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SPECIAL ANATOMY
OF THE
GASTEROPODA OF THE UNITED STATES.
BY JOSEPH LEIDY, M. D.
OF PHILADELPHIA.

SPECIAL ANATOMY
OF THE TERRESTRIAL
GASTEROPODA OF THE UNITED STATES.

INTRODUCTION.

WHEN the researches were commenced in the winter of 1844, of which the following chapters are the result, it was the proposition of Dr. Binney for the author to give a complete anatomical and physiological description of the terrestrial Gasteropoda of the United States, including the special and general anatomy, with the embryology of the several genera. Before the special anatomy was fairly completed, the death of Dr. Binney put a stop to the work; and, a different course of observation having occupied the author's attention, the subject is now published, after a long delay, in its present incomplete state, from notes taken at the time.

The animals dissected are as follow: —

LIMAX; *L. variegata*, *L. agrestis*, *L. campestris*.

ARION; *A. hortensis*.

TEBENNOPHORUS; *T. carolinensis*.

VAGINULUS; *V. floridanus*.

HELIX ; *H. albolabris*, *H. thyroidus*, *H. sayi*, *H. tridentata*, *H. fallax*, *H. palliata*, *H. ligera*, *H. intertexta*, *H. suppressa*, *H. auriculata*, *H. elevata*, *H. profunda*, *H. concava*, *H. fuliginosa*, *H. perspectiva*, *H. alternata*, *H. cellaria*, *H. exoleta*, *H. multilineata*, *H. hirsuta*, *H. solitaria*, *H. dentifera*, *H. arborea*, *H. pulchella*, *H. berlanderiana*, *H. gularis*, *H. inflecta*, *H. texasiana*.

BULIMUS ; *B. fasciatus*, *B. decollatus*, *B. virgulatus*, *B. dealbatus*, *B. caribbæorum*.

PUPA ; *P. incana*.

SUCCINEA ; *S. obliqua*.

GLANDINA ; *G. truncata*.

CHAPTER I. — GENERAL REMARKS UPON THE EXTERIOR FORM AND STRUCTURE OF THE TERRESTRIAL NAKED GASTEROPODA.

Upon examining a *Limax* or an *Arion*, we find it composed of a thick, vermiform body, with a broad, ribbon-like, pedal disc, running the whole length of its inferior surface. The anterior, obtuse extremity forms the head ; and from it protrude four retractile tentaculæ, upon the outer side of the tip of the two superior, or longer of which, is placed the eye. The mouth is situated at the antero-inferior part of the head ; and immediately below it is a deep depression, or blind sac. The posterior part of the body forms the tail, and is acute. Upon the antero-superior part of the body is placed the mantle, which covers the pulmonary chamber, and contains within

it a rudimentary, laminar, calcareous testa. The anterior part of the mantle is free and movable, and the head, indirectly through the retractor muscle of the buccal body, is capable of being retracted beneath it. On the right edge of the mantle the pulmonary orifice exists; and at the posterior side of the latter the anal aperture is placed. Upon the right side of the head, a short distance posterior to the superior tentacula of that side, the genital orifice is situated. The body has two distinct cavities; the pulmonary chamber, containing a vascular net-work upon its surface, the heart, the renal organ, and the rectum; and the visceral cavity, separated from the former by a muscular partition, containing the digestive and generative apparatus and the nervous centres.

In *Tebennophorus* the mantle covers the whole upper surface of the body, and encloses no testaceous rudiment. Its anterior edge is unattached, and the head is retractile beneath it. The pulmonary chamber is placed beneath the anterior part of it; and the muscular membrane bounding the visceral cavity in a great part of its extent, is but loosely attached to the outer integument.

In *Vaginula*, the body appears broad from the mantle, which encloses the whole body except the comparatively narrow pedal disc, forming a lateral, angular projection as it is inflected inferiorly to the margin of the pedal disc. In transverse section it is semi-elliptical, as represented in figure 4. The mantle contains no testaceous rudiment. The head can be but slightly protruded. The respiratory orifice is situated on the right side of the tail,

between it and the extremity of the pedal disc. The anal aperture opens at the posterior margin of the latter orifice. The generative apparatus has two distinct external apertures, distant from each other. The male genital orifice is placed just beneath the mouth, between it and the blind sac, inclining to the right. The female orifice is situated upon the inferior part of the left side of the mantle, midway between the head and tail.

As usual, the body has two cavities, of which the pulmonary occupies a position at the right posterior part, beneath the mantle, and extending backwards on the right to the tail.

CHAPTER II. — GENERAL REMARKS ON THE TERRESTRIAL TESTACEOUS GASTEROPODA.

A testaceous gasteropod resembles a slug with the greater portion of the viscera squeezed out upon the back, and arranged in a turbinate manner. The turbinate mass is always an exact mould of the testaceous covering of the animal; its length in the spiral direction holds no proportion with that of the foot, or that part of the body which the animal protrudes from the shell, and differs very much, not only in different genera, but also in different species of the same genus. With an increase in length a proportionate decrease in breadth is observable, and vice versa. In *Pupa* it reaches its maximum length and narrowness; in *Succinea* it has the minimum length, and the greatest proportionate breadth.

When the foot is protruded from the shell, every part of the exterior surface of the turbinated mass is still in contact with the interior surface of the latter, and is retained so by means of the comparatively capacious pulmonary chamber. When the foot is retracted, it is at the expense of the latter cavity; so that the pulmonary chamber of the testaceous genera is as much larger than that of the naked genera as the size of the foot super-added, whilst the extent of the pulmonary net-work of blood-vessels remains the same.

The testacea have a muscle which is peculiar, namely, the retractor-muscle of the foot, which has its origin, in common with the retractors of the tentaculæ and buccal body, from the columella of the shell. Narrow at its commencement, it increases in breadth, splits into several bands, and diverges as it descends to get its insertion into the whole of the inner margin of the excavation of the foot, excepting anteriorly, where its place is occupied by the retractor of the buccal body.

The head occupies the anterior portion of the foot, and in *Helix*, *Bulimus*, *Pupa*, and *Succinea* offers nothing peculiar from that of *Limax*. In *Glandina* a third pair of tentacular appendages exists. These are non-retractile, auriculate in form, and originate just postero-inferiorly to the base of the inferior, retractile tentaculæ, and project horizontally backward.

The body of the testacea, like that of slugs, has two great cavities. The visceral cavity includes the greater part of the turbinated mass, and the excavation of the

foot. The pulmonary chamber occupies a position on the outer side of the lower one to three whorls of the turbinated mass. The collar apparently takes the place of the mantle in slugs. In all the genera it is attached around the base of the turbinated mass, and is perforated on the right side by the pulmonary orifice. On the outer border of the latter the anal aperture is placed.

As in slugs, the genital orifice is situated on the right side of the head, just posterior to the tentaculæ.

CHAPTER III. — ON THE TEGUMENTARY COVERING OF THE TERRESTRIAL GASTEROPODA.

Besides a testa capable of enclosing the whole body, which most of the terrestrial Gasteropoda possess, they have a thick envelop, composed of mucous and muscular membrane. The exterior, highly irritable and contractile investment consists of an actively secreting mucous membrane, (Figs. A, B, C, 1) with a substratum of interlaced muscular fibres (2). In the naked genera it is pretty

FIGURE A.

FIG. A is a diagram representing the disposition of the coverings of the body in *Limax* and *Arion*. 1. mucous lamina; 2. muscular substratum; 3. muscular peritoneum; 4. visceral cavity; 5. rudimentary testa; 6. pulmonary chamber.

uniformly developed throughout, but is thickest upon the pedal disc, the tail, and the upper surface of the mantle, and thinnest upon the head, tentaculæ, and reflected border of the mantle.

FIGURE B.

In the testaceous genera, upon the part of the body corresponding to the interior of the shell, it appears as if the mucous layer had been pushed downwards to form the collar (fig. C, 1*) ; but it may be still traced over the surface of the turbinated portion, as a delicate, tessellated epithelium.

FIGURE C.

The mucous glands are very numerous in the mucous

FIG. B, disposition of the tegumenta in *Tebennophorus*. 1. mucous lamina ; 2. muscular lamina ; 3. peritoneum ; 4. visceral cavity ; 5. pulmonary chamber ; 6. interval between the two muscular layers.

FIG. C, disposition of the tegumenta in *Helix*, *Bulimus*, &c. The references are the same as in figs. A and B, except 1*, which is the collar.

layer; its epithelial cells are flattened, from three to six sided, granular, and with large, round nuclei.

The muscular substratum (figs. A, B, C, 2) of the mucous lamina is composed of unstriped fibres, arranged transversely, obliquely, and longitudinally. It is inflected outwards beneath the mantle, in *Limax* and *Arion* to form the outer parietes of the pulmonary chamber. Between this portion and the mucous layer is placed the rudimentary testa (fig. A, 6). In *Tebennophorus*, it is inflected inwards (fig. B, 5) beneath the anterior portion of the mantle, to form the parietes of the pulmonary cavity. Its transverse fibres predominate within the tentaculæ, its longitudinal fibres, in the exterior pulmonary parietes of the testaceous genera, and especially accumulate on the outside of and parallel to the rectum, so as to serve as an efficient agent in the retraction of the collar, and an aid in the expulsion of matters from the rectum.

Interior to the musculo-mucous investment of the body is a second covering, (figs. A, B, C, 3) which may be considered as a sort of peritoneum. It is a muscular membrane, and encloses the digestive and generative apparatus. It is usually pretty closely attached to the outer tegument, except in *Tebennophorus carolinensis*, in which the two are separated in all parts of the body, except above the pedal disc, where they are firmly blended together, as in all Gasteropoda. It forms the partition or diaphragm between the visceral and pulmonary cavities. This membrane is composed of transverse

and longitudinal, unstriped, nuclear fibres, and is the origin of the especial retractor muscles of different organs.

CHAPTER IV. — OF THE DIGESTIVE APPARATUS.

LIMAX. The orifice of the mouth is bounded by a pair of contractile lips, is situated at the anterior part of the head, and opens into the cavity of the buccal body. When the latter is retracted by its peculiar muscle, the oral orifice becomes lengthened into a canal by the inversion of a portion of the external integument.

The buccal body is an irregularly oval-shaped, muscular organ, resembling in appearance a gizzard, and contains within it the masticatory apparatus. Just within the upper lip, attached to the entrance of the buccal body, is the dental plate, a crescentic, corneous lamina, used for cutting the food. Its anterior face is convex, and presents several vertical ridges. Into its upper convex edge, a band of muscular fibres is inserted, by the contraction of which the inferior, concave, cutting edge is advanced beyond the line of the upper. The middle of the cutting edge is extended into a short, conical toothlet. This plate is brought into view when the animal is eating, by the advancement of the buccal body. The floor of the cavity is occupied with a gouge-shaped, muscular tongue, the tip and upper surface of which are free, and are covered by a corneous lamina studded with a great number of conical dentures, with the points projecting backwards, arranged in transverse rows. These

teeth preserve the same form in the lines from before backwards; the central line always differs from the others, and the teeth also vary gradually in form and size as they pass off from the central line laterally. They also vary slightly in form in different species. This lamina protrudes from the buccal body posteriorly, into a short, rounded, protuberant, blind sac, within which it appears to undergo a constant growth, as it is worn away by attrition anteriorly; for its use appears not only to facilitate the passage of the food onwards to the œsophagus, but also to act as a sort of rasp for triturating it, by means of the powerful muscles composing the buccal body. Into the posterior, inferior part of the buccal body, below the blind sac of the lingual lamina, is inserted, in a transverse, curved line, its retractor muscle. This muscle has its origin, in common with the retractors of the tentacles, from the muscular investment of the visceral cavity, posterior to the pulmonary cavity, and to the right of the rectum.

The œsophagus proceeds from the upper, posterior part of the buccal body backward to the stomach. It is short, and dilates gradually into the latter.

The stomach is a capacious, membranous receptacle, when extended being two-thirds the length of the animal. In *L. variegata* and *L. agrestis*, anteriorly it is dilated, and elongated-oval in form, posteriorly it is intestiniform. In *L. campestris*, it is nearly uniformly cylindrical throughout. Where the stomach terminates in the small intestine, it makes a turn forward with the latter, pro-

ducing, in *L. variegata* and *L. campestris*, a sort of cul-de-sac posteriorly. Into the angle formed by the stomach and intestine, on each side, opens a biliary duct, which, in *L. agrestis*, however, are more removed toward the small intestines.

The intestine forms a single convolution among the lobes of the liver, and then passes obliquely forward from the left to the right side, to join the rectum. It is capacious, and pretty uniformly cylindrical throughout.

About the middle of the oblique portion going to join the rectum, in *L. agrestis*, opens a short, cylindrical cul-de-sac. In *L. variegata* the intestine, upon reaching the retractor muscles of the buccal body and tentacles, winds around their origin, turns backward a short distance, and then again forward to the rectum, producing in this way a sigmoid flexure. From the termination of the latter in the straight portion, there proceeds backward as far as the termination of the visceral mass, a long, cylindrical cul-de-sac.

The rectum is short and straight, and penetrates into the pulmonary cavity, upon the right side of which it proceeds to the pulmonary orifice, at which it terminates by the anal aperture.

The salivary glands are two in number, flat, oval or irregular in outline, of a grayish pink hue, and are situated upon the anterior parietes of the stomach. They are composed of several lobuli, which are conglomerated. From each gland proceeds a duct, along the oesophagus to the buccal body, into which they open on each side of

the entrance of the œsophagus. In *L. campestris*, the two glands are conjoined, so as to form a collar around the commencement of the stomach.

The liver, by far the largest viscus in the body, occupies a position at the posterior part of the latter. It is of a brownish color, and consists of two principal lobes, an anterior and a posterior, which are further divided, the anterior into three or four, and the posterior into two lobes. Each lobe is composed of a number of lobuli held together by bloodvessels. From the convergence of branches, an hepatic duct is formed for each principal lobe, which opens in the side of the angle formed at the termination of the stomach in the intestine. The posterior cul-de-sac of the stomach usually contains some bile, which is a thin, glairy, drab-colored fluid.

ARION. The digestive apparatus offers but little peculiarity from that of *Limax*. The retractor muscle of the buccal body is not so strong, and is divided into two lateral bands. The œsophagus is narrower and longer. In the form of the stomach and absence of a cul-de-sac to the small intestine, it resembles *Limax campestris*. The rectum, in its course to the pulmonary orifice, perforates the renal organ.

TEBENNOPHORUS. The buccal body has a conspicuous curve downwards, and the buccal pouch of the lingual lamina is longer than in *Limax* or *Arion*, and curves upwards from the postero-inferior part of the

buccal body. The retractor muscle of the latter is split into two bands as in *Arion*, but one stronger. There are also two small retractor muscles to the lower lip. The œsophagus is comparatively long. The stomach is cylindrical and sacculated, and, posteriorly with the small intestine, forms a wide cul-de-sac. The small intestine is like that of *L. campestris* and *Arion*. The salivary glands occupy a position on each side of the œsophagus. The ducts are tortuous.

VAGINULA. The buccal body possesses no retractor muscle. The dental plate is broad, and, upon the anterior surface, has a pectinate appearance, from the numerous ridges upon it. Its cutting edge is devoid of the conical toothlet. The œsophagus is moderately long and capacious. The stomach is cylindrical and sacculated, and posteriorly forms a deep, capacious cul-de-sac, independent of the small intestine. It is strongly muscular and shining, the transverse muscular fibres being very distinct. The anterior hepatic duct opens into the angle formed by the cul-de-sac and the intestine, the posterior into the fundus of the latter. The small intestine is pretty uniformly cylindrical, and holds the usual course to near its termination in the rectum, when to reach the latter it turns abruptly backward, and joins it on the right side, just posterior to the middle of the body. The rectum is straight, and proceeds backwards, along the right side of the body, within the pulmonary cavity, and terminates between the extremity of the tail

and the pedal disk, at the side of the pulmonary orifice. The salivary glands are arborescent, or fasciculated in appearance. The ducts are short and delicate. The lobuli of the liver are looser, or more separated, than in the preceding genera.

HELIX. The buccal body has the same appearance, generally, as in the slugs. The retractor muscle is much stronger, and has its origin in common with the retractor of the foot and tentaculæ, from the columella of the shell; at its insertion it forms a semicircle around the posterior inferior part of the buccal body. The pouch of the lingual lamina is always a prominent object. In *H. cellaria* and *H. concava*, the buccal body is proportionately nearly twice the length of that of the other species. The dental plate varies in some degree in different species: in *H. ligera*, *H. intertexta*, &c. it is smooth anteriorly, and in the middle projects downwards into a large, conical toothlet; in *H. albolabris*, *H. tridentata*, &c. the anterior surface presents a number of curved ridges, each of which projects inferiorly as a sort of toothlet.

The œsophagus is generally long and narrow. In some species it is unusually long and contracted, as in *H. concava*, *H. cellaria*, *H. hirsuta*, *H. perspectiva*, etc.; in others it is long, and dilated in the middle, as in *H. auriculata*; in many it is capacious, and gradually passes into the stomach, as in *H. exoleta*, etc.

The stomach is usually cylindroid, and more or less sacculated. The posterior cul-de-sac is always present.

The small intestine comes off from the stomach at a very acute angle, and into the latter two hepatic ducts empty. It is pretty uniformly cylindrical, and forms, as in slugs, a single convolution or a sigmoid curve, among the lobes of the liver, and penetrates to the pulmonary cavity at its right posterior angle. The rectum, in all the testaceous genera, corresponds in length to the pulmonary cavity, the right side of which it occupies to the pulmonary orifice, at the outer border of which it terminates by the anal aperture. It is cylindrical, usually wider than the small intestine, and is frequently somewhat sacculated. Upon the outer side of the rectum, running its whole length, is a band of muscular fibres, the object of which is, apparently, the retraction of the collar, the shortening of the rectum, and the expulsion of its contents.

The salivary glands are generally elongated, oval, with lobed edges. They are usually united together and situated on the œsophagus, or commencement of the stomach. When the œsophagus is narrow they surround it ; when dilated, they occupy one-half or two-thirds of its surface. The salivary ducts are long and large.

The liver is four lobed, three of which lobes are anterior or inferior, and the fourth posterior or superior. The fourth lobe, conjoined with the testicle, forms the very summit of the turbinated mass. The ducts from the anterior lobes converge to form a single trunk, which, with that from the posterior lobe, open into the junction, or angle, of the cul-de-sac of the stomach with the intestine.

BULIMUS. The digestive apparatus in *B. dealbatus*, *B. decollatus*, and *B. virgulatus*, resembles that of *H. auriculata*; the œsophagus is long, narrow, and dilated in the middle; the stomach is cylindroid, and more or less sacculated. The stomach of *B. fasciatus* resembles that of *Limax variegata*, being large and capacious anteriorly, cylindrical and sacculated posteriorly. The rectum is capacious and sacculated.

PUPA. A characteristic of this genus is the very great proportionate length of the viscera, corresponding to the numerous whorls of the shell. The retractor muscle of the buccal mass is long and strong. The dental plate has two central, conical toothlets in its cutting edge. The œsophagus is very long and narrow. The stomach is very long, and even forms a fold upon itself. The rectum is very long and sacculated; the muscle on its outer side is well developed.

SUCCINEA. A characteristic of this genus, the reverse of Pupa, is the great breadth and shortness of the viscera. The dental plate has an upper, quadrangular piece, superadded to the ordinary, crescentic plate. The stomach resembles that of *Limax variegata*. Its mucous membrane presents several longitudinal rugæ. The small intestine does not undergo the same relative diminution with the other viscera. The rectum is very short, and, from the transverse position of the pulmonary cavity, it is placed along the right of the breadth,

instead of the length of the latter, as usual. The salivary glands are situated one on each side of the commencement of the stomach ; their ducts, just before opening into the buccal body, become dilated.

GLANDINA. The oral orifice is triangular, and bounded by three papillated lips, one upper and two lateral. The buccal body is a very long muscular cylinder, a little curved downward at the posterior part. There is no cul-de-sac for the lingual lamina protruding behind ; and the retractor muscle is divided into three fasciculi, one central and passing into the buccal body posteriorly, the others lateral and inserted as usual. Externally, it has a very thin investment of longitudinal muscular fibres, continuous with those of the retractor muscle and the origin of the especial muscles of the tongue. This layer is very delicate and transparent ; and at the anterior third of the buccal body, laterally and inferiorly, it presents several fasciculi, which pass to the tegumentary lips. Beneath the exterior covering, and readily seen through it, is a thick and strongly fasciculated, transverse layer of muscular fibres. When the buccal body is laid open the oral orifice is found to be continuous with a triangular canal with smooth sides, running one-third its length. At the posterior superior termination of the canal, is the opening of the œsophagus and orifices of the salivary ducts. There is no dental plate. The posterior two-thirds of the buccal body is occupied by a long oval organ, composed of numerous, strong fasciculi of muscular fibres, arising

laterally and inferiorly at the posterior part of the buccal body ; the former passing inwards and forwards, the latter forwards to the anterior extremity of the organ, which is free, and projects into the triangular, oval canal. The lateral fasciculi leave between them superiorly an interstice, at the bottom of which is found the lingual lamina, in the form of a tube, closed posteriorly, and open and reflected downwards and backwards upon the anterior, free tip of the organ. Into the posterior extremity of the lamina, the middle fasciculus of the retractor muscle of the buccal body is inserted ; and, just anterior to this insertion, a small, attrahent fasciculus, arising from the roof of the buccal body, posterior to the orifice of the œsophagus, which gets to the lamina by means of the interstice of the muscular organ superiorly. The teeth of the lingual lamina are arranged diagonally, from the middle line, in parallel rows, passing from within outwards.

The œsophagus issues from a fissure at the upper posterior line of the anterior third of the buccal body. It is long and cylindrical, and rather wider at its termination than at its origin. The stomach is irregularly cylindroid, and has a cul-de-sac at its commencement, projecting anterior to the entrance of the œsophagus. The small intestine is capacious.

The salivary glands are conjoined, so as to form a circular collar around the posterior part of the œsophagus. The salivary ducts are long, and enter the same fissure of the buccal body at which the œsophagus issues. The

anterior lobes of the liver are comparatively very small, while the posterior lobe is correspondingly large ; and to the whole there is but a single duct.

CHAPTER V. — OBSERVATIONS ON THE TISSUES OF THE
DIGESTIVE APPARATUS.

The mucous membrane of the alimentary canal is usually smooth throughout. In the stomach it frequently presents a number of transverse folds, corresponding to the contractions which produce the sacculated appearance of the organ ; and in several species of different genera it presents a few longitudinal rugæ, as in *Limax variegata*, *Bulimus fasciatus*, *Helix exoleta*, etc. In its whole extent it is formed of a columnar epithelium and a nucleolated-nucleated basement membrane. The columnar cells of the epithelium are long and pyramidal, the upper part or base being broad, and the attached extremity very narrow. They are filled with a very fine, indistinct, granular matter, intermingled with coarser, highly reflective granules. Each contains an oval, granular nucleus, with a minute nucleolus.

The muscular investment of the intestinal canal is strongest upon the stomach and rectum. In *Vaginulus*, *Pupa incana*, etc. it is strong and shining upon the stomach. It consists of two layers, an internal transverse and an external longitudinal. They are both composed of white, shining, strap-shaped bands, with the extremities pointed and closely adapted to each other. None of

the transverse bands surround the stomach, all being much too short. They are indistinctly granular in structure, and each contains one or two elongated nuclei.

The lobules of the salivary gland are composed of the dilated commencements of the ducts, lined with soft, granular cells, which are oval in form, and contain a round, granular nucleus with a minute nucleolus. The basement membrane of the salivary ducts is amorphous. The epithelial cells lining the trunks bear considerable resemblance to those found in their follicular commencement. Outside of the basement membrane, twine narrow, muscular fibres in various directions. They are nucleated, and where the nuclei exist are wider than at the intervening parts.

The lobuli of the liver are composed of the rounded commencement of the biliary ducts, and are lined with polygonal cells, which become globular on the removal of pressure. The hepatic cells contain a fine, granular matter, fine and large oil-globules, and a round, nucleolated nucleus.

CHAPTER VI. — OF THE GENERATIVE APPARATUS.

All the terrestrial Gasteropoda under consideration are monœcious, or hermaphroditic, though none are capable of self-impregnation. They are also all oviparous.

LIMAX. The testicle is a round, or oval body, partially concealed by the liver; it is brown in color, and

has the appearance of being composed of rounded acini. In *L. variegata*, it is lobulated. The epididymis is an undulated, or moderately tortuous tube, leading from the testicle to the inner side of the junction of the ovary with the prostate gland. It opens into a groove upon the inner side of the interior of the oviduct which is continuous, at its inferior extremity, with the vas deferens. Opening into the termination of the epididymis, and lying against the inner side of the ovary, is a small, compound, follicular body, which appears to be common to all the terrestrial Gasteropoda. The prostate gland is a white, or cream-colored body, occupying the inner side of the whole length of the oviduct. It has a transverse, striated appearance, and numerous openings into the groove leading from the epididymis to the vas deferens.

The vas deferens is a comparatively short tube, passing from the prostate gland to the penis. In *L. variegata*, it joins the summit of the latter; in *L. agrestis* and *L. campestris*, it enters near the base.

The penis, in *L. variegata*, is a long, cylindroid, irregular body, lying at the right anterior part of the visceral cavity, and joining at its termination a short cloaca. Into its summit is inserted the retractor muscle, which has its origin from the muscular investment of the visceral cavity, just posterior to the position of the pulmonary cavity. The interior of the penis is lined by mucous membrane, its exterior of muscular membrane. In *L. agrestis* and *L. campestris*, the organ which corresponds to the penis of *L. variegata* becomes of a somewhat pro-

blematical character. In *L. agrestis*, it is an elongated, conical organ, with a protuberant base. Its summit is divided into three cœca; the retractor muscle is inserted into its side. Upon the interior it presents several longitudinal folds of mucous membrane, and at its lower part, corresponding to the protuberance of the base, an oval, pointed papilla. In *L. campestris*, the organ is spiral, and has but a single pointed summit.

The ovary is a large, white, semi-elliptic organ, usually more or less curved and lobulated, and situated at the summit of the oviduct. In *L. agrestis* and *L. campestris* it is always two-lobed, or double. The oviduct is a long, wide, soft, white, tortuous, sacculated tube, passing from the ovary to the vagina. The neck or portion immediately joining the vagina, commences usually where the prostate gland terminates, and is contracted to less than half the calibre of the upper portion of the tube. Its interior surface exhibits a number of transverse folds, corresponding to the contractions which produce the sacculated appearance of the organ, and upon the inner side upon each side of the spermatic groove, or longitudinal fold.

The generative bladder, in *L. variegata*, is a large pointed, oval receptacle, opening by a very short, wide tube or duct, into the vagina. In *L. agrestis* it is large, elongated oval, and opens by a short duct into the angle formed by the junction of the vagina with the male portion of the generative apparatus. In *L. campestris* it is a small oval sac, with a longer, narrow duct, opening into the tube leading from the penis to the cloaca.

In all three species of *Limax*, the cloaca is a short canal opening at the generative orifice on the right side of the head.

ARION. The generative apparatus resembles more that of *L. variegata* than the other species. The penis is cylindrical, dilated at base, and has its retractor muscle inserted into the latter point. The generative bladder is large, oval, pointed at summit, and has a very short but muscular duct, joined midway by the vagina. At the latter junction is inserted a second retractor muscle. The cloaca is long and dilated in the middle.

TEBENNOPHORUS. The testicle lies upon the right side, partly concealed by the liver; it is round and lobulated. The epididymis is more tortuous than in the preceding. The vas deferens is very long, tortuous, and muscular. It joins the penis at its summit, and has the retractor muscle inserted into it the length of the penis above the latter. The penis is irregularly cylindroid, bent at its summit.

The ovary is exceedingly lobulated. The oviduct is tortuous, wide, and very much sacculated. The prostate gland is longer than in *Limax* or *Arion*. The generative bladder is large, globular, or nearly so. Its duct is rather less than half the length of the oviduct. At its junction with the neck of the latter, an oval, muscular organ exists, the dart sac. Within the latter at the bottom, is a hemispherical papilla, upon the summit of which

is placed a white, calcareous, calcarate dart. At the junction of the vagina, common to the neck of the oviduct, duct of the generative bladder, and the dart sac, with the penis, there are two short retractor muscles inserted. The cloaca is narrow and cylindrical, and has surrounding two-thirds of its middle, a thick, glandular organ. Interiorly, the penis, cloaca, etc. have a longitudinally rugous surface.

VAGINULUS. A remarkable peculiarity of this genus is the removal of the male and female portions of the sexual apparatus from each other. The former, except the testicle and prostate gland, occupies the usual position, but opens externally between the mouth and olfactory orifice ; the latter is placed in the middle inferior part of the visceral cavity, and opens exteriorly on the right side, inferiorly just posterior to the middle of the body.

The testicle is situated between the posterior part of the stomach and the liver, on the right side. It is not lobulated, but has the same aciniform arrangement as in the preceding genera. The epididymis is moderately tortuous, and becomes the vas deferens at the junction of the ovary with the oviduct. The vas deferens takes a remarkable course to get to the penis. It is, at first, attached for a short distance to the commencement of the oviduct, which it leaves, and then winds around its lower extremity, where it is joined by a comparatively very small prostatic gland. It continues its attachment to the lower part of the oviduct to the junction of the

latter with the duct of the generative bladder, where it receives a small duct from the duct of the latter organ, and then passes nearly to the external female orifice, where it turns abruptly forwards between the muscular peritoneum and the right edge of the podal disk, and continues this course to the head. It now turns abruptly backwards to the right, and again appears within the visceral cavity, and passes to the base of the penis.

The penis is a conico-cylindroid, contorted organ, contained within a thin, muscular sheath. Its apex presents a small, round papilla, or glans; and into its base is inserted the retractor-muscle, which arises just anterior to the pulmonary cavity. The lower part of the preputial sheath of the penis is joined by the common duct of a highly developed, multifid vesicle. This latter organ consists of twenty-five long, narrow, cylindrical, blind tubes, contorted at their termination, and opening separately into a common tube, containing, in the specimen examined, attached to its bottom, a narrow, cylindroid organ, which, probably, may have been an uncalcified dart.

The tube formed by the præputium and the duct of the multifid vesicle, as previously mentioned, opens exteriorly immediately beneath the mouth. The ovary is small and unusually lobulated. The oviduct is a narrow, cylindrical tube, which winds forwards and then back again so as to form a double spiral, after which it makes a curve downwards, and is joined by the duct of the generative bladder. The latter organ is globular; its

duct is short, gradually increases in breadth, and is spirally twisted. From the duct, as previously mentioned, passes a small offset to the vas deferens. The common duct of the bladder and oviduct, or vagina, is cylindrical, and, just before terminating, is joined by a short, wide tube, derived from a large, oval sac, which is filled with a delicate, reticulated substance. This sac is peculiar to *Vaginulus*; its use is problematical.

The position of the female orifice of generation has been already stated.

HELIX. The testicle, very unlike that of slugs, is imbedded or commingled with the parenchyma of the posterior or superior lobe of the liver; and, instead of having an aciniform appearance, it is composed of fasciculi of short cœca. It is usually of a lighter color than the liver. The epididymis is long, and generally very much convoluted, and contains a white, silky, tenacious, substance, often distending the tube to a considerable degree, composed of spermatozoa. At its junction with the prostate gland, it always receives the duct of a small accessory gland, composed, in different species of *Helix*, of from three to nine acini.

The prostate gland is generally larger than in the *Limaces*; in *H. exoleta* it is unusually large.

The vas deferens generally corresponds in length with the curve passing from the termination of the prostate gland downwards to the cloaca, and thence to the summit of the penis. In *H. exoleta* and *H. albolabris* it is

considerably longer, and in the latter presents several large convolutions. In *H. intertexta*, *H. ligera*, *H. gularis*, and *H. suppressa*, it is much shorter. Generally, it is a white, narrow, cylindrical, frequently undulated tube. Sometimes it is distinctly and strongly muscular, as in *H. albolabris*, *H. tridentata*, *H. elevata*, etc. In *H. fuliginosa* its lower part is dilated to the diameter of the penis, and is strongly muscular. In *H. albolabris*, *H. tridentata*, and *H. exoleta*, at its commencement it presents a dilated and glandular appearance. In *H. solitaria* it is much dilated, annulated, and glandular at its termination. In all instances except in *H. cellaria* and *H. alternata*, it joins the summit of the penis; in the two latter it joins the penis at the side, very near the summit.

The penis varies very much in form and size; most usually it partakes of a conico-cylindroid form. In *H. sayi*, *H. texasiana*, *H. inflecta*, and *H. auriculata*, it is very large and long, cylindrical, collapsed, and flaccid. In *H. concava* it is long, clavate, and bipartite at the summit. In *H. alternata*, *H. perspectiva*, and *H. solitaria*, it is short, stout, and clavate. In *H. albolabris*, *H. tridentata*, *H. multilineata*, *H. arborea*, *H. dentifera*, and *H. palliata*, it has a thick, preputial membrane, originating around its base, and rising upwards so as to envelop it for one or two-thirds of its extent. In *H. profunda* the base of the penis protrudes into a sheath joining the cloaca, in the form of a cone with its apex bent upon itself. In *H. ligera*, *H. intertexta*, and *H. sup-*

pressa, it is wholly enveloped in a sheath derived from a tubular offset from the duct of the generative bladder.

The muscular tunic of the penis is thick and strong. The internal lining mucous membrane usually presents a number of large rugæ, longitudinal and oblique; frequently there is but a single, large, longitudinal fold, as in *H. alternata*, *H. albolabris*, etc. At the point of entrance of the vas deferens there is generally one or two pendant, valve-like folds of the lining membrane.

In *H. albolabris*, *H. tridentata*, and *H. multilineata*, the surface of the membrane is everywhere distinctly papillated; in the others it is smooth.

The penis of *H. cellaria* on the outside presents a row of minute, round, glandular bodies.

The retractor muscle is in all cases, except in *H. solitaria*, inserted into the summit of the penis, or into the vas deferens near its termination in the latter. In the excepted case, it is inserted into the side of the penis, above its middle. In *H. multilineata* there are some accessory fibres passing from the latter to the preputium; in *H. profunda* to the base of the penis; in *H. albolabris*, *tridentata*, etc. from the vas deferens to the preputium. The penis joins at its base the cloaca.

The ovary has the same general form and color as in slugs, but rarely presents any thing more than a trace of lobuli, usually having a uniform, homogeneous appearance. The oviduct does not differ from that of the slugs. Its neck is usually narrow, and of variable length, and is joined at the lower part by the duct of the genital blad-

der, to form the vagina. In *H. concava* and *H. multilineata*, the neck is long, dilated at its lower part, and strongly muscular, and its internal surface presents a number of longitudinal rugæ. In *H. profunda* and *H. fuliginosa*, it is long, cylindrical, and strongly muscular.

The genital bladder, constantly existing, presents considerable variation in the form, size, and length of the duct. It is generally subrotund, oval, or pyriform in shape, and large. In *H. solitaria* the duct is wide, as long as the oviduct, and dilated at its lower part. In *H. perspectiva* it is as long as the oviduct, and narrow. In *H. alternata*, *H. ligera*, *H. intertexta*, *H. concava*, *H. suppressa*, and *H. gularis*, it is rather more than half the length of the oviduct. In the remaining species generally, the bladder reclines upon the lower part of the prostate gland, and its duct is about the length of the neck of the oviduct. In *H. multilineata* it does not reach the prostate gland, and so gradually passes into its duct as to be a mere, long, cœcal tube. In *H. berlanderiana* the duct of the bladder is as short as that of *Arion*. Usually, the surface of the bladder is smooth; in *H. profunda* and *H. exoleta* it is transversely folded; in *H. fuliginosa* it is regularly, longitudinally folded. In *H. concava* and *H. multilineata*, the duct of the bladder at its termination dilates, and is strongly muscular. In *H. solitaria* the lower third is dilated. In *H. fuliginosa* and *H. profunda*, it is strongly muscular the greater part of its extent. In *H. albolabris*, *H. palliata*, *H. tridentata*, etc. it is dilated to the size of the bladder,

is strongly muscular, and internally presents a number of regular, longitudinal folds, sometimes undulated at the sides, extending to the lining of the bladder in the form of line-like plicæ. In *H. ligera*, *H. intertexta*, *H. gularis*, and *H. suppressa*, an offset from the duct of the bladder passes down, and encloses the penis, dart sac, and cloaca.

The vagina, or common duct of the oviduct and duct of the genital bladder, holds no correspondence with the length of the penis; it is always shorter, usually not more than one-third the length, and is also narrower. In *H. fuliginosa*, it is surrounded by a thick, glandulous body.

In *H. ligera*, *H. intertexta*, *H. gularis*, and *H. suppressa*, there exists, opening into the cloaca, a curved, cylindrical, strongly muscular dart sac, longer and narrower than the penis. The bottom of the tube, for one-fourth the length of the latter, is occupied by the papilla from which arises the dart. The muscular layer, for more than half the length of the tube, at the middle of the latter, closely envelops the dart, and terminates abruptly below in a sort of papilla, from which the point of the dart projects into the lower part of the tube. The dart is a very long, narrow, curved, cylindrical, tubular, flexible, calcareous spiculum, terminating in a sharp, spear point. At the base of the dart, there opens into the dart sac, in *H. ligera* and *H. suppressa*, a single, short, pyriform follicle, the simplest homologue of the multifid vesicle. In *H. intertexta* and *H. gularis*, there is a pair of such follicles,

but longer. Into the summit of the dart sac is inserted a retractor muscle, originating from the angle formed by the division of the duct of the genital bladder into two parts. Opening into the tube which leads from the penis to the cloaca, in *H. Berlanderiana*, is a cylindrical, curved, muscular organ, about one-half the length and as thick as the penis, which is probably a dart sac, although in the specimen dissected no dart was found. In *H. concava*, opening into the cloaca, is a short, rounded, muscular cavity, probably a dart sac, which, however, in the individuals dissected, were also destitute of the organ.

The cloaca, or common receptacle of the termination of the male and female organs of generation, is a short, wide, muscular tube, holding no relationship with the length of the penis, and opening exteriorly on the right side of the head.

In many species of *Helix*, the anatomy of the generative apparatus is so very similar, that they appear to differ in nothing but size. Thus, *H. albolabris*, *H. tridentata*, *H. dentifera*, *H. palliata*, *H. arborea*, and *H. fallax*, are alike; *H. intertexta*, *H. gularis*, *H. suppressa*, and *H. ligera* are also alike, except that the two latter have but a single vesicle to the dart sac, while the former have a pair. *H. auriculata*, *H. texasiana*, and *H. inflecta*, are alike, and also *H. thyroidus* and *H. pulchella*.

It is a very remarkable fact in the special anatomy of the generative apparatus of the genus *Helix*, that while the flagellate form of the penis and those accessory

organs, the dart sac and multifid vesicles, are so common in European species, they are very rare in American species. In not one of the latter does the flagellate form of penis exist. A rudiment, or simplest condition of the multifid vesicles, only exists in four species; *H. intertexta* and *H. gularis*, in which there is a single pair of follicles, and *H. ligera* and *H. suppressa*, in which there is but one short follicle. The dart sac exists certainly in only the four latter species, probably in *H. berlanderiana*, and doubtfully in *H. concava*.

BULIMUS. In *B. fasciatus* the penis is long, cylindrical, and strongly muscular. The vas deferens joins it near the summit; and the retractor muscle, which is very long, is inserted into the latter. The oviduct is long, and its central part presents the peculiarity of being colored brown. The genital bladder is ovate, situated near the ovary, and its duct is narrow, and as long as the oviduct. The vagina is broad and muscular. At the base of the penis, there opens a short, cylindrical duct, derived from a single, multifid vesicle, which presents six or seven rounded or ovate divisions. There is no dart sac.

In *B. dealbatus* the penis is very long; its upper portion is narrow and very tortuous, and flagellate in appearance; although the true flagellum, or the free portion of the summit of the penis beyond the insertion of the retractor muscle, is very short. The lower third of the penis is dilated, and presents an annular constriction;

at its base it is enveloped by a short prepuce. The vas deferens follows the course of the penis nearly to its summit. The genital bladder is oval; its duct as long as the oviduct.

In *B. virgulatus* the penis is long, irregularly cylindroid, and has its base enclosed in a short prepuce. The vas deferens terminates in, and the retractor muscle is inserted into, its summit. The genital bladder is oval; its duct is not more than one-third the length of the oviduct, and dilates as it passes downwards.

In *B. decollatus* the penis is short, conico-cylindroid, and simple. The vas deferens enters near its base; the retractor muscle is inserted into its summit. The genital bladder is small; its duct is narrow, and not longer than the neck of the oviduct.

PUPA. In *P. incana* the penis is short, narrow, and cylindrical. The vas deferens is of a very great length when compared with what it is usually in the other genera. Its lower part, about the length of the penis, is dilated to the size of the latter organ, is strongly muscular, and terminates at the base of the penis. The retractor muscle is inserted into the summit of the latter. The lining membrane of the penis presents a single, longitudinal fold. At the base of the penis is a short, muscular sac, or protuberance, probably a dart sac, although the individual dissected possessed no such instrument. The genital bladder is oval; its duct is as long as the oviduct, and midway receives a long, narrow duct, de-

rived from a granular, glandular organ combined with the testicle in the posterior lobe of the liver.

SUCCINEA. The testicle is not separated into distinct fasciculi by the parenchyma of the liver as in *Helix*, but forms a single mass. The epididymis is very much convoluted, and appears always to be distended with spermatic matter. The prostate gland is unusually short, occupying the upper half only of the length of the oviduct, and is thick, clavate, and more or less colored by pigmentum nigrum cells upon the surface. The penis is long, cylindroid, curved downward at its upper part, and is joined at its summit by the vas deferens. The retractor muscle is inserted into the penis a short distance below its summit. The genital bladder is large and globular; its duct is nearly as long as the oviduct, and is narrow. The vagina is moderately long and muscular. The cloaca is short.

GLANDINA. The testicle is an oval mass, separated from the liver as in the *Limaces*. The epididymis appears from a hilum in the side of the testicle; at first but slightly tortuous, it becomes convoluted just before ending. Its accessory glandula is large. The penis is long, large, and clavate, very gradually enlarging from the base to the summit. The vas deferens, which joins the latter point, is long, moderately tortuous, and wide. The retractor muscle is inserted into it near its termination in the penis. The bladder is oval, constricted;

its duct is as long as the oviduct. The vagina is moderately broad. The cloaca is short. The exterior generative orifice is on the right side of the head, considerably posterior to the inferior tentaculæ.

CHAPTER VII. — GENERAL REMARKS UPON THE JUNCTION OF DIFFERENT PORTIONS OF THE GENERATIVE APPARATUS, AND THE STRUCTURE OF ITS TISSUES.

The testicle was mistaken by Swammerdam, Cuvier, and others for the ovary, and the latter organ and prostate gland for two portions of the testicle. A microscopic examination of these different organs at once, very easily settles their true nature; although, even without this mode of analysis, we would suppose the epididymis would indicate the character of the gland of which it is the duct, and leave the remaining two organs to be considered as belonging to the female apparatus. In *Helix*, the structure of the testicle consists of dense fasciculi of short coecal pouches, which are simple, bifurcate, or trifurcate. These contain polygonal spermatothori, which are finely granular with a round nucleus, or filled with granular globules of uniform size, or with coils or bunches or fasciculi of spermatozoa. The epididymis always contains, more or less, and is frequently distended with, a white, silky, filamentous substance, composed of spermatozoa. The latter consist of very delicate and, comparatively, enormously long filaments, terminating, at one extremity, in a thickened head. They vary

in length in different species of these gasteropods. The head assumes two principal forms ; it is either sigmoid and pointed, as in *H. albolabris*, *H. multilineata*, etc., or else it is spiral and pointed, as in *H. alternata*, *H. solitaria*, etc. In the vas deferens, the spermatozoa may often be detected in movement, which is slow and vibrating in character.

The prostate gland, although situated along the tract of the oviduct, evidently belongs to the male apparatus, as is proved by its emptying solely into the vas deferens in *Vaginulus*, and in its being placed between the termination of the epididymis and the commencement of the vas deferens only, as is very conspicuously observed in *Succinea*. In structure, it is composed of closely packed, tortuous, tubular, simple follicles, lined with short, thick, pyramidal epithelia, which are densely granular, and contain a round, nucleolated nucleus. The object of this organ probably is to dilute the very tenacious spermatic matter as it oozes from the epididymis into the spermatic groove on the inner side of the oviduct.

In all the terrestrial gasteropods examined, there was found a small, glandular body, from which proceeds a short duct to join the termination of the epididymis. It consists of from two to nine rounded follicles joining a common duct, and, from the constancy of its existence, must be deemed important.

The ovary is soft and homogeneous in appearance ; viewed by the microscope, it is found to be almost wholly

composed of immature ova, polygonal cells with a germinal vesicle and macula.

The sides of the oviduct are soft, and in great measure composed of a tissue consisting of large, polygonal cells, with from one to five small, round nuclei.

The organ denominated genital bladder, from its opening into the vagina, or at the termination of the latter, and in Vaginulus from its belonging almost wholly to the female organs, must be considered rather as a portion of the female apparatus than a prostatic sac, as it is called by Owen. By many authors, this has been termed the spermatheca, from its supposed function of holding spermatic fluid received from the male organs ; and with some reason ; for in several instances I have found it to contain a tenacious mass, which upon microscopic analysis was found to be composed of spermatozoa. This cannot, however, be considered wholly as its use ; for it secretes a mucoid matter, which may probably facilitate the passage of the ova through the vagina and cloaca. The mucoid matter within the bladder is frequently found to contain immense numbers of an infusorial parasite, which I have described under the name of *Cryptoicus*.¹

The epithelium of the bladder consists of very long, caudate, columnar cells, with elliptical, granular nuclei, and a small, round nucleolus.

¹ Journ. Acad. Nat. Sci. N. S. Vol. I.

CHAPTER VIII. — OF THE RESPIRATORY AND CIRCULATORY APPARATUS.

The lung of the Terrestrial Gasteropoda is a simple cavity, with an orifice communicating with the exterior, upon the right side of the body. The surface of this pulmonary cavity in part of its extent, and more particularly near the pulmonary orifice, is covered by a close intertexture of blood-vessels. The blood of the body is conveyed directly to the lungs by two principal vessels, the pulmonary arteries, which join the capillary rete of the pulmonary surface. From this rete passes off the pulmonary vein to the heart, which is systemic, and consists of an auricle and ventricle. The auricle receives the pulmonary vein; from the ventricle passes off the aorta, to be distributed throughout the body.

LIMAX. The pulmonary cavity is situated beneath the mantle, and has nearly the same size and form. It is separated from the visceral cavity by the muscular peritoneum, but contains the rectum, renal organ, and heart. The pulmonary orifice is situated at the antero-inferior edge of the mantle, on the right side of the body. When open it appears round; it is closed by means of circular, muscular fibres. The pulmonary rete is principally displayed upon the roof of the cavity, and from it converge three principal trunks, to form the pulmonary vein which passes to the auricle of the heart.

The heart, enclosed within a pericardium, is situated near the middle of the pulmonary cavity. The auricle and ventricle are pyriform, and placed base to base. The sides of the latter are considerably thicker than those of the former, and present internally several well-marked fasciculi, crossing in different directions. Between the auricle and ventricle is a double valve. From the apex of the ventricle passes off the aorta, which pierces the muscular peritoneum, and divides into two principal branches, — one passing to the sub-œsophageal ganglia devoted to the viscera in the anterior part of the visceral cavity, the other passing to supply the viscera posteriorly. Upon the right of the heart, attached to the roof of the pulmonary cavity, is placed a large, glandular organ, considered as the kidney; from the whole of its right margin proceeds a duct backwards, which then curves to the side of the rectum, at the left side of which it remains attached to the pulmonary orifice.

ARION. The pulmonary cavity is situated as in *Limax*. Its whole interior surface presents an intricate rete, from which converge six or seven pulmonary veins to the auricle of the heart.

The renal organ forms a complete circle around the heart, and is perforated by the rectum, in the course of the latter to the pulmonary aperture.

TEBENNOPHORUS. The pulmonary cavity is situated beneath the anterior portion of the mantle. It is formed

by an inflection of the muscular layer of the integument of the body. The renal organ is placed to the right of the heart, and at its posterior part is perforated by the aorta.

VAGINULUS. The pulmonary cavity is situated between the muscular peritoneum and the integument of the body. Its principal portion is placed upon the right side, anterior to the middle, but extends to the left side, over the back, and along the right side to the pulmonary aperture, between the tail and posterior extremity of the podal disc. The heart is placed in the anterior portion of the cavity. The auricle receives a vein from the right and another from the left side. The renal organ is placed posterior to the heart, between the passage leading from the pulmonary cavity to its orifice, and the course of the rectum.

HELIX. In this genus, as is also the case in all the testaceous genera under examination, the pulmonary chamber is comparatively very large, for reasons already stated, and occupies a position on the outside of the lower one or two whorls of the turbinated mass of the viscera. In front, it is bounded by the collar, in the right side of which is the pulmonary orifice. The floor of the cavity is formed, as in slugs generally, by the muscular peritoneum. The roof, or outer wall, is occupied on the right side by the rectum, posteriorly by the heart and renal organ, and anteriorly by the pulmonary

rete of capillary vessels. The pulmonary rete is most developed in the vicinity of the pulmonary orifice ; and from it in a line with the latter, along the course of the rectum, proceeds backward a single pulmonary vein to the heart. The renal organ is elongated, pyramidal, and is placed to the right of the heart and pulmonary vein. Its duct commences upon the right border of the gland, courses backward to the rectum, along the inner side of which it passes to the pulmonary aperture.

The remaining testaceous genera present nothing peculiar in the character of the pulmonary or circulatory apparatus.

GENERAL REMARKS. The heart, in warm weather, beats about fifty-five times in a minute, but to some extent appears to be under the control of the animal, for if disturbed or irritated it pulsates much slower.

In composition, the heart consists of distinctly granulated, unstriped, muscular fibres, with oval nuclei, which are hardly visible before the application of acetic acid to them.

The interior of the heart and aorta is lined with a tessellated epithelium ; and the exterior of the former and interior surface of the pericardium are covered by the same. The cells are granular, with distinct, round, or oval, granular nuclei, and a minute nucleolus.

The pericardial epithelium separates its peculiar fluid very freely, the pericardium frequently appearing distended with the liquor pericardii. In *Helices*, it fre-

quently contains numbers of an entozoon, which I have named *Distoma vagans*.¹ The blood-vessels, especially in the liver, exhibit a white, opaque appearance, which is dependent upon the deposit in the sides of the vessel of innumerable, oil-like granules.

The blood contains numerous blood-corpuscles, which vary in size, are granular, and exhibit numerous radiating, projecting points of variable length, — frequently greater than the diameter of the corpuscle.

The pulmonary cavity is lined with a tessellated epithelium, the cells of which are faintly granular, with a few coarser granules, and a distinct, round or oval, granular, nucleolated nucleus.

The renal organ is a gland which exhibits a foliated, or plicated appearance, within a capsule. The surfaces of the plicæ communicate with the duct existing along the whole right border of the organ, and are covered with polygonal, organic cells, every one of which contains a large, white, round, opaque mass, resembling uric acid in appearance.

CHAPTER IX. — ON THE NERVOUS CENTRES, AND THE DISTRIBUTION OF THE NERVES.

The nervous centres consist of three distinct sets of ganglia, which are all placed within the anterior part of the body or head.

The first set, or supra-oesophageal ganglia, form a trans-

¹ See Journal Acad. Nat. Sci. New Series, Vol. I.

verse band, above or in front of the buccal body, usually at its anterior part, but varying in the latter position, to some degree depending upon the movements of the buccal body. When the latter is protruded, the band of ganglia is thrown back to the commencement of the oesophagus; when retracted it is placed just behind the upper lip. It consists of two symmetrical halves united by a short, transverse commissure. Each half is composed of several ganglia, aggregated to a greater or less degree in different genera and species. Sometimes they are so aggregated, or are so covered by enveloping tissue, as to appear a single mass; in others five or six distinct masses may be readily counted.

The second set, or sub-oesophageal ganglia, form a circular mass, placed infero-posteriorly to the buccal body, in the excavation of the foot. It is asymmetrical, and is composed of several ganglia, more or less aggregated together; from four to seven masses can generally be counted. It is usually more developed upon the right than the left side, and passes through all the shades of color, in different genera and species, from white, yellow, to orange. Through the opening formed by the arrangement of the ganglia into a circle, passes the cephalic branch of the aorta. The supra-oesophageal and sub-oesophageal ganglia are connected together on each side of the buccal body by a double commissure, which varies in length in different genera; thus, in *Helices*, etc., it is generally so long as to allow of much movement of the supra-oesophageal ganglia forward with the buccal body,

while in *Vaginulus* it is so short that the two sets of ganglia form a close ring around the anterior part of the buccal body.

The third set of ganglia are the stomato-gastric, consisting of two minute, lateral masses, united by a short, transverse commissure, and always placed upon the buccal body immediately postero-laterally to the commencement of the œsophagus. The stomato-gastric ganglia are connected with the supra-œsophageal on each side, by means of a long, delicate commissure, which is more or less loose, and permits a free movement of the former ganglia with the buccal body to which they are fixed.

From the supra-œsophageal ganglia pass off on each side, — 1st, a minute branch along the course of the supra-sub-œsophageal commissure; 2d, three or four small branches to the retractor muscles of the tentaculæ; 3d, a large branch, the superior tentacular nerve; 4th, one or two small branches to the base of the superior tentacle, for its integument; 5th, the inferior tentacular nerve; 6th, small branches to the integument of the lips.

From the sub-œsophageal ganglia pass off, — 1st, numerous branches on each side, to the podal disk, and laterally to the integument; 2d, a branch on the right side to the penis; 3d, a branch to the vas deferens and prostate gland; 4th, on each side a branch to the retractor muscle of the buccal body; 5th, a large one to each side of the collar and pulmonary chamber; 6th, a branch which follows the posterior aortic vessel, which gives off

branches to the muscular peritoneum ; 7th, branches to the origin of the tentacular retractors ; 8th, branches to the oviduct, ovary, testicle, stomach, intestine, and liver.

From the stomato-gastric ganglia pass off on each side, — 1st, a nerve to the external muscular structure of the buccal body ; 2d, two branches which penetrate posteriorly into the buccal body ; 3d, a branch to the salivary duct and gland ; 4th, a branch to the œsophagus and stomach ; 5th, branch to the interior of the buccal body anteriorly.

The above distribution of the nerves has been principally derived from dissections of *Glandina* and *Helix albolabris*. In the former genus, upon what is the nerve to the inferior tentacle in the other genera, there is formed, near the base of the tentaculæ, a ganglionic enlargement, from which passes off the true, inferior tentacular nerve of this animal, and two other large branches to the third, or external tentacle.

The nervous centres are composed of ganglion globules, varying very much in size ; some are very large, others are not more than one-eighth the diameter of the larger ones and nuclear bodies. The globules are more or less polygonal, from mutual pressure, are distinctly granular, and contain a nucleus which is comparatively of enormous size. The latter usually fills one-half or two-thirds of the cell or globule, is more distinctly and darkly granular, and contains from one to seven small, round, transparent nucleoli. The sepa-

rate nuclear bodies resemble the nuclei of the ganglion globules, but are much smaller, and contain but a single nucleolus. The nerve fibres pass through the ganglionic centres, among the globules in every direction ; but none of them appear to originate or terminate in the latter. None of the ganglionic cells are caudated.

The nerves consist of bundles of tubuli, containing an oleo-albuminous matter, which in the fresh nerve is semi-fluid, faintly granular, homogeneous, and translucent, but after the matter is pressed out of the tubuli it separates into two portions, one of which is a tenacious, fluid substance, containing the other in the form of oil-like globules of no determinate size. The wall of the tubuli is amorphous and transparent, and has attached to it, and projecting externally, oval, granular, nucleolated nuclei.

The nerves, especially in those emanating from the supra-oesophageal ganglia, are enveloped in a sheath formed of large, elongated, polygonal, transparent cells, containing in the centre an oval nucleus surrounded by a mass of coarse, granular bodies, which are endowed with a very active molecular movement.

CHAPTER X. — ON THE ORGANS OF ESPECIAL SENSE.

TOUCH. The soft, mucous integument is very irritable ; but tactile sensibility is most developed in the tentaculæ, which are two pairs of tubular prolongations of the external integument, from the anterior part of the body or head. The superior pair of tentaculæ are

several times longer and thicker than the inferior pair. They are conico-cylindroid in shape, with the free extremity or point dilated, or bulbous, in the outer side of which the eyes are placed. The inferior pair are short, conico-cylindroid, and slightly bulbous at the point.

The integument is thick at the base of the tentaculæ, but gradually becomes thinner as it approaches the free extremity, where it is delicate and transparent. The color is the same on the general investment of the body, except at the free extremity of the tentaculæ, where, from its transparency, the structure beneath shows through, and appears whitish. On the superior tentaculæ it is rougher than upon the inferior, from the polygonal folds being deeper. It is but loosely attached to the parts within, except at the free extremity, where it becomes firmly united.

The retraction of the tentaculæ takes place by means of the contraction of the retractor muscle, which forms within the tentaculæ a cylindrical tube, and is inserted into the integument at their free extremity, so that when they are retracting the integument becomes inverted, and the point of the tentacula first disappears from view and, in protrusion, is last to appear. The latter movement takes place through the relaxation of the retractor muscle, and the gradual contraction of the circular, muscular fibres forming the basis of the integument, commencing at the base of the tentaculæ and proceeding towards the free extremity, by which course of movement the latter is pushed out.

Within the tube of the retractor muscle of the tentaculæ, passes to the free extremity of the latter the tentacular nerve. When the tentaculæ are retracted, the nerve becomes tortuous, and spiral, but when fully protruded it is nearly straight, or merely undulated.

Near the free extremity of the superior tentaculæ the nerve undergoes a sudden constriction, and then dilates into a gangliform enlargement, from the outer side of which proceeds a small division of the tentacular nerve, as the optic nerve, to the eye. The gangliform enlargement is composed, on the exterior, of the nerve-tubuli of the tentacular nerve, and on the exterior, of a soft, white, finely granular matter, containing, in the exterior layer, round, granular, nuclear bodies. Anteriorly, the enlargement undergoes a constriction, and then dilates into the large, bulbous mass of the extremity of the tentaculæ. This latter mass is white, soft, and finely granular. Upon its exterior, the nerve-tubuli of the exterior of the first gangliform enlargement diverge, and divide into a number of large branches, which laterally subdivide into numerous smaller branches, and thus inclose the granular mass.

The inferior tentaculæ present the same nervous structure, except that there is no well-marked constriction between the tentacular nerve and the first gangliform enlargement, nor between the two enlargements, nor is there any optic nerve.

The space between the tentacular nerve and the retractor muscle, is filled with a filamentous tissue, con-

taining round, granular, nucleolated nuclei, and large, round or elliptical, transparent cells, with nuclei similar to those which lie free in the tissue.

The integument of the tentaculæ is very freely supplied with nerves from the supra-oesophageal ganglia.

TASTE. If existent, it is probably dependent upon nerves distributed within the buccal body, and derived from the stomato-gastric ganglia. The structure of the lingual lamina precludes any idea of its existence there.

SMELL. The presence of this sense is undoubted, though there is much discrepancy of opinion as to its situation. I have suspected that it probably may be placed in the blind sac, or depression, which opens just below the mouth. This sac varies in its degree of development in the different genera; in *Limax* it is a superficial depression; in *Vaginulus* it extends backwards beneath the buccal body for half an inch, is conical in shape and yellowish-white in color; in *Bulimus fasciatus* it extends back, in the excavation of the foot, to the tail, and is folded several times upon itself.

HEARING. The acoustic apparatus consists of a pair of transparent, vesicular bodies, placed upon the postero-inferior part of the sub-oesophageal ganglia, one on each side. They are placed in a depression of the ganglia, formed by a separation of the nerve-tubuli as they pass from and into the latter, immediately upon the gan-

glionic globules. Their interior is filled with a transparent fluid, containing numerous otoconites, which vary in size, are oval in form, transparent, composed of concentric layers of carbonate of lime, and frequently have a small cavity in their centre. During life, and for a short time after the death of the animal, the otoconites are endowed with a peculiar vibratory movement, by which they are disposed to accumulate into a mass in the centre of the auditory vesicle. After the cessation of the movement, they become diffused through the fluid of the vesicle.

SIGHT. The eyeball is placed beneath the integument, on the outer side of the constriction which exists between the gangliform swellings at the free extremity of the superior tentacula. The optic nerve is derived from the inferior part of the first gangliform enlargement, is tortuous or undulating, and reaches the eyeball at its posterior part. Its course is frequently indicated by a deposit of pigmentum nigrum.

The eyeball is globular, and is invested exteriorly by a transparent tunic, corresponding to the sclerotica and cornea.

The choroidea forms two-thirds of a sphere, and is inflected anteriorly into a sort of depressed disk, perforated in the centre. It consists of a delicate, translucent membrane, with a deposit of a single layer of irregularly rounded, or oval, black pigment cells. The interior of the choroidea contains a clear, consistent vit-

reous humor ; but the character of the retina I did not detect at the time. Whether a crystalline lens exists or not I am in doubt ; at the time of making the investigations, in several instances I thought I discerned it very distinctly ; but in other instances, even when larger species were examined, if it existed it escaped my observation.

REFERENCES TO THE PLATES.

PLATE I.

LIMAX VARIEGATUS.

FIG. I. The integument laid open, with the viscera in situ. 1. Buccal body; 2. salivary gland; 3. stomach; 4. intestine; 5. termination of intestine in the rectum; 6. blind tube from the termination of the intestine; 7. oviduct; 8. pulmonary chamber; 9. heart; 10. renal organ; 11. left superior tentacle; 12. sub-œsophageal ganglia; 13. left stomatogastric ganglion; 14. liver; 15. origin of the retractor muscle of the penis.

FIG. II. The viscera dissected apart. 1. Buccal body; 2. stomach; 3. intestine; 4. termination of do.; 5. blind tube from do.; 6. salivary glands; 6.* salivary duct; 7. liver; 8. hepatic duct; 9. testicle; 10. epididymis; 11. prostate gland; 12. penis; 13. retractor of do.; 14. ovary; 15. oviduct; 16. genital bladder; 17. pulmonary chamber; 18. aorta; 19. cephalic branch of do.; 20. visceral branch of do.; 21. sub-œsophageal ganglia; 22. left superior tentacle.

FIG. III. The generative apparatus. 1. Testicle; 2. epididymis; 3. prostate gland; 4. penis; 5. retractor of do.; 6. ovary; 7. oviduct; 8. genital bladder; 9. cloaca.

FIG. IV. The pulmonary chamber laid open and magnified four diameters. 1. Floor formed by the muscular peritoneum; 2. pulmonary orifice; 3. rectum; 4. anal aperture; 5. renal organ; 6. duct of do.; 7. pericardium laid open; 8. heart; 9. pulmonary vein; 10. pulmonary arteries; 11. aorta.

FIG. V. Testa.

FIG. VI. Dental plate.

PLATE II.

FIGS. I.—IV. ARION HORTENSIS.

FIG. I. Organs in situ. 1. Buccal body; 2. stomach; 3. intestine; 4. termination of do.; 5. liver; 6. testicle; 7. ovary; 8. oviduct; 9. cloaca; 10. pulmonary chamber; 11. heart; 12. retractors of the penis and vagina.

FIG. II. Genitalia, two diameters. 1. Testicle; 2. epididymis; 2.* vas deferens; 3. prostate gland; 5. penis; 6. ovary; 7. oviduct; 8. genital bladder; 9. cloaca; 10. retractors of the penis and vagina.

FIG. III. Digestive apparatus. 1. Buccal body; 2. retractors of do.; 3. œsophagus; 4. stomach; 5. intestine; 6. rectum; 7. anus; 8. salivary glands; 9. ducts of do.; 10. liver; 11. duct of liver.

FIG. IV. Pulmonary chamber, magnified. 1. Floor of the cavity; 2. pulmonary orifice; 3. pulmonary arteries; 4. auricle; 5. ventricle; 6. pericardium; 7. aorta; 8. renal organ; 9. intestine; 10. anus.

FIGS. V.—VI. *LIMAX CAMPESTRIS*.

FIG. V. The digestive apparatus. 1. Buccal body; 2. its retractor; 3. stomach; 4. intestine; 5. terminal portion of do.; 6. anus; 7. salivary glands; 8. liver.

FIG. VI. Generative apparatus. 1. Testicle; 2. epididymis; 2.* vas deferens; 3. accessory gland of do.; 4. prostate; 5, 6. penis; 8. oviduct; 9. genital bladder; 10. cloaca.

FIGS. VII.—IX. *LIMAX AGRESTIS*.

FIG. VII. Body laid open, and viscera dissected apart. 1. Buccal body; 2. stomach; 3. intestine; 4. blind tube of do.; 5. salivary glands; 6. liver; 7. testicle; 8. epididymis; 9. prostate; 10. receptacle of the penis; 11. trifurcate gland of do.; 12. sac of penis; 13. retractor muscle; 14. ovary; 15. oviduct; 16. genital bladder; 17. pulmonary chamber.

FIG. VIII. Lower portion of the genitalia. 1. Prostate; 2. receptacle of penis; 3. trifurcate gland of do.; 4. sac of penis; 5. retractor; 6. oviduct; 7. bladder; 8. cloaca.

FIG. IX. Receptacle of the penis laid open. 1. penis; 2. longitudinal folds of the receptacle; 3. trifurcate gland.

PLATE III.

TEBENNOPHORUS CAROLINENSIS.

FIG. I. Integument laid open, and the viscera in situ enclosed within the muscular peritoneum.

FIG. II. Muscular peritoneum laid open; the organs in situ. 1. Pulmonary chamber laid open; 2. muscular peritoneum; 3. buccal body; 4. stomach; 5. liver; 6. intestine; 7. testicle; 8. ovary; 9. oviduct; 10. dart sac; 11. heart; 12. renal organ; 13. pulmonary orifice.

FIG. III. Digestive apparatus and pulmonary chamber. 1. Buccal body; 2. retractors of do.; 3. œsophagus; 4. stomach; 5. intestine; 6. rectum; 7. salivary glands; 8. ducts of do.; 9. liver; 10. ducts of do.; 11. pulmonary chamber; 12. pulmonary veins; 13. renal organ; 14. heart.

FIG. IV. Generative apparatus. 1. Testicle; 2. epididymis; 2.* vas deferens; 3. prostate; 4. penis; 5. retractor of penis; 6. ovary; 7. oviduct; 8. genital bladder; 9. dart sac; 10. cloaca; 11. glandular structure of do.; 12. right superior tentacle.

FIG. V. Penis, dart sac, etc. laid open. 1. Penis; 2. folded lining of do.; 3. vas deferens; 4. dart sac, containing the dart; 5. neck of oviduct; 6. duct of bladder; 7. cloaca.

FIG. VI. The dart, enlarged.

FIG. VII. Glandular layer of the cloaca, enlarged.

FIG. VIII. Globular form of the genital bladder.

FIG. IX. Spermatozoa, highly magnified.

FIG. X. A bunch of imperfect spermatozoa from the testicle, highly magnified.

FIG. XI. Granules from the testicle, highly magnified.

FIG. XII. Imperfect ova from the ovary, highly magnified.

PLATE IV.

VAGINULUS FLORIDANUS.

FIG. I. Integument laid open; the viscera in situ. 1. Buccal body; 2. salivary gland; 3. stomach; 4. intestine; 5. rectum; 6. liver; 7. testicle; 8. multifid vesicle; 9. heart.

FIG. II. Viscera separated. 1. Buccal body; 2. stomach; 3. intestine; 4. salivary glands; 5. liver; 6. course of rectum, renal duct, and pulmonary passage; 7. testicle; 8. epididymis; 9. receptacle of penis; 10. multifid vesicle; 11. ovary; 12. oviduct; 13. genital bladder; 14. parenchymatous sac of the vagina.

FIG. III. Part of the digestive apparatus. 1. Œsophagus; 2. stomach; 3. intestine; 4. liver; 5. hepatic ducts.

FIG. IV. Genitalia. 1. Testicle; 2. epididymis; 3. vas deferens; 4. prostate; 5. receptacle of penis laid open; 6. penis; 7. retractor of penis; 8. base of multifid vesicle; 9. ovary; 10. oviduct; 11. genital bladder; 12. parenchymatous sac of vagina laid open.

FIG. V. Visceral cavity, with the greater portion of the viscera removed. 1. Buccal body; 2. salivary glands; 3. œsophagus; 4. rectum; 5. pulmonary passage; 6. pulmonary cells between the integument and muscular peritoneum; 7. pulmonary artery from the left

side; 8. heart; 9. renal organ; 10. renal duct; 11. penis, seen within its receptacle; 12. base of the multifid vesicle; 13. parenchymatous sac of the vagina; 14. vagina; 15. sub-œsophageal, and 16. supra-œsophageal ganglia; 17. olfactory sinus.

FIG. VI. Dental plate: a. size of nature; b. magnified, with the retractor muscle attached.

PLATE V.

BULIMUS FASCIATUS.

FIG. I. The viscera dissected apart. 1. Buccal body; 2. lingual pouch; 3. retractor of buccal body; 4. stomach; 5. intestine; 6. rectum; 7. anus; 8. salivary glands; 9. ducts of do.; 10. liver; 11. position of the testicle commingled with the posterior lobe of the liver; 12. epididymis; 12.* vas deferens; 13. accessory gland of the epididymis; 14. prostate; 15. penis; 16. retractor of do.; 17. multifid vesicle; 18. ovary; 19. oviduct; 19.* glandular portion of do.; 20. genital bladder; 21. pulmonary chamber; 22. pulmonary aperture; 23. pulmonary artery; 24. pulmonary vein; 25. pericardium; 26. auricle; 27. ventricle; 28. aorta; 29. renal organ; 30. renal duct; 31. orifice of do.; 32. supra-œsophageal ganglia; 33. stomato-gastric ganglia; 34. sub-œsophageal ganglia.

FIG. II. Buccal body laid open, enlarged. 1. Upper lip; 2. lower lip; 3. dental plate; 4. sides of buccal cavity; 5. tongue; 6. entrance of œsophagus; 7. œsophagus; 8. salivary ducts; 9. lower part of buccal body; 10. retractor muscle.

FIG. III. The muscular tongue, with the tubular prolongation of the lingual lamina into the lingual pouch.

FIG. IV. Dental plate: a. magnified; b. size of nature.

FIG. V. Excavation of the foot. 1. Buccal body turned forward; 2. retractor muscle; 3. attrahent fasciculi; 4. lingual pouch; 5. retractors of the foot; 6. olfactory sinus.

PLATE VI.

HELIX ALBOLABRIS.

FIG. I. The animal, with the pulmonary chamber (1) laid open and turned back from the visceral mass (2); 3. the mouth; 4. the cloaca, voluntarily protruded.

FIG. II. The viscera, all dissected apart. 1. Buccal body; 2.

retractor of do.; 3. œsophagus; 4. stomach; 5. intestine; 6. rectum; 7. anus; 8. salivary glands; 9. liver; 10. testicle; 11. epididymis; 11.* vas deferens; 11.** accessory gland of epididymis; 12. prostate; 13. penis; 14. retractor of do.; 15. ovary; 16. oviduct; 17. genital bladder; 18. pulmonary chamber; 19. pulmonary vein; 20. heart; 21. renal organ; 22. its duct; 23. anus; 24. cephalic branch of aorta; 25. supra-œsophageal ganglia.

FIG. III. Genitalia. 1. Testicle; 2. epididymis; 2.* vas deferens; 2.** dilated commencement of do.; 3. accessory gland of epididymis; 4. prostate; 5. penis; 6. prepuce; 7. retractor muscle; 8. ovary; 9. oviduct; 10. genital bladder; 11. muscular organ on the duct of do.; 12. cloaca.

FIG. IV. Penis, etc. laid open. 1. Vas deferens; 2. retractor of penis; 3. penis; 4. a longitudinal papillated fold of the lining membrane; 5. prepuce; 6. bladder laid open; 7. muscular organ at its base; 8. neck of oviduct; 9. orifice of do.; 10. cloaca.

FIG. V. A second appearance of the interior of the organ at the base of the bladder (1). 2. Longitudinal folds; 3. neck of oviduct; 4. orifice of do.

FIG. VI. Portion of oviduct laid open, exhibiting the spermatic groove, and, within it, the orifice of the prostate gland. 1. Epididymis; 2. accessory gland; 3. spermatic groove; 4. side of the oviduct.

FIG. VII. Pyramidal epithelia from the prostate gland, highly magnified. 1. Mass of cells; 2. isolated cells.

FIG. VIII. Imperfect ova from the ovary.

FIG. IX. Dental plate, much magnified.

FIG. X. Eye, much enlarged.

FIG. XI. Portion of renal organ, moderately magnified.

PLATE VII.

FIG. I. *H. cellaria*; II.—V. *H. alternata*; IV., VII. *H. perspectiva*; VIII. *H. palliata*.

FIG. I. Viscera of *H. cellaria*, dissected apart. 1. Buccal body; 2. retractor of do.; 3. œsophagus; 4. stomach; 5. intestine; 6. rectum; 7. anus; 8. salivary gland; 9. liver; 10. duct of do.; 11. testicle; 12. epididymis; 12.* vas deferens; 13. prostate; 14. penis; 15. retractor of penis; 16. ovary; 17. oviduct; 18. genital bladder; 19. vagina; 20. pulmonary chamber; 21. heart; 22. renal organ.

FIG. II. Viscera of *H. alternata*. 1. Buccal body; 2. œsophagus; 3. stomach; 4. intestine; 5. rectum; 6. salivary gland; 7. liver; 8. testicle; 9. epididymis; 10. prostate; 11. penis; 12. retractor of do.;

13. ovary; 14. oviduct; 15. genital bladder; 16. pulmonary chamber; 17. heart; 18. renal organ; 19. renal duct; 20. pulmonary aperture.

FIG. III. Dental plate, magnified. 1. Muscle; 2. the plate.

FIG. IV. Penis laid open. 1. Penis; 2. thick longitudinal fold; 3. vas deferens; 4. retractor of penis.

FIG. V. Spermatozoa, highly magnified.

FIG. VI. Digestive apparatus of *H. perspectiva*. 1. Buccal body; 2. retractor of buccal body; 3. œsophagus; 4. stomach; 5. intestine; 6. salivary gland; 7. ducts of do.; 8. hepatic ducts.

FIG. VII. Genitalia. 1. Testicle; 2. epididymis; 3. accessory gland of do.; 4. prostate; 5. penis; 6. retractor of do.; 7. ovary; 8. oviduct; 9. genital bladder; 10. cloaca; 11. right superior tentacle.

FIG. VIII. Dissection of *H. palliata*. 1. Buccal body; 2. stomach; 3. intestine; 4. rectum; 5. anus; 6. salivary gland; 7. liver; 8. epididymis; 8.* vas deferens; 9. accessory gland of do.; 10. prostate; 11. penis; 12. retractor of do.; 13. ovary; 14. oviduct; 15. genital bladder; 16. retractor of buccal body; 17. pulmonary chamber; 18. heart; 19. renal organ; 20. supra-œsophageal ganglia.

PLATE VIII.

FIGS. I.—VI. *HELIX MULTILINEATA*.

FIG. I. Digestive apparatus. 1. Buccal body; 2. retractor of do.; 3. lingual pouch; 4. stomach; 5. intestine; 6. salivary gland; 7. hepatic duct.

FIG. II. Genitalia. 1. Testicle; 2. epididymis; 2.* vas deferens; 3. accessory gland of epididymis; 4. prostate; 5. penis; 6. prepuce; 7. retractor of penis; 8. ovary; 9. oviduct; 10. genital bladder; 11. vagina; 12. cloaca; 13. right superior tentacle.

FIG. III. Penis (1) laid open to exhibit the papillary structure on its inner surface; 2. prepuce; 3. vas deferens; 4, 5. neck of oviduct and vagina laid open; 6. bladder; 7. orifice of bladder.

FIG. IV. Portion of the inner surface of the penis, magnified two diameters.

FIG. V. Spermatozoa, highly magnified.

FIG. VI. Spermatozoa in coil.

FIGS. VII.—X. *H. SOLITARIA*.

FIG. VII. Digestive apparatus. Same references as Fig. I.

FIG. VIII. Genitalia. 1. Testicle; 2. epididymis; 2.* vas deferens; 3. accessory gland of do.; 4. prostate; 5. penis; 6. retractor of do.; 7. ovary; 8. oviduct; 9. bladder; 10. cloaca.

FIG. IX. Spermatozoa and granules from the epididymis, highly magnified.

FIG. X. Portion of the renal organ at its commencement, exhibiting the relation of the duct at its outer edge.

FIG. XI. *HELIX BERLANDERIANA*.

FIG. XI. Genitalia of *Helix Berlanderiana*. 1. Testicle; 2. epididymis; 3. accessory gland of do.; 4. prostate; 5. penis; 6. double retractor of do.; 7. sac of the dart?; 8. ovary; 9. oviduct; 10. bladder; 11. cloaca.

PLATE IX.

FIGS. I. — III. *H. PROFUNDA*.

FIG. I. Digestive apparatus. 1. Buccal body; 2. retractor of do.; 3. œsophagus; 4. stomach; 5. intestine; 6. salivary gland; 7. ducts; of do.; 8. hepatic ducts.

FIG. II. Inferior part of the genitalia. 1. Prostate; 2. vas deferens; 3. penis; 4. retractor of do.; 5. prepuce; 6. oviduct; 7. bladder; 8. vagina; 9. cloaca; 10. tentacle.

FIG. III. 1. Vas deferens; 2. penis; 3. retractor of do.; 4. prepuce laid open; 5. glans penis; 6. genital bladder and duct laid open, exhibiting the interior, longitudinal folds; 7. neck of oviduct; 8. vagina; 9. cloaca; 10. tentacle.

HELIX FULIGINOSA.

FIG. IV. *H. fuliginosa*, with all the viscera dissected apart. 1. Buccal body; 2. retractor of do.; 3. œsophagus; 4. stomach; 5. intestine; 6. rectum; 7. anus; 8. salivary gland; 9. ducts of do.; 10. liver; 11. testicle; 12. epididymis; 13. accessory gland of do.; 14. prostate; 15. penis; 16. retractor of do.; 17. ovary; 18. oviduct; 19. bladder; 20. glandular structure surrounding the vagina; 21. pulmonary chamber; 22. heart; 23. renal organ; 24. retractor muscle of the foot; 25. supra-, 26. sub-œsophageal, and 27. stomato-gastric ganglia.

FIGS. V. VI. *H. AURICULATA*.

FIG. V. Digestive apparatus. 1. Buccal body; 2. lingual pouch; 3. retractor of buccal body; 4. œsophagus; 5. stomach; 6. intestine; 7. salivary gland; 8. ducts of do.; 9. hepatic ducts.

FIG. VI. Genitalia. 1. Testicle; 2. epididymis; 2.* vas deferens; 3. accessory gland of epididymis; 4. prostate; 5. penis; 6. retractor of do.; 7. ovary; 8. oviduct; 9. genital bladder; 10. vagina; 11. cloaca.

FIGS. VII.—IX. AUDITORY APPARATUS OF *H. PULCHELLA*.

FIG. VII. Inferior ganglia of the sub-oesophageal mass, highly magnified, with the auditory vesicles attached.

FIG. VIII. Side view of one of the auditory vesicles.

FIG. IX. Otoconites, very highly magnified.

PLATE X.

FIGS. I.—III. *H. EXOLETA*.

FIG. I. Digestive apparatus. 1. Buccal body; 2. lingual pouch; 3. retractor of buccal body; 4. stomach; 5. intestine; 6. salivary gland; 7. ducts of do.; 8. hepatic ducts.

FIG. II. Genitalia. Same references as Fig. VI. Pl. IX.; 2.** glandular commencement of vas deferens.

FIG. III. Penis laid open. 1. Longitudinal folds; 2. vas deferens; 3. valvular folds; 4. retractor of penis; 5. vagina; 6. orifice of do.

FIGS. IV. V. *H. ELEVATA*.

FIG. IV. Viscera dissected apart. 1. Buccal body; 2. œsophagus; 3. stomach; 4. intestine; 5. rectum; 6. anus; 7. salivary gland; 8. liver; 9. testicle; 10. epididymis; 11. accessory gland of do.; 10.* vas deferens; 12. prostate; 13. penis; 14. retractor of do.; 15. ovary; 16. oviduct; 17. genital bladder; 18. pulmonary chamber; 19. pulmonary vein; 20. heart; 21. renal organ; 22. duct of do.; 23. pulmonary orifice; 24. supra-, 25. sub-oesophageal, and 26. stomato-gastric ganglia.

FIG. V. Penis laid open. 1. Longitudinal folds of interior; 2. vas deferens; 3. retractor of penis.

PLATE XI.

FIGS. I.—IV. *H. SAPI*.

FIG. I. Digestive apparatus. 1. Buccal body; 2. retractor of do.; 3. lingual pouch; 4. œsophagus; 5. stomach; 6. intestine; 7. salivary gland; 8. salivary ducts; 9. hepatic ducts.

FIG. II. Genitalia. Same references as Fig. VI. Pl. IX.

FIG. III. Portion of the oviduct laid open. 1. Transverse folds of the sides; 2. spermatic groove.

FIG. IV. Dental plate, largely magnified.

FIGS. V.—VI. *H. HIRSUTA*.

FIG. V. Viscera dissected apart. 1. Buccal body; 2. œsophagus; 3. stomach; 4. intestine; 5. rectum; 6. anus; 7. salivary gland; 8. liver; 9. testicle; 10. epididymis; 11. accessory gland of do.; 10.* vas deferens; 12. prostate; 13. penis; 14. retractor of do.; 15. ovary; 16. oviduct; 17. genital bladder; 18. pulmonary chamber; 19. heart; 20 renal organ.

FIG. VI. Accessory gland of the epididymis, highly magnified.

FIGS. VII.—IX. *H. THYROIDUS*.

FIG. VII. Digestive apparatus. Same references as Fig. I.

FIG. VIII. Genitalia. Same references as Fig. VI. Pl. IX.

FIG. IX. Penis laid open. 1. Longitudinal folds; 2. valvular fold; 3. vas deferens; 4. retractor of penis; 5. orifice of vagina.

PLATE XII.

FIGS. I.—III. *H. INTERTEXTA*.

FIG. I. Genitalia. 1. Testicle; 2. epididymis; 3. accessory gland of do.; 2.* vas deferens; 4. prostate; 5. penis; 6. retractor of do.; 7. sac of the dart; 8. glandular pouches; 9. ovary; 10. oviduct; 11. genital bladder; 12. duct of do. to the vagina; 13. division of the duct, enclosing the lower part of the genitalia; 14. retractor of the dart sac; 15. portion of the duct of the genital bladder, enclosing the cloaca; 16. cloaca.

FIG. II. Lower part of the genitalia laid open. 1. Penis; 2. portion of the duct of the genital bladder, which encloses the lower part of the genitalia, laid open; 3. vas deferens; 4. neck of the oviduct; 5. duct of the bladder; 6. the portion of do. to the vagina; 7. dart sac; 8. glandular pouches; 9. dart; 10. orifice of the vagina.

FIG. III. a. the dart, the size of nature; b. do. much magnified.

FIGS. IV.—VII. *H. LIGERA*.

FIG. IV. Digestive apparatus. 1. Buccal body; 2. retractor of do.; 3. œsophagus; 4. stomach; 5. intestine; 6. salivary gland; 7. hepatic duct.

FIG. V. Genitalia. Same references as Fig. I.

FIG. VI. Animal with the penis and lower portion of the dart sac.

FIG. VII. Dental plate.

FIG. VIII. Genitalia of *H. suppressa*, magnified seven diameters. Same references as Fig. I.

FIGS. IX.—XI. *H. CONCAVA*.

FIG. IX. Digestive apparatus. Same references as Fig. I. Pl. XI.

FIG. X. Genitalia. Same references as Fig. VI. Pl. IX., except 11, which is probably a dart sac; 12. cloaca.

FIG. XI. Dental plate, much magnified.

PLATE XIII.

FIG. I.—III. *SUCCINEA*.

FIG. I. Viscera dissected apart. 1. Buccal body; 2. stomach; 3. intestine; 4. rectum; 5. anus; 6. salivary gland; 7. ducts of do.; 8. liver; 9. testicle; 10. epididymis; 11. accessory gland of do.; 12. prostate; 13. penis; 14. ovary; 15. oviduct; 16. genital bladder; 17. pulmonary chamber; 18. heart; 19. renal organ.

FIG. II. Genitalia. Same references as Fig. VI. Pl. IX.

FIG. III. Dental plate. a. Natural size; b. magnified; 1. muscle; 2. dental plate; 3. accessory plate.

FIG. IV. Nerve centres of *Helicina orbiculata*, highly magnified. 1. Supra-oesophageal ganglia; 2. stomato-gastric ganglia; 3. sub-oesophageal ganglia; 4. auditory vesicles.

FIG. V. Spermatozoa from the epididymis, very highly magnified.

PLATE XIV.

GLANDINA TRUNCATA.

FIG. I. Animal deprived of its shell. 1. Turbinate mass of viscera; 2. anterior third of the buccal body protruded as in eating; 3. mouth; 4. generative aperture; 5. superior tentacles; 6. inferior tentacles; 7. external tentacles.

FIG. II. Viscera dissected apart. 1. Buccal body; 2. oesophagus; 2.* exit of do.; 3. stomach; 4. intestine; 5. rectum; 6. anus; 7. salivary gland; 8. ducts of do.; 9. liver; 10. hepatic duct; 11. testicle; 12. epididymis; 13. accessory gland of do.; 12*. vas deferens; 14. prostate; 15. penis; 16. retractor of do.; 17. ovary; 18. oviduct; 19. genital bladder; 20. vagina; 21. cloaca; 22. pulmonary chamber; 23. pul-

monary vein; 24. heart; 25. aorta; 26. renal organ; 27. duct of do.; 28. orifice of do.; 29. retractor muscles of buccal body, tentacles, and podal disk; 30. supra-oesophageal ganglia; 31. stomato-gastric ganglia; 32. superior tentacles retracted; 33. Distoma sacs.

FIG. III. Inferior view of the protruded portion of buccal body. 1. Mouth; 2. external tentacles.

FIG. IV. Diagram of nervous centres. 1. Sub-oesophageal ganglia; 2. supra-oesophageal ganglia; 3. stomato-gastric ganglia.

PLATE XV.

FIG. I. Genitalia of *Bulimus dealbatus*. 1. Testicle; 2. epididymis; 3. accessory gland of do.; 4. prostate; 5. vas deferens; 6. penis; 7. retractor of do.; 8. ovary; 9. oviduct; 10. genital bladder; 11. vagina; 12. cloaca.

FIG. II.—IV. PUPA INCANA.

FIG. II. Viscera dissected apart. 1. Buccal body; 2. retractor of do.; 3. oesophagus; 4. stomach; 5. intestine; 6. rectum; 7. anus; 8. salivary gland; 9. liver; 10. pulmonary chamber; 11. collar; 12. pulmonary aperture; 13. pulmonary vein; 14. heart; 15. aorta; 16. renal organ; 17. duct of do.; 18. testicle; 19. epididymis; 20. accessory gland of do.; 21. prostate; 22. vas deferens; 23. penis; 24. retractor of do.; 25. dart sac (?); 26. ovary; 27. oviduct; 28. genital bladder; 29. an accessory gland joining the duct of the genital bladder by the duct 30; 31. retractor muscles; 32. sub-oesophageal ganglia.

FIG. III. Penis laid open. 1. Penis; 2. longitudinal fold; 3. retractor of penis; 4. vas deferens; 5. orifice of do.

FIG. IV. Dental plate, magnified.

FIGS. V. VI. *BULIMUS DECOLLATUS*.

FIG. V. Digestive apparatus. 1. Buccal body; 2. lingual pouch; 3. retractor of buccal body; 4. oesophagus; 5. stomach; 6. intestine; 7. salivary gland; 8. ducts of do.; 9. hepatic ducts.

FIG. VI. Lower portion of the Genitalia.

FIGS. VII. VIII. *B. VIRGULATUS*.

FIG. VII. Digestive apparatus. Same references as in digestive apparatus of Fig. II.

FIG. VIII. Genitalia. Same references as Fig. I.

PLATE XVI.

FIG. I. Nervous system of *Glandina truncata*, magnified. 1. Supra-

œsophageal ganglia; 2. sub-œsophageal ganglia; 3. stomato-gastric ganglia; 4. nerve to the upper lip; 5. to the integument of the superior tentaculæ; 6. to the lateral lips; 7. supra-œsophageal, stomato-gastric ganglionic commissure; 8. superior tentacular nerve; 9. an accessory branch; 10. nerve to the inferior and external tentaculæ; 11. ganglionic enlargement of do.; 12. inferior tentacular nerve; 13. external tentacular nerves; 14. nerves to the buccal body; 15. to œsophagus and stomach; 16. to salivary ducts and gland; 17. supra-œsophageal, sub-œsophageal, ganglionic commissures; 18. nerves to podal disk; 19. nerves to collar and pulmonary chamber; 20. to retractor of buccal body; 21. follows course of aorta, and supplies the oviduct, ovary, testicle, etc.; 22. supplies integument, collar, pulmonary chamber, and retractor muscles, at origin; 23. to penis; 24. to cloaca and integument in vicinity; 25. numerous branches to integument on each side, and podal disk; 26. to retractor muscles; 27. to tail and podal disk; 28. large branch to integument on each side.

FIG. II. Supra-œsophageal and stomato-gastric ganglia of *Helix albolabris*. 1. Supra-œsophageal ganglia; 2. stomato-gastric ganglia. 3. supra-œsophageal, sub-œsophageal, ganglionic commissures; 4. supra-œsophageal, stomato-gastric, ganglionic commissures; 5. superior tentacular nerve; 6. inferior tentacular do.; 7. to commencement of olfactory sinus; 8. inferior part of mouth and buccal body; 9. to integument of lips; 10. integument at side of mouth, and generative aperture on the right side; 11. recurrent branch to superior tentacular muscle; 12. to retractor of podal disk; 13. to buccal body; 14. to œsophagus; 15. to salivary glands.

Dr. J. Leach, del.

J. DeLarue sc.

Limax variegatus, Drap.

Dr. J. Leidy, del.

J. DeLong, sc.

I - IV. *Arion hortensis*.

V, VI. *Limax campestris*.

VII - IX. *L. agrestis*.

Dr. J. Leidy, del.

J. DeLong, sc.

Tebeniophorus carolinensis.

Dr. J. Leach del.

J. DeLarue sc.

Vaginulus floridanus.

Dr 1 'entry del

A. Delarue, sc.

Bulimus fasciatus.

Dr. J. Leach, del.

J. DeLarue, sc.

Helix albolabris

Imp. de J. DeLarue

Dr. J. Leach del.

J. De laune sc.

I. *II. cellaria* II - V. *II. alternata*.
VI, VII. *II. perspectiva* VIII. *II. palliata*

Dr. J. Leidy del.

J. DeKay sc.

I — VI *H. multilinea* VII — X *H. solitaria*.

XI *H. Berlanderiana*.

Imp. de J. P. Leidy.

Dr. J. Leidy del.

J. DeKay sc.

I - III *H. profunda*

IV *H. fuliginosa*

V, VI *H. auriculata*

VII - IX *H. pulchella*

Dr J Leidy del

J. DeLong sc

I - III. *H. exoleta*. IV, V. *H. elevata*.

Dr J. Leidy, del.

J. Polakus sc.

I - IV. *H. Sayi*. V, VI. *H. hirsuta*.

VII - IX. *H. thyroideus*.

Imp. de J. Polakus, R. de la Montagne 5^{te} Genevieve 6.

De J. Lachap. del.

J. Delarue sc.

I — III *H. intertexta.* IV — VII. *H. ligera.*
 VIII. *H. suppressa.* IX — XI. *H. concava.*

Dr Leach del

J. DeLarue sc

I - III *Succinea ovalis*

IV *Helicma orbiculata*

V *Helix albolabris*

Dr J. Leach del

J. DeLarue sc

Glandina truncata.

Dr J Leidy, del

J Delarue sc.

I. *Bulimus dealbatus*.

II - IV. *Pupa incana*.

V, VI. *Bulimus decollatus*.

VII, VIII. *B. virgulatus*.

I. *Glandina truncata*.

II. *Helix albolabris*.

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