely than the female to those of Amphibia, owing to the existence of two Testicles† and their seminal ducts. The Testicles are situated at the upper end of the Kidnies on each side of the Aorta, their size being subject to much variation according to the season of year;

\* There is even the same peristaltic motion of their contents in both cases.

† As an occasional variety there is sometimes one, and more rarely there are three Testicles.

so that at breeding time they are of extraordinary size, and at other periods frequently scarcely perceptible. (Tab. XVI. fig. XV. a.) The left is generally larger than the right, as has also been remarked by TANNENBERG and TIEDEMANN;† their shape is usually oval, their colour yellowish; and their very soft and delicate parenchyma, inclosed within a thin and vascular membrane, frequently gives to the whole Testicle a striking and, physiologically, very remarkable resemblance to one of the Ova in the Ovary, consisting merely of yolk. Several canals issuing from each Testicle unite to form the very much convoluted seminal duct, composing the Epididymis, (fig. XV. b.) which is particularly distinct at the pairing season, and which often presents a peculiar imperforate seminal vessel ascending towards the Renal Capsules, or cavity of the Thórax. The seminal duct, descending towards the Cloaca, is arranged in close serpentine convolutions; is firmly attached to the Ureter (fig. XV. c.); immediately before its termination at the edge of the Rectum, close to the Ureter of the same side, presents a small vesicular dilatation; and, as is also the case in several Amphibia and Fishes, a small gland that may be compared to the human Prostate. Each seminal duct terminates on a wart-shaped projection, which together correspond to the double Penis of Lizards; but there is also occasionally a larger Penis, essentially similar to that of Tortoises, *e. g.* according to TIEDEMANN, in the Ostrich, Cassowary, Bustard, and Stork, and likewise in Ducks and Geese. It consists of tongue-shaped body, grooved superiorly for conducting the semen, and moved by peculiar muscles: in Ducks it is of very considerable length, amounting to some inches, being protruded at the time of copulation like the Penis of Snails

† *Zoologie*, b. ii. s. 697; and G. TANNENBERG, *Spicilegium Observationum circa partes Genitales Masculas Avium*. Gott. 1789.

or the long tongue of Serpents, and at other times being concealed within a peculiar sac of the Cloaca. We must not quit the genital organs of Birds without noticing the remarkable differences in the size and plumage of this Class connected with them, inasmuch as this circumstance, as well as the developement of the Ova external to the body, indicate an approximation to the type of the more perfect Insects.

#### SECTION IV. *Sexual Organs in Mammalia.*

##### (a.) FEMALE.

§. 740. In the female procreative organs of the preceding Classes we have observed, 1st, the Ovaries, invariably existing; 2d, in some species only, *e. g.* Bivalves, Crabs, and even among Amphibia, in the Pipa, external organs subservient to the support of the young, not immediately connected with the internal genital organs, and often originally devoted to other functions; 3d, internal organs which permit the birth of the young either in a state of complete developement, or still included within an egg,—as is the case in some Insects, *e. g.* the Scorpion,—in Snails,—in most Fishes,—in Salamanders and Vipers. It is only in Mammalia that all these organs are combined, and consequently in them we find, 1st, as generative organs,—the Ovaries; 2d, as internal organs for conveying and perfecting the Ovum,—the Oviducts, (Fallopian Tubes,) Uterus, and Vagina, together with the external copulative organs

situated at the orifice of the latter; 3d, as external nutritive organs,—the Mammæ, the existence of which, we shall find, is connected with the composition of the Ovum in Mammalia, in which the yolk of the Ovum in Birds (forming, as it were, a receptacle of Chyle for the nutrition of the young after the period of incubation) is for the most part wanting, thereby rendering necessary the existence of another organ for the nutrition of the young after birth. These latter organs are the only ones which have hitherto been looked for in vain in only two species, viz. the Ornithorhynchus and Echidna. We shall proceed successively through the different forms of these organs, assuming the human organization as the general prototype, and considering more particularly the different deviations from it.

§. 741. 1. *Ovaries*. There are invariably two, even in the Ornithorhynchi and Echidna; but in several species they approximate considerably to the form of these organs in Birds and Amphibia, in so far as it is very easy to detect their composition of individual ovular vesicles. This is particularly the case in the Rodentia, *e. g.* in the Rabbit, Rats, Guinea-Pig, Hedgehog, and, according to CUVIER, above all in the Opossum. So, also, the Ovaries of Swine are composed of several globular masses of various sizes; which, however, are not so much individual Ova as separate small Ovaries, because when cut into they present a dense texture with little cells exactly like a human Ovary, and are also found in the same state during pregnancy. (Tab. XX. fig. IX.) Lastly, I may mention the singular elongated form they present in the Porpoise, as observed by HUNTER,\* resembling the figure of the Pancreas, and corresponding to their shape in the human embryo.

2. The *Fallopian Tubes* (Oviducts) continue to present

\* *Philosoph. Trans.* 1787, p. 444. (Their length five inches.)

their expanded orifices to the Ovaries, as was the case in Amphibia and Birds: inferiorly, however, they open into the Uterus instead of the Cloaca, and differ from those of Women principally in their smaller size in proportion to the Uterus, in their more contorted course, and in the less indented margin of their abdominal orifice, (Tab. XX. fig. IX. b.) which is occasionally very large, *e. g.* according to HUNTER, five or six inches across in the Porpoise.

§. 742. 3. The *Uterus*. When in the preceding Classes of Animals we found internal organs for containing the young during the period of their development, and the living young ones born either as such or enclosed within an egg, those organs consisted merely in dilated portions of the Oviducts, forming as it were two Uteri; each of which emptied itself by its own aperture through the common sexual opening. Among Mammalia this, according to HOME,\* is the case in the *Ornithorhynchus*; in which each Oviduct is somewhat dilated inferiorly, thus forming a kind of Uterus, opening opposite to its fellow into the short Vagina in such a manner that the orifice of the Bladder is intermediate between the two openings of the Uteri, neither of which is surrounded by a Cervix. (Tab. XX. fig. X.) The nearest approach to this form is in the perfectly double Uterus of most of the *Rodentia*, *e. g.* Hares, Rabbits, Rats, and Mice, which opens with two separate projecting orifices into the Vagina, each half like the Oviducts of Birds and Amphibia, completely resembling an Intestine, even in the arrangement of its muscular fibres: of the same kind are, also, the Uteri of Swine, formed almost precisely in the same manner. Next come the different kinds of Uterus single in the middle, but with lateral Cornua. It is necessary first, however, to notice the remarkable

\* *Phil. Trans.* 1802, p. 81.

structure of this organ (*Uterus aufractuosus*) in the marsupial animals,—Opossums, Kangaroos, Wombat, &c.

§. 743. In them, as in the animals with a perfectly double Uterus, there are two openings into the Vagina, with the orifice of the urinary bladder between them: each of these uterine orifices leads to a separate canal bending considerably inwards, and resembling an ordinary intestine-like Uterus, the upper extremity of which unites with that of the opposite side to form a capacious cavity terminating in a point inferiorly. (Tab. XX. fig. XIII.) This central cavity is incompletely divided into two lateral halves by a longitudinal ridge, and appears to be completely closed at its lower part when unimpregnated. According to HALLÉ,† however, during pregnancy, and also during parturition, and for some time subsequently, it opens into the Vagina by a narrow fissure, through which the young passes in the state of a perfect embryo, (occasionally weighing 21 grains, when the mother weighs 56 pounds,) by means of the Vagina, into the bag containing the mammæ: the semen, on the contrary, probably passes through the lateral canals in its course to the central cavity, which receives the Ova from the Ovaries by means of two Oviducts, that become larger as they descend. A gelatinous substance, like that found in the Frog or Shark, is secreted within this Uterus during pregnancy in such quantity that the lateral canals are completely obstructed by it, and the young animals firmly incased within it. A similar jelly is found likewise in the pregnant Uterus of most Mammalia, where it serves, however, merely to close the orifice of the Uterus, *e. g.* in the Cow, Horse, Dog, &c.

§. 744. There is this peculiarity in the Uterus of the Carnivora, certain Rodentia, *e. g.* the Agouti and Guinea-

† *Philos. Trans.* 1795.

Pig, Bats, Cetacea, Ruminants, Swine, and Solipeda, that though opening inferiorly by a single orifice, it is elongated superiorly into a Cornu on each side, (Uterus bicornis,) which is usually longer and more intestine-like in proportion as it serves to lodge a greater number of Ova. Such is the case, for instance, in the straight-horned Uterus of the Dog and Cat Genera, of the Bat and Seal, as well as in the Uterus of the Pig, Hedgehog, and Mole, with Cornua bending downwards: a long-horned Uterus of this kind, which comes nearest to a double Uterus, might be properly called Uterus bipartitus; and that with short Cornua, on the contrary, distinguished more peculiarly as Uterus bicornis. In those animals, *e. g.* Ruminants and Solipeda, where there is usually but one young one at a time, the Cornua of the Uterus are shorter, forming as it were merely appendages to the central part, with this difference, however, that in the Ruminants, *e. g.* the Sheep, and Cow, (Tab. XX. fig. XVI.) there is an imperfect septum in the body of the Uterus (bicornis divisus), which is wanting in the Solipeda (Uterus bicornis simplex). The mode of attachment of the long-horned and double Uterus of Mammalia is also remarkable, not consisting merely, like that of the Oviducts of the inferior animals, in a kind of Mesentery, of which the broad ligaments of the simple Uterus are rudiments; in addition to these there are also round and vascular fibrous cords, which exist as round ligaments passing through the abdominal rings even in the more simple form of Uterus, *e. g.* the human, but are here double, extending in the same manner downwards from the region of the crura of the Diaphragm resting on the spine, as from the abdominal ring upwards.\*

\* These superior round ligaments of the Uterus have been particularly noticed by RUDOLPHI and NITZSCH. (MÜCKEL'S *Archiv.* b. ii. h. 2.) The true character of the round ligaments is very obscure, but they appear to

§. 745. The last principal form of the Uterus is triangular or oval, which we first perceive in the Anteaters and Armadilloes, (which approach to Birds by the existence of a Cloaca,) and also in Sloths, but in such a manner that its orifice does not form a proper Cervix, and, consequently, the organ resembles the Bursa Fabricii, or a portion of the Oviduct of Birds, rather than the human Uterus.† Much more similar to the latter is the single Uterus of Apes, and that not only in shape but also in the nature of its parietes. The double as well as the bicornute Uterus resemble a true Intestine or an Oviduct in this respect, that their parietes are thin, but their muscular fibres, on the contrary, very distinctly perceptible: the single Uterus, on the other hand, and even that of Anteaters, but more particularly of Apes and Man, has extremely thick parietes, the muscular fibres being much less evident, especially in the unimpregnated state. Lastly, the Makies form a transition from the anthropomorphous structure of the Uterus of Apes to that of the Carnivora by the division of the fundus into two cornua; a structure that exists constantly in the Uterus of the human embryo, and occasionally presents itself as a permanent malformation in the adult.

§. 746. 4. *External Organs for Copulation.* In Birds and Amphibia, the last dilatation of the Intestinal Canal (Cloaca) served in the female as the external organ of

me to correspond most perfectly with the retroverted elevator muscles of the Testicles, (Gubernaculum of HUNTER,) of the origin of which we shall have occasion to speak hereafter. It is remarkable, also, how the vessels of these ligaments form an immediate connection between the internal organs for lodging the young and the external abdominal surface, where there are similar external nutritive organs (Mammæ); which last are originally placed in the inguinal region. The upper ligaments I consider as merely repetitions of the lower, and they seem also to be much less vascular.

† This resemblance to Birds has been also remarked by MECKEL, *Translation of CUVIER.*

Copulation; whilst, on the contrary, in Fishes, the urinary and sexual orifices were distinct from the anus, but situated behind it: in the Mammalia the urinary and sexual openings are again equally distinct from the anus, but are placed in front of it. The Ornithorhynchus, Echidna, and Beaver, however, are exceptions; as in them there is a common opening to the Vagina and Rectum. It is an approximation to this structure that in the Tardigrada and Edentata, according to CUVIER, and also in the Seal, according to MECKEL, the orifices of the Vagina and Anus are very close together, and the Urethra and Vagina nearly one canal. The latter is also the case in the Ornithorhynchi, Anteaters, and Marsupial Animals, where the orifice of the Urethra is close to the opening of the Uterus, and where, consequently, the sexual appear to open into the urinary passages; whilst the reverse is the case in other animals, and the Urethra opens more towards the margin of the Vagina, as in Man. Even in the Bear and Genet-Cat the orifice of the Urethra is still high up in the Vagina.\* On the other hand, it is remarkable, that in Makies it perforates the Clitoris. That organ, which is a rudiment of the male Penis, appears to be common to the females of all Mammalia, and exists even in the Cetacea and the Ornithorhynchus.† It is found particularly large in the lascivious Apes; is furnished with a bone in Cats and some Rodentia, and also, according to CUVIER, in the Bear and Otter; in the Opossum, on the other hand, it is bifurcated, corresponding to the double Penis of the male. Lastly, we have to notice, as important deviations in the external organs of female Mammalia from those of the human female, the

\* See DAUBENTON'S Plates in BUFFON'S *Hist. Nat.* vol. viii. tab. xii vol. ix. tab. xxxvii. The Vagina itself in Mammalia usually presents longitudinal, and rarely transverse, folds.

† HOME, *Philos. Trans.* 1802. p. 307.

absolute deficiency of the Nymphæ and of the Hymen, which latter, however, is compensated, though imperfectly, by muscular contractions, or by folds of membrane in some Species, e. g. the Manati, the Mare, Hyæna, Daïman, some Apes, &c.

§. 747. 5. *External Organs for the Support of the Young.* These consist of the Mammæ, together with the bag within which they are lodged in the Marsupial Animals. Both are organs which we here observe in this form for the first time in the animal series; though the nutrition of the young in the dorsal cells of the Pipa (§. 735.), and the milky fluid secreted in the crop of Doves, are phenomena of the same nature; whilst the whole process corresponds to the transference of the young, or of the Ovum, from an internal to an external organ, as is very commonly the case even in the inferior Classes of Animals. The Mammæ have ~~not~~ yet been discovered in the Ornithorhynchus and Echidna, though it is not improbable that they do not appear until the young animals begin to suck; a supposition rendered still more probable from the circumstance, that, according to D'ABOVILLE,\* the Mammæ appear to be produced in the same way in the Opossum, being, consequently, placed irregularly, and disappearing† at the end of the term of sucking; besides that in most Mammalia the nipples are first perfectly developed during pregnancy, the corresponding glands at other times being flattened, and differing but little from the rudiment of the same parts in the male. The mammæ differ from those of the human female more in external form than in internal structure, for in the latter respect we have to notice only the exist-

\* VOIGT'S *Magazin*, b. v. st. 2.

† In this point, as well as in form and office, there is a great similarity between the Mammæ and the Placentæ, particularly the parts formed from the Uterus, inasmuch as they also first originate in the pregnant state.

ence of larger receptacles for milk, which purpose is in the other case answered by the nipple. The number and position of the teats, on the contrary, are remarkable, the former ordinarily corresponding\* to the number of young, and, consequently, of Placentæ, which in the animals with long cornua to the Uterus is considerable: the position, on the contrary, presents in the series of animals a gradual and regular recedence from the external genital parts towards the Thorax, a circumstance which again most decidedly reminds us of the very generally existing relation between the sexual and respiratory organs. To give some instances of this recedence; in the fish-like Mammalia, the nipples, according to HUNTER,† are situated in two folds at the sides of the Labia Pudendæ. (Tab. XX. fig. XIV.) They are placed in the inguinal region in the marsupial animals, where they are contained within a peculiar bag opening by a longitudinal fissure, and furnished with two (marsupial) bones and several muscles: at the time of parturition the aperture of this bag is brought close to the opening of the Vagina, and receives the immature young as they are expelled from it. The teats occupy the inguinal region, also, in the Ruminants and Solipedæ, and in part, at least, in the Rôdentia, where some are found on the abdomen. They are placed upon the abdomen in the amphibious Mammalia, and in Pachydermata, (except the Manati and Elephant, in which they are thoracic,) and also, or at least in part, in the Carnivora, where, when they are very numerous, some are placed upon the Thorax. Lastly, there is a single pair of proper pectoral nipples in Bats, Apes, and Man.

\* It is interesting to find that in animals where the ovum has several Placentæ, there are frequently several teats to one Breast, e. g. in the Cow.

† *Philos. Trans.* 1767. p. 415.

## (b) MALE.

§. 748. These are particularly distinguished from those of the Classes immediately preceding by their more absolute separation from the intestinal canal, the Semen and Urine no longer passing through the Anus, but being discharged by a peculiar canal in the Penis, which we already found in the inferior Classes. They are more simple than the female organs, consisting of Testicles and seminal canals, Vesiculæ Seminales and Penis, with the addition of rudiments of the Uterus (Prostate) and Mammæ.

1. *The Testicles* of Mammalia differ from those of other vertebral animals chiefly in their more distinctly fibrous parenchyma, formed by the convolutions of vessels, the softness of which is compensated by an inflexion (Corpus Highmori) of the external covering of the organ; the convolutions of the vessels often appearing externally in the form of a dark serpentine line, particularly in some Rodentia. The size and situation of the Testicles vary much more in the different species than their internal organization. The size is most considerable in the inferior species, particularly in the Rodentia, reminding us of the large Testes of Fishes. As concerns their position, we cannot fail to recognise an evident approximation to the inferior formations, inasmuch as in the web-footed animals, the Daman, Elephant, Ornithorhynchus, and Echidna (Tab. XX. fig. XI.), they are uniformly lodged, as in the human foetus, within the abdomen close to the Kidnies. In other Mammalia, on the contrary, we find the Testicles escaping from the abdomen at a certain period of life, and in such a manner, that during increased sexual impulse and enlargement of their size they again recede into the abdomen; as is the

case in most Rodentia, *e. g.* Rats (Tab. XX. fig. VI. f.\*), Mice, Squirrels, Beavers, &c. and those animals that approximate to them in form and mode of life, *viz.* Shrews, Moles, Hedgehogs, and Bats. In other instances they remain permanently without the abdomen, either merely under the skin of the inguinal region, as is the case, according to CUVIER, † in the Otter, or of the sheath of the Penis, *e. g.* in the Hog; or lastly, as is the case in most of the remaining Mammalia, in a peculiar sac (Scrotum) hanging behind or in front of the Pelvis. The descent of the Testicles takes place as in the human fœtus ‡ in such a manner that they are enveloped and fixed by a reflection of the Peritoneum, and protrude through a fissure in the abdominal muscles into a sac like that of a hernia, formed by the Peritoneum: when the Testicles are proportionally very large, *e. g.* in the Rat, each of them with its seminal duct is attached by a kind of Mesentery, like the Uterus in the female. In passing through the abdominal muscles, some fibres are detached from them, constituting the elevator muscle of the Testicle, whilst the pouch of peritoneum forms a canal, (Canalis tunicæ vaginalis propriæ testis,) which soon closes partially in Man, but in all other animals remains pervious, and is of extraordinary width, when, as in the Rodentia, the Testicles recede periodically. || When

† According to him, this is also the case in the Camel, where, however, EMMERT has discovered a complete Scrotum. (*Salzb. Med. Zeit.* 1837.)

‡ See SEILLER's excellent Treatise, *De descensu testicularum*, &c. 1817.

|| This process is physiologically very remarkable, and its character appears to me determinable by an analogy with the structure of the female. The male Testicle may be regarded as an Ovum from the female body in a higher stage of organization, the similarity of the two parts, *e. g.* in Birds, having been already pointed out. As the Ovum is so generally transferred from an internal to an external organ, though ultimately to be thrown off, so also is it as regards the Testicle; and it is only in a very active condition of

the Testicle actually recedes in the animals just mentioned, its elevator muscle together with the peritoneal sac are inverted, exactly like the Feeler of a Snail, the former then appearing as the Gubernaculum; and instead of the Testicle, a funnel-shaped opening presenting itself externally, within which the muscular fibres are reflected, and thus rendered capable of bringing about the re-protrusion of the Testicle. (Tab. XX. fig. VI. l.)

§. 749. 2. *The Seminal Ducts.* In Mammalia, as in Man, the excretory vessels of each Testicle unite to form a common seminal duct, which makes many convolutions close to the Testis under the name of Epididymis. Its size is generally proportioned to that of the Testis, and, consequently, is extremely large in the Rodentia (Tab. XX. fig. VI. g. i.), forming a little head inferiorly, and less closely connected to the Testicle than in Man, the union between them being very loose, according to CUVIER, in the Opossum, and in the Ornithorhynchus, according to HOME. The course of the seminal ducts themselves, and their insertion into the neck of the urinary Bladder, (which reminds us of the openings of the Uterus on each side of the bladder in the Ornithorhynchus,) are almost precisely the same as in Man, except that when the Testicles are lodged within the abdomen they are more serpentine,\* and their parietes

the productive functions that we again find it approximated in some animals to the central organs of re-production. Even the point at which the Testicle protrudes is important, because we may compare the abdominal ring to the inguinal fissure in Rays and other Fishes, in which we found that it was chiefly intended for the issue of the Ova; and may consider, consequently, the Gubernaculum as the inverted and elongated margin of this orifice attached to the Epididymis rather than to the Testicle itself. Lastly, the fact that the Epididymis is surrounded by the Gubernaculum, in the same manner as a part of the Oviduct (the corner of the Uterus) by the round ligament, is a proof of the truth of the analogy of the latter organ before pointed out.

\* In that respect, e. g. in the Echinæ (Tab. XX. fig. XI. c.) they again

thinner. Dilatations of the seminal ducts before their entrance into the neck of the Bladder are found particularly in Solipeda, Ruminants, and, according to CUVIER, in the Elephant, and agree completely with the part which we considered as supplying the place of the Vesiculæ Seminales in the preceding Class, and even in some Fishes. They are distinguished not merely by the increase of their diameter, but also by the greater density and more glandular nature of their parietes, and the cellular structure of their internal surface.

§. 750. 3. *Vesiculæ Seminales and Prostate.* In female Mammalia we find the Uterus, the receptacle and at the same time the secretory apparatus for the product of impregnation, formed between the Bladder and Rectum by the swelling of the Oviducts: in males, we meet, in the same situation, receptacles for semen and secretory organs; and, as in both, we find an imitation of the Uterus, we cannot but consider them as rudiments of that organ. These parts are, like the Uterus, ordinarily divided into lateral cornua, and vary so much in their form, that different names have been given to them at different times, on which account the general view of their character above proposed appears most suited to remove these contradictions. True Vesiculæ Seminales, connected immediately with the seminal ducts like those of Man, appear to occur in Mammalia without any particular order, \* e. g. in Apes, Bats, Rodentia, Moles, Hedgehogs, Pachydermata, and Solipeda; they are wanting, on the contrary, in the web-footed animals, which approach closest to Amphibia and Fishes, except

approximate to the closely convoluted seminal ducts of Birds following the course of the Ureters.

\* HALLER (*Elem. Phys.* vol. vii. p. 455,) believes that they occur chiefly "quadrupedibus non valde ferocibus, neque a carne certa sola viventibus;" but the relation is unquestionably more uncertain.

in the Manati; in the Echidna, Ornithorhynchus, and also in most Ruminants, in the marsupial animals, and in the rapacious animals, which, by the great development of their muscular system, remind us of Birds. They are peculiarly large in the Rodentia; in the Guinea-Pig, for instance, presenting two long cornua bending outwards, and attached by a peculiar Mesentery, thus offering a striking resemblance to the form of the Uterus in the female: in the Rat, on the contrary, they appear more pectiniform. (Tab. XX. fig. VI. k.) They are likewise of extraordinary size in the Hedgehog, where they consist of from eight to ten bundles, which it is necessary to separate from each other, in order to discover the much smaller urinary bladder placed among them. In other species, *e. g.* Swine, they have a more glandular appearance, thus serving to support HUNTER's view of them as secretory organs rather than receptacles. As to the Prostate, it is proved to be truly analogous to the female Uterus from the fact that it exists in the males of all Mammalia; because, as MECKEL (*Notes to CUVIER's Comp. Anat.*) has shewn, the accessory Vesiculæ Seminales, as they are called, are to be considered as the Prostate in those species where the existence of the latter was denied by CUVIER. The form and size of the organ vary considerably: the latter is very striking in the Hedgehog, where there are four lobes; in the Ruminants, where it has occasionally been considered as a Vesicula Seminalis; and also its bicornute termination in the Squirrel and several rapacious animals. According to CUVIER, it is but imperfectly formed in the Seal and Otter.

§. 751. 4. *Penis*. In the preceding Classes a peculiar male organ of copulation was still very often wanting: in the present, however, it exists in all the species, but in such a manner that there is a very distinct gradation in its

structure to its form in the inferior Classes. Among the first members of such a series is the Penis concealed within the Cloaca of the Ornithorhynchus and Echidna; which, from its position, and also from the circumstance stated by CUVIER,\* that it is not perforated, but that the Urethra opens at its root into the Cloaca, very closely resembles the Penis of Birds and Tortoises. (Tab. XX. fig. XI. p.) Next to this structure comes that of the Penis of the Beaver;† which, being placed at the margin of the Cloaca, discharges the urine into it, but is perforated, however, in its whole length. Here, also, we may arrange the bifurcation of the Penis, each point being furnished with a semicanal on its inner side, between which the Urethra opens, a structure found in the Opossum and some other marsupial animals, and corresponding to the double Penis of several Amphibia. Lastly, the prickles and scales pointing backwards, found on the Glans of some Mammalia, *e. g.* the Cat Genus, and particularly well marked in the Guinea-Pig, may be viewed as repetitions of similar structures which occur more particularly on the organs of copulation of Insects. In general the Penis of Mammalia is in other instances essentially the same as in Man, though in less important points there are numerous differences. Thus, as regards the composition of the Penis by two Corpora Caverosa, which is indicated in Mammalia as well as in Man by the two crura from which it arises, the septum dividing the two halves is occasionally wanting, *e. g.* in the Cetacea, Solipeda, Ruminantia, the Opossum, &c.: the structure of the Corpora Caverosa themselves can be more readily discovered in the Penis of the larger Mammalia than in that

\* HOME, however, (*Phil. Trans.* 1802.) describes the Penis in both cases as perforated, at least for the transmission of semen.

† BONN, *Anatome Castoris*. Lugd. Bat. 1805, p. 41. Hence it is not possible to distinguish the sexes externally.

of Man to consist of venous plexuses,\* and not of cells; as has been shewn in the Elephant by CUVIER, and in the Horse by TIEDEMANN.† The Urethra is frequently supported by a peculiar bone, in which it occasionally runs as in a groove, *e. g.* in the Dog. (Tab. XX. fig. XII.) This bone is particularly large in the Whale, and in several Carnivora; is smaller in Apes, Cats, and Rodentia; and is wanting, according to CUVIER, in hoofed animals, the Porpoise, and the Hyæna. There is frequently a cartilaginous epiphysis at its extremity, which then generally forms a large part of the Glans. Besides the manner in which the Glans is armed, as already mentioned, it frequently presents swellings or peculiar projections from its usually conical point, *e. g.* in the Rhinoceros and Horse. The Penis is usually covered to a considerable extent by the Prepuce, the Glans within the latter often presenting a striking resemblance to the Os Uteri within the Vagina: the Prepuce itself is in many species so closely connected with the other integuments, that it is attached to the perineum or abdominal surface in the form of a sheath. Such is the case in the Rodentia; where the orifice of the Prepuce is close to the anus, and where the Penis in the relaxed state points backwards, either straight, or with an S shaped curve, though when erect it turns forwards: there is nearly a similar disposition in Cats and Camels. On the contrary, the sheath of the Penis in most other Mammalia is attached to the surface of the abdomen as far as the umbilicus, except in the Quadrumana and Bats, where, as in Man, the Penis is merely suspended from the arch of the Pubes,—a position by which the structure

\* These venous plexuses have a very remarkable resemblance to the corresponding ones in the Uterus.

† MECKEL'S *Archiv.* b. ii.

of the peculiar muscles of the Penis and Prepuce is partly modified, and partly rendered necessary.\*

(c.) SECRETORY ORGANS WHICH ARE RELATED TO  
THE SEXUAL FUNCTION.

§. 752. We have before adverted to the fact that the generative function is essentially excretory, from which arises its close relation to the respiratory function, together with the evident repetition of the respiratory organs within the sphere of the sexual, *i. e.* as urinary organs; whilst, lastly, the sexual organs themselves, and particularly the male, present themselves as little else than secretory organs, though regulated by a peculiar sense. But as we found that in the inferior Classes of Animals other secretions were poured into the sexual passages in addition to the common ones, so also is it in Mammalia, and particularly in the male sex. In these secretions we discover for the most part repetitions of those which we before found at the termination of the Intestinal Canal: consequently, as in those instances, we find either spherical glands, or larger glandular sacs, (§. 526.) the former of which (COWPER'S Glands) generally open into the Urethra, and the latter upon the Prepuce. 1. COWPER'S Glands are wanting in the Amphibious Mammalia, in Otters, Solipeda, some Ru-

\* In the Sea-Otter the bone of the Penis is six inches long, and is surrounded at its anterior extremity by a mass of cellular substance, which in a state of erection, when injected with blood, forms a Glans, four inches long, and six in circumference. The anterior surface thereof presents a deep depression, in the centre of which is the extremity of the bone of the Penis: the Erectores are very powerful. (HOME, *Phil. Trans.* 1796, p. 385.)—*Translator.*

minants, and in but few of the rapacious animals, *e. g.* according to CUVIER, in the Bear and Raccoon; in most other animals, particularly those in which the anal glands are much developed, they are commonly larger than in Man, especially in Cats, in the Hyæna, several Rodentia, &c.; and, according to CUVIER, are even much increased in number in the marsupial animals. 2. *The Glands of the Prepuce.* We may in some respects arrange under this head the glandular bags of the Beaver, which secrete castor, though they are still much connected with the Cloaca, and constitute a very evident transition from the anal pouches as they are found in the Hyæna. To this head belongs, also, the bag which furnishes the Musk of the Musk Animal, (*Moschus moschiferus*,) and which, being placed in the vicinity of the umbilicus, empties itself into the Prepuce: according to PALLAS there is an analogous bag in the Antelope *gutturosa*. Similar glandular sacs exist in the Rodentia (*e. g.* the Rat, Tab. XX. fig. VI. n.) on each side of the Prepuce, and, though smaller, in most Mammalia, and even Man. Of the same nature are also the glands of the inguinal region in the Hare. In the female sex these glands are either altogether wanting, *e. g.* the bag of the Musk Animal, or are much smaller.

§. 753. On taking a general review of the course of developement of the sexual system, we cannot fail to perceive that the relative position of any individual in the animal series is expressed more definitely in this than in the other branches of the sphere of Vegetative Life. The cause consists, on the one hand, in the existence in this System of a peculiar sense, the resemblance of which in a physiological point of view to the sense of Taste has not only been already pointed out, but is also indicated anatomically by the tongue-like shape of the true copulative

organ; on the other hand, in the higher character of the sexual organism, which is the medium for the reproduction of the whole body, and consequently also of the superior animal structures. But, as for the first reason, the organ of the sense of Taste was more developed in Man than in Animals, so also, on both accounts, the human sexual organs attain a higher degree of development. We find the proofs of this partly in the disposition of the sexual organs, which, as well by the position of the soft parts as by that of the bony sexual cavity, *i. e.* the smaller inclination of the Pelvis, (§. 277.) necessitate a mode of copulation which occurs but rarely in other animals, and then only as a consequence of an organization in other respects imperfect; partly in the increased degree of sensibility, which may be traced to the more decidedly papillary structure of the skin of the Glans, and to the development of Nymphæ and stronger transverse folds of the Vagina, the anterior and most delicate of which appears as the token of Virginité; and, lastly, in the structure of the human Ovary, (where the generative elements are ideal rather than material,) and of the Uterus, which by its simple globular form appears to be the determining cause of the more perfect and spherical form of the female bosom.† On the other hand, the perfection of the human sexual organism is ideal, in so far as the stimulus of sex is no longer connected with the organ merely, but is influenced by the beauty of the general form of the body, whilst the rude sexual impulse of animals here assumes the nobler form of Love.

\* Thus both the Beaver and Whale probably copulate from before, in both instances owing to the great development of the caudal vertebrae, and in the former likewise on account of the cloacal structure.

† Compare what has been said (§. 746.) on the character of the Breasts, and their position upon the Thorax.

CHAPTER II. *Of the Development of the individual Organism in the different Classes of Animals.*

§. 754. As it is the use of Anatomy to examine and point out the appearances of the forms of organization, and of Physiology, on the contrary, to elucidate their functional phenomena, the consideration of the history of the development of the individual animal frame, which consists essentially in a uniformly progressive metamorphosis, belongs more particularly to the province of the latter (Physiology), and forms one of the most difficult, but at the same time most important objects within its range. But even here the fundamental principles must be deduced from Anatomy for the purposes of Physiology, of which we shall have to examine the most important, viz. those that distinguish the individual animal as forming a repetition of the order of succession in the animal series, first premising some general observations on the formation of the animal frame at large.

§. 755. We recognize the general similarity between the individual development of the animal, and the order of succession in the series of animals, by the following particulars:

I. That as the animal kingdom commences with the most simple beings, to which the globular form, as the characteristic of animality, (§. 23. 27.) appears to be eminently peculiar, in the same manner each individual animal proceeds

primarily from a spherical mass,—the Ovum; in which, as in the seed of Plants, (§. 713.) the Embryo is originally lodged, and so far ideally that it long remains invisible as a material object. Hence, as regards its form, the Ovum may be in the first instance compared with the Globe Animal (Volvox), differing, however, in its internal organization in containing the tendency to a higher formation, constituting an ideal principle,\* that, like the germinative power of a seed may long remain dormant, but when favoured by the concurrence of certain external circumstances, forms the efficient cause of the farther development of the embryo. Hence, too, the living Ovum, *i. e.* external to the body of the mother, or impregnated by the semen, is not in itself an animal; but contains the idea of an animal.

II. As the Animal Kingdom begins in Water, the lowest animals being always aquatic, so also the embryo is originally surrounded by the fluids of the Ovum.

III. As the lowest animals consist of uniform, punctiform masses of elementary animal matter, so also does each individual embryo in the first instance.

IV. As the lowest animals are characterised by their imperfect self-existence and their dependence on external objects, so also the embryo, the existence of which immediately depends upon the Ovum, with which it has the closest connections, its most important organs being external formative organs that disappear at a subsequent period. As forming such organs for the foetus, and also as portions of the Ovum, we have to consider, 1. The common covering or shell, which is a product of the Oviduct or Uterus, and either appears solid, and without vessels (shell), or, as a

\* As in the seed, so in the Ovum, this principle appears to be communicated by the act of fecundation alone, and consequently all the endeavours must be fruitless, the object of which is to discover the impregnating force as a material agent.

Chorion, receives the vessels belonging to the branchial bag, and occasionally is connected (as a Placenta) with the Uterus. 2. The Chyle-bladder (yolk-bag, Vesicula umbilicalis), which, as the absolute product of the Ovary, composes the vegetative part of the fœtus, on the one hand forming the first source of preparation of blood, and on the other being related to the Intestinal Canal. 3. The fœtal covering (Amnion), which, in its relation with the fœtus, presents a repetition of that existing between the Chorion and Vesicula Umbilicalis. 4. An external respiratory organ; which, however, is only a repetition of the inferior formations of that kind, and therefore forms either actual branchiæ, or a branchial bladder (Allantois), representing the excretory, as the Vesicula umbilicalis does the ingestive, portion of the vegetative sphere in the fœtus. 5. An organ (the Funis) which forms a communication between the embryo (the centre of the Ovum) and the external (peripheral) structures, and consists of vessels, the organs of communication peculiar to the vegetative sphere.

V. As the lowest animals are furnished only with the most absolutely essential organs, and therefore present an extremely simple structure, so also is it in the embryo of the higher species. A few words on this point are necessary, as it either has not been perceived or not understood by those who deny the similarity existing between the development of the individual animal and that of animals in general: when it is said that the higher animals also have originally only the most essential organs, it by no means follows that such organs must be identical with those of the lower animals; were that the case, both organisms must subsequently continue the same, and, consequently, it necessarily follows that the primary and essential organs of the embryo of higher animals must be altogether different from those of the Polype, for instance: and, hence we see

sufficient reason, why it should happen that in the higher part of the animal kingdom, characterized by the central nervous masses of the vertebral column, the formation commences with them, and with the animal sphere in general, whilst, on the contrary, the vegetative organs are primary in the inferior animals, characterized by the predominance of the vegetative sphere.

VI. Lastly, as the individual forms of the animal kingdom attain the utmost perfection only gradually, and in definite series of development, so also must the individual animal be developed according to a given order of succession. Even this principle has occasionally been so far mistaken, that it has been imagined that the fœtus of Mammalia, for instance, must be first like one of the Mollusca, and successively an Insect, a Fish, a Bird, without considering that in the Animal Kingdom there exist different series of development, that one series extends from the Zoophyte to the Butterfly, another from the same point to the Sepia; whilst others again reach from the Fish to the Bird, and from the Bird to the Mammalia, each individual Organism not passing through every series of development, but merely through those corresponding to its nature and character, and none of the stages of metamorphosis which it passes through corresponding precisely to any inferior one, but merely agreeing with it in general import; for were it otherwise, they must continue to be identical. We next proceed to the particular consideration of the principal forms of the Ovum and the stages of development in the different Classes of Animals; an infinitely extensive field on which we can here trace only some elementary positions, many points being still clothed with great obscurity, and affording inexhaustible materials for further investigation.

SECTION I. *Of the Developement of Zoophytes.*

§. 756. Where the animal itself is little more than an ovum that moves, takes in nourishment, and propagates itself, the metamorphosis from an ovum into an animal must necessarily be very inconsiderable. Hence, the ovum is frequently merely a portion of the body of the mother, detached, and continuing to exist independently: or, in those Genera (§. 716. 717.) which evacuate Ova, the Embryo is evolved from the Ovum in the most simple manner; for it appears, from the observations of MULLER, GADE, CAVOLINI, and SPIX, that the Embryo in the Ovum of Medusæ and Actiniæ, for instance, is of a very simple form, resembling an infusory animalcule, no other organs of formation belonging to it than the membranes and fluids of the Ovum itself: \* a process of developement which here appears very generally to take place before the Ova quit the body of the mother; *e. g.* in the Medusæ, where they are placed upon the arms of the animal. The young animal ultimately breaks through its coverings in order to enter on a state of independent existence, and when this happens before the Ovum quits the body of the mother, or, at least, when the young animal is at that period completely formed, its birth is of the viviparous kind, and takes place through the mouth. (§. 717.)†

\* The Yolk-bag (*Vesicula umbilicalis*) and unvascular *Chorion* appear here, as in many other of the lower animals, to be the only parts forming the ovum, the *fœtus* being composed immediately of the contents of the former.

† The Ova of Sponges are quite visible to the naked eye, and are seen disseminated through the whole texture of the animal. They are bodies of

SECTION II. *Of the Development of Mollusca.*

§. 757. In all the Species of this Class we found true Ovaries, the Ovum, too, generally admitting of a more complete examination, and being developed either as in the preceding Class within, or else external to, the body of the mother. The form and arrangement of the Ova of some *Aceplala* have been already treated of (§. 719.), as well as the situations in which they are farther developed. Even here, however, we cannot discover organs for assisting in the developement of the fœtus, though the form of the Embryo itself has already many peculiarities. Thus we find the young of the River-muscle glued together in the Gills by a viscid mucus, in which they move vigorously, and vary considerably in shape from the adult, the situation of the hinge (*Cardo*), where we found the Heart lodged,

a yellow colour, somewhat translucent, pear-shaped, tapering more or less at the narrow end in different species. Their whole outer surface is covered with delicate projecting cilia, and when viewed through the microscope in conjunction with the parent, it is seen that the rapid vibration of the cilia produces a distinct current in the water around them, flowing always from the rounded free extremity to the tapering fixed extremity, thereby, during the period of their attachment, assisting certain little granules, which are constantly thrown off from the parent, in producing the currents of water observed to issue from the orifices of the canals in the Sponge. For some time after they are propelled from the interior of the Sponge they swim about by means of the cilia on their surface, and exhibit spontaneous motions like those observed by CAVOLINI in the ova of the *Gorgonia* and *Madrepore*. They at length fix themselves in a favourable situation, lose their original form, and become flat, transparent, circular films, through which horny fibres shoot, soon spreading themselves out and assuming the form of the parent. (GRANT, *Edinb. Phil. Journ.* vol. xiii. 382.)—Translator.

occupying the whole extent of the back (Tab. II. fig. XII. D.), the little shells being imperfectly closed, and furnished on the front edge with a peculiar projection, probably an elongation of the Branchiæ, or a longer feeler of the margin of the Cloak. In the Ascidiæ, where the young are lodged on the external surface of the old animal, their form as mere Ova is more decidedly marked in proportion as they are smaller: they then consist merely of an external gelatinous case, (which may be considered as the shell of the Ovum (egg), subsequently forming the leathery covering of these animals, and continuing as such through life,) and of an internal blackish yolk-bag (Vesicula umbilicalis), connected with the muscular sac (Cloak) and Intestines. (Tab. II. fig. V. IV.) It is remarkable, too, that the young ones of a large species of Ascidiæ approximate to the smaller kinds in consequence of the close juxtaposition of the two orifices of the body, of the smaller mass of the Liver, and the thinness of the leather-like case.\*

§. 758. The Ova of the Gasteropoda are usually developed external to the body of the mother, though, as we have already seen, the *Cyclostoma viviparum* has a tube-shaped Uterus in which that process takes place. SWAMMERDAM† states the following facts: the Ova in the Uterus of the individual that he examined were of different sizes, some more and others less developed: in one animal there were 12, in another 14, Ova attached by one or two threads supplying the place of a Placenta (Tab. III. fig. XII.): in another animal he found only one young one, and that already hatched: the more developed ova presented themselves first, and those that were less so, were lodged towards the fundus of the Uterus. He invariably observed the fetus floating unattached in the fluids of the Ovum, and

\* MECKEL'S *Archiv.* b. ii. h. 4.

† *Bib. Nat.* p. 75.

the smaller ones performing a rotatory motion. A similar motion was observed by STIEBEL\* in the foetus contained within the Ova of the *Limneus stagnalis*, which are developed externally to the body of the mother: in these Ova, too, when just deposited, such as were impregnated were distinguished by containing a yellow point, and by their shape, which was oval, and not, as in the unimpregnated, round. In from four to five days after it is laid, the state of the Ovum changes: a black point appears in addition to the yellow one; the latter, the rudiment of the foetus, which consists chiefly of Liver, moving constantly round it: on the sixteenth day the pulsation of the Heart can be perceived, and the young animal is hatched between the 20th and 30th. As regards the Ova of the Cephalopoda, I find those of the Cuttle-fish to consist of a yellowish yolk, and with the shape of elongated triangles with the corners rounded off. Some remarkable circumstances relating to their development external to the body of the mother have been described by CAVOLINI,† though already known to ARISTOTLE: in the impregnated Ovum, which is compared to a myrtle-berry, we may very distinctly observe a double membrane, and a peculiar yolk, with which the foetus is connected by an elongation of the Pharynx, and which diminishes in proportion to the increase of the foetus floating in a peculiar fluid and performing respiratory motions: a mode of development which, if closely examined, contradicts many hypotheses on the Physiology of the Ovum.

\* *Limneus Stagnalis Anatomie*. Gott. 1815. It is extremely probable that these rotatory motions serve to determine the convolutions of the Liver, and by that means of the shell.

† *Von Erzeugung der Fische und Krabse*. s. 55.

SECTION III. *Of the Development of the Articulata.*

§. 759. The young of Intestinal Worms are most commonly developed within the body of the mother,\* and born alive either within or without the Ovum, *e. g.* *Ascaris*, *Cucullanus*, &c.; less frequently they are born completely formed, but motionless within the Ovum; and less frequently still, as mere Ova, *e. g.* *Acanthocephala*, *Tœniæ*, &c. According to RUDOLPHI, the Ova of some Species, *e. g.* *Echinorhynchus* and *Cucullanus*, appear to be attached by a kind of Placenta to the Ovaries† or Oviducts; and it is also remarkable (on the same authority), that the Embryo of the *Cucullanus* is always attached to the membranes of the Ovum by the posterior part of the body elongated, consequently by a kind of Funis. (Tab. V. fig. VII. C. D.) In these Ova, likewise, we find two membranes and fluids, the Embryo by its extreme simplicity approaching to the Zoophyte in the same proportion that it differs from the perfectly formed animal. The same description applies pretty nearly to the extraneous Worms, in which the young are also generally born living, as has already been mentioned of the Earth-worm and others. (§. 727.) BERKENMEYER† found the Ova of the Leech forming four Clusters, from which 150 young proceeded, and still remained under the abdomen of the mother for two months.

\* RUDOLPHI, *Entozoorum Historia*, vol. i. p. 321.

† Should not these attachments be compared rather to the Calyx of the Ovum in Birds, than to a Placenta?

‡ VOIGT'S *Magazin*, b. iv. st. 1. s. 92.

§. 760. In the Crustacea, it has been pretty clearly proved by the labours of CAVOLINI, as I have also satisfied myself in the ova of the Cray-fish, that the little Ova contained in the Ovary consist merely of the chyle-bladder (analogous to the yolk and albumen of the Ovum of Birds), around which a firm shell is formed after the Ovum has quitted the Oviduct, and is lodged under the tail of the animal. The Embryo is developed with the abdominal surface curved over the yolk, the latter diminishing in proportion as the fœtus increases, and therefore, probably, even here being taken into its abdomen, as we shall find still more evidently the case in the higher animals. Such, also, are probably the nature of the Ovum and the mode of development in Insects, the minute size of which, however, commonly prevents a complete examination: in the tolerably large Ova of the *Gryllus verrucivorus*, however, I could distinguish in the same manner an external firm and horny shell and a finer internal one, the latter of which surrounded the uniform, yellow, and somewhat resinous yolk, without any trace of white, (albumen.) The same may be observed in the larger Ova of Butterflies; an evident analogy with Birds, as we shall hereafter see, arising from the existence of these shells, the size of the yolk, and the extent, peculiar to this and the preceding Class, to which the young are perfected after they have been discharged from the body of the mother. To this there is an exception only in a few inferior species, *e. g.* Scorpions, Aphides, &c.

§. 761. We must, however, notice particularly the Metamorphoses that take place in this Class after the young animal has quitted the Ovum, and which consist not merely in the increase, in the greater development and in changes of the relations of individual organs, but

present perfect alterations of form and of internal structure as well as of mode of life; and in thus displaying the animal remaining for certain periods in different states of development, present a most important and interesting series of phenomena, which has furnished a copious subject of enquiry to such naturalists as MALPIGHI, SWAMMERDAM, DE GEER, REAUMUR, HEROLD, and others; but of which we can here notice only the most prominent particulars. Even in those Worms, *e. g.* the Earth-worm, where there is a distinct Cuticle, a new one is from time to time formed under it, and the old one thrown off: this process, however, is more decided, when the covering is so firm as to admit of being rejected in one piece. This is peculiarly true of the Crustacea, where the shell of the Crab, for instance, splits at its upper part, the animal creeping out, being as it were re-generated from an Ovum, though without any change of its form, and completely quitting the old shell, the new one quickly attaining an equal degree of solidity. The same ordinarily happens in the apterous Insects covered with less solid horny shells, or merely by a cuticle, *e. g.* Spiders, Scorpions, Scolopendræ, &c.: in other Insects, on the contrary, the body no longer retains the shape it had originally when it quitted the Ovum, but undergoes a more or less complete metamorphosis. The latter is the case in the Orthoptera, Hemiptera, and Neuroptera, which, when they quit the Ovum, are apterous, but ultimately appear as winged Insects after many changes of their coverings. The other kind of metamorphosis, where the Insect returns to the condition of an Ovum, occurs in Diptera, Hymenoptera, Coleoptera, and Lepidoptera. The Larva here originally issues from the Ovum, like the Apterous Insect, frequently changing its coverings as it increases in size, and then, after having spun a soft covering and fixed it

to plants, &c. as to a material organ, becomes torpid as a Pupâ within it, a metamorphosis even of its internal organs\* taking place during this death-like, sleep, which is terminated by the eruption of the perfect Insect from its horny shell.

#### SECTION IV. *Of the Developement of Fishes;*

§. 762. The mode of developement of the larger Cartilaginous Fishes from the Ova was already known by ARISTOTLE, and has been farther illustrated by MONRO, CAVOLINI, and HOME. But little is known, however, of this process in the Osseous Fishes, where the smallness of the Ova is an impediment to the enquiry, though there is not any reason to suppose that it differs essentially from that in the smaller Cartilaginous Fishes observed by CAVOLINI. I may remark, however, that in the larger Ova of Osseous Fishes which I examined, *e. g.* of the Trout, the whole egg appeared to me to consist merely of clear and nearly transparent yolk, almost like the Ovum of Crustacea; whilst, on the contrary, in the mature Ova of the Syngnathus, CAVOLINI found a yolk separate from and floating in a small quantity of white (albumen), and having upon it the Cicatricula, the point of origin of the Embryo. This is still more distinct in Rays and Sharks, in which the yolk and white are not only more decidedly separated, but

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enclosed within a horny shell with four pointed extremities. It has been already stated (§. 733. 734.) that the Ova of Osseous Fishes are ordinarily hatched external to, and those of Cartilaginous Fishes within, the body of the mother. The fœtus in Fishes in general appears to be developed in essentially the same manner as in Crustacea. According to CAVOLINI'S microscopical observations, it is formed in the same manner upon the Yolk-bag, (Vesic. Umbilic.) around which it is bent upon its abdominal surface, (Tab. X. fig. XI.) and which, consequently, forms the most essential organ to, the process of its developement, the external shell appearing merely as such, and not yet assuming the character of a Chorion (vascular membrane). We find here, also, that the contents of the Yolk-bag are received from the abdominal surface, and pass into the Intestinal Canal, where it long remains visible, attached in the form of a swelling (Bursa Entiana). The want of an Allantois (§. 755.) is probably supplied in the Embryo of Fishes, (and perhaps also of the inferior animals\* that breathe by Gills) by the Gills themselves, as being the permanently existing external respiratory organ: it must be left, however, to further investigation to determine whether the considerable urinary bladder, already noticed, in some Fishes should not be considered as the persistent Allantois,—although it is rendered probable by what I have stated of the urinary bladder of Amphibia, (§. 670.) Lastly, the various modes of supporting the respiration of the fœtus are remarkable, as they have recently been observed by HOME† in the Ova of Sharks: when the young are hatched external to the body of the mother, the firm Shells have two lateral fissures on each side, which permit the ac-

\* We have already observed that the Sepiæ move the Gills even within the Ovum.

† *On the Mode of Breeding of the Oviparous Shark.* Phil. Trans. 1810.

cess of water (Tab. X. fig. X.); on the contrary, when they are developed within the Oviducts, the hard shell is wanting, and they are surrounded by the gelatinous mass already noticed, (§. 734.) which probably is subservient, as well to nutrition as to respiration. (Tab. X. fig. IX.)

SECTION V. *Of the Development of Amphibia.*

§. 763. We proceed first to the history of the development of the Frog, which, though of easy observation, and already frequently examined, is as yet but imperfectly known as far as regards its early periods. We have already seen that the Ova, consisting chiefly of Yolk, receive a covering of gelatinous matter in the Oviduct. After the expulsion of the Ova, during which they are impregnated, this gelatinous substance swells rapidly in the water, and presents in its central part the blackish yolk surrounded by a delicate membranous shell, and provided with a little bright point or Cicatricula. The Yolk, according to SWAMMERDAM, consists of two halves, of which one appears to be analogous to the white of the egg of Birds: upon it is formed the Embryo contained within a thin Amnion, which, when made to protrude through the Chorion by the pressure of the Yolk, was probably the part called an Allantois by SWAMMERDAM: the Yolk is taken up so rapidly into the Embryo, that when the latter is only a few lines long and barely perceptible, it is seen to move without any Yolk-bag (Vesic. Umbilic.) within the Chorion, which is without vessels and not in any way con-

nected to it, the Amnion itself seemingly covering the Embryo like a Cuticle, and, consequently, the primary external organs of development disappearing at a very early period. (Tab. XIII. fig. IX.) But as excretory, *i. e.* external respiratory organs are not less indispensable to the foetus than nutritive or vegetative organs, we meet with external Gills (§. 603.), which, if we view the Amnion itself as here forming the outer membrane of the Embryo, project in the same manner between it and the Chorion as does the Allantois in the higher animals.\* During this time it is probable that some of the external jelly of the Ovum passes through the shell to the foetus for the purposes of nutrition and respiration, in the same manner as in the foetus of the Shark (§. 762.), inasmuch as there is an evident diminution of its quantity during the growth of the animal. The foetus ultimately breaks its way through the unvascular Chorion, appearing completely as a Fish, and having a great resemblance to a little Shark from its shape (Tab. XIII. fig. XI.), and from the position of the mouth on the under surface, with two little sucking tubes (fig. 3. a.) near it: it presents within the abdomen a roll of spirally convoluted Intestine, respire by means of Gills, and lives on the gelatinous substance of the Ovum. Subsequently, there is a farther metamorphosis as in Insects: the Gills are first increased in size, are then obliterated, and for a time compensated by the existence of a little tube on the left side (fig. 4. c.), through which the water is respired: lastly, the extremities protrude, the tail shrinks and disappears, and the animal in the interim changing its coverings several times, (and consequently throwing off the coat formed by the Amnion,) advances from the state of a Larva to that of the perfect animal.

\* I have already mentioned that I consider the (so called) urinary bladder as the Allantois, (§. 670.): it is not developed until the Gills are obliterated.

§. 764.- The progress of developement is almost completely similar in the Land-Salamander, except that it is carried on within the body of the mother. In a pregnant female I found the Ova joined by a thin gelatinous mass into a string, and lodged within the double intestine-like Uterus. (Tab. XIII. fig. IV.) The foetus lay unattached within the thin unvascular Chorion, which consequently was not fixed by any Placenta: it had evident Gills, and was capable of existing external to the Ovum, so much so that I kept one alive in water for three weeks. The Vesicula Umbilicalis was large, and attached to the abdomen of the foetus, which lay curved around it within the Ovum: it was particularly remarkable, also, inasmuch as it here clearly formed an integral\* part of the Intestinal Canal, of which I satisfied myself in the dissection of a Larva of some size. (Fig. XIII. 3. b. c. d.) In more advanced Larvæ the whole sac is converted into a convoluted portion of Intestine, invariably of a bright yellow colour. We find, also, a Vein proceeding to the Liver, which probably serves for the absorption of the contents of the bag (Yolk), and runs externally over the Vesic. Umbil. within the membrane covering the surface of the Embryo, and which may here again be considered as the Amnion: from these circumstances we derive an explanation of the opening of the Veins of the abdominal coverings into the Liver, as already noticed. (§. 701.) As regards the mode of developement of Tortoises, I can only describe the Ova that I found in the Mud-Tortoise: they were nearly like those of a Pigeon,

\* Here, consequently, the entrance of the Vesicula Umbilicalis (Yolk-bag) into the Intestinal Canal is most decidedly marked. Is it not also probable, that the convoluted Intestine of the Larva of the Frog (§. 763.), or even the spiral valve of the Intestine of Sharks and Rays, (being as it were a convolution of Intestine consolidated into one mass,) may be structures dependent upon the Vesic. Umbil. or even formed from it?

with a hard white shell, a globular Yolk with a large Cicatricula, and much White (Albumen) scarcely coagulable by boiling. I did not observe any receptacle for air.

§. 765. I find the Ova of the *Coluber natrix* furnished with a soft, leather-like shell, and without any distinction between Yolk and Albumen, but containing a yellowish mixture of the two: nor is it unimportant to observe, that when placed in water they swelled considerably. When hardened by spirit, I found the whole shell occupied by the solid contents, and, consequently, these Ova do not contain air, any more than those of Lizards, as stated by EMMERT and HOCHSTETTER.\* From what I have observed in the *Coluber natrix*, the mode of developement in the Ova of Serpents appears to be essentially the same as in those of Lizards, except that, as already mentioned, they are hatched in many instances in the Oviducts: I shall therefore proceed to give the result of the excellent observations of the above naturalists on the Ova of Lizards. In them, as in the Ova of the Frog and Salamander, the external Shell, corresponding, to the Chorion of Mammalia, is without vessels, and consists of one firm leather-like, and two thinner, layers. Within there is contained the large Yolk with but little white surrounding it: on it is formed the Embryo in a distinct and permanent Amnion filled with a peculiar fluid, but like the external shell (Chorion) without vessels. It (the Embryo) is connected by vessels (and not by a duct leading to the Intestinal Canal) with the Yolk, the membrane of which is very vascular, and within which it is probable that blood and vessels are first formed. The excretory organ (Allantois), also, opposed to the Yolk-bag (Vesic. Umbilic.) here appears more distinctly: nay, the Embryo in this case being without

\* REIL'S *Archiv.* b. x. h. 1.

Gills, it forms a true branchial bladder,\* connected with the Cloaca by a Urachus, and in that sense protruding from the Cloaca in the same manner as we shall find it in Birds. This (branchial) bladder is very vascular, and is usually called the Chorion, although it is merely analogous to the Allantois of Mammalia, being lodged like it, or like the Gills of the Larva of the Frog, between the Amnion and the outer coverings of the Ovum. During the gradual growth of the foetus the Yolk becomes progressively smaller and ultimately disappears, without any immediate connection however with the Intestinal Canal. Such, also, is the case as regards the Allantois, (branchial bladder,) the Urachus of which remains in part as a small oblong urinary bladder: the Amnion and Shell are thrown off, and the animal is fully developed, (though not until after a considerable space, the period of hatching occupying from two to three months,) and then frequently rejects its skin,† though without passing through any metamorphosis. A complete investigation of the incubated Ova of the Crocodile would be very desirable: in a young one that had probably but recently escaped from the Ovum, I find the Yolk-bag (Vesicula Umbilic.) lying within the abdomen quite full, of large size, and distinctly connected with a convolution of Intestine.

\* The Allantois becoming obliterated in the Lizard forms a repetition of the large urinary bladder of the Frog, in the same manner that the Larva of the latter by its Gills, subsequently obliterated, repeats the type of formation of Fishes.

† The changes of the external covering which occur in the Amphibia appear to characterise this Class as an intermediate transition to the higher formations; a character, too, which the same process most evidently presents in the inferior species of Insects.

SECTION VI. *Of the Development of Birds.*

§. 766. Though there is not any process of development that has been so frequently studied as that of Birds, and particularly of the Chick within the egg, yet there remain even here many dubious points to be determined. We shall proceed to take a brief view of the most essential phenomena, and then point out how closely the process of formation in this approaches to that observed in the preceding Class. As regards the egg itself, the question has been disputed whether the albumen deposited on its external surface is derived from the Ovary or the Oviduct. The former opinion\* is supported by the fact, that the White, generally speaking, is merely an appendage of the Yolk, and must necessarily have the same origin; and also that in old Hens malformed Ova are occasionally deposited, consisting solely of White. In favour of the latter, TIEDEMANN† observes, that the mature Yolk when in the Ovary is precisely of the same weight as when in the egg. The Yolk, too, when in the Ovary, does not present any trace of White, but, on the contrary, corresponds exactly to the Yolk of the egg itself, except that it is somewhat paler: other proofs are afforded by the concentric layers in which the White is deposited, in which an internal and an external portion may be distinguished, as well as by the evident deposition of gelatinous matter around the Ova of several Amphibia and Fishes in their passage through the

\* Advanced particularly by JOERG, in his *Grundlinien der Physiologie*, Leipzig, 1815, t. i. s. 236.

† *Zoologie*, b. iii. s. 110.

Oviduct. Altogether, both as regards these Ova, and also all such as present White in addition to the Yolk, the idea originally proposed by HARVEY, and since confirmed by TIEDEMANN, appears to be most correct. According to this, the complete germ of the Ovum, with the disposition to the formation of White (Albumen), proceeds from the Ovary, during its lodgement in the Oviduct is nourished by absorption. (like an Hydatid,) increases in size, and is organically developed at the same time that its separation into two different parts becomes more distinct. The materials that are to be thus taken into the Ovum are usually secreted by the extremities of the vessels of the upper part of the Oviduct, whilst, on the contrary, those of the lower part deposit its calcareous shell.\* In the Ovum of Birds there are two circumstances, however; for consideration, which we do not meet with in the preceding Classes. The first of these consists in two twisted cords, placed pretty nearly in the longitudinal axis of the egg, containing a delicate canal opening into the yolk-bag, ramifying from each pole of the Yolk towards the large and small extremity of the egg, and known by the name of Chalazæ, Grandines. Their origin appears to me to depend on the separation of the membrane of the Yolk from the external membrane of the egg, the former remaining connected with the latter at its two poles, and this connection being gradually elongated into the two tubes in question in proportion as the membranes are farther separated by the interposition of new layers of albumen, and becoming twisted by the motion of the Yolk. The second object consists in the air-bag, which is formed by the separation of the two thin layers of the membrane lining the shell at its larger extremity, and is

\* This copious secretion of Carbonate of Lime in Birds and Amphibia presents an interesting analogy with the equally abundant secretion of earthy matter from the Kidneys.

accompanied by a corresponding decrease of the albumen; on which account it appears only after the egg is laid, and increases nearly ten-fold\* during incubation. It contains atmospheric air, and is subservient to the respiration of the Chick, the development of which is completely interrupted if it be injured.†

§. 767. The Ovum of Birds, like that of the perfect Insects, is developed external<sup>to</sup> to the body of the mother. We here again find the Yolk-bag as an external organ for the formation of the foetus, and the support of the vegetative processes of the body, and an Allantois, incorrectly called Chorion, forming a respiratory organ: there are, in addition, an unvascular Amnion surrounding the embryo, and a membrane lining the shell, which is analogous to the true Chorion. The progressive development of these parts occupies twenty-one days in the egg of the Hen, and takes place in the following order. As we have already seen, the egg is formed essentially by the membrane of the shell (Chorion) and the Yolk with its albuminous appendage. The relation between them is repeated in the formation of the embryo and Amnion, which proceeds in such a manner, that the Cicatricula, which presents itself as a spot as large as a lentil upon the Yolk before impregnation, and even in small Ova within the Ovary,|| increasing in size during the first day of incubation, is elongated and surrounded by some cloudy circles (Circuli, Halones). This spot is larger on the second day, the two laminæ of the

\* According to PARIS. See MECKEL'S *Archiv.* b. i. h. 2, s. 315.

† Consequently, even in the Embryo there is already an indication of the peculiar development of Respiration in the Bird.

‡ As a morbid process the Ovum may however be developed in the Oviduct, or even in the cavity of the abdomen; of which TIEDEMANN (*Zoologie*, b. iii. s. 145.) has given instances, and as I have myself observed.

|| TIEDEMANN, *L. c.* t. iii. s. 96.

membrane of the Yolk being separated in its centre, (Areola pellucida, Tab. XVI. fig. XVII.) and the interspace occupied by an aqueous limpid fluid, in which, and inclosed within the lower lamina, (called the false Amnion,) lies the embryo, consisting only of the most essential part of the body, viz. the Spine, with a double swelling corresponding to the brain, and the Sinus rhomboidalis, and with the cavities of the Chest and Abdomen completely open, and turned towards the Yolk. (Fig. XVII. c.) About the third day there are evident traces of a vascular system in the most important external organ of formation, the Yolk-bag, (Vesic. Umbilic.) and in the cloudy circles. (Hyalones.) In the third day it becomes still more distinct, those circles disappearing, and a circular rete of veins (figura venosa) surrounded by a ring-like vein, (Vena terminalis,) which OKEN\* has aptly compared to the circle of vessels in the Medusæ, (§. 686.) presenting itself at the same time that the pulsating Heart (punctum saliens) is first observed. Hence the existence of the embryo is dependent on the principal opponent parts of the organism, viz. the vascular and nervous systems, the body still continuing closely attached to the source of vegetative life furnished to it by that of the mother, *i. e.* to the Yolk-bag.

§. 768. Even on the third day, but still more evidently on the fourth, the Intestinal Canal is discoverable as a slender thread running direct from the head to the tail, without any perceptible cavity, and, according to WOEFFE,† origi-

\* *Zoologie*, b. ii. s. 362.

† *Nov. Comment. Acad. Scient. Petropolit.* t. xii. p. 459.—According to him, the Intestinal Canal is originally open in front: but is it not probable that it appears so merely because the Yolk-bag here forms originally an integral part of it (§. 764.), the Embryo, when examined, being separated from the Yolk, and the anterior side of the intestine, viz. the Yolk-bag itself, in that way removed?

nating from the spurious Amnion, *i. e.* the inner membrane of the Yolk. At the same time with this nutritive organ the respiratory organ also presents itself, having originally the form of a small vascular urinary bladder, opening, as in the Amphibia, into the Cloaca\* (fig. XVIII. h.): it rapidly increases in size, and protrudes as an Allantois between the true Amnion and Yolk-bag: in the latter days of incubation it lines the inside of the greater part of the membrane of the shell; contains a limpid fluid, with occasionally some urinary concretions; and presents a beautiful net-work of dark coloured Arteries arising as umbilical vessels from the Iliac Arteries, and of scarlet red veins, which enter the Liver by the Umbilical Vein: hence, also, it is a true branchial organ, and the Chick dies forthwith if the air be prevented by a coating of varnish from passing through the pores of the calcareous shell. This Allantois is not obliterated until the Chick begins to take in air by the mouth, and is ready to break its way through the shell. The spurious Amnion disappears on the fifth day, when we find the true Amnion completely developed, by which means the Yolk-bag is farther separated from the Chick. As to the Yolk-bag itself, it decreases in proportion as the Allantois and Chick increase: it gradually receives (probably by means of the Chalazæ) the Albumen, which is more and more compressed towards the narrow end of the egg, and totally disappears towards the eighteenth day, the Yolk appearing in a corresponding degree more fluid. The vascular net-work of the Yolk-bag, formed by a large Mesenteric Vein and a

\* The *Bursa FARRICH* (§. 495.) has been occasionally viewed as a rudiment of the canal between the Cloaca and Allantois, (Urachus;) but were that the case it would certainly be placed in front of the Rectum. It appears to me to be rather an organ antagonising the Allantois on the dorsal side, and on that account to be a secretory, *i. e.* a metamorphosis of a respiratory organ. Hence, also, we may understand why it is found more vascular in young Birds.

smaller Mesenteric Artery, gradually increases: from the ninth day we find at the extremities of the Veins peculiar yellow vessels (*Vasa vitelli lutea*), which appear internally as flocculent cords,\* and serve chiefly for the absorption of the Yolk, and for its conversion into blood, the Chick at that time being apparently nourished chiefly in this way, and the connection between the Yolk-bag and the Intestinal Canal at this period at least problematical; for though in my own investigations I always found a loop of intestine which is without the abdomen connected to the Yolk-bag by means of a transparent ligament, it was only during the latter periods of incubation that I could distinguish a pervious canal (*Ductus vitello-intestinalis*) between them. In proportion as the formation of the Chick advances, and as the originally extensive umbilical fissure contracts, *i. e.* about the twentieth day, the Yolk-bag, which by this time is diminished in size by one half, becomes enclosed within the abdomen; the substance of the Yolk passing into the Intestinal Canal to be absorbed from thence by the lacteals, in the same manner as before by the yellow vessels (*vasa lutea*), and to be employed in the nutrition of the young Bird. The great increase in the size of the air-sac during incubation has been already noticed, so that I need only mention that in the later periods it contains Carbonic Acid as well as atmospheric air, and that by respiration and perspiration the weight of the whole egg during its development diminishes from 16 to  $13\frac{1}{2}$  drachms.

\* I consider these flocculent cords, particularly from examining the egg of the Turkey, merely as duplicatures of the Yolk-bag with large absorbing villi.

SECTION VII. *Of the Developement of Mammalia.*

§. 769. The developement of the Ova of some Fishes and Amphibia within the body of the mother was in fact a process of hatching, inasmuch as the Ovum already contained within itself the conditions necessary for the formation of the foetus, *i. e.* was furnished with a large receptacle of chylous matter, originally derived from the body of the mother. In this Class, however, there is a difference: in the same manner that the germ of the Ovum was less sensibly existent within the Ovary, so also is the Ovum less perfectly furnished with the internal conditions necessary for the existence and formation of the foetus, and in a corresponding degree requires for those purposes the interposition of a constant mutual influence between itself and the body of the mother,—an influence that necessitates the existence of an external formative organ *around* the Ovum, and not, as we have before seen similar essential structures, *within* it. This external formative organ in the Ovum of Man, as well as that of other Mammalia, consists in its external covering, the Chorion and Placenta developed upon it, and here for that reason extremely vascular. We here, also, find a yolk-like organ, which, very probably in this case also, is derived from the Ovary alone, and originally forms the sole content of the Chorion, *viz.* the Vesicula Umbilicalis: there must necessarily, however, be some difference in its function, inasmuch as it is not originally

developed to its full extent like the Yolk, nor like it becomes gradually smaller by serving as a deposit of nutritive matter for the foetus, but, on the contrary, in many Mammalia still continues to increase during the early periods of the growth of the foetus; besides that it is never so decidedly connected with the Intestinal Canal as the Yolk; and, lastly, because of the very early period at which it disappears in many other Mammalia, and even in Man himself.\* The Allantois, too, the primary respiratory organ of the Ovum of the Bird, has totally different relations in the Ovum of Mammalia; for here neither air nor water penetrate the Ovum from without, and consequently the separation of phlogistic matter (whether in the form of excretion or expiration) must be effected by means of a mutual action taking place between the foetus and the body of the mother.† That function is here assumed by the Chorion or its Placenta,‡ whilst the Allantois itself appears unvascular, the umbilical vessels connected with it at its root ramifying upon the Chorion, and also, according to the observations of EMMERT, the

\* The points of resemblance and of dissimilarity between the Yolk-bag and the Vesicula Umbilicalis have been minutely examined by EMMERT. (*Reil's Archiv.* b. x. h. i. s. 69.) where, however, the first and important distinction here pointed out has not been alluded to.

† We are here reminded of what has been already observed of the mediate respiration of Intestinal Worms through other Animals; nor is the less perfectly obvious oxidation of the fluids in either case to be considered as a sufficient cause for refusing to admit the existence of a respiratory process.

‡ On this account the Allantois of Amphibia and Birds has been usually called the Chorion. The two are, however, in all cases completely distinct, and the Allantois of Birds resembles the Chorion of Mammalia merely in being vascular. The Allantois is uniformly a perfectly closed sac continuous with the Urachus, containing only fluid in its cavity, and is interposed between the Amnion and Chorion: the Chorion, on the contrary, forms the entire external covering of the Ovum, and contains within its cavity the Allantois, Vesicula Umbilicalis, and Foetus.

vessels of the Vesicula Umbilicalis itself opening into those of the Chorion, which never happens in the Ovum of Birds and Lizards. Nay, the Allantois itself becomes gradually less and less distinct, until at length in Man it is scarcely to be discriminated as a peculiar organ, its cavity, occupying the space between the Amnion and Chorion, being quite consolidated before the fœtus arrives at maturity. Lastly, the Amnion of Mammalia is in several species distinguished from that of the preceding Classes by its vascularity,—in which we find a repetition of the vascularity of the Chorion,—the Amnion bearing the same relation to the fœtus as the Chorion to the Yolk or to the Vesicula Umbilicalis. We next proceed to examine the various conditions of these external formative organs in the different species of this Class.

§. 770. The Chorion differs in condition chiefly according as it performs its functions simply as such, or as it has one or more Placentæ formed upon it for that purpose. The former is particularly the case in the Ovum of the Solipeda, where the external surface has merely very delicate tufts of vessels like those of the villous membrane of an Intestine, with similar correspondent villi on the Uterus; the surfaces of the Uterus and Ovum consequently adhering but loosely together, and usually with a considerable quantity of white chylous fluid between them. The little tufts of vessels are more completely separate from each other upon the surface of the Chorion of the Ovum of Swine. These little Placentæ, however, become yet more perfect (and receive the name of Cotyledons or Carunculæ) in the Ovum of Ruminants, where they appear in large numbers, from 60 to 100, as dense cup-shaped vascular masses: corresponding to them are similar productions from the internal membrane of the Uterus (Glandulæ uterinæ), which shrink after parturition, and disappear like the Mem-

brana decidua of the human Uterus: the vascular extremities of these productions on each side are interlocked with each other like the fingers of two folded hands, and when drawn asunder permit the escape of a dense chylous fluid. (Tab. XX. fig. XVI.) In most of the animals that have claws, on the contrary, there is but a single Placenta,\* its shape being of various kinds, but essentially similar to that of Man. The following are the most important peculiarities presented by this organ: in the Rodentia, the Placenta again presents nearly the same appearance of Cotyledons as in the Ruminants, *i. e.* is like a deep cup or bowl, and in such a manner that it has corresponding to it a small distinct Placenta formed from the Uterus: in the Beaver, it is kidney-shaped. In the smaller Carnivora, *e. g.* the Mole, it is oval, and externally very flocculent. In the Hedgehog, according to BLUMENBACH,† it is gradually formed into a kidney-shaped and very firm mass: in the Pole-Cat, the Placenta is double, and connected by a ribband-like portion to a belt surrounding the Ovum. In Martins, Cats, and Dogs, (Tab. XX. fig. XV.) it is exactly in the shape of a belt. In the annular Placenta of the foetus of the Dog, which has a similar flat uterine Placenta with broad villi corresponding to it, I remarked particularly its dark green edges, with a fluid effused upon them greater in quantity in proportion to the size of the foetus, originally of a dark brown colour, but in the mature foetus dark green, gelatinous, and not affected by acids. I cannot but consider this as being an evident separation of a large quantity of Carbon, and, therefore, as the consequence of a true respiration by means

\* The foetus of the Porpoise too, according to BARTHOLINUS, quoted by TIEDEMANN, (*Zoologie*, t. I. s. 570.) has but a single Placenta, though the finis is divided.

• *Handbuch der Vergleich. Anat.* s. 489.

of the Placenta in the form of expiration; and I think it not improbable, also, that a part of the mucous chylous fluid found about the Placenta in other animals may have a similar origin. The Placentæ of the remaining Genera of Animals, particularly of Apes, resemble that of Man still more closely.

§. 771. As the Chorion regulates the shape of the Ovum by forming its outermost covering, I may here mention that the whole is usually, as in Man, of an oblong round form: in such a manner, however, that in animals with a long-horned or a double Uterus, the Placenta is placed laterally, and not, as in Man, at its upper broader extremity. In animals where the Uterus is single, but has Cornua, *e. g.* in the Ruminants and Solipeda, processes of the Ovum usually extend into the cornua, which, however, as will be seen, are chiefly formed by the Allantois extending the Chorion. The vessels of the Chorion and Placenta pass to the fœtus in Mammalia in the same manner as in Man, though they do not form in any other instance so long a funis. In several Rodentia and Carnivora particularly, the fœtus is so closely approximated to the membranes of the Ovum, and the vessels issuing from the Umbilicus divide so speedily, that frequently there is scarcely any funis more than in the Ovum of Birds and Lizards. In other species, and in the Ruminants, where it is more definitely existent, it is but of moderate length, (in the Ruminants it is covered by a peculiar flocculent membrane, Tab. XX. fig. 16.) and usually consists of two Veins and two Arteries: whilst in the Horse, on the contrary, as in Man, there is but one Vein and two Arteries. We are not as yet enabled to decide whether there is a true Chorion and Funis in the Marsupial Animals and the Ornithorhynchi; or whether, on the contrary, they are formed after the manner of some Amphibia, *e. g.* the Sala-

mander, (§. 764.) without these organs, and are on<sup>o</sup> that account born as abortions.

§. 772. • The Amnion, which in Man as well as in the preceding Class is unvascular, is here, as we have already remarked, occasionally moderately vascular, and particularly in the Animals with hoofs. We may remark especially the elegantly serpentine vessels in the Amnion of the Horse, and the peculiar yellowish scales on that of the Cow. The shape of the Amnion is always oval, and we find it almost always separated from the Chorion by a space containing fluid, of which, consequently, it frequently fills only about half the cavity. The interspace between the Chorion and Amnion in Mammalia likewise affords space for the lodgement of the sac-shaped Allantois protruding from the umbilical fissure: that organ presents itself as a closed bladder, shaped almost like an Intestine, and either easily separable from the Amnion and Chorion, or closely adhering to them on every side. The former is the case in Ruminants (Tab. XX. fig. XVI. X.) and Swine; the latter in the Horse: the Carnivora (fig. XVII. 4.) and Rodentia are intermediate between both. This organ, as was already shewn by NEEDHAM and HALLER, appears to exist in all species of Mammalia; and even when, as in Man, it can itself scarcely be distinguished, its existence is nevertheless demonstrated by the presence of its fluid and of the Urachus, which in some animals is very large, and in others disappears at a very early period.\* In the Dog, however, I have succeeded in inflating the Allantois in the form of a perfect sac, after having opened the Chorion and Amnion, though without separating it from those membranes, which could not have been done without laceration on account of numerous reticular threads by which it is connected to

\* This is the case in the Hedgehog, where the existence of the Urachus was on that account denied by BLUMENBACH. *Manual of Comp. Anat.* p. 497.

them. Its parietes are altogether without vessels, those which take their course about the Urachus quitting the Allantois to enter the Chorion: several branches from their extremities, however, particularly in Ruminants and Swine, are reflected, together with a portion of the Chorion itself, towards the Allantois, and becoming attached to it, appear as the parts called *Diverticula Allantoidis*, and by DZONDI,\* *Membranæ excretoriæ*.†

§. 773. As regards the *Vesicula Umbilicalis*, (called also *Tunica erythroides*;) I agree with DOELLINGER† in considering it as the most essential part of the germ derived from the female Ovary, the first development of the embryo taking place on its surface nearly in the same manner as we have already witnessed with regard to the Yolk-bag: at least this is rendered probable from its being proportionally largest in the smallest embryos,—from its connection with the Peritoneum of the Fœtus,—from its having peculiar vessels like those of the Yolk, (*Vasa Omphalo-meseraica*;)—and from its containing a more chylous fluid than the other membranes. But as its communication with the Intestine, as already noticed, is never so complete as that of the Yolk, it appears in Mammalia to serve merely as the first organ for the preparation of blood, and not also as in Birds for a permanent chylous receptacle. We shall review some of the different forms it assumes. Though it appears to exist in all Mammalia, yet in most, and in Man himself, it is obliterated at an early period, or at least is very speedily changed from a bladder into a little vascular

\* *Supplementa ad Anatomiam et Physiologiam potissimum comparatam.*  
Lips. 1806.

† They have also been described as prolongations of the Chorion by JOERG. (*Grundlinien der Phys. t. i. s. 293.*)

‡ MECKEL'S *Archiv.* b. ii.

membrane. The latter is especially the case in the Rodentia; where, however, I find the Omphalo-mesaraic vessels forming a separate cord, among the umbilical vessels at an advanced stage of the Ovum, and which has also been observed by EMMERT\* in Bats. In the Ruminants, too, it soon disappears, and in the Horse I find it small and very much diminished towards the middle of gestation. It is much more evident, on the other hand, in the Ova of several Carnivora during the whole period of gestation, particularly in Cats and Dogs. (Tab. XX. fig. XV. 5.) In the latter it is nearly as long as the foetus, (longer in the commencement and shorter towards the end of pregnancy,) has an oblong shape, and is situated lengthways where the umbilical vessels enter the membranes. It is here, and also in the Horse, uniformly surrounded to a considerable extent by a duplication of Chorion,† and is attached to it at each extremity nearly in the same manner as the Yolk is fixed by its Chalazæ. In the Horse it is placed lengthways in the direction of the Funis. On the other hand, it neither is, nor can be, found within the Allantois, as stated by OKEN.‡

§. 774. So far then of the consideration of the external organs of developement in the foetus of Mammalia. The essential parts of the formation of the foetus itself coincide with the mode of origin in the preceding Classes; inasmuch as that here also the vertebral column presents itself

\* REIL's *Archiv.* b. x. h. i. s. 65.

† EMMERT, (*l. c.* p. 63,) indeed, states that it is likewise connected with the Allantois, which, however, I have never found to be the fact; on the contrary, in the Ovum of the Dog I have always been able to remove the lamina of the Chorion placed on the under side of the Vesicula Umbilicalis without opening the Allantois. The mode of origin, too, of these two laminae appears to me to be very simple, the umbilical vessels escaping around the Urachus from the Pelvis being distributed to the Chorion, partly below and partly above the Vesicula Umbilicalis.

‡ OKEN und KIESER, *Beyträge zur vergleichenden Zoologie.*

as the first organ, and still precedes all others in the course of the further developement of the body; that the animal is here, also, primarily aquatic, appearing in the first instance as a Zoophyte on account of the uniform punctiform substance of its body; and that here, also, the formation of external organs, of extremities, is the last part of the process: it agrees also with that of Man as concerns the relations of individual organs, the considerable size of the liver, the peculiar circulation of the blood, &c.

Here again, consequently, we find that the difference between Man and Animals is but inconsiderable *materially*, on the contrary, almost immeasurable *ideally*; for whilst the latter appear to be born merely in order to pursue the dictates of Instinct, and the gratification of their propensities, to Man, on the contrary, are imparted a capacity for the most perfect intellectual developement, and the susceptibility of Art, Science, and Religion.

## APPENDIX. N<sup>o</sup>. I.

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### A FEW OBSERVATIONS ON THE DISSECTING AND PREPARING OF THE BODIES OF ANIMALS.

THOUGH the art of anatomising the bodies of Animals is essentially the same as that practised upon the body of Man, and though want of space precludes me from treating the subject minutely, I conceive that a few remarks may not be altogether unacceptable to those who feel desirous of pursuing such studies for themselves.

The first thing that I have to observe is, that all dissections of small and soft objects, *e. g.* Worms, Zoophytes, Insects, Mollusca, and Embryos, where it is desirable to obtain even tolerably accurate results, should be performed *under water*, by which the parts are kept floating and separated from each other, and, consequently, present themselves more distinctly. A very simple contrivance for investigations of this kind may be prepared in the following manner:—A mass of tough wax (not too soft) is to be laid upon one, or more, porcelain saucers or capsules of different sizes, which are then to be put in a warm place until the

wax melts so as to cover the surface evenly to the depth of  $\frac{1}{2}$  or  $\frac{3}{8}$  of an inch. If the object to be examined be laid upon this surface, it may be fixed by needles in any position that is wished, and, when covered with clear water, developed and dissected by means of suitable instruments. Of them, the best are very delicate Forceps; pointed, well made, sharp-cutting Scissars; and small Knives like Cataract-needles, some round, others with cutting edges, and fixed in slender wooden handles. For separating parts I have also employed small horn probes and fine brushes; whilst, for examining them, a good magnifying glass is frequently indispensable. If it is wished to preserve a preparation thus made, wax, coloured at pleasure as for the purpose of injections, is to be formed into little Tablets about  $\frac{1}{4}$  of an inch thick: one of these is then to be placed upon the saucer or capsule containing the preparation; the latter may then be transferred to it, arranged suitably upon it, fixed there by means of short needles, and both together then placed in Alcohol. Nor must I forget to mention, that the examination of very delicate organizations may frequently be conducted with greater facility and accuracy, if the object be previously allowed to remain some time in Spirit, and thereby to become harder and contracted. This applies particularly to the dissection of nervous organs, and to the examination of very small Embryos, of Mollusca, and Worms.

There are various modes of destroying Worms, Insects, Mollusca, &c. for the purpose of dissecting, without injuring their organization: Mollusca, Snails, for instance, as SWAMMERDAM has remarked, are to be allowed to die in water, because by that means their body swells, and all the parts become more distinctly visible; they may afterwards be kept in Spirit (though not too long) for dissection. Worms, the larger Zoophytes, (for the smaller must be

examined whilst alive,) Caterpillars, &c. and also the smaller Amphibia and Fishes, are best destroyed by means of Spirit: Insects, on the contrary, by being dipped rapidly in boiling water, or in Oil of Turpentine.

As regards the dissection of larger animals, we may here use with advantage knives of a large size, and instead of Forceps, suitable hooks with handles.

In animals of considerable size we can generally make artificial skeletons only, after the bones have been sufficiently cleaned by boiling or maceration. In smaller animals, on the contrary, such as Birds, Amphibia, and Fishes, of which last it is very difficult to make good skeletons, the object will be best accomplished by at once making the bones as clean as possible, without injuring the capsular ligaments, soaking the preparation in water that is incessantly changed, and, lastly, bleaching it for some time in the sun.

Lastly, we may mention injections as affording a very essential assistance in zootomical investigations for physiological purposes: in small animals, and in the more minute parts, these must consist of compositions with wax, very fluid and coloured; but above all of Mercury. The latter, however, is not suitable for very soft bodies, *e. g.* Medusæ, &c. in which cases we may employ injections of coloured milk, and similar substances.

APPENDIX. N<sup>o</sup>. II.

DISCOVERY OF A CIRCULATION IN  
INSECTS.

AN Essay by M. CARUS,\* which has appeared whilst the second volume of this Translation was in the press, contains the particulars of his discovery of a Circulation in certain Insects; a circumstance that may safely be characterized as by far the most important addition that has been made to Comparative Physiology in modern times. The observations on which it is founded were made in the autumn of 1826, and an abstract of their results presented in September of that year to the Union of German Naturalists and Physicians, which then held its meeting at Dresden, many of the members of which, *e. g.* OKEN, HUSCHKE, HEYNE, PURRINJE, OTTO, WEBER, and MULLER, had ocular proofs of the reality of the phenomena.

His first observations were made upon the Larva of the *Agrion puella*, which swims with great velocity by means

\* *Entdeckung eines einfachen vom Herzen aus beschleunigten Bluhkreislaufes in den Larven netzflughcher Insecten.* Mit drei Kupf. taf. Leipzig 1824. 4.to.

of three vertical laminae attached to the caudal extremity, and diverging from each other at very acute angles. In the young Larva there is not any trace of wings, but as it advances in age rudiments of wings make their appearance over the rings of the thorax, and gradually increase to their full size, whilst the caudal laminae, on the contrary, in the same proportion fade away, and are partially or completely detached. Each of the caudal laminae in its natural vertical position presents an inferior abdominal, and a superior dorsal, edge, has two tracheal trunks running along its centre and ramifying through it, and consists of granular substance contained between two strata of the external integuments. A current of blood-globules enters each caudal lamina somewhat nearer to its abdominal than its dorsal edge, and running through the greater part of its length, suddenly turns and bends its course back towards the body somewhat nearer to the dorsal than the abdominal margin of the lamina. The path or channel thus formed in the midst of the granular substance is perfectly transparent, except where it is occupied by the blood-globules, or crossed by branches of the Tracheae. The parietes of the channel are not strictly defined, nor formed by any thing like the coats of a vessel, the blood with its globules circulating through the granular parenchyma, a circumstance, however, which is not peculiar to this case, but also occurs generally in the first states of the circulation, as it presents itself, for instance, in the embryo of Fishes; and in the *Figura venosa* of the incubated Egg. The blood-globules are elongated, like a grain of wheat, considerably larger than those of the human blood, and float in a fluid, which is invisible because of its transparency, but the existence of which is proved by the variations in the position of the globules in the current, sometimes following its direction, at others crossing it transversely or more or less obliquely.

When the animal is vigorous, this current is unceasing and uninterrupted, although its velocity is accelerated at regular intervals, and that not only in the abdominal or excurrent, (arterial,) but also in the dorsal or recurrent, (venous,) part of its course through the lamina. When the animal becomes exhausted, or the caudal laminae excised, the circulation through them is interrupted, and, in the same manner as under the same circumstances in the Larvæ of Frogs and Salamanders, the disturbance displays itself not merely by a cessation of the process, but also by retrograde movements of the currents, or by oscillatory motions of the blood-globules.

In proportion as the wings are developed, the circulation in the caudal laminae diminishes, and ultimately ceases, preparatory to the detachment of the laminae themselves. At the same time, however, the circulation presents itself under a new form in the wings themselves. These organs consist of two layers of the integuments, including between them a collection of granular substance divided like network into little islands by the intersection of transparent canals, the largest of the canals taking its course round the margin of the wing, and the whole organ being interspersed with minute Tracheæ. These canals present a circulation similar to that in the caudal laminae, the excurrent (arterial) stream taking its course along the inner margin of the wing, and the recurrent (venous) returning along the outer; whilst occasionally other transverse currents take their course through the net-work of the wing from its inner to its outer margin. As the wings are farther developed, the circulation in them, like that in the caudal laminae, gradually becomes weaker, and ultimately ceases.

The next observations were made on the Larva of a neuropterous Insect, (probably a *Semblis* or *Sialis*;) the body of which was sufficiently transparent to admit of being satis-

factorily examined by the microscope. The dorsal vessel was seen distinctly pulsating, but principally at one point, viz. its posterior extremity, the motion in the anterior part being merely propagated to it from the posterior; these two divisions of the dorsal vessel having the relation to each other of a Heart and Aorta. Excepting the dorsal vessel there were not any traces of regularly defined blood-vessels in the other parts of the body, although regular currents of blood-globules presented themselves with the following appearances. On each side of the body, and external to the great lateral tracheal trunks, a rapid and continuous current of blood-globules presented itself, consisting, as in the former cases, of a succession of single globules, and proceeding from the head towards the posterior extremity of the body, where each of the currents entered the Heart or posterior part of the dorsal vessel, which again propelled its contents with accelerated velocity through the anterior part of the vessel towards the head. The lateral currents, also, presented an accelerated motion corresponding to each contraction of the Heart, and proving that they must communicate at the anterior part of the body with the dorsal vessel, though the opacity of the head of the animal was such as to render it impossible to ascertain the mode of anastomosis. At the point where the legs were inserted into the thorax on each side, the lateral current bent outwards in order to penetrate the substance of the upper phalanx of each leg to a certain extent, and again returned to the body, thereby forming a loop corresponding to the insertion of each leg.

The aquatic Larva of the *Ephemera vulgata*, according to M. CARUS, presents the phenomena of the circulation with still greater distinctness than the preceding animals, and even more clearly than it is possible to recognize it in the Larvæ of Frogs and Salamanders. In it the circulation

is at once visible (with the microscope) in the three last segments of the body; but by a little attention is discoverable, not only in the three terminal caudal spiculæ and in the upper phalanges of the legs, but also in the head, and particularly in the roots of the antennæ. In the posterior part of the body there are on each side two currents of blood, not boundèd by any regular parietes like those of vessels, situatèd on each side of the intestinal canal, and rather towards the abdominal surface of the animal: of these two streams on each side, the outer is the smallest, and the inner the most considerable. The external one resembles the lateral current in the Larvæ already described, and communicates with the internal by several intermediate branches: it is probably from this one, too, that the lateral streams are detached in the form of loops into the upper phalanges of the legs, though it is not possible precisely to ascertain this point, nor even whether the two lateral currents on each side continue distinct in the thorax, which it is most probable that they do, as the current in the upper phalanges of the legs is of the same size as the external of the two which appear in the posterior part of the body, from which the internal differs by its greater size. At the ninth abdominal segment of the body these two lateral currents on each side, which flow posteriorly from the head towards the caudal extremity of the body, change their direction, and are inflected so as to enter the pulsating heart, from which the current of blood is again impelled towards the head. Before the lateral currents enter the heart they give off three streams, one for each of the three caudal spiculæ, running through the greater part of the length of each spicula, and being then suddenly reflected towards the heart. It is not possible to ascertain precisely from which of the two lateral currents of the body these caudal streams are detached, though most probably from the

external: that they come direct from the heart is improbable, as the excurrent (arterial) division of each (caudal) stream corresponds to the abdominal surface of the spicula, and the recurrent (venous) to the dorsal, the heart being situated on the dorsal, and the lateral currents on the abdominal, aspect of the body. The currents in these caudal spiculæ present the phenomena of the circulation with peculiar distinctness, and are particularly remarkable from the circumstance that the excurrent and returning streams, though in close approximation, and not separated in any visible manner, continue to flow without disturbing each other. The excurrent stream is accelerated at regular intervals, corresponding to the pulsations of the heart; the recurrent, on the contrary, being always somewhat more sluggish, and the first to stagnate and cease when the strength of the animal is impaired.

When the extremity of one of the caudal spiculæ is cut through, the blood-globules are expelled in some quantity with an evident jet, and accumulate on the injured surface, where, when they are dried up by exposure to the atmosphere, they change their natural limpidity for an evident apple-green colour.

It has been already mentioned that the heart propels its contents through the anterior part of the dorsal vessel towards the head: the current, however, in the thorax and in the upper part of the head is concealed by the opacity of the horny segments of the cutaneous skeleton, and by the contents of the stomach. In the anterior part of the head, however, we can discover currents in the roots of the Antennæ, forming loops like those in the legs, the current in each proceeding from the cranial surface of the head, and, in returning through the root of the Antennæ, taking its course towards the laryngeal region. Nay, by means of the direct light of the sun thrown on the object, an indistinctly

defined; but very evidently existing, current may be traced forwards through the thorax and over the upper part of the head, and may be seen to be reflected towards the posterior part of the body in the laryngeal region. Hence, consequently, this Larvæ presents the first instance in which it was possible to trace a true and perfect circulation through the whole body.

The endeavours of M. CARUS to discover any evidence of a circulation in fully developed Insects, *e. g.* House-flies, Gnats, Ephemerae, &c. were without success until a very recent period. (May, 1827.) On examining the wings of the *Simulie viridis*, immediately after its metamorphosis from the Larva state, he discovered the circulation through all the vessels of the wings with the utmost possible distinctness. The wings were still soft, but perfectly developed for flight: the circulation was still visible, though in a less vigorous state, two days afterwards, when the animal died. Still more recently he has observed currents of blood in the Larvæ of Water-Beetles, (*Hydrophilus* and *Dyticus*,) and adds, from a notice by A. V. HUMBOLDT of the travels of EHRENBURG and HEMPRICH, (in Africa?) that those naturalists have also observed similar currents in the wings of a Mantis. Hence it follows, that even at this early period of the discovery, a circulation has been detected in four Orders of Insects, *viz.* Neuroptera, Coleoptera, Diptera, and Orthoptera; a circumstance that affords the strongest excitement to farther investigation in other Insects, and under various circumstances.

Of the objects and character of this circulation little can at present be said: its existence, however, in the rudiments of wings tends in a very remarkable and unexpected manner to confirm the idea deduced by OXEN from analogical considerations, and already quoted in a former part of this Treatise, (§. 149.) *viz.* that the wings of Insects are ex-

siccated Gills. As regards the cessation of Circulation in the perfect Insect, or rather its limitation to the dorsal vessel, M. CARUS endeavours to show, that though an extreme instance, there are analogous cases, in which, though of less extent, a circulation that once existed no longer presents itself in the fully developed state. Thus, the medulla contained in the cavities of the bones of young Birds disappears as they advance to full developement, and with it the vessels by which it was supported. Such, also, is the case with their feathers, which in the early periods of their formation are exceedingly vascular, and thus, probably, connected with the respiratory function. So, also, in the Foetus of Mammalia, the allantoid circulation disappears, and its vessels are obliterated in proportion to the developement of pulmonary respiration. The fact that the currents of fluids in the Larvæ of Insects are not defined by vascular parietes, enables us to comprehend the rapidity and facility with which the traces of the circulation are lost in the perfect Insect. On the other hand, the existence of a circulation at one period, and its cessation at another, elucidate many circumstances connected with the physiology of these animals; for instance, the contrast between the rapid growth and transformations of the Larva, and the stationary existence of the perfect Insect; the inconsiderable size to which the body attains in this, as compared with other Classes of animals; the frequently very short duration of the existence of the perfect Insect in proportion to the prolonged periods of its Larva state; its almost total independence of nutrition; and the absence of the power of re-producing parts that have been lost or destroyed.

It still remains to determine at what period of developement the phenomena of the Circulation first present themselves; to observe more precisely its occurrence in other

Orders and Species, particularly those where the Larva is not aquatic, and where, perhaps, it exists only in the Ovum; to fix the period and manner of the cessation of the currents of blood; and to distinguish, on the one hand, the cases where the Circulation may be supposed to cease even in the Larva state, or, on the other, to continue in the perfect Insect.

Lastly, it may be remarked that the phenomena of this Circulation, so far, at least, as it has been traced, do not throw any light on the obscure subject of the mode of nutrition in perfect Insects; which, therefore, must still be supposed to be effected, according to the idea of CUVIER, without the intermedium of Vessels. On the other hand, the demonstration of the original existence, and subsequent cessation of a Circulation, renders more than ever untenable the hypothesis lately suggested by DR. KIDD, (*Phil. Trans.* 1826.) that the Tracheæ, already recognised as respiratory organs, are, at the same time, employed in the conveyance of nutritive fluids.



PRINTED BY RICHARD CRUTWELL,  
ST. JAMES'S-STREET, BATH.

