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THE DISSECTION
OF
THE FROG.

BY

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THE FROG; *Rana temporaria* and *R. esculenta*.

Examine a living frog in an aquarium, noting,—the walking, leaping, and swimming movements; the colour of the skin under different circumstances; the attitude when at rest; the depressed rounded body; the absence of a neck and tail, the short fore limbs and the inverted manus; the sacral “hump” at junction of vertebral column with urostyle; the long femur and crus, and the greatly elongated webbed pes. Study movements of external nostrils and floor of mouth in respiration; the elevation and depression of lower eyelid, and, if possible, the method of feeding; and in the male edible frog the expansion of the vocal sacs during croaking.

A. External Characters.

1. Make an outline sketch of the frog from the side, and indicate—
 - (a) The mottled colour of the skin.
 - (b) The eye, with the semi-transparent lower eyelid half raised.
 - (c) The interocular gland and the dark patch behind the eye containing the tympanic membrane.
 - (d) The extent of the gape, the position of the external nostrils, and the opening of the cloaca.
2. Sketch—
 - (a) The manus (4 times nat. size), showing callosities on palmar aspect, and if a male the swollen cushion at base of index.
 - (b) The pes (2 nat. size), showing the long tarsal region and the webbed digits.
3. Number the digits in both limbs from within outwards, noting the short hallux (I) with a spur at its base, and the long IV. digit of the pes.
4. Examine (low power) and sketch—
 - (a) A portion of the web showing the branched pigment cells and the blood-vessels.
 - (b) A portion of the epidermis, showing openings of unicellular and spherical cutaneous glands.

B. Buccal Cavity.

1. Open mouth, and note—

- (a) The premaxillary, maxillary, and vomerine teeth, the projection of the eyeballs, the internal nares and Eustachian tubes.
- (b) The absence of mandibular teeth, the position, form, and mobility of the tongue, the lingual veins; the glottis and wide œsophagus, and if a male edible frog the openings into the vocal sacs.

2. Sketch—

- (a) The roof of the mouth, showing a bristle passing from one of the external nostrils into the mouth, and another through the drum of the ear along the Eustachian tube.
- (b) The floor of the mouth, showing the tongue connected to the hyoid cartilage, the glottis, and (if present) the openings of the vocal sacs.

C. Circulatory, Respiratory, and Alimentary Systems.

1. Fix the frog on its back by means of pins through the fore and hind limbs, cover with water, and divide with scissors the skin along the middle line from the pelvis to the mandible, noting the large subcutaneous lymph spaces.

2. Pin back the skin, and make a sketch showing—

- (a) The anterior abdominal vein running along the middle line under cover of the abdominal walls, to disappear behind the large xiphoid cartilage of the sternum.
- (b) The right and left cutaneous and the brachial veins uniting under the pectoral muscles, the lingual and maxillary veins, and the hypoglossal nerve.
- (c) The mylohyoid muscle, the sternal and abdominal portions of the pectoral muscle, the rectus abdominis, obliquus externus and obliquus internus muscles.

3. Make an incision along the wall of the abdomen a little to the left of the middle line, and observe under the right portion the anterior abdominal vein which originates from the pelvic veins, and after receiving the small cystic, parietal, and cardiac veins, divides to enter the right and left lobes of the liver.

4. (a) Carefully detach the abdominal vein from the muscles, or make an incision a little to the right of the vein, and reflect the abdominal walls; note the peritoneum lining the body cavity, and covering the viscera.

- (b) Remove the sternum and ventral portion of the pectoral girdle, so as to expose the heart and lungs, taking care not to injure the abdominal or cutaneous veins.

5. Indicate in an outline drawing of the frog—

- (a) The heart lying within the pericardium.
- (b) The lungs,—if collapsed, they should be inflated by introducing a blow-pipe through the glottis.
- (c) The fibres of the rudimentary diaphragm attached to the œsophagus and the pericardium.
- (d) The entire right and divided left lobes of the liver, and the gall bladder.
- (e) The anterior abdominal vein entering the lobes of the liver, and its cystic and cardiac branches.
- (f) The exposed portions of stomach, duodenum, small and large intestine, the mesentery, and mesenteric veins.
- (g) The bilobed bladder which, if necessary, may be inflated from the cloaca.
- (h) If a female, the ovaries, corpora adiposa, and the long convoluted oviducts.

6. Examine the peritoneum, tracing it from each side to the under surface of the vertebral column where it is reflected as a double layer to form the mesentery and provide sacs or folds for the abdominal viscera.
7. If a female, examine and remove the ovaries and oviducts. For directions see page 12.
8. Note, without injuring the peritoneum, the position and relations of the following structures to be afterwards examined—
 - (a) The liver and gall bladder ; (b) the stomach and duodenum, with (c) the pancreas lying between them ; (d) the small and large intestine, and (e) the spleen near their junction ; (f) the testes yellow oval bodies in front of (g) the flattened dark-red kidneys ; (h) the bilobed bladder projecting from the front wall of the cloaca.

9. Examine and make a diagram (4 nat. size) of the following veins—

- (a) System of the superior vena cava, consisting of—
 - (1) The external jugular formed by the lingual and mandibular.
 - (2) The innominate formed by the internal jugular and subscapular.
 - (3) The subclavian formed by the brachial and the musculo-cutaneous.

Cut open the pericardium, tilt forward the apex of the heart, and observe the two superior venæ cavæ entering the sinus venosus.

- (b) System of the inferior vena cava—

The femoral and sciatic veins carry the blood from the hind limb. Each femoral divides to form a pelvic vein, the anterior branches of the two pelvic veins by uniting in the middle line give rise to the anterior abdominal vein, while the posterior branches by uniting with the sciatics form the renal portal veins.

The system of the inferior vena cava includes—

- (1) The renal portal vein which formed by the union of the posterior division of the pelvic vein with the sciatic, receives the dorso-lumbar vein (from the posterior walls of the abdomen and from the oviducts in the female) as it enters the outer margin of the kidney.
- (2) The anterior abdominal vein formed by the union of the anterior ends of the two pelvic veins : after receiving cystic, parietal, and cardiac branches, it enters the liver.
- (3) The hepatic portal vein formed by the union of the gastric, splenic, and mesenteric veins (the splenic usually uniting with one of the mesenteric veins). It unites with the branches of the anterior abdominal vein and enters the liver.
- (4) The renal veins (4 or 5) which unite to form the inferior vena cava. The vena cava receives
 - (i) The ovarian or spermatic veins, and
 - (ii) The right and left hepatic veins, and then opens into the sinus venosus.
- (c) System of the pulmonary veins. Trace the pulmonary veins from the lungs, and observe that they unite to form a single trunk which opens into the left auricle.

10. The heart and arteries.

a. The Arteries.

Distend the oesophagus with a cylindrical piece of wood or a roll of paper, and after carefully cleaning the aortic arches, study and make a diagram (4 nat. size) of the heart, truncus arteriosus, and the following arteries—

- (a) The carotid arch, giving off
 - (1) The lingual artery.
 - (2) The carotid artery, which arises from the carotid gland, and divides into an external carotid branch and an internal carotid branch—the latter entering the cranium supplies the brain.
- (b) The systemic arch (4th arch of fish, 2nd of tadpole) which bending round the oesophagus unites with its fellow of the opposite side to form the dorsal aorta. Each arch gives off the following branches before uniting—
 - (1) The laryngeal artery.
 - (2) The oesophageal arteries.
 - (3) The occipito-vertebral artery.
 - (4) The subclavian, for the shoulder and fore limb.

The dorsal aorta gives off—

- (1) The cœliaco-mesenteric which divides into (i) the cœliac for the stomach and liver, and (ii) the mesenteric for the intestines and spleen. The cœliaco-mesenteric sometimes arises from the left systemic arch.
- (2) The urino-genital arteries, for the kidneys, genital organs, and fatty bodies.
- (3) Lumbar branches for the body walls, and a small medium branch (hæmorrhoidal) for the large intestine.
- (4) The iliac arteries (the terminal bifurcation of the dorsal aorta) (which supply the bladder (hypogastric) and the anterior walls of abdomen (epigastric); each then extends along the thigh as a femoral artery, and each femoral divides into a tibial and peroneal branch.
- (c) The pulmo-cutaneous arch, dividing into
 - (1) The pulmonary artery for the lung, and
 - (2) The cutaneous which supplies the skin of the back and sends small branches to the side of the head.

The thyroid gland is represented by small bright oval bodies in connection with the lingual arteries, and between the systemic and pulmo-cutaneous arches, the thymus by two small round bodies, one behind each suspensorium. The spleen lies near the large intestine, and the adrenal glands are embedded in front of the kidneys.

The mandibular branches of the 5th and 7th, and all the branches of the 9th and 10th cranial nerves, and of the 1st spinal nerve should now be examined. For description see pages 26, 28, and 32.

b. The Heart and Blood.

- (a) Examine a drop of blood (high power). Observe—and draw
 - (1) The oval nucleated yellowish-red corpuscles which, when seen on edge, have a flattened appearance.
 - (2) The granular amœboid colourless corpuscles which are few in number and often provided with two or more nuclei.
- (b) Cut out the heart leaving portions of the large vessels attached, and examine it in a watch-glass filled with spirit. Observe the divisions; sinus venosus, atrium, ventricle, and truncus arteriosus.
 - (1) Open the atrium and observe the septum dividing it into two chambers; notice the opening of the sinus venosus to the right of the septum, into the large right auricle and the opening of the united pulmonary veins to the left of the septum into the small left auricle.
 - (2) Open the truncus arteriosus longitudinally, and observe the longitudinal valve which separates the left passage leading to the opening into the pulmo-cutaneous arches, from the right leading to the carotid and systemic arches. Observe also the semilunar valves which separate the synangium from the pylangium and the pylangium from the ventricle.
 - (3) Cut across the ventricle and notice the small cavity and the thick spongy walls.
- (c) Make a sketch (6 nat. size) showing the cavities of the heart and truncus arteriosus, and the various valves.

11. The Larynx and Lungs.

Expose the hyoid apparatus by removing the muscles attached to its under surface, introduce a probe through the glottis into the right lung, remove the ventral wall of the laryngeal chamber, and slit up the right lung along the probe with a pair of scissors.

Examine and sketch (2 nat. size)—the lower jaw to be included in the sketch—

- (a) The hyoid indicating the body and the anterior and posterior cornua.
- (b) The larynx showing the arytenoid and laryngo-tracheal cartilages, and the vocal cords stretching across the small laryngeal chamber.
- (c) The lungs indicating the sacculated cavity of the right lung in direct communication with the air chamber.

12. The Alimentary Canal.

- (a) Observe the wide œsophagus; the tubular stomach distinctly separated from the duodenum by the pyloric constriction, the gall bladder lying between the divided left lobe and the smaller entire right lobe of the liver, the bile duct entering the duodenum, the pancreas sending numerous ducts into the bile duct, the spleen attached to the mesentery, the small and large intestine, and the cloaca.
- (b) Cut across the œsophagus, immediately behind the posterior cornua of the hyoid and the large intestine at its junction with the cloaca, and then remove the whole length of the alimentary canal, taking with it the lungs, liver, pancreas, and spleen, but leaving the dorsal aorta and kidneys. Uncoil the intestine and make a drawing showing all the structures removed.
- (c) Slit open the alimentary canal, and note the longitudinal folds of the stomach, the pyloric valve, the transverse folds of the duodenum, and the opening of the common bile duct.

D. Reproductive Organs and Kidneys.

1. The female frog.

a. The reproductive organs—

Observe—

- (a) The ovaries suspended by peritoneum in front of the kidneys, the ova projecting from the surface of the ovaries and the fatty bodies from their upper ends.
- (b) The long convoluted oviducts opening in front by small apertures into the body cavity, and after dilating opening behind into the cloaca.

Make a diagram showing the ovaries, fatty bodies, and oviducts.

Make an incision into one of the ovaries, and note that the ova project freely into the central cavity, and that in addition to the mature dark ova (abundant during the breeding season), there are numerous, almost colourless, developing ova. Examine a portion of the ovary containing young ova, first with low and then with high power, and draw an ovum showing the vitelline membrane, vitellus, germinal vesicle, and germinal spots.

b. The kidneys—

Observe that they lie in a lymph space behind the peritoneum, and that a simple duct passes from each to open separately into the dorsal wall of the cloaca.

Make a diagram showing the kidneys, adrenal glands, ureters, and cloaca.

2. The male frog.

Observe—

- (a) The kidneys lying behind the peritoneum.
- (b) The testes suspended by peritoneum in front of the kidneys.
- (c) The delicate vasa efferentia which carry the spermatozoa from the testes into the tubules of the kidney.
- (d) The duct (Wolfian) which extends from the outer margin of each kidney to the cloaca, and acts both as vas deferens and ureter.
- (e) The vesicula seminalis developed in connection with the outer margin of each duct—in *R. esculenta* the vesicula seminalis is represented by a simple dilation of the common duct.

Make a diagram showing the testes, vasa efferentia, kidneys, common ducts, vesiculæ seminalis, and cloaca.

Cut open the cloaca and look for the openings of the oviducts and ureters, and also for the rectal and vesicle openings.

Examine (high power) a small portion of testis; note and draw the spermatozoa.

Examine again the dorsal aorta, noting especially the branches to the kidneys and genital organs, and its bifurcation into the two iliaes, and then proceed to study the sympathetic nervous system and the 2d to 10th spinal nerves and their principal branches. For spinal and sympathetic nerves, see pages 30 and 32.

E. The Skeleton.

Before beginning the examination of the skeleton the frog may be immersed for two or three minutes in boiling water.

1. The skull.

- a.* Remove the skin and subcutaneous tissues from the roof of the skull, and observe the parieto-frontals and nasals, the premaxillæ, maxillæ, and squamosals, the quadrato-jugals, and the exposed portions of the exoccipitals, prootics, and sphenethmoid.
- b.* Remove the mucous membrane from the roof of the mouth, and observe the parasphenoid and vomers, the pterygoids, and palatines, and the under surface of the maxillæ, premaxillæ, and quadrato-jugals, and the exposed portions of the exoccipitals, prootics, and sphenethmoid.
- c.* Examine the mandibular arch—
 - (*a*) The upper portion (quadrate cartilage) known as the suspensorium; note that it supports the squamosal, and serves by its lower end for the attachment of the mandible, while it is united by its upper end to the auditory capsule.
 - (*b*) The lower portion or mandible, each half of which consists partly of cartilage (Meckels), and partly of cartilage bones—the long angulo-splénial underneath, and the small mento-meckelian at the symphysis, and the dentary on the upper margin.
- d.* Examine the hyoid arch, noting—
 - (*a*) The columella in connection externally through a piece of cartilage (suprastapedial) with the membrana tympani, and fixed by its inner end to the stapes.
 - (*b*) The anterior process of the hyoid attached to the auditory capsule below the fenestra ovalis.
 - (*c*) The body consisting of the fused ventral portions of the hyoid and the four branchial arches of the tadpole.
 - (*d*) The ossified posterior processes (remains of fourth branchial arch) which project obliquely backwards one at each side of the larynx.
- e.* Draw (2 nat. size)—*
 - (*a*) The hyoid arch, showing the anterior and posterior cornua, and the short processes from the angles of the body.
 - (*b*) The upper surface of the skull, showing—
 - (1) The membrane bones,—parieto-frontals, nasals, premaxillæ, maxillæ, and squamosals.
 - (2) The cartilage bones,—exoccipitals, sphenethmoid, prootics, and quadrato-jugals.
 - (*c*) The under surface of the skull, showing—
 - (1) The membrane bones,—parasphenoid, vomers, premaxillæ, and maxillæ.
 - (2) The cartilage bones,—exoccipitals, sphenethmoid, pterygoid, palatine, prootic, and quadrato-jugals.
 - (*d*) The mandible, showing Meckels, cartilage, and the angulo-splénial, mento-meckelian, and dentary bones.

* The cartilage should be coloured blue, and the cartilage bones dotted by way of distinguishing them from the membrane bones.

- (f) Remove carefully, under water, the parieto-frontals, the right nasal, the right premaxillæ, maxillæ, and squamosal. Examine and make a sketch (2 nat. size), showing the exposed portion of the chondrocranium, the large anterior fontanelle, and the two small posterior fontanelles, the exoccipitals, sphenethmoid, prootics, and quadrato-jugals; and, in addition, on the left side, the nasal, premaxillæ, maxillæ, and squamosal.
- (g) Remove the skull from the vertebral column, and make a sketch (2 nat. size) of the posterior aspect, showing the condyles (formed by the exoccipitals) at each side of the foramen magnum, the prootics, the columellæ, and the upper ends of the anterior cornua of the hyoid, the tympanic ring, and the suspensorium enclosed between the squamosals and pterygoids.

2. The vertebral column.

- (a) Expose and make a drawing (2 nat. size) of the dorsal surface of the vertebral column, showing the nine vertebræ and the long urostyle, and indicate also the pelvic arch in connection with the large transverse processes of the ninth vertebra (sacrum).
- (b) Observe the intervertebral foramina and the intervertebral discs, and then examine the individual vertebræ, noting that the 2d to the 7th resemble each other, while the 1st, 8th, and 9th are peculiar.
- (c) Make drawings (4 nat. size) of the 1st, 3d, 8th, and 9th vertebræ.
 - (a) The 1st or atlas vertebra. Indicate the forward projection of the centrum, the narrow arch and rudimentary spine, the concave facets for the occipital condyles, and the flattened articular processes for the second vertebra, and note the absence of transverse processes.
 - (b) The 3d vertebra. Indicate the procœlous centrum, the neural arch and its spine, the anterior and posterior articular processes (zygapophyses), and the large transverse processes.
 - (c) The 8th vertebra. Indicate in a section that the centrum is amphiœlous.
 - (d) The 9th vertebra (sacrum). Indicate the single convex anterior facet for the 8th vertebra, the two convex posterior facets for the urostyle, and the long expanded transverse processes which support the ilia.
- (d) Make a sketch of the urostyle, showing the two facets in front, the cartilage projecting from the hollow posterior end, the dorsal ridge, and the small aperture through which the 10th spinal nerve escapes from the canal in the front of the ridge.

3. The pectoral girdle and sternum. (To be examined in the second frog after the muscles have been dissected.)

a. The sternum note from before backwards.

- (a) The episternum, a small circular plate of cartilage.
- (b) The narrow bony omosternum.
- (c) The epicoracoids, consisting of a piece of cartilage at each side of the middle line between the coracoids.
- (d) The sternum proper, consisting externally of bone and internally of cartilage.
- (e) The large bifid cartilaginous xiphisternum.

b. The pectoral girdle. Observe—

- (a) The præcoracoid, a narrow bar of cartilage, extending from the sternum to the anterior margin of the scapula.
- (b) The post-coracoid, a flattened bone extending from the sternum to the posterior margin of the scapula and entering into the formation of the glenoid cavity.
- (c) The clavicle (a membrane bone) ensheathing the anterior margin of the præcoracoid.
- (d) The scapula, a short expanded bony plate which forms the upper portion of the glenoid cavity.
- (e) The suprascapula, a large thin plate of cartilage in which a limited amount of osseous and calcareous matter is usually deposited.

Make a drawing (2 nat. size) showing the sternum and pectoral girdle, colouring the cartilage blue and the clavicle red, in order to distinguish it from the cartilage bones.

4. The fore-limb.

Remove the muscles and examine the bones, and make a sketch (2 nat. size) showing—

- (a) The humerus with a rounded head, deltoid and condylar ridges, and a spheroidal articular surface for the radio-ulna.
- (b) The radio-ulna concave and simple above, with an olecranon process, but divided below and presenting three facets for the carpals.
- (c) The six carpals—radiale, ulnare, centrale, and three distalia.
- (d) The metacarpals and phalanges of the digits—the 1st digit (pollex) having no phalanges; the II. and III. digits, two phalanges each; and the IV. and V., three phalanges each.

5. The pelvic girdle.

Note that all three portions of the girdle enter into the acetabulum, the ilium forming the largest ($\frac{1}{2}$), and the pubes the smallest segment ($\frac{1}{4}$).

Examine—(a) The ilia, noting the crests, and that the two bones held apart in front by the long processes of the sacrum unite behind to form an iliac symphysis; (b) the ischia fused together and forming a median crest; (c) the pubes, represented by a small triangular piece of cartilage. Make a drawing (2 nat. size) showing the pelvic girdle from the side.

6. The hind-limb.

Examine the hind-limb, noting—

- (a) The long slender curved femur with a spherical head and a laterally expanded lower end.
- (b) The tibio-fibula, longer than the femur but less curved, and with both ends expanded and a distinct groove indicating the line of union of the two bones.
- (c) In the tarsal region—
 - (1) The greatly elongated tibiale (astragalus) and fibulare (calcaneum), separate in the middle but connected above and below by epiphyses.
 - (2) The small distal tarsals and the nodules which support the spur.
- (d) In the foot—
 - The five complete digits; the I. (hallux) and II. with two phalanges each, the III. and V. with three each, and the long IV. digit with four phalanges.

Make a sketch of the hind-limb (nat. size) and of transverse sections of the femur and tibio-fibula (2 nat. size).

F. The Nervous and Muscular Systems and Sense Organs (*second frog*).

1. Reflect the skin along the back and notice the large lymph spaces, the cutaneous branches of the dorsal nerves crossing them, and the position of the lymph hearts—one at each side of the urostyle, and one within the margin of each supra-scapula.
2. Examine the following muscles—
 - (a) The depressor mandibuli, which extends from the skull over the scapula to the angle of the jaw.
 - (b) The trapezius, extending from the exoccipital to the dorsal border of the scapula.
 - (c) The latissimus dorsi, extending from the dorsal fascia behind the scapula to be inserted into the deltoid ridge of the humerus.
 - (d) The temporal, passing from the auditory capsule to the coronoid process of the mandible.
 - (e) The pterygoid, which rises in front of the temporal and is inserted into the mandible behind the coronoid process.
 - (f) The masseter, from the quadrato-jugal to the outer surface of the mandible near its articulation.

Observe that (d), (e), and (f) elevate the mandible.

The pectoral girdle and sternum should now be examined (see page 8).

3. After noting, clear away the infraspinalis, levator anguli scapulæ, and retrahens scapulæ, and also the extensor dorsi communis and intertransversalis muscles, and the right supra-scapula. Cut across the membrane between the skull and the atlas, and then remove carefully the roof of the cranium so as to expose the brain by cutting from the foramen magnum first through the side walls, and then across in front of the parieto-frontals. Expose the spinal cord and filum terminale by removing the neural arches and the upper segment of the canal of the urostyle.
4. Remove the pigmented pia mater, note and draw (3 nat. size) the olfactory and cerebral lobes, the optic thalami (indicating the position of the pineal gland, probably removed with the roof of the skull), the optic lobes, cerebellum and medulla oblongata, and the spinal cord (showing the brachial and lumbar enlargements), the dorsal fissure, and the filum terminale.
5. Examine the cavities of the brain.
 - (a) The fourth ventricle, a triangular space behind the cerebellum roofed over by a vascular membrane.
 - (b) The iter, a narrow passage leading from the fourth to the third ventricle.
 - (c) The cavities of the optic lobes which communicate with the iter.
 - (d) The third ventricle situated between the optic thalami and covered by the choroid plexus. Remove the plexus, noting the hollow peduncle of the pineal gland projecting from the roof of the ventricle, the band of fibres known as the posterior commissure, also the infundibulum projecting downwards towards the pituitary body.
 - (e) The lateral ventricles. Each communicates by a small aperture (the foramen of Monro) with the third ventricle, and extends a short distance into the olfactory lobe.

In an outline sketch of the brain (3 nat. size), indicate the cavities mentioned.

6. Examine the olfactory bulbs, and expose the olfactory sacs in order to see the smelling membrane in which the olfactory nerves terminate.

Make a sketch (4 nat. size) showing the two chambers (one opened) and the olfactory nerves.

7. Cut across the medulla, and then raise the cerebral lobes, and after noting cut as near to the skull as possible the following nerves—
 - (1) The optic nerves forming the chiasma as they extend towards the optic lobes.
 - (2) The 3rd, 4th, and 6th nerves which pass to the muscles of the eye.
 - (3) The 5th nerve running forwards to escape in front of the auditory capsule.
 - (4) The 7th nerve passing out of the skull immediately behind the 5th.
 - (5) The 8th, entering the auditory capsule.
 - (6) The 9th and 10th, escaping by an aperture behind the auditory capsule.
8. Examine and sketch the under surface of the brain (3 nat. size), showing the cerebral lobes, the optic chiasma, the tuber cinereum and the pituitary body, the crura cerebri, the medulla oblongata, and the roots of the cranial nerves.
9. Examine the eye of the frog, and at the same time the eye of the sheep or ox.
 - a. The frog—
 - (a) Remove one of the eyes, and note the cornea, and behind it the elliptical pupil surrounded by the iris; also the sclerotic pierced by the optic nerve. Cut round the equator of the eye and observe (1) the choroid and retina; (2) the vitreous humour filling the cavity of the eyeball; and (3) in the anterior portion the lens, iris, and aqueous chamber.
 - b. The ox or sheep.
 - (a) Remove the muscles and other tissues so as to expose the sclerotic and optic nerve, and note the conjunctiva covering the cornea and extending over the anterior portion of the sclerotic, also the iris perforated by the pupil.
 - (b) After puncturing the cornea and noting the aqueous humour which escapes from the anterior chamber, remove the cornea by cutting round the margin, and note the pupil, iris, lens, and posterior chamber, and the ciliary muscle which connects the outer margin of the iris to the cornea and sclerotic.
 - (c) Separate the ciliary muscle from the cornea and sclerotic; remove the sclerotic from the anterior portion of the eyeball; observe the choroid and the vessels and nerves (ciliary) which reach it through the sclerotic. Raise a portion of the choroid and note the retina, and then after cutting through the choroid and retina by a circular incision midway between the outer margin of the iris and the equator of the eye, remove the lens and the structures in connection with it, and examine under water, noting (1) the anterior portion of the retina (ora serrata) lying within the choroid; (2) the circle of folds (ciliary processes) in front of the ora serrata projecting from the anterior portion of the choroid to fit into depressions on the outer margin (suspensory ligament) of the capsule of the lens; (3) the layer of dark pigment (uvea) on the posterior surface of the iris; (4) the capsule of the lens, and the lens after removal from its capsule.
 - c. Examine next the posterior portion of the eye, noting (1) the vitreous humour enclosed by the delicate hyaloid membrane; (2) the retina lying between the vitreous humour and the choroid with blood vessels radiating in its substance from the point of entrance (blind spot) of the optic nerve; (3) the lustre of the greenish coloured tapetum lucidum.
 - d. Indicate the structures seen in an ideal section (2 nat. size).

10. The III., IV., and VI. nerves and the muscles of the eye.
 - a. The oculo-motor (III.) sending branches to—
 - (a) The levator bulbi which extends from the side of the skull under the eyeball to the upper jaw, giving off a few fibres to act as a depressor of the lower eyelid.
 - (b) The superior, inferior, and internal recti which arise from the inner angle of the orbit and are inserted into the sclerotic.
 - (c) The inferior oblique, which extends from the palatine bone to the under surface of the sclerotic.
 - (d) The retractor bulbi which encloses the optic nerve.
 - b. The pathetic (IV.) supplying the superior oblique which extends from the palatine to the upper surface of the sclerotic.
 - c. The abducens (VI.) supplying the external rectus and the retractor of the bulb.
 - d. Make a sketch showing the optic nerve, the eyeball, and the muscles inserted into the sclerotic.
11. The Trigeminal (V.) which passes from the cranium in front of the auditory capsule and divides into—
 - a. The ophthalmic branch which extends forwards under the superior rectus muscle to communicate with the IV. nerve and supply the Harderian gland, nasal mucous membrane and the skin in the region of the nasal capsule.
 - b. The maxillary branch which runs forwards under the eyeball to reach the lower eyelid and the skin covering the upper jaw.
 - c. The mandibular branch which, at first continuous with the maxillary portion, bends round the inner surface of the upper jaw to reach and extend along the outer surface of the mandible. Look for branches to the temporal and pterygoid muscles and the skin covering the lower jaw.

The ganglion (Gasserian) on the root of the V. nerve with which the VI. and VII. nerves and the sympathetic are connected, lies in the foramen of the pro-otic bone.
12. The facial nerve (VII.) which leaves the skull immediately behind the trigeminal and divides into—
 - (a) The palatine branch which runs forwards under the orbit, and is distributed partly to the roof of the mouth and partly along with the mandibular branch of the V. to the front of the palate and the outer aspect of the mandible.
 - (b) The hyomandibular branch which runs outwards over the auditory capsule and columella to the angle of the mouth, where it divides, one portion extending towards the anterior cornu of the hyoid, the other running along the inner surface of the mandible to reach the symphysis.
13. The auditory nerve (VIII.) which enters the auditory capsule to terminate in the internal ear. For the anatomy of the auditory organ, see the "Dissection of the Skate."

The next three nerves (glossopharyngeal, vagus, and hypoglossal) are best examined in a dissection from below. See page 8. When the mylohyoid is removed, and the œsophagus distended, the hypoglossal will be seen appearing immediately in front of the brachial plexus, and then arching forwards in the substance of the genio-hyoid muscle to end in the muscles of the tongue. About two lines in front of the hypoglossal is the glossopharyngeal. It escapes from the skull behind the auditory capsule, and runs forward at first nearly parallel to the hypoglossal, but it soon crosses the hypoglossal as it passes to the base of the tongue. Running obliquely across the space between these two nerves at a deeper level is the vagus, while crossing the space it gives off the laryngeal nerve, and, after passing under the hypoglossal, it breaks up into branches for the heart, lungs, and stomach.

14. The glossopharyngeal nerve (IX.) leaves the skull along with the vagus immediately behind the auditory capsule, and divides into—
 - a. An anterior branch which bends round the auditory capsule to join the facial nerve in front of the columella.
 - b. A posterior branch, which, after passing under the petrohyoid muscle and the hypoglossal nerve, takes a sinuous course between the geniohyoid and the hyoglossus towards the base of the tongue, which it enters.
 15. The pneumogastric or vagus (X.), which, immediately after passing through the skull, leaves the IX. nerve and expands to form a ganglion. After giving off branches to the dorsal muscles, it reaches the walls of the pharynx, and runs obliquely downwards and backwards to break up into the following branches—
 - a. The laryngeal branch, which, passing between the glossopharyngeal and hypoglossal nerves and over the pulmo-cutaneous artery, reaches and supplies the larynx.
 - b. The cardiac, which reaches the inter-auricular septum by passing dorsal to the pulmonary artery.
 - c. The pulmonary, which extends along the pulmonary artery to the lung.
 - d. The gastric, which extends downwards along the side of the œsophagus to reach the stomach.
- Indicate in ventral and lateral views of the head, the distribution of the V., VII., IX., and X. nerves.

16. The sympathetic nervous system. This system consists of two ganglionated cords, which anteriorly lie in contact with the vertebral column, while posteriorly they are in connection with the sides of the aorta. The anterior pair of ganglia communicate with the 1st spinal nerve and send branches forwards which, after communicating with the ganglia of the IX. and X. cranial nerves seem to end in the Gasserian ganglion. Each of the eight following ganglia are connected to their corresponding spinal nerves by a single commissure, while the tenth ganglion has several branches reaching it from the tenth (coccygeal) nerve.

Numerous small branches pass from the various ganglia to the adjacent viscera and blood vessels, and a special set of branches (cardiac) arise from the first ganglion to reach the auricles and the large vessels which pass to and from the heart, while other filaments, springing chiefly from the third, fourth, and fifth ganglia, unite to form a plexus (solar) on the dorsal aspect of the stomach.

Make a sketch showing a transverse section of the spinal cord, the roots of a pair of spinal nerves, and a pair of sympathetic ganglia connected to these nerves. Make a second sketch showing the 10 pairs of sympathetic ganglia, their connections with each other, and the cranial and spinal nerves and the cardiac and solar plexuses derived from them.

17. The spinal nerves. Observe that—

- a. The hypoglossal (1st spinal nerve = XI. cranial of man), escapes between the first and second vertebræ to cross first the vagus and then the glossopharyngeal, it next passes beneath the mylohyoid muscle to reach the base of the tongue. Besides supplying the tongue muscles, it sends small branches to the muscles of the back and the floor of the mouth. Add this nerve to the sketch showing the V., VII., IX., and X.
 - b. The second and third spinal nerves unite immediately after escaping from the spinal canal to form the brachial nerve, which supplies the muscles of the shoulder, and then extends along the arm to divide into the radial and ulnar nerves for the forearm and hand.
 - c. The fourth, fifth, and sixth spinal nerves supply the skin and muscles of the trunk.
 - d. The seventh, eighth, and ninth spinal nerves run obliquely backwards (forming the larger part of the cauda equina), to escape behind their respective vertebræ, and unite to form the sciatic plexus. The seventh, before uniting with the eighth, sends branches (ileohypogastric and crural) to the walls of the abdomen, the skin and muscles of the thigh. The sciatic plexus condenses to form the sciatic nerve which extends along the thigh to divide above the knee into the tibial and peroneal nerves for the leg and foot.
 - e. The tenth nerve (coccygeal) escapes through a small aperture in the urostyle, and is distributed to the walls of the cloaca and bladder, and the other structures in the pelvic region.
18. Make a sketch (2 nat. size) showing the under surface of the brain and spinal cord, with the origin and principal branches of all the cranial and spinal nerves on the one side and the sympathetic system and sense organs on the other.

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UNIVERSITY OF EDINBURGH
ZOOLOGICAL LABORATORY.

DIRECTIONS FOR THE EXAMINATION
OF
AMŒBA, PARAMŒCIUM,
VORTICELLA, HYDRA, LUMBRICUS, HIRUDO,
ASTERIAS AND ECHINUS.

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A M Œ B A.

Amœbæ are often found amongst the deposits of fresh water pools. When a small quantity of the material containing Amœbæ is introduced into a small glass aquarium, and some fresh water added, a thin film usually appears on the surface of the water. This film, when examined, will be found to be composed chiefly of small organisms, some of which are likely to be amœbæ.

Take by means of a pipette a small portion of the film, and allow a drop to fall on a glass slide. Lay a narrow strip of moistened writing paper near to the drop, and apply a covering glass so that one edge rests on the paper. Look for an Amœba with a low power, and then examine with a high power, noting that it consists of an irregular shaped central portion from which blunt processes (pseudopodia) of various sizes, project, and that when active the form of the body and processes are constantly changing.

A. Observe—

1. That the body consists of—

- (a) A central mass of granular protoplasm (endosarc) which extends into some of the pseudopodia, and usually contains a nucleus, a contractile vacuole, and food particles.
- (b) A thin almost transparent outer film (ectosarc) which contains few granules.

2. The change in form, the appearance and disappearance of the pseudopodia, and the movements of the granules. Note that the pseudopodia seem at first to consist only of ectosarc, but that as some of them increase in size the granular endosarc flows into them, and further that a pseudopodium may throw out new processes, and then advance, dragging, and ultimately completely absorbing the body and processes behind it.

B. Draw an Amœba at intervals of one or two minutes to show the changes of form, and indicate by arrows the directions of the currents of granules.

C. Examine—

1. The food particles, and note that they usually lie at first in a small quantity of water (food vacuole), and that the food may consist of minute plants or animals, and that in addition to food there are often grains of sand and other substances. Study the process of ingestion of the food particles, and the expulsion of the non-nutritious particles, and note that they enter or escape from any part of the surface.
2. The contractile vacuole, if visible, and watch its pulsations.
3. The nucleus which may be made more distinct by adding a drop of acetic acid to the preparation.

D. Add to one of the drawings the nucleus, the contractile vacuole, also the food vacuoles, and any foreign substances which may be present.

E. Look for encysted Amœbæ and for Amœbæ in process of division by transverse fission.

PARAMŒCIUM.

Paramœcium, Stentor and other ciliated infusoria are usually abundant in stagnant water. Opalina is often found in the rectum of the frog and newt.

Examine a drop of water containing Paramœcia with a low power and observe that they swim rapidly by means of their cilia, and that as they glide along they usually rotate on their longitudinal axis so as to show distinctly at intervals the mouth and pharynx on the ventral aspect.

A. Arrange a few fibres of fine cotton-wool over the drop, apply a covering glass, and examine with a higher power—

1. The Ectosarc.

Note (a) The thin cuticular layer perforated for the cilia.

(b) That the cilia form an almost uniform layer except in the region of the mouth where they are somewhat irregular and longer.

(c) The striated layer, the lines running nearly longitudinally.

(d) The two dorsally placed contractile vacuoles, from which several canals radiate—observe the rhythmical contractions of the vacuoles.

(e) The trichocysts; if not visible, they should be afterwards looked for, when acetic acid or some staining solution has been added.

2. The Endosarc.

Note (a) The granules moving in a definite direction.

(b) The nucleus with a nucleolus at its side—may not be visible until acetic acid is added.

(c) The food entering the endosarc from the pharynx and following the same course as the granules, the food particles lying at first in food vacuoles, but at a later stage in contact with the protoplasm.

(d) That the undigested portions of food escape by an anal aperture which usually appears some distance from the mouth.

B. Some of the Paramœcia may be fed with carmine, to show better the course of the circulation of the food particles, while others should be treated with acetic acid or stained with majenta, to show the nucleus, nucleolus, and trichocysts.

C. Examine with the low power and note if any of the Paramœcia are in contact with each other (conjugating) or in process of division by transverse fission.

D. Make a diagram of Paramœcium, showing all the structures referred to, and draw any other Infusoria that may be present in the preparation.

VORTICELLA.

Vorticellidæ are found both in fresh and salt water, adhering to plants, insects, &c., and when present in considerable numbers appear to the naked eye as little white tufts.

A. Remove a small piece of weed to which the Vorticellæ are attached, place in a drop of water on a slide, lay a piece of moistened writing paper near the weed, and apply a covering glass. Examine with low power, and note—

1. That the colony is composed of a number of individuals, each of which has a bell-shaped body, supported at its narrow end on a stem.
2. That this stem is constantly being retracted in a spiral form.
3. That during retraction of the stem, the body assumes a spherical form by the margin being bent closely inwards.
4. In addition look for—
 - (a) Specimens in process of budding.
 - (b) The small free swimming buds.
 - (c) The buds conjugating with adult fixed forms.
 - (d) Specimens in process of division by longitudinal fission.
 - (e) The half which becomes free, noting the posterior circlet of cilia which exists during its free-swimming stage.

B. Examine under high power, and notice—

1. That the bell has the margin bent outwards, forming a thickened edge (the peristome), and that it is vertically striated near the base.
2. That this peristome bears cilia.
3. That there is a ciliated disk-shaped portion—the epistome—filling up most of the mouth of the bell.
4. That at one point a space—the vestibule—is left between the peristome and epistome, and that there is a narrow pharynx continuous with the vestibule.
5. The stem, consisting of—
 - (a) An outer generally straight sheath, and
 - (b) A central striated portion, which has a slight spiral form within the outer sheath.
6. That on irritation the epistome is retracted, while the peristome is folded closely over it, so that the body assumes a rounded form, which is followed by the retraction of the body by the stem throwing itself into a spiral form.
7. That the body consists of cuticle, clear ectosarc, and granular endosarc.
8. The contractile vacuole near the upper edge of the bell.
9. That food vacuoles are present, and that they circulate slowly down one side and up the other.

C. Place a few particles of powdered carmine near the vorticellæ and notice that the cilia sweep them into the vestibule, near the bottom of which they are aggregated into a food vacuole.

D. Add to the preparation acetic acid or a staining fluid, and note the horse-shoe-shaped nucleus.

HYDRA; *Hydra viridis* or *H. fusca*.

Examine a living hydra with the naked eye or with a pocket lens, and note the cylindrical body with one end attached by means of a disc (foot), and the other surrounded by long active tentacles six to ten in number. Observe that the body changes its form, being sometimes elongated with all the tentacles extended, while at other times it is contracted to form a short thick column with the tentacles reduced to rounded nobs. Observe, further, that when elongated, the tentacles move about apparently in search of food, and that when small crustacea, &c., are secured they are conveyed to the oral aperture situated in the centre of the oral cone. If there are any buds present, note what stage of growth they have reached.

- A.** Place a living specimen in a watch glass in a drop of water and examine with a low power, noting again the body, tentacles, oral cone, foot, and buds if present, and also—
 1. That the mouth leads into a central cavity, which, though closed posteriorly, extends into the tentacles, into which food particles freely enter.
 2. That the walls of the body and tentacles consist of two layers, an outer layer (ectoderm), and an inner layer (endoderm), which in *H. viridis* contains chlorophyll granules.
 3. The genital sacs, if present, the testes projecting from the body immediately behind the tentacles, and the ovaries from the body near its base.
- B.** Make a sketch showing the hydra in an extended and in a contracted state, and indicate in the latter sketch all the structures referred to above.

C. Place on a glass slip and examine with a high power, noting—

1. The large ectoderm neuro-muscular cells, with their nuclei, and the processes which form the fibrillated layer between the ectoderm and endoderm.
2. The small interstitial cells lying between the large ectoderm cells.
3. The threadcells (nematocysts), some with the thread still coiled up within the sac, and others with the thread everted. Observe that some of the threads are short, while others are long, and that some of the long threads have three short barbs at their base. If the threads are not visible, a drop of acetic acid usually leads to their eversion.
4. The endoderm cells forming a single layer with delicate processes (cilia) projecting into the body cavity, and with food particles and vacuoles scattered through the protoplasm, and in *H. viridis* with, in addition, chlorophyll granules.
5. A testis, which when flattened by pressure on the cover glass, is seen to contain ripe or developing spermatozoa. The ripe sperms consist of a head and of a long motile filament, while the developing sperms may either be—(1) in the form of small round granular or hyaline ectoderm cells; or (2) small oval cells with a process growing out from one end to form the filament.
6. An ovary which may contain—(a) a number of small round cells; (b), a large round nucleated cell, surrounded by small cells; (c) a ripe ovum,—a large irregular-shaped amoeba-like cell, with a distinct germinal vesicle and a germinal spot; or (d), an ovum in process of segmentation enclosed in a thick capsule.

D. Indicate in an ideal transverse section the ectoderm cells with their thread cells and processes, the interstitial cells between them, and the endoderm cells, with their cilia, vacuoles and granules lying within the fibrillated layer. Indicate also the various stages seen in the development of the spermatozoa and ova, and a segmented ovum if present, within its capsule.

Advanced Students should make and examine transverse sections of the body and tentacles of hardened specimens, in order to study and draw the ectoderm and endoderm cells, their various processes, and the nematocysts.

THE EARTHWORM; *Lumbricus terrestris*.

Observe in a living earthworm the natural movements, and the rows of setæ which subserve locomotion—the four rows of setæ are easily detected by carrying the finger along the ventral surface from behind forwards; the dark dorsal and pale ventral surface and the iridescent cuticle; the clitellum; the small retractile lobe (prostomium) in front of the mouth and the numerous rings (somites) between the mouth and the terminal anal segment.

A. Make a sketch (2 nat. size) of the dorsal surface of the first 40 or 50 segments showing—

- (a) The prostomium.
- (b) The enlarged segments (29 to 36 inclusive) which form the clitellum.
- (c) The dorsal vessel (if visible) running along the median line and the position of the single row of minute dorsal pores.

B. Make a similar sketch of the ventral surface showing—

- (a) The mouth between the prostomium and the 1st segment.
- (b) The 8 setæ in each segment (except 1st, 2d, 3d, and last)—2 ventral and 2 lateral on each side of the median line.
- (c) The clitellum.
- (d) The thickening of the epidermis in the region of the inner setigerous glands (8th to 11th segments).
- (e) The 4 apertures of the spermathecae—two on each side—between the 9th and 10th and 10th and 11th segments.
- (f) The genital openings between the ventral and lateral setæ, (1) of the 2 oviducts in the 14th segment and (2) of the vasa deferentia in the 15th segment.
- (g) The openings of the segmental organs (nephridia), some internal and others external, to the ventral setæ,—nephridia absent from 1st and 2d segments.

- C.** Fix the earthworm with the dorsal surface upwards by one pin through the 1st, and another through the 50th segment, and cover with salt solution. Cut along the middle line from the 25th to the 1st segment, and fix back the skin by introducing pins obliquely through the 3d, 7th, 12th, 16th and 20th segments.

Observe and indicate in a drawing (2 nat. size)—

- (a) The mesenteries (intersegmental muscular septa), and the segmental organs in connection with them.
 - (b) The supra-oesophageal nerve ganglia (3d segment).
 - (c) The pharynx (1st to 7th segments) oesophagus (8th to 15th segments), and the calcareous oesophageal glands, proventriculus (16th to 17th), gizzard (18th), and the intestine, invested with buff-coloured pigment, extending backwards from the 19th segment.
 - (d) The bilobed anterior and the usually simple posterior seminal vesicles (9th to 12th segments).
 - (e) The two pairs of spermathecae.
 - (f) The dorsal vessel above the intestine, breaking up into a plexus over the pharynx, and the dilated lateral vessels arching round the intestine from the 8th to the 15th segments.
- D.** With a pair of fine scissors remove one of the segmental organs. Mount in salt solution, and examine first with low and then with high power, noting and drawing—
- (a) The ciliated funnel-shaped opening by which the segmental tube communicates with the body cavity (coelom), in front of the mesentery.
 - (b) The narrow portion which pierces the mesentery.
 - (c) The coiled glandular portion behind the mesentery lined with ciliated epithelium, and surrounded by capillaries in connection with the dorsal and sub-intestinal blood vessels.
- E.** Examine in salt solution, first with low and then with high power, a portion of a seminal vesicle. Note and draw—
- (a) Sperm-polyplasts in various stages of development.
 - (b) Free spermatozoa—usually better seen in contents of spermathecae.
- F.** In the same preparation look for and sketch, if present, the following stages in the life history of the gregarina of the earthworm (*Monocystis lumbrici*).
- (a) Free gregarinae.
 - (b) Cysts containing—
 - (1) Two entire gregarinae or a single gregarina.
 - (2) Gregarinae partly broken up.
 - (3) Pseudo-naviculæ.

- G.** After turning the right seminal vesicles to one side and observing the three oesophageal calcareous glands (12th and 13th segments); the lateral blood vessels joining the sub-intestinal vessel; and the pharyngeal plexus formed by the breaking up of the longitudinal vessels; carefully turn aside the portion of the alimentary canal exposed, and fix to the left of the middle line.
1. Examine the nervous system, noting the small nerves running forwards from the supra-oesophageal ganglia towards the prostomium, the lateral commissures passing downwards to the ventral nerve-cord, so as to complete the nerve ring, and the ventral cord formed by a pair of fused ganglia in each segment from the fourth backwards connected by a pair of united commissural cords.
 2. Continue the examination of the genital organs, noting at each side of the nerve-cord—
 - (a) The two pairs of spermathecae (between the 9th and 10th, 10th and 11th segments).
 - (b) The two small ovaries (one near each side of nerve-cord in 13th segment).
 - (c) The oviducts which open internally in 13th segment, and externally through 14th segment.
 - (d) The two pairs of small testes (front of 10th and 11th segments), and the seminal ducts which have four rosette-shaped ciliated internal openings (two in the 10th and two in the 11th segment), and two external openings in the 15th segment,—testes only visible when seminal vesicles are small.
 3. Make an enlarged drawing (4 nat. size) shewing the genital organs and the exposed portion of the nervous system.
- H.** Remove the ovary and oviduct from one side, and examine with low power in salt solution.
- (1) Sketch the pear-shaped ovary and the ripe and unripe ova in its interior.
 - (2) Sketch the trumpet-shaped oviducts indicating their wide ciliated internal openings into which the ova find their way on escaping from the ovary.

I. Cut along the middle line from the 25th to the 40th segment, and after fixing the skin at each side, examine the blood vessels. Make a diagram shewing, in a side view, the dorsal, sub-intestinal, latero-neural, and sub-neural trunks, and the lateral branches connecting the dorsal with the sub-intestinal, and the dorsal and sub-intestinal with the sub-neural. Remove the worm from the salt solution and continue the incision along the middle line.

- (a) Collect and examine (high power) the perivisceral fluid, noting and drawing the granular amoeboid corpuscles.
- (b) Cut across the dorsal vessel and examine the blood (high power), noting and drawing the small oval colourless blood corpuscles.
- (c) Strip off a small portion of the cuticle from the middle line of the back and examine (high power), noting the row of comparatively large dorsal pores, and the extremely small canals scattered irregularly over the surface, and the fine lines which cause the iridescence.
- (d) Examine the setæ from various segments (low power), noting and drawing the modified forms in the region of the clitellum, and in the 10th, 15th, and 23d segments.

J. Examine a prepared transverse section of earthworm—

1. With low power ; note and draw—

- (1) The body wall consisting of (a) the structureless cuticle, (b) the epidermis, (c) a pigmented circular muscular layer, (d) a longitudinal muscular layer divided by the setæ into four broad and four extremely narrow bands, (e) the parietal layer of coelomic epithelium.
- (2) A mesentery (if present) extending between the body wall and the intestine.
- (3) The alimentary canal, indicating (a) the pigmented visceral layer of the coelomic epithelium, (b) the longitudinal muscular layer, (c) the circular muscular layer, (d) the typhlosole and its blood vessel, (e) the dorsal and sub-intestinal blood vessels, and the lateral vessels if present.
- (4) The nerve cord, and the three vessels in connection with it.
- (5) The setæ (two lateral and two ventral on each side), the muscles extending from their inner ends to the body wall, and the setigerous glands between the muscular bands.
- (6) The segmental organs and their apertures internal or external to the ventral setæ.

2. With high power ; draw a portion to show—

- (1) The nucleated cells of the epidermis.
- (2) Circular and longitudinal muscular fibres of the body wall and intestine.
- (3) The long granular cells of the visceral layer of the coelomic epithelium and the ciliated nucleated cells of the intestinal epithelium.
- (4) The muscular fibres and epithelium of the mesentery, if visible.
- (5) The nerve cord which consists of (a) a muscular sheath, in connection with which are three large fibres, (b) nerve fibres, especially abundant in the centre and on the dorsal aspect, and of (c) ganglionic cells, which in the ganglia occupy the ventral surface and sides.

Advanced students may further examine the epithelium covering the various organs and lining the body cavity, and the blood vessels in preparations, made from the tissues of a fresh earthworm, treated with $\frac{1}{2}$ p.c. solution of silver nitrate, and mounted in glycerine.

THE MEDICINAL LEECH; *Hirudo medicinalis*.

A. Natural Movements.

Observe that the leech crawls by fixing the anterior sucker as far as possible ahead of the posterior, and then after detaching the posterior sucker by shortening itself, it brings the posterior sucker to within a short distance of the anterior, the posterior having been fixed, the anterior is then detached, and the process repeated. When ascending a vertical surface, note that the body is thrown into a loop by the posterior sucker being fixed immediately behind the anterior. Observe further, that it sometimes completely detaches itself, and after assuming a ribbon-like form swims along in an undulating manner with the dorsal surface upwards when moving in a vertical direction, but with one of the margins usually upwards when moving in a horizontal direction.

B. External Characters.

Note—

1. The dark olive colour of the slightly convex dorsal surface, and at each side of the middle line (*a*) an orange band, (*b*) a similar band interrupted by dark elongated spots, (*c*) a dark, narrow band bordered with orange on the one side and with yellow on the other.
 2. On the flattened ventral surface a number of dark patches scattered irregularly over a pale olive ground between two broad dark bands.
 3. That the body is made up of a large number of rings, and that the 1st, 2nd, 3rd, 5th, and 8th rings are in some leeches provided with a pair of simple eyes arranged around the anterior end; from the presence of eyes it may be inferred that the 1st and 2nd rings represent the 1st and 2nd segments, the 3rd and 4th, the 3rd segment; and that the 5th, 6th, and 7th rings represent the 4th segment; the segments between the 4th and the posterior sucker are probably made up of 5 rings each, the posterior sucker seems to consist of 7 segments.
 4. The anterior sucker formed by the upper lip projecting backwards at each side of the mouth, and the large posterior sucker with the anus lying between its dorsal margin and the last ring—apply the anterior sucker to the skin, and note the presence of the three toothed ridges.
 5. On the ventral surface, the penis in the centre of the 24th ring behind the mouth, and the female genital opening between the 29th and 30th rings, the openings, if visible, of the large mucous glands of the 39th, 40th, and 41st rings, and the small apertures of the segmental organs on every 5th ring.
- Make a sketch of the dorsal and another of the ventral surface to show the external characters.

C. Dissection.

The leech having been killed with chloroform, should be fixed under water, and an incision carried along the dorsal surface from the third to the second last ring. The skin should then be carefully reflected and fixed with pins at each side of the middle line, in order to expose the alimentary canal and its appendages. In doing this, note the dorsal and the lateral blood vessels and the absence of a distinct body cavity.

1. Examine and draw the digestive tract, indicating—

- (1) The thick-walled tubular pharynx connected by muscular fibres to the body wall.
 - (2) The thin-walled stomach with 11 pairs of saccular diverticula (which correspond to the ganglia of the nerve-cord from the 4th to the 14th inclusive), and that the 11th pair of diverticula send long projections backwards towards the end of the body.
 - (3) The small tubular intestine running along between the projection of the 11th pair of diverticula to dilate slightly before opening to the exterior between the last ring and the upper margin of the posterior sucker.
2. Indicate in the same sketch, the position of the dorsal and lateral blood vessels—the remains of the reduced body cavity.
3. Examine (high power) the blood (which is coloured with hæmoglobin) for the colourless corpuscles.
4. Make an incision along the pharynx, stomach, and intestine, and note—
- (1) The position of the circular muscles which on contraction close both ends of the fusiform cavity, and the muscles which radiate to the skin, and serve for producing the sucking action, and also the longitudinal folds containing muscular fibres which serve for driving the blood backwards into the gastric diverticula.
 - (2) That the stomach is constricted by incomplete septa, which extend inwards between the diverticula, and that communicating by a small aperture with the pharynx in front, it projects slightly into the intestine behind.
 - (3) That the gastric diverticula consist of a small anterior and of a larger posterior chamber, the posterior chamber of the 11th extending, as already seen, nearly to the end of the body.

5. Cut across the pharynx near its centre, and the intestine near its termination, and carefully remove the intestinal tract, in order to expose the blood vessels, nervous system, and the reproductive and segmental organs.

Observe—

- (1) The ventral blood vessel enclosing the nerve cord and sending branches to communicate with the lateral blood vessels.
- (2) The segmental organs (17 pairs corresponding to the 2d to the 18th ganglia inclusive) consisting of convoluted tubes in connection with rounded vesicles.
- (3) The 9 pairs of testes (corresponding to ganglia 8 to 16 inclusive) with their ducts opening into the two vasa deferentia, and that the vasa deferentia become convoluted to form the large vesiculæ seminalis which communicate with the penis—the penis lies in a bent sheath which, springing from a large sac, opens through the 24th ring behind the mouth.
- (4) The 2 small ovaries lying in the segment behind the vesiculæ seminalis, which communicate by slightly twisted oviducts with a muscular uterus—the uterus opening to the exterior between 29th and 30th rings behind the mouth.
- (5) The 4 mucous glands, if visible, lying behind the ovaries.
- (6) The nerve cord extending backwards from the œsophageal ring to end in a large ganglion lying above the posterior sucker. Noting—
 - (a) The two supra-œsophageal ganglia giving off 5 pairs of optic nerves and communicating with the 3 small buccal ganglia which lie one above and one at each side of the buccal cavity.
 - (b) The commissures connecting the supra-œsophageal ganglia with the sub-œsophageal ganglion, which is made up by the fusion of 3 or 4 embryonic ganglia, and from which several (4) pairs of nerves extend to the surrounding tissues.
 - (c) The 2d to the 21st post oral ganglia, each giving off 2 pairs of nerves, the 22d ganglion giving off only 1 pair of nerves, and the 23d (made up of 6 or 7 embryonic ganglia) giving off 7 pairs of nerves.
- (7) Examine with a low power and sketch a portion of the double nerve cord lying in the ventral blood vessel, and one of the ganglia with its lateral branches.
- (8) Make a drawing, showing (a) the ventral and lateral blood vessels, (b) the nephridia, (c) the generative organs and the nervous system.

6. Examine the buccal cavity, noting the **Y**-shaped oral aperture, and the toothed ridges which lie on the inner surface of the three lobes formed by the strong buccal muscles.
7. Remove one of the toothed ridges, examine (low power), and sketch.
8. Advanced students should prepare and
 - (1) Examine (low power), and afterwards sketch transverse sections—
 - (i) Through the middle of the body, showing (*a*) cuticle ; (*b*) epidermis and dermis, containing capillaries and simple glands ; (*c*) external circular, longitudinal, internal circular, radiating and dorso-ventral muscular fibres; dorsal, lateral, and ventral blood vessels; and the nerve cord or ganglia ; (*d*) the stomach and its diverticula ; (*e*) the nephridia, testes, and vasa deferentia.
 - (ii) Through the anterior end of the body, noting (*a*) the ocelli, closed capsules containing large transparent cells ; (*b*) the nerve cells of the supra-oesophageal ganglia ; (*c*) the cup-shaped glands in the epidermis.
 - (2) Examine (high power) (*a*) one of the ovaries teased in salt solution, and sketch several ova ; (*b*) one of the testes prepared in the same way, and draw the spermatozoa ; (*c*) one of the ganglia teased in carmine or picro-carmine, and sketch the ganglion cells.

THE STAR-FISH ; *Asterias rubens*.

Observe in the living star-fish the natural movements. Notice that locomotion is effected by the pedicels or tube feet on the under (oral) surface of the rays, these pedicels having suckers at their tips, whilst the terminal pedicels of the rays are unprovided with suckers, and act as tentacles.

Turn the star-fish on its aboral surface and observe how it twists round the tip of one or more of its rays until the pedicels situated there can be attached, the pedicels further back being then applied by a similar and progressive twisting of the ray, until by this spiral-like movement the disc is drawn over.

A. Make a sketch (natural size) of the slightly convex aboral surface, showing the central pentagonal disc with the five rays radiating from it ; the whitish circular madreporic tubercle placed towards one side of the disc and opposite the point of junction of the two rays which form the *bivium* ; the minute anal opening placed slightly to the left of an imaginary line from the tubercle to the tip of the opposite ray ; the calcareous ossicles bearing short spines embedded in the soft tissue of the integument, and the short stems bearing pincer-like heads—the pedicellariæ.

Remove one of these pedicellariæ, examine with low power and draw.

B. Sketch the flat oral surface, showing—

- (a) The large central mouth.
- (b) The five ambulacral grooves running along the oral faces of the rays.
- (c) The two double rows of pedicels nearly filling these grooves.
- (d) At the tip of each ray the small red eye spot.

- C.** 1. Remove and examine under low power one of the pedicels, noting the sucker-like tip strengthened by five or six calcareous plates.
2. Examine also a pedicel from the tip of the ray, and notice that it is not terminated by a sucker.
3. Pull off carefully the pedicels from a portion of one of the rays, and notice the radial nerve extending along the centre of the ambulacral groove to end in the eye-spot.

D. Fix the star-fish, mouth downwards, under water. Select the ray furthest from the madreporic tubercle, and cut through the skin along each side of the ray from the base to the tip; dissect off this strip of skin, and make a drawing of the organs exposed, viz. :—

- (a) The two large brown sacculated hepatic cæca lying along nearly the whole length of the ray on each side of the ambulacral plates;—notice that near the base of the ray each cæcum ends in a delicate tube; and that the two tubes unite to form a single hepatic duct which opens into the large membranous pyloric sac of the stomach.
- (b) The stomach, with its eversible cardiac pouches projecting into each ray below the hepatic duct;
- (c) The two reproductive glands, the duct from each passing into the side of the inter-radial partitions, where it joins with that from the next ray to open to the exterior in the angle between the rays.

E. Reflect the skin from the central disc, taking care not to injure the madreporic tubercle, and sketch—

- (a) The stomach, with its cardiac and pyloric sacs.
- (b) The short intestine near its centre.
- (c) The rectal glands opening into the intestine.
- (d) The retractor muscles of the cardiac pouches.
- (e) The short œsophagus.

F. Remove the pyloric cæca and reproductive organs carefully from the dissected ray, and examine and sketch the ampullæ of the pedicels. Scrape off some of these, and notice that the pores for the pedicels are placed between the ambulacral ossicles and alternately near the base and near the ridge, appearing to be in two rows though forming only a single irregular one.

G. Cut transversely through the ray, and sketch—

- (a) The ambulacral ossicles sloping up to meet in a ridge at the centre, and forming the ambulacral groove.
- (b) The small plates—interambulacral plates—on which they rest.
- (c) The inter-radial septa formed by junction of the inter-ambulacral plates of adjacent rays.
- (d) The cut section of the radial water tube lying below the ridge formed by the ambulacral plates.
- (e) The radial blood-vessel lying below the water-vessel.
- (f) The radial nerve lying external to the blood-vessel.

Dissect out carefully the stone canal which extends from the madreporic tubercle to the circum-oral water tube; trace one of the radial water vessels to the ring, and notice the sinus running parallel to the stone canal, and opening into a circular vessel beneath the water ring, from which spring the radial blood-vessels.

THE SEA URCHIN; *Echinus esculentus*.

A. Observe the natural movements of the living animal, noticing that it uses for locomotion not only the pedicels or tube feet, like the star fish, but also the spines which cover the test; and that on a flat surface it uses its teeth also for this purpose, by projecting them and pushing itself over them. Touch any part of the test, and observe that the adjacent spines and pedicellariæ all converge to the point of stimulation, the pedicellariæ attempting to grasp the irritating object.

B. Make a drawing of the sea urchin from the side, indicating :—The spheroidal form; the small tubercles bearing movable spines; the five ambulacral areas perforated for the pedicels, and the five inter-ambulacral areas between them. Notice that the ambulacral areas are wide where they commence at the mouth, and narrow towards the aboral region.

C. Scrape off the spines from a small portion of both areas, and sketch—

- (a) The double row of plates in each area bearing the tubercles, which are of various sizes, and bear corresponding sized spines.
- (b) The perforations in the ambulacral plates for the pedicels.

D. Scrape off a few of the spines in the aboral region, and indicate the arrangement of the plates exposed :—

- (a) The five genital plates perforated for the genital ducts, one of them larger and rougher than the others serving as the madreporic tubercle.
- (b) The five smaller ocular plates placed between the genitals—one at the apex of each ambulacral area.
- (c) The central semi-membraneous area surrounded by the genital plates, and perforated by the anal opening.

E. Sketch the oral surface, showing the large membraneous area with the mouth, occupied by the five teeth in the centre; and the five pairs of tentacles projecting from the sinuses which surround the lantern.

F. Remove, examine (low power), and draw the following structures :—

- (a) One of the spines, indicating its fluted appearance and the cup or socket at its base surmounted by a ridge with muscular fibres adhering, which held the spine in contact with the tubercle on the surface of the test.
- (b) Several of the pedicellariæ,—noting that they consist of a long slender stem, partly calcareous and partly membraneous, and of a head made up of three movable mandibles.
- (c) One of the pedicels with its sucker-like tip containing five or six calcareous plates.

G. Cut with a pair of scissors round the "equator line" of the echinus, and separate the two halves without tearing across the intestine, and lay the upper portion beside the lower with aboral surface downwards. Make a sketch showing—

- (a) The dentary apparatus, or Aristotle's Lantern.
- (b) The alimentary canal passing from the lantern and coiling round the test, to terminate in the centre of the aboral region.
- (c) The generative organs hanging in lobes from the test around the anal aperture, and opening by five ducts to the exterior.
- (d) The stone canal which passes from the madreporic tubercle in a direct central line to end in the water ring surrounding the œsophagus.
- (e) The polian vesicles.
- (f) The five radial water vessels which pass down outside the alveoli to reach the ambulacral area.
- (g) The pedicels springing from the radial vessel, and the ampullæ formed on the tube which projects into the test from the bases of the pedicels.
- (h) The membranous sinus which runs alongside the upper part of stone canal.

H. Sketch the dentary apparatus in position from the side and from above, showing—

- (a) The five pairs of long triangular alveoli connected by interalveolar muscles.
- (b) The teeth lying between the alveoli.
- (c) The radii extending across the base of the lantern.
- (d) The rotulæ articulating at their outer ends with the alveoli, and at their inner with the radii.
- (e) The transverse muscles connecting the radii.
- (f) The protractor muscles extending from the top of each alveolus to the inter-ambulacral areas.
- (g) The retractor muscles extending from the oral ends of the alveoli to the auricles.

I. Cut away carefully with scissors the tips of the alveoli on one side of the lantern, to expose the pentagonal ridge, which forms the nerve ring, on the inner surface of the oral membrane. Trace the radial nerves from the nerve pentagon along the ambulacral areas to their termination in the eye-spots on the ocular plates.

J. Remove a portion of the nerve cord and examine with the microscope (low power), noting the lateral branches, and also the radial water vessel and its lateral prolongations.

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THE DISSECTION

OF

THE SKATE.

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THE SKATE. *Raia batis* OR *Raia clavata*.

Examine the living skate in an aquarium, and note that it swims in an undulating manner principally by the action of the large pectoral fins, that in breathing the water enters by the mouth and the two spiracular apertures, and after passing over the gills, escapes through the gill slits, and also by the spiracular apertures; note also that in breathing the spiracles and gills beat rhythmically from 30 to 32 times per minute, and that the mouth sometimes opens and closes at the same rate.

A. External characters—

1. Examine the skate, noting—

- (a) The rhomboidal form, and that it is depressed from above downwards.
- (b) The colour—dark dorsally and ventrally in *R. batis*, dark dorsally, white ventrally in *R. clavata*.
- (c) The thick skin—smooth in *R. batis*, rough in *R. clavata*, owing to the presence of small denticles (placoid scales).
- (d) The large dermal denticles scattered more or less over the dorsal and ventral surfaces of *R. clavata*, but only along the dorsal surface of tail of *R. batis*.
- (e) The delicate sensory tubes beneath the skin, and their numerous external apertures (best seen in *R. batis*).
- (f) The anterior projecting rostrum.
- (g) The large triangular-shaped pectoral fins.
- (h) The smaller bi-lobed pelvic fins.
- (i) The long narrow tail with its terminal caudal fin.
- (j) The pair of elongated claspers (in the male only).

2. Make a sketch of the dorsal and ventral aspects, indicating as far as possible the above characters; and also—

(1) In the dorsal view—

- (a) The oval-shaped depressed eyes.
- (b) The spiracular apertures, spiracular cartilages, and pseudo-branchiæ.
- (c) The minute apertures of the aqueducti vestibuli at the posterior end of the head.
- (d) The pair of dorsal fins.

(2) In the ventral view—

- (a) The large mouth with its upper and lower jaws covered with flat enamelled teeth (generally raised into sharp ridges in male of *R. clavata*).
- (b) The nasal apertures, connected by the naso-buccal grooves with the mouth.
- (c) The fronto-nasal process—the fold of integument between the naso-buccal grooves.
- (d) The ten gill clefts arranged in two semi-circular rows, and behind the last gill openings a pair of slit-like markings resembling a sixth pair of clefts.
- (e) The ridges formed by the pectoral and pelvic girdles.
- (f) The large cloacal aperture.
- (g) The pair of small abdominal pores posterior to it.

3. Cut out and sketch one of the large denticles, noticing that it consists of a flattened bony base buried in the integument and a projecting sharp enamelled spine.

B. Alimentary system.

1. Cut away the whole of the ventral wall of the abdomen between the pectoral and pelvic girdles, noting—
 - (a) The skin.
 - (b) The muscles.
 - (c) The internal peritoneal lining.
2. Sketch the viscera thus exposed, *in situ*, indicating—
 - (a) The tri-lobed liver.
 - (b) The stomach.
 - (c) The large intestine (colon).
 - (d) The rectum and rectal gland.

Note also the red lobulated spleen.
3. Turn forwards the liver, and note in addition to the above—
 - (a) The duodenum.
 - (b) The pale bi-lobed pancreas.
 - (c) The gastro-hepatic and the duodeno-hepatic omenta between the liver and the stomach and the liver and the duodenum respectively.
 - (d) The gastro-splenic omentum attaching the spleen to the dorsal surface of the stomach.
 - (e) The mesogaster and mesorectum suspending the stomach and rectum respectively from the dorsal wall of the abdomen.
4. Examine the liver, noting—
 - (a) Its division into three lobes.
 - (b) The gall bladder between the right and middle lobes.
 - (c) The short cystic duct from the gall bladder, the two hepatic ducts, one from the right lobe, the other from the middle and left lobes, and the common bile duct into which they open,—trace the bile duct to the point where it opens into the duodenum.
5. Examine the pancreas and the pancreatic duct. Trace the duct to the duodenum into which it opens opposite the aperture of the bile duct.
6. Cut out the liver, and ligature the alimentary canal in front of the stomach, and behind the rectal gland; cut through the mesenteric attachments and remove the whole alimentary tract. Make a sketch of the part of the alimentary tract removed, and indicate the position of the pancreas and the pancreatic and bile ducts.
7. Cut open the stomach and duodenum, and note the pyloric valve between them, and the longitudinal folds of the mucous membrane of the stomach.
8. Wash out the colon, noting the external spiral line indicating the attachment of the valve inside. Fill the colon with air by a blow-pipe, and tie at each end: allow to dry for some days, and then cut apertures so as to examine further the arrangement of the spiral valve.

c. The reproductive and excretory systems.

1. Of the male.

(a) Examine and sketch—

- (1) The pair of testes,—smooth on ventral, lobulated on dorsal surface.
- (2) The much-coiled epididymes,—note the narrow connection between the testes and epididymes.
- (3) The coiled vasa deferentia (barely visible in young fish) terminating in an enlarged portion, the seminal vesicle.
- (4) The sperm sac lying external to the seminal vesicle.
- (5) The pair of elongated lobed kidneys on each side of the posterior part of the vertebral column, and external to the peritoneum, by which they are covered.

(b) Remove the pelvic girdle (for future examination) without injury to the cloacal chamber. Cut open the cloaca, and note the large anal aperture and the median urino-genital papilla.

(c) Carefully cut along the papilla and expose the urino-genital sinus, and note in it the apertures of the ureters and of the sperm sacs.

(d) Insert a bristle into each of these apertures, then remove the thick peritoneum covering the kidneys, and note the ureters running along the inner edge of the kidneys and communicating with them by numerous efferent ducts, also the yellow inter-renal bodies situated between the ureters and kidneys.

(e) Cut open one of the sperm sacs, and note at its neck the aperture of the seminal vesicle.

(f) Examine (high power) the contents of the sperm sac, and sketch a spermatozoon, noting its twisted elongated head and the long tail.

2. Of the female.

(a) Examine and sketch—

(1) The ovaries.

(2) The anterior portions of the oviducts, noting that the right and left unite in the middle line on the ventral aspect of the œsophagus, and open into the abdominal cavity by a single median aperture.

(3) The rounded oviducal gland, the secretion of which forms the case or "purse" for the ovum.

(4) The posterior portion of the oviducts.

(5) The kidneys.

(6) The bi-lobed urinary bladder.

(7) The delicate mesonephric ducts running forwards from the bladder.

(b) Carefully remove the pelvic girdle without injuring the cloaca, dissect off the peritoneum from the kidneys, and note the ureters on their inner edge, and the yellowish inter-renal bodies.

(c) Cut open the cloaca and note the apertures of the rectum and oviducts, and the central small urinary papilla.

(d) Insert a blowpipe through the urinary papilla and inflate the bi-lobed bladder. Cut it open and note the minute apertures of the ureters.

D. Prepare the skeleton of the skate,

1. The skull, note—

- (a) The four labial cartilages on each side, the first supporting the lateral flap of the fronto-nasal process, the second on the outer margin of the nasobuccal groove, the third forming the internal, and the fourth the external margin of the nasal aperture.
- (b) The flat floor of the skull.
- (c) The roof, with the anterior and posterior fontanelles.
- (d) The foramen magnum.
- (e) The two rounded occipital condyles.
- (f) The indentation for the odontoid process of the vertebral plate.
- (g) The anterior projecting rostrum.
- (h) The pair of rostral cartilages at the sides of the rostrum.
- (i) The nasal capsules.
- (j) The auditory capsules.
- (k) The following apertures on one side—
 - (1) In the region of the eye a large aperture for the optic nerve.
 - (2) Some minute apertures over the optic foramen for the passage of 4th nerve.
 - (3) Behind the optic foramen a small aperture for 3rd nerve.
 - (4) Anterior to the auditory capsule the aperture for 7th nerve.
 - (5) Above and anterior to (4) the aperture of 5th nerve.
 - (6) In the lower posterior part of the auditory capsule, the aperture for 10th nerve.
 - (7) External to (6) the aperture of 9th nerve.
 - (8) Two apertures in the nasal capsule for the passage of the orbito-nasal and the palato-nasal divisions of 5th nerve.
 - (9) On the surface of the posterior part of skull the apertures of the aqueducti vestibuli.

Make a sketch of the skull from above, from below, and from the side.

2. The jaws and branchial arches, note—

- (a) The upper jaw (palato-ptyergoid arch).
- (b) The lower jaw (mandibular arch).
- (c) The hyomandibular cartilage connecting the jaws to the lower portion of the auditory capsule.
- (d) The small spiracular cartilage (metapterygoid) between the hyomandibular cartilage and the auditory capsule.
- (e) The hyoid arch articulating with the hyomandibular, and composed of a dorsal epihyal, a median ceratohyal, and a ventral small hypohyal segment.
- (f) The five branchial arches composed of (from above downwards) pharyngo-, epi-, cerato- and hypo- branchial portions,—note that the hypobranchial portions of the first branchial arch meet in the middle line, to form a narrow bar slightly behind the lower jaw; that the hypobranchials of the fifth arch meet in the middle line to form a large basibranchial plate with a pair of anterior horns; and that the pharyngobranchials of the fourth and fifth arches unite with each other.

Note the pair of elongated thymus glands lying dorsal to the pharyngo-branchials.

Make a sketch showing the jaws and branchial arches from below.

3. The pectoral girdle and pectoral fins, note—

- (a) That the two sides unite in the middle line forming a bar—the coracoid portion of the girdle—across the body on the ventral surface.
- (b) The two halves on the dorsal surface, forming the scapular portions of the girdle.
- (c) The small supra-scapular portions, forming the attachment of the girdle to the vertebral plate.
- (d) The three glenoid facets on each external edge of the girdle, which form articulating surfaces for the fins.
- (e) The three fontanelles on each side.
- (f) The three divisions of each fin, viz.—
 - (1) The long propterygium, articulating with the anterior glenoid facet, and composed of several pieces, one of which reaches the antorbital cartilage.
 - (2) The small mesopterygium articulating with the middle glenoid facet.
 - (3) The long metapterygium, which consists of several pieces, and articulates with the posterior glenoid facet.
- (g) The long jointed cartilaginous fin rays.

Sketch the pectoral girdle and one of the fins.

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- (g) The long jointed cartilaginous fin rays.

Sketch the pectoral girdle and one of the fins.

4. The pelvic girdle and pelvic fins (already detached). Note—

- (a) That it consists of a bar (pubis) with small anterior and posterior projecting processes—the prepubic and iliac processes.
- (b) The anterior and posterior lobes of the fin, and the two acetabular facets.
- (c) The fin rays of the anterior lobe of fin attached directly to the pelvic girdle—the anterior (preaxial) ray being much thicker than the others.
- (d) The basipterygial portion of fin supporting the fin rays which form the posterior lobe—observe that it is divided into several pieces, which in the male are connected with the sharp cartilages of the clasper.

Sketch the pelvic girdle and one of the fins.

Examine a clasper, noting the groove along its edge and the form of the cartilages.

5. The vertebral column, note—

- (a) The unsegmented anterior vertebral plate.
- (b) The odontoid process at its anterior end.
- (c) The two articulating surfaces for the condyles of the skull.
- (d) The free vertebræ forming the remainder of the column.
- (e) The fin rays of the dorsal fins attached to basal pieces.

6. Make transverse and longitudinal sections through—

- (a) The vertebral plate, noting the flat ventral surface, the lateral and dorsal ridges, and the neural canal.
- (b) The vertebræ immediately behind the vertebral plate, noting—
 - (1) The partially ossified bi-concave centra.
 - (2) The transverse processes bearing small cartilaginous nodules (rudimentary ribs).
 - (3) The neural and interneural processes.
 - (4) The neural spine.
 - (5) The neural canal, formed by the neural processes and spine.
 - (6) The soft remains of the primitive notochord filling the spaces between adjacent vertebræ.
- (c) The caudal vertebræ, noting—
 - (1) The centrum.
 - (2) The neural processes.
 - (3) The neural spine.
 - (4) The neural canal.
 - (5) The hæmal processes.
 - (6) The hæmal spine.
 - (7) The hæmal canal.
 - (8) The remains of the notochord.

Make a sketch of the vertebral column complete, and of the transverse and longitudinal sections examined.

Second Skate.

Examine the arteries and veins described under I., 1 and 2, p. 20, and after removal of the alimentary canal and liver as described above, examine—

E. The nervous system.

Remove the roof of the skull and the upper part of the anterior vertebral plate, so as to expose the brain and a portion of the spinal cord, taking care to leave uninjured the eye and ear of the left side.

1. Note—

(a) The gelatinous matter contained in the anterior portion of the cranial cavity.

(b) The arachnoid fluid.

(c) The dura mater lining the cartilaginous walls of the cavity.

(d) The pia mater enveloping the brain and spinal cord.

2. Make a sketch (2 nat. size) of the dorsal surface of the brain, etc., indicating—

(a) The elongated olfactory nerves.

(b) The fused cerebral lobes.

(c) The optic thalami.

(d) The pineal gland (lying on the optic thalami).

(e) The rounded optic lobes.

(f) The elongated cerebellum, its anterior and posterior lobes marked by elevations (gyri) and depressions (sulci).

(g) The medulla oblongata and the convoluted corpora restiformia which form part of the medulla and lie on each side of the cerebellum.

(h) The spinal cord which is divided by fissures into a pair of dorsal and a pair of ventral columns.

(i) The cranial and spinal nerves within the cavity of the skull and vertebral column.

3. Carefully make out the distribution of the cranial nerves :—

I. The large olfactory nerve springing from the cerebral lobe and passing forwards to enter the nasal capsule, where it forms a cylindrical band, from which small branches pass to the transverse folds of the nasal mucous membrane.

II. The optic nerves forming the optic chiasma and passing outwards through the optic foramina to enter the eye-balls.

III. The oculo-motor arising from the crura cerebri and passing outwards and forwards to supply the superior and internal recti muscles of the eye, and then downwards to the inferior rectus and inferior oblique muscles.

IV. The pathetic arising from the anterior region of the cerebellum and supplying the superior oblique muscle of the eye.

- V. The trigeminal arising in conjunction with the 7th and 8th nerves from the medulla and dividing into three branches:—
- (a) The first branch,—orbito-nasal,—consisting of a dorsal division which passes forwards over the muscles of the eye, and a ventral which passes over the external rectus, but under the superior and internal recti and superior oblique, to meet and unite with the dorsal branch—the common trunk then passes to the nasal capsule, within which it divides into two branches, one running transversely over the nasal sac, while the other passes forwards to the rostrum to supply the gelatinous tissue, etc., in the anterior region of the head.
 - (b) The second branch runs forwards external to the orbito-nasal and divides into two branches—(1) the palato-nasal which passes beneath the muscles of the eye to supply the ventral parts of the rostrum, fronto-nasal process, etc.; and (2) the maxillary which supplies the upper jaw, antorbital cartilage, etc.
 - (c) The third branch—mandibular—which runs forwards parallel to the maxillary nerve, and supplies the mandible and part of the upper jaw.
- VI. The abducens leaving the skull, close to the 5th and 7th nerves, to supply the external rectus muscle of the eye.
- VII. The facial, which, after passing through its foramen in the skull, divides into two branches—(a) the palatine nerve, which passes in front of the spiracle to supply the pseudo-branchiæ and mucous membrane of mouth; (b) the hyomandibular, which passes outwards in front of the auditory capsule to be distributed over the hyomandibular cartilage, jaw muscles, etc., and supply small branches (chorda tympani) to the mandible.
- VIII. The auditory entering the anterior part of auditory capsule to send branches to the vestibule and ampullæ.
- IX. The glossopharyngeal passing obliquely through the ventral portion of auditory capsule to be distributed round the first gill cleft (hyoid half-gill and anterior half-gill of first branchial arch.)
- X. The vagus passing backwards close to the auditory capsule and along the anterior vertebral plate to send four branches to the gills of the four posterior gill clefts, and then dividing into a ventral (gastric and cardiac) branch, and a lateral branch which supplies the sensory tubes, etc.
- Make a sketch showing the distribution of the cranial nerves.
4. Examine the spinal nerves; observe that each arises by two roots which pass separately through the wall of the spinal column to unite outside; note that the first 16 nerves of each side unite to form the brachial plexus which gives off branches to the pectoral fin, while the remainder supply the various parts of the body walls, fins, etc.

5. Cut through the spinal cord behind the medulla, and the cranial nerves within the skull; carefully remove the brain with the handle of a scalpel, and examine and sketch the ventral surface, indicating—
 - (a) The cerebral hemispheres.
 - (b) Optic chiasma.
 - (c) Lobi inferiores beneath the optic thalami.
 - (d) Pituitary body (hypophysis cerebri) and infundibulum.
 - (e) The three lobed saccus vasculosus.
 - (f) The crura cerebri and the anterior portion of the medulla oblongata.
 6. Lift up the cerebellum and note the cavity of the 4th ventricle covered by a delicate vascular membrane. Note between the optic thalami, and covered by the pia mater, the cavity of the 3rd ventricle. Cut open the optic lobes and mesencephalon to expose the aqueductus Sylvii connecting the 3rd and 4th ventricles.
 7. Cut across the cerebral hemispheres, and note that there are no lateral ventricles.
- F. Examine the eye of the left side.**
1. Note its external characters, viz. :—
 - (a) Its elongated and depressed form.
 - (b) The absence of eyelids.
 - (c) The cornea forming the front of the eyeball.
 - (d) The pupil.
 - (e) The pigmented iris, with a fringe hanging downwards from its upper margin.
 2. Dissect off the skin and note—
 - (a) The cartilaginous sclerotic covering the posterior two-thirds of the eye and continuous with
 - (b) The transparent cornea covering the anterior portion.
 - (c) The superior oblique muscle attached to the upper anterior portion of the eyeball, and passing to the anterior part of the orbital cavity.
 - (d) The superior rectus muscle attached to the upper posterior portion of the eye.
 - (e) The internal rectus muscle immediately in front of the superior rectus, passing beneath the superior oblique, and attached to the anterior portion of the eye.
 - (f) The external rectus muscle attached to the posterior part of the eye and to the orbital cavity immediately behind the superior rectus.
 - (g) The inferior oblique muscle attached to the lower anterior portion of the eye.
 - (h) The inferior rectus muscle inserted into the lower portion of the eye.
 - (i) The cartilaginous peduncle articulated by its inner end to the skull and by its outer to the eyeball.

Make a sketch of the eyeball with the muscles attached.
 3. Cut open the eye transversely near the junction of the sclerotic and cornea, and note—
 - (a) The aqueous humour between the iris and cornea.
 - (b) The crystalline lens.
 - (c) The black choroid coat lining the interior surface of the sclerotic.
 - (d) The iris continuous with the choroid and the aperture (pupil) in its centre.
 - (e) The vitreous humour filling the posterior chamber of the eye.
 - (f) The retina lying within the choroid and covering the posterior portion of the eye.

Make a sketch showing an ideal section of the eye.

G. Cut open the nasal sac and note the folds formed by the mucous membrane; the folds lie parallel to each other and at right angles to a longitudinal median ridge.

H. Carefully cut away from above, in thin slices, the cartilage of the left auditory capsule, and expose the membranous labyrinth, noting—

- (a) The large rounded vestibule with its two depressions filled with endolymph.
- (b) The aqueductus vestibuli leading upwards from the vestibule to the exterior.
- (c) The anterior and posterior, and the lateral horizontal semicircular canals, and the three ampullæ.
- (d) The large soft otolith lying in the vestibule.

Note the distribution of the VIIIth. nerve to the vestibule and ampullæ.

Make a diagram showing the vestibule, semi-circular canals, and the aqueduct.

I. Circulatory system.

1. Remove the abdominal wall to expose the viscera, slightly stretch the mesenteric membranes, and note—

- (a) The portal vein in the duodeno-hepatic omentum,—observe that it is formed by the gastric, duodenal, intestinal, splenic and pancreatic veins, and that it passes to the middle lobe of liver, giving off branches to the right and left lobes.
- (b) The celiac artery arising from the aorta, on the dorsal side of the cesophagus, and dividing into gastric, hepatic, and duodenal arteries.
- (c) The superior mesenteric artery, arising from the aorta posterior to the celiac, and dividing into intestinal, splenic, and pancreatic arteries.

Mark these arteries by inserting bristles, and then cut out the liver to within half an inch of its anterior end, so as not to injure the hepatic sinus (for description see 10, p. 22), or the alimentary canal.

2. Examine (low and high power) a drop of the blood, noting the large oval nucleated red corpuscles, and the smaller multi-nuclear white corpuscles.

3. Remove the ventral wall of the pericardial chamber in front of the pectoral girdle within the line of the branchial clefts, noting the pericardium and the pericardial fluid and the opening, in the middle line, of the pericardial chamber which leads into the two canals (pericardio-peritoneal) that bring the pericardium into communication with the abdominal cavity.

4. Examine the heart, noting—

- (a) The semicircular sinus venosus.
- (b) The thin-walled auricle.
- (c) The thick muscular ventricle.
- (d) The pylangium (conus arteriosus), extending forwards from the ventricle.
- (e) The synangium (bulbus arteriosus), anterior to the pylangium.

5. Dissect out—

(a) ^{BRANCHIAL} The ventral aorta, passing forwards from the syngangium.

- (b) The right and left posterior innominate arteries, arising from the root of the ventral aorta,—trace them and note that they each divide into three afferent branchial arteries for the lamellae of the three posterior gill clefts.
- (c) The right and left anterior innominate arteries, arising from the anterior end of the ventral aorta,—note that each divides into two afferent branchial arteries for the lamellae of the first and second gill clefts.

Note the red coloured thyroid gland situated at the anterior end of the ventral aorta. Make a sketch of the heart and afferent branchial vessels.

6. Carefully expose the gill chambers, and note the hypo-branchial artery crossing the afferent branchial arteries, internal to the gills. Arising from the hypo-branchial artery are the anterior and posterior coronary arteries.
7. Note that the gill sacs are completely separated from each other by fibrous septa, extending from the outer borders of the arches, and that the septa are supported by cartilaginous rays. Observe that the gill lamellae are attached along their whole length to the septa.
8. Turn the heart forwards and examine the sinus venosus. Insert a bristle or probe into the sinus, and then slit it open. Note that the bristle has passed into the Cuvierian sinus.
9. Carefully cut away the part of the pectoral girdle over the sinus, and examine the venous system, noting the apertures in the Cuvierian sinus of the anterior and posterior cardinal veins, the brachial vein, the hepatic sinus, and on the dorsal side the chief lymphatic trunk.
10. Pass a bristle along the hepatic sinus, and note that the sinus communicates at each end with a Cuvierian sinus, and receives the hepatic veins from the liver.
11. Pass a bristle along the posterior cardinal veins or inflate with a blow-pipe, and note that the right and left communicate with a median (cardinal) sinus near the centre of the abdominal cavity. From this sinus they pass backwards separately to the posterior end of body.
12. Trace the brachial veins along the margin of abdominal cavity, and note the branches joining them from the pectoral fins. Look for the femoral and iliac veins, and observe, that having united, they again separate into an outer branch (epigastric) which joins the brachial, and an inner branch (ileo-haemorrhoidal) which enters the cardinal sinus.
13. Note that the caudal vein from the tail divides into two renal portal veins which break up in the kidneys.

14. Cut away the basi-branchial plate on the floor of the mouth; carefully dissect off the mucous membrane from the roof of the mouth, and examine the efferent branchial arteries.

Observe that the efferent branchial arteries unite to form the dorsal aorta. Note

- (a) That the two branches from the lamellæ of the 1st gill cleft unite with two branches from the lamellæ of the 2nd gill cleft to form the first efferent artery.
 - (b) That the two branches from the 3d gill cleft form the second efferent artery.
 - (c) That the third efferent artery is formed of three branches—two from the 4th and one from the 5th gill cleft.
15. Note—
- (a) The vertebral arteries springing from the 1st pair of efferent arteries and passing through the anterior vertebral plate to the brain and spinal cord.
 - (b) The common carotid arteries arising from the anterior branch of the first efferent arteries just before they emerge from the first gill cleft. Trace them forwards, and note that each gives off a small spiracular artery, and then bifurcates to form
 - (1) An external carotid supplying the jaws, etc.
 - (2) An internal carotid—the right and left internal carotids meet in middle line and pass through a foramen in the floor of the skull to supply the brain, etc.
 - (c) The brachial arteries springing from the aorta in front of the third efferent arteries.
16. Trace the dorsal aorta backwards, and note—
- (a) The origins of the celiac and superior mesenteric arteries.
 - (b) The spermatic arteries supplying the testes (ovarian if a female).
 - (c) The inferior mesenteric artery supplying the rectum and rectal gland.
 - (d) The renal arteries supplying the kidneys.
 - (e) The iliac arteries.
 - (f) The continuation of the aorta along the hæmal canal of the vertebral column as the caudal artery.
17. Slit up the conus arteriosus, and note the three longitudinal rows of valves, each row consisting of five semi-lunar valves, the fifth valve of each row being largest.
18. Carefully remove the heart, including the sinus venosus, from the pericardial chamber, cut open the auricle and ventricle, and note—
- (a) The delicate walls of the auricle.
 - (b) The thick walls of the ventricle and the muscular columnæ carneæ strengthening them.
 - (c) The large aperture between the sinus venosus and the auricle, and the two folds forming the sinu-auricular valve.
 - (d) The two folds forming the valve of the auriculo-ventricular aperture—look for the small cusps in the triangular spaces left between the large folds.

J. The sympathetic nervous system.

1. Note the series of sympathetic ganglia running along each side of the vertebral column (a large ganglion lies close to the inner side of each Cuvierian sinus). Observe that the ganglia are connected by commissures to each other, and to the cerebro-spinal nerves.

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DISSECTION
OF
THE RABBIT.

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THE RABBIT; *Lepus cuniculus*.

A. External characters. Observe—

1. The **head**, consisting of a rounded cranial portion, and an elongated facial portion.
 - (a) The **mouth**, a small transverse aperture on the under surface of the front of the head, bounded by the upper and lower **lips**.
 - (b) The **external nostrils** or anterior nares, a pair of oblique slits at the fore end of the snout, connected with the mouth by a median hairless groove.
 - (c) The **vibrissæ**, long stout hairs on the upper lip.
 - (d) The **eyes**, each protected by an upper and a lower **eyelid**, and by a third eyelid or **nictitating membrane**, formed by a fold of opaque white skin that can be pulled across the eye from its inner corner.
 - (e) The large movable **external ears**, each supported at its base by cartilage.
2. The **trunk**, made up of two portions; the anterior portion or **thorax**, and the posterior portion or **abdomen**.
 - (a) The **anus**, with at each side a hairless patch, the **perinæal space**, on which the ducts of the perinæal glands open.
 - (b) The **urinogenital opening**, in front of the anus; in the male, small and situated at the end of the **penis**, which is loosely covered by a sheath, the **prepuce**; in the female, large and slit-like.
 - (c) In the adult male, the **scrotal sacs**, into which the **testes** descend, two ovoid pouches of skin, one on either side of the root of the penis.
 - (d) In the female, the **teats**, four or five pairs of small projections, the anterior pair being thoracic in position, the remaining three pairs abdominal.
3. The short **tail**.
4. The **limbs**.
 - (1) The **fore-limb**, consisting of—
 - (a) The upper arm or **brachium**, closely applied to the side of the thorax, and enclosed in the skin of the trunk.
 - (b) The fore-arm or **anti-brachium**.
 - (c) The hand or **manus**, provided with five clawed digits, and having its palmar surface covered with hair. The innermost digit, the **pollex**, is the shortest, and does not reach the ground.
 - (2) The **hind-limb**, much longer than the fore-limb, and divided into—
 - (a) The thigh or **femur**, which is inclosed in the skin of the trunk.

- (b) The leg or **crus**.
- (c) The foot or **pes**, which is very long, and provided with four clawed digits—the first digit or **hallux** being absent. Its sole, or plantar surface, is covered with hair.

B. The Abdominal Viscera.

Fix the animal with its ventral surface upwards. Make an incision through the skin over the sternum, and continue it forwards to the mandibular symphysis, and backwards to the pubic symphysis. Dissect carefully the skin from the underlying parts.

Note the **panniculus carnosus**, a thin sheet of muscle covering the whole ventral surface of the trunk and neck; and in the female the **mammary glands** with their ducts passing to the teats.

Open the abdomen by a mesial incision from the posterior end of the sternum to the symphysis pubis. From this make transverse cuts on either side along the margin of the ribs. Pin out the flaps and note the following viscera in position.

- (a) The **liver**, a large dark red body, consisting of several lobes.
- (b) The **stomach**, immediately behind the liver and partly covered by it.
- (c) The **duodenum**, long and narrow.
- (d) The **small intestine**, long, narrow, reddish, and much coiled.
- (e) The **cæcum**, wide, dark in colour, coiled, and marked by a spiral constriction, and ending in the **vermiform appendix**.
- (f) The **colon**, with sacculated walls, lying between the folds of the cæcum.
- (g) The **rectum**.
- (h) The **urinary bladder**, in front of the symphysis pubis.

Observe that the **peritoneum** lines the body cavity, and invests, or extends over, its various contents.

Turn the alimentary tract aside in order to expose the following parts:—

- (i) The **spleen**, an elongated dark red body behind the stomach, and attached to its cardiac end by the gastro-splenic omentum.
- (j) The **kidneys**, lying behind the peritoneum and attached to the dorsal wall of the abdomen, the right one being the more anterior.
- (k) The **adrenal bodies**, small, round, yellowish structures, one near the inner margin of each kidney.
- (l) The **diaphragm**, a muscular partition separating the thorax from the abdomen.
- (m) The **mesentery**, a double fold of peritoneum supporting the alimentary canal.
- (n) The **coeliac ganglia**, situated in the mesentery, opposite the right adrenal body.

C. Dissection of the Alimentary System. Note—

1. The stomach.

Turn the liver forwards and observe the dilated **cardiac** end, and the end of the œsophagus; the narrow **pyloric** end; and the greater and lesser **curvatures**.

2. The **duodenum**, running from the pylorus along the right side of the abdomen posteriorly and returning to form a long U-shaped loop.
3. The **pancreas**, (seen on turning the duodenum over to the left side), consisting of a number of fatty-looking lobules scattered in the mesentery of the duodenal loop.

The **pancreatic duct** receiving smaller ducts, and opening into the ascending limb of the duodenum: an accessory duct opens into the upper end of the duodenum.

4. The **liver**, its convex anterior surface applied to the diaphragm, and attached to it by the suspensory ligament, its concave posterior surface applied to the stomach; its five lobes, viz. :—

- (a) The **left central lobe**, lying against the left half of the diaphragm.
- (b) The **left lateral lobe**, largest in size and partially sub-divided, lying between the left central lobe and the stomach.
- (c) The **right central lobe**, lying against the right half of the diaphragm, and grooved on its posterior surface for the gall-bladder.
- (d) The **caudate lobe**, closely applied to the right kidney.
- (e) The **Spigelian lobe**, smallest in size, and fitting into the lesser curvature of the stomach.

The **gall-bladder**, elongated, thin-walled, dark green or brown in colour, embedded in the right central lobe of the liver.

The **bile-duct**, running from the small end of the gall-bladder to open into the duodenum immediately beyond the pylorus. It receives hepatic ducts from the various lobes of the liver.

5. The **small intestine**, continuous with the duodenum.
6. The **sacculus rotundus**, the dilated end of the small intestine opening into the side of the cæcum.
7. The **cæcum** and **vermiform appendix**.
8. The **colon**, with its rows of sacculations.
9. The **rectum**, terminating in the **anus**.

General structure of the alimentary canal.

1. The **stomach**. Tie a ligature round the œsophagus near its entrance to the stomach, and another round the duodenum an inch beyond the pylorus. Remove the stomach from the body; slit it up along its posterior aspect; wash it, and note—
- (a) The **external serous coat**, bluish-white and glistening.
- (b) The **middle muscular coat**, thickened towards the pylorus.
- (c) The **internal mucous coat**, with prominent rugæ.
- (d) The **pyloric valve**, and the opening of the bile duct.

2. The **small intestine**. Prepare and examine a piece. Note—
 - (a) The **villi**, minute processes of the mucous membrane.
 - (b) **Peyer's patches**, of a honey-combed appearance, occurring at intervals along the whole length of the small intestine on its free margin.
3. The **cæcum**. Remove it from the body; slit it open longitudinally, and note—
 - (1) The internal papillose surface.
 - (2) The prominent spiral fold.
 - (3) The openings of the sacculus rotundus and the colon.
 - (4) The inner surface of the vermiform appendix, similar to a Peyer's patch.
4. The **colon**. Slit it open; note the papillose surface and the sacculations.
5. The **rectum**. Note its smooth mucous lining.

D. The Thoracic Viscera.

Open the thorax by a longitudinal incision on each side of the sternum, and remove the sternum with the attached portions of ribs.

Note the following parts in position—

1. The **thymus gland**, variable in size, in the anterior part of the thorax.
2. The **heart** and **pericardium**.
3. The **lungs**, **trachea**, and **bronchii**, the left lung divided into two lobes, the right into four. Inflate the lungs from the trachea.
4. The **diaphragm**, with its central tendon and its two posterior muscular crura.
5. The **phrenic nerves**, lying between the heart and the lungs, and dividing posteriorly to supply the diaphragm.
6. The **pleuræ**, lining the cavity of the thorax and reflected over the lungs, forming two sacs, one on each side with a space between (the **mediastinum**).
7. The **œsophagus**, running in front of the back bone and piercing the diaphragm.

E. The Circulatory System.

Remove the thymus gland, expose the heart and the roots of the great vessels.

The heart and great vessels. Note —

1. The **heart**, conical in form, with its apex or ventricular portion directed backwards and to the left, and its base or auricular portion forwards.
 - (a) The **left ventricle**, forming the apex and left side of the ventricular portion.
 - (b) The **right ventricle**, forming the right side of the ventricular portion, but not reaching to the apex.

- (c) The **right auricle**, dorsal in position to the base of the right ventricle with an **auricular appendix**.
 - (d) The **left auricle**, anterior to the left ventricle, with an **auricular appendix**.
2. The **great vessels**.
- (a) Vessels opening into the right auricle.
 - (1) The **right superior vena cava**, running along the inner side of the right lung, to open on the dorsal wall of the right auricle.
 - (2) The **left superior vena cava**, running along the inner side of the left lung, to open into the left side of the right auricle.
 - (3) The **inferior vena cava**, piercing the diaphragm and running forwards, a little to the right of the middle line of the body, to open into the posterior end of the right auricle.
 - (b) Vessels arising from the right ventricle.
 - (1) The **pulmonary artery**, arising from the anterior border of the right ventricle and arching over to the dorsal surface of the left auricle, where it divides into **right** and **left pulmonary arteries**.
 - (c) Vessels opening into the left auricle.
 - (1) The **pulmonary veins**, opening on the dorsal surface of the left ventricle.
 - (d) Vessels arising from the left ventricle.
 - (1) The **aorta**, arising from the middle of the base of the heart behind the root of the pulmonary artery, running forwards, then arching over to the left side, and descending at the left side of the vertebral column. The **ductus arteriosus**, an obliterated vessel connecting the aorta with the pulmonary artery.

The veins.

- 1. The system of the **venæ cavæ**.
 - (a) The **right superior vena cava** formed by—
 - (1) The **right subclavian vein**, from the fore-limb and shoulder.
 - (2) The **right external jugular vein**, from the side of the neck, formed by the union of the anterior and posterior facial veins.
 - (3) The **right internal jugular vein**, close to the trachea, joining the external jugular vein at its point of union with the subclavian.
 - (4) The **vena azygos**, lying close to the vertebral column on the right side of the aorta, and passing round the right side of the œsophagus and trachea to join the vena cava close to the auricle. It receives seven or eight pairs of **intercostal veins**.
 - (5) The **anterior phrenic vein**, passing forwards from the diaphragm along the inferior vena cava.

- (6) The **right anterior intercostal vein**, joining the vena cava just in front of the vena azygos.
- (7) The **right internal mammary vein**, from the inner surface of the ventral thoracic wall, joining the vena cava at the level of the first rib.
- (b) The **left anterior vena cava**, differing from the right only in so far as it receives no azygos vein, and has a different course in order to reach the heart.
- (c) The **posterior vena cava**, running forwards through the liver dorsally, to pierce the central tendon of the diaphragm, and open into the right auricle. Note the following veins joining it—
 - (1) The **posterior phrenic veins**, from the diaphragm.
 - (2) The **hepatic veins**, generally four in number, joining the inferior vena cava in the liver substance.
 - (3) The **renal veins**, (one pair), from the kidneys. Each receives a small vein from the adrenal body, and one from the dorsal wall of the abdomen.
 - (4) The **spermatic veins** (ovarian in the female), (one pair), from the testes (or ovaries).
 - (5) The **ilio-lumbar veins**, (one pair), from the hinder part of the abdominal walls.
 - (6) The **external iliac veins**, (one pair), direct continuations of the femoral veins from the thigh.
 - (7) The **internal iliac veins**, (one pair), running through the pelvis from the dorsal aspect of the thighs.
- 2. The **portal system**. Observe the **portal vein** lying close to the posterior vena cava, and dividing to supply the various lobes of the liver. It is formed by the junction of—
 - (1) The **lieno-gastric** from the walls of the stomach and the spleen.
 - (2) The **duodenal**, from the duodenum and the pancreas.
 - (3) The **anterior mesenteric**, carrying blood from the small intestine, cæcum, colon, and rectum.
 - (4) The **posterior mesenteric**, from the rectum.

The **pulmonary system**. (See above, p. 10, 2, (c).)

The **arteries**.

- 1. The **aorta**. Trace this artery along its whole length, noting the following branches—
 - (a) The **innominate artery**, from the arch of the aorta dividing into—
 - (1) The **right subclavian artery**, running on as the **brachial artery** and giving off the **vertebral** and the **internal mammary arteries**.
 - (2) The **right carotid artery**, dividing into the **internal** and the **external carotid arteries**.
 - (b) The **left carotid artery**, dividing into the **left internal** and the **external carotid arteries**.

- (c) The **left subclavian artery**, corresponding in its distribution to the right subclavian artery.
- (d) The **intercostal arteries**, (several pairs of small arteries).
- (e) The **celiac artery**, dividing into the **hepatic** artery and the **lienointestinal** artery.
- (f) The **anterior mesenteric artery**, dividing into numerous branches.
- (g) The **renal arteries**, passing each to the hilum of a kidney.
- (h) The **spermatic or ovarian arteries**.
- (i) The **posterior mesenteric artery**.
- (j) The **lumbar arteries**.
- (k) The **median sacral artery**.
- (l) The **common iliac arteries**, formed by the bifurcation of the aorta, running to the hind limbs as the **femoral** arteries. Each gives off in the abdomen—
 - (1) The **ilio-lumbar artery**.
 - (2) The **internal iliac artery**, and
 - (3) The **vesical artery**.

The **pulmonary artery**. (See above, p. 10, 2, (b).)

F. Dissection of the Heart.

Remove the heart from the body by cutting through the great vessels about half an inch from the heart.

1. The **auricles**. Expose the cavities of both auricles by cutting away their outer walls.

- (1) The **right auricle**. Note the thin wall, thicker in the appendix, and marked by muscular ridges ; note also—
 - (a) The openings of the three **venæ cavæ**.
 - (b) The **Eustachian valve** between the openings of the left superior vena cava and the inferior vena cava.
 - (c) The **septum auricularum** with the **fossa ovalis**.
 - (d) The **right auriculo-ventricular** opening.
- (2) The **left auricle**. Note the thin wall, thicker in the appendix.
 - (a) The openings of the **pulmonary veins**.
 - (b) The **left auriculo-ventricular** opening.
 - (c) The **coronary sinus** (the dilated portion of the coronary vein), embedded in the posterior wall of the left auricle.

2. The ventricles.

Make a transverse section of the ventricles, about one third of an inch from the apex. Note the shape of the cavities of the ventricles and the relative thickness of their walls.

- (1) The **right ventricle**. Remove its outer wall, and note—
 - (a) The **tricuspid valve** of the right auriculo-ventricular opening, formed of three membranous flaps attached to its margin ; the **chordæ tendineæ** passing from these flaps to the muscular processes of the walls of the ventricle.

- (b) The opening into the **pulmonary artery**, guarded by three semi-lunar cusps.
- (2) The **left ventricle**. Remove its outer wall, and note—
 - (a) The **mitral valve** (bicuspid) of the left auriculo-ventricular opening, corresponding in structure to the tricuspid valve, but with larger muscoli papillares.
 - (b) The muscular ridges of the wall of the ventricle (**columnæ carneæ**).
 - (c) The opening into the **aorta** guarded by three semilunar valves.
[Note also the opening of the **coronary arteries**.]

G. Dissection of the Urinary and Reproductive Systems.

The **male** rabbit.

1. The **urinary system**. Examine one of the kidneys, noting (1) its ovoid shape ; (2) the hilum, or point of entrance of the vessels and ureter. Make a longitudinal section, and note—
 - (a) The **cortical substance** forming the outer layer.
 - (b) The **medullary substance**.
 - (c) The **pyramids**, conical papillæ.
 - (d) The **pelvis**, or expanded anterior end of the ureter.

Trace the ureter from the kidney to the bladder. Note the general form and the thin wall of the bladder.

2. The **reproductive system**. Open the **scrotal sacs** along their ventral surface. Note—
 - (a) The **testes**, with the **spermatic veins** and **arteries** entering at their anterior ends.
 - (b) The **epididymes**, masses of convoluted tubes lying along the inner border of the testes.
 - (c) The **vasa deferentia**, a pair of whitish tubes extending from the epididymes, to enter the abdominal cavity where, after looping round the ureters, they reach the neck of the bladder.

Inflate the bladder and the urino-genital canal, from the urethra : remove the symphysis pubis by cutting through the bones about a quarter of an inch from the middle line : detach the two **crura penis** from the ischia, and make out the following structures—

- (a) The **urino-genital canal**, the continuation posteriorly of the neck of the bladder.
- (b) The **penis**, with the **corpora cavernosa** dorsally, and the **corpus spongiosum** ventrally pierced by the urethra.
- (c) The **uterus masculinus**, a somewhat bi-lobed median sac projecting from the dorsal surface of the urino-genital canal.
- (d) The **openings of the vasa deferentia**, on the ventral wall of the uterus masculinus.
- (e) The **prostate**, a glandular body connected with the neck of the bladder and the uterus masculinus.

- (f) **Cowper's glands**, a pair of brown ovoid masses immediately behind the prostate.
- (g) The **rectal glands**, a pair of brown bodies about an inch long, situated on either side of the rectum.
- (h) The **perinæal glands**, similar in appearance to the rectal glands but shorter, situated on either side of the penis. Trace their **ducts** to their openings on the perinæal spaces.

Slit up the urethra, and continue the incision along the wall of the bladder in the middle line. Note—

- (a) The **openings of the ureters**, on the dorsal wall of the bladder.
- (b) The **verumontanum**, a small papilla on the dorsal wall of the urethra immediately beyond the neck of the bladder.
- (c) The **opening of the uterus masculinus**, on the dorsal wall of the urethra anteriorly to the verumontanum.
- (d) The **openings of the prostatic ducts**, usually four in number, at the sides of the verumontanum.

The **female rabbit**.

1. The **urinary system**—as in the male, except for the position of the openings of the ureters into the bladder.
2. The **reproductive system**. Inflate the bladder and vagina from the urino-genital opening, and remove the pubic symphysis by cutting through the bones about a quarter of an inch from the middle line.

Note—

- (a) The **clitoris**, corresponding in position and structure to the penis of the male.
- (b) The **vestibule**, or **urino-genital canal**.
- (c) The **vagina**, running from the neck of the bladder upwards.
- (d) The two **uteri**, opening separately into the vagina.
- (e) The **Fallopian tubes**, continuous with the uteri, and suspended by folds of peritoneum—the **broad ligaments**: the fimbriated ends of the Fallopian tubes lying near the ovaries.
- (f) The **ovaries**, a pair of ovoid bodies attached to the dorsal wall of the abdomen: the **Graafian follicles**, small projections on the surfaces of the ovaries.
- (g) **Cowper's glands**, on the dorsal wall of the vestibule.
- (h) The **perineal and rectal glands**, similar to those in the male.

H. Dissection of the Head and Neck.

(The following dissection is made chiefly on account of its physiological importance.)

1. Lay the skin well back on both sides of the neck, and observe the following **muscles**—
 - (a) The **platysma**, a very thin superficial muscle: cut through this longitudinally in the middle line.
 - (b) The **sterno-mastoid**, near the middle line, running from the sternum

forwards and outwards, crossing below the jugular vein, to the mastoid process of the skull.

- (c) The **sterno-hyoid**, nearer the middle line, running from the sternum to be attached to the inner third of the cornu majus of the hyoid bone.
 - (d) The **sterno-thyroid**, below, and external to, the sterno-hyoid, running from the sternum to the lower border of the thyroid cartilage of the larynx.
 - (e) The **thyro-hyoid**, running from the thyroid cartilage to the hyoid bone.
 - (f) The **stylo-hyoid**, running from the tip of the cornu majus of the hyoid to the styloid process.
 - (g) The mandibular muscles.
2. On the right side, carefully raise up the sterno-mastoid muscle along its inner aspect, and fix the muscle in position with a hook, and observe the following **nerves**—
- (a) The **pneumogastric (vagus)**, a stout cord running parallel to the carotid artery. Trace this nerve to its point of emergence. Note that it gives off—
 - (1) The **superior laryngeal**, which crosses the carotid artery on its dorsal aspect, and goes to the larynx. Very soon after leaving the pneumogastric it gives off **superior cardiac (cardiac depressor)**. Trace this nerve down the neck, lying alongside the sympathetic, in the connective tissue of the sheath of the common carotid artery.
 - (2) The **inferior laryngeal (recurrent laryngeal)**, which passes round the subclavian artery. (On the left side it passes round the innominate artery.)
 - (3) Branches to the heart, lungs, and œsophagus.
 - (b) The **hypoglossal**, seen running parallel to the cornu majus of the hyoid bone, and passing under the stylo-hyoid muscle and over the carotid artery. Trace it forwards to the tongue and backwards to the skull. Note that just before crossing the point of bifurcation of the carotid it gives off the **ramus descendens noni**, which crosses the carotid on its ventral aspect a little way down.
 - (c) The **sympathetic**, already seen in connection with the superior cardiac. Trace it downwards to the **inferior cervical ganglion**, a little above the junction of the jugular vein with the superior vena cava.
 - (d) The **phrenic**, already seen between the heart and the lung. (See above, D. 5.) Trace it forwards to its origin from the fourth cervical nerve. [It receives a branch also from the fifth and sometimes from the sixth.]
 - (e) The **spinal accessory**, a small nerve emerging from the skull with the pneumogastric and the glosso-pharyngeal. (Seen on breaking away the tympanic bulla.)

- (f) The **great auricular**, arising from the third cervical nerve, and running from the under surface of the sterno-mastoid muscle to the ear, where it divides into two branches.
3. The **trachea**. Clear away the muscles connected to it and raise it up. Note its rings of cartilage, incomplete on their dorsal aspect; the **larynx**, at its upper extremity; and its bifurcation to form two **bronchi** posteriorly. Trace the bronchi to the lungs.
 4. The **thyroid gland**, made up of an elongated lobe on each side of the trachea below the larynx, connected by the **isthmus** which lies in contact with the trachea.
 5. The **larynx**, at the upper extremity of the trachea. Observe the following parts connected with it :—
 - (a) The **epiglottis**, at the root of the tongue, forming a covering for the glottis.
 - (b) The large **thyroid** cartilage.
 - (c) The **cricoid** cartilage.
Make a longitudinal section in the middle line, and in the interior of the larynx note—
 - (d) The **arytenoid** cartilages, mounted on the posterior portion of the cricoid.
 - (e) The **true vocal cords**, stretching from the arytenoid cartilages to be inserted on the inner aspect of the thyroid cartilage.
 - (f) The **false vocal cords**, above, and parallel to, the true vocal cords.
 - (g) The **ventricles** of the larynx, shallow pockets between these.
 - (h) The **glottis**, the opening between the vocal cords.
 6. Cut through the symphysis of the lower jaw, and remove the left half of the jaw from its articulation with the skull. Dissect out the paired **salivary glands**. Note—
 - (a) The **parotid**, a large gland, underneath, and in front of, the outer ear: trace its **duct (Stenson's)** from the anterior part of the gland to its opening in the cheek near the second upper premolar tooth.
 - (b) The **sub-maxillary**, a more compact gland, near the angle of the jaw and internal to the parotid. Trace its **duct (Wharton's)** from the posterior portion of the gland to its opening on the floor of the mouth between the lower incisors and the root of the tongue.
 - (c) The **sub-lingual**, an elongated gland, lying along the inner border of the ramus of the jaw. It has many **ducts** opening singly.
 - (d) The **infra-orbital gland**, found just above the zygoma. Trace it downwards underneath the zygomatic arch, and observe its **duct** opening far back in the mouth.
 7. Examine the **buccal cavity**, and note—
 - (a) The **roof of the mouth**, formed of the transversely corrugated hard palate and the smooth **soft palate**. Observe the **teeth** (to be afterwards studied); the **naso-palatine canals**, two small apertures behind the second incisor teeth; and the **tonsils**, near the termination of the soft palate.

- (b) The **floor of the mouth**. Observe the **tongue**, attached to the floor of the mouth, with the **papillæ foliatæ**, a pair of oval patches opposite the last molar teeth, and the **circumvallate papillæ**, a pair of small white papillæ, a little above and behind the papillæ foliatæ. Note also the **teeth**, and the inner aspects of the **cheeks**, smooth except for a hairy patch on each.
- (c) The **pharynx**, the posterior portion of the buccal cavity communicating with the mouth, nasal chamber, œsophagus, and glottis. Remove the soft palate, and observe on the inner aspect of a bony process of the skull, in the position of the back of the soft palate, the paired valve-like **openings of the Eustachian tubes**.

I. The Skeleton of the Rabbit.

The vertebral column.

Note the following regions, each distinguished by certain peculiarities in the vertebræ (1) **cervical**, or neck region; (2) **thoracic**, or chest region; (3) **lumbar**, or loin region; (4) **sacral** region; and (5) **caudal**, or tail region.

Examine a typical vertebra, say the third lumbar, and note—

- (a) The **body** or centrum, the epiphysial plates and inter-vertebral discs, and on its ventral aspect a descending process (**hypapophysis**).
 - (b) The **neural arch**, composed of two halves springing from the back of the centrum, each made up of an anterior part or **pedicle**, and a posterior part or **lamina**.
 - (c) The **processes** springing from the arch.
 - (1) The **spinous process**, projecting backwards from the junction of the two laminæ.
 - (2) The **transverse processes**, projecting outwards, one on each side of the arch.
 - (3) The **articular processes**, projecting two anteriorly and two posteriorly from the junction of the pedicle with the lamina.
 - (4) The **accessory processes**, one on each side of the hinder end of the neural arch.
 - (d) The **notches**, situated one on the upper, the other on the lower border of each pedicle, and forming, when the vertebræ are joined, the **intervertebral foramina**.
1. The **cervical vertebræ**.
- (a) Examine the seven vertebræ of the neck, noting the following **common characters**—
 - (1) The shortness of the centra.
 - (2) The small size of their spinous processes.
 - (3) The perforated transverse processes.
 - (b) Examine the **first vertebra** or **atlas**, noting—

- (1) The absence of a centrum.
 - (2) The large canal divided into two parts by a transverse ligament.
 - (3) The broad horizontal transverse processes.
 - (4) The anterior articular facets deeply concave for articulating with the condyles of the skull.
- (c) Examine the **second vertebrae** or **axis**, and note—
- (1) The centrum bearing the odontoid process (body of first vertebra).
 - (2) The spinous process, large and bifid.
 - (3) The small transverse processes.
- (d) Examine the five remaining cervical vertebrae, noting—
- (1) The form of the centra, and the facets upon the posterior end of the centrum of the seventh vertebra for the heads of the first pair of ribs.
 - (2) The small spinous processes, except in the seventh vertebra.
 - (3) The broad inferior lamellæ of the transverse processes, except in the seventh.
2. The **thoracic vertebrae**.
- (a) Examine the vertebrae of the thoracic region, twelve, sometimes thirteen, in number, and note—
- (1) The long slender spinous processes.
 - (2) On the centra, anteriorly and posteriorly, except in the case of last three or four vertebrae, the facets for the heads of the ribs.
 - (3) The transverse processes, with articular facets on their under surfaces for the tubercles of the ribs, except in the last three or four vertebrae.
 - (4) The hypapophyses, beginning at the ninth thoracic vertebra, and increasing in size from the vertebra backwards.
 - (5) The notches, forming the foramina for the spinal nerves.
3. The **lumbar vertebrae**, usually seven in number. (See above, **I**.)
- Note in addition—
- (a) Their large size relative to the other vertebrae.
 - (b) The strongly developed processes, especially the transverse processes.
 - (c) The short stout centrum of the last vertebra.
4. The **sacral vertebrae**. Note—
- (a) That these are four in number, and are fused.
 - (b) That only the first of these directly supports the pelvis by its large broad expansion.
5. The **caudal vertebrae**. Note—
- (a) These are about sixteen in number.
 - (b) Their processes and arches become reduced posteriorly till the last vertebrae are represented only by centra.

The ribs and sternum.

1. The **Ribs**. (a) Examine a **typical rib** (4th or 5th), noting—
 - (1) The bony **vertebral** portion, curved above, nearly straight below; the **head** of the rib articulating with a facet formed by the centra of two adjacent vertebræ; the **tubercle** articulating with the transverse process of the vertebra; and beyond the tubercle, a small projection for the attachment of ligaments.
 - (2) The cartilaginous **sternal** portion, connecting the vertebral rib with the sternum.
 - (b) The ribs in general. Note the gradual increase in the length of the ribs from the first to the sixth, and beyond the sixth the gradual shortening: beyond the ninth rib the want of tubercles, and the facets for the head of the ribs confined to one centrum: the sternal portions of the seven first ribs reaching the sternum, those of the eighth and ninth connected with the ribs in front of them: the remainder being **floating ribs**.
 2. The **sternum**. Observe that it is constituted of the following parts.
 - (a) The **manubrium** or anterior portion, keeled on its ventral aspect.
 - (b) The **xiphisternum**, or posterior portion, long and slender, ending behind in a plate of cartilage.
 - (c) Between these, four long portions and one short.
- Note the position of the **facets** for the articulation of the ribs, the first on the manubrium, the others between the several sternæ.

K. The Skull.

The **cranium** proper. For the purposes of study, the cranium may be regarded as composed of certain segments, viz. :—

- (a) The **occipital segment**. Note—
 - (1) The **basi-occipital**, forming the floor of the hinder end of the cranial cavity, and bounding the foramen magnum in front.
 - (2) The **ex-occipitals**, bounding the foramen magnum laterally, and forming the greater part of the condyles. Note, at the outer side of each, the long backwardly directed par-occipital process or paramastoid, closely applied to the tympanic bulla.
 - (3) The **supra-occipital**, a large median bone, bounding the foramen magnum posteriorly.
- (b) The **parietal segment**. Note—
 - (1) The **basi-sphenoid**, directly in front of the basi-occipital, having on its dorsal surface the **sella turcica** for the lodgement of the pituitary body.
 - (2) The **ali-sphenoids**, a pair of wing-like bones fused to the sides of the basi-sphenoid, and forming part of the floor of the cranial cavity. From the ventral surface of each there

projects downwards a vertical plate of bone, the **external pterygoid process**, connected along its inner edge with the palatine bone.

- (3) The **parietals**, meeting at the sagittal suture, and forming a large part of the roof of the cranial cavity.

(The **inter-parietal**, a small irregularly lozenge-shaped bone, lies between the parietals and the supra-occipital.)

(c) The **frontal segment**. Note—

- (1) The **pre-sphenoid**, a small laterally compressed bone, in front of the basi-sphenoid, forming the lower margin of the optic foramen, from which it extends backwards to form the anterior boundary of the sella turcica, and forwards to form two thin vertical blades, diverging from each other to form part of the inner wall of the orbit.
- (2) The **orbito-sphenoids**, a pair of plate-like bones, fused with the pre-sphenoid, and surrounding the optic foramen, behind which they form part of the wall of the cranium and of the orbits.
- (3) The **frontals**, forming the roof and sides of the anterior part of the cranial cavity, and the upper part of the wall of the orbit, each bearing a prominent supra-orbital process, and articulating with each other in the middle line, with the parietal behind, and with the orbito-sphenoid and pre-sphenoid below.

(d) The **nasal or olfactory segment**. Note—

- (1) The **mesethmoid**, a median vertical plate of cartilage, extending downwards and forwards in front of the pre-sphenoid, having its upper and posterior border ossified and expanded horizontally to form the perforated **cribriform plate**.
- (2) The **nasals**, a pair of elongated bones forming the roof of the nasal cavities, articulating with each other in the middle line, and with the frontals posteriorly.
- (3) The **ethmo-turbinals**, intricately folded plates of bone, fused to the lower surface of the cribriform plate.
- (4) The **maxillo-turbinals**, more delicate and more complex bones attached to the maxillæ in front of the ethmo-turbinals.
- (5) The **naso-turbinals**, thin bones forming pouches and fused with the inner surfaces of the nasal bones.
- (6) The **vomers**, a pair of slender plate-like bones fused along their ventral margins, and embracing the lower edge of the mes-ethmoid cartilage, and connected posteriorly with the ethmo-turbinals.

Note the **lacrymals**, small plate-like bones, indirectly connected with the nasal capsules. They form part of the anterior walls of the orbits, and articulate with the frontals and maxillæ.

The **auditory capsules**. Note—

- (a) The **periotics**, irregularly shaped bones in the side wall of the cranium, between the squamosals and the occipital segment, each consisting of a dense **petrous** portion, and a cancellated **mastoid** portion with a downwardly directed **mastoid process**.
- (b) The **tympanics**, in each of which may be recognised a tubular upper portion (the neck or external auditory meatus), and an expanded lower portion (the bulla).
- (c) The **auditory ossicles**, seen on breaking away the outer wall of the tympanic bone. Observe—
 - (1) The **malleus**, with its long process (the **manubrium**) attached to the **tympanic membrane**.
 - (2) The **incus**, articulating with the malleus, and giving off two processes, the long and short **crura**.
 - (3) The **os orbiculare**, a small disc of bone attached to the long crus of the incus.
 - (4) The **stapes**, a stirrup-shaped bone articulating with the os orbiculare, and having its base inserted into the **fenestra ovalis**.

Connected with the auditory capsules are the **squamosals**, a pair of bony plates in the cranial wall below the parietals, articulating with the periotics, orbito sphenoids, and ali-sphenoids. Each sends forwards and outwards a stout zygomatic process to articulate with the jugal bone.

Bones in connection with the **Jaws**.

(a) The **upper jaw**.

- (1) The **maxillæ**, a pair of large irregular bones, in each of which the following parts may be distinguished: the body or **alveolar portion**, extending backwards into the front part of the orbit, and inwards to form the **transverse palatal process** (part of the hard palate); the **zygomatic process**, prolonged upwards into the **orbital process**, which forms the anterior boundary of the orbit; the **fenestrated facial plate**, forming the lateral boundary of the olfactory chamber.
- (2) The **pre-maxillæ**, a pair of bones forming the anterior part of the upper jaw, articulating with each other in front and with the maxillæ behind, and each sending a long, slender **nasal process** backwards between the nasal bone and the maxilla as far as the anterior process of the frontal.
- (3) The **pterygoids**, a pair of narrow vertical plates of bone attached to the skull at the junction of the alisphenoids with the basi-sphenoid.
- (4) The **palatines**, a pair of nearly vertical plates of bone, articu-

lating with the pre-sphenoid above, the pterygoids and alisphenoids behind, and with the maxillæ in front.

- (5) The **jugals**, a pair of laterally compressed bones. Each jugal articulates with the squamosal, and forms the greater part of the zygomatic arch, and anteriorly fuses with the zygomatic process of the maxilla.

(b.) The **lower jaw**.

- (a) The **mandible**, consisting of a pair of bones, each made up of a stout horizontal portion bearing the teeth, and a thinner posterior portion, the **angle**, from which the ascending ramus takes rise and ends in the elongated **condyle**, which articulates with the under surface of the zygomatic process of the squamosal.

- (b) The **hyoid** bone, consisting of a median portion or **body**, and two pairs of **cornua** projecting backwards.

The Appendicular Skeleton.

The pectoral girdle.

1. Remove the **scapula** from its muscular connections, and note—
 - (a) Its triangular form, the apex directed downwards and forwards, and providing the **glenoid cavity** for the head of the humerus.
 - (b) The **spine**, running along the outer surface, and ending in the **acromion process**, which bears on its posterior surface the long **metacromion process**.
 - (c) The **coracoid process**, overhanging the glenoid cavity.
2. The **clavicle**. Note its small size, its slender form, and its position in the ligament that runs from the scapula to the sternum.

The fore limb.

Remove the muscles from the fore limb, and examine the following parts:—

1. The **humerus**, an elongated bone, forming the skeleton of the upper arm, its **head** articulating with the glenoid cavity of the scapula, its **trochlear end** with the **supra-trochlear fossa** in front, which communicates by the **supra-trochlear foramen**, with the **olecranon fossa** behind.
2. The bones of the **fore-arm**.
 - (a) The **radius**, an elongated, slightly curved bone, lying in front of the ulna at the elbow joint, but along its inner side at the wrist, articulating at the elbow with the grooves of the trochlea of the humerus, and with the anterior surface of the ulna, and at the wrist with the carpal bones.
 - (b) The **ulna**, an elongated bone articulating at the elbow with the humerus by the sigmoid notch on its enlarged end, and with the radius by two small surfaces, and at the wrist by its small end with the carpal bones. Note, behind the elbow joint, the **olecranon process** of the ulna.
3. The **wrist**, composed of two rows of carpal bones.
 - (a) The **proximal row**, consisting of (1) the **scaphoid** (radiale) on the

- inner side, articulating with the radius; (2) the **semilunar** (intermedium), articulating with the radius; (3) the **cuneiform** (ulnare), on the outer side, articulating with the ulna.
- (b) The **distal row**, consisting of (1) the **trapezium**, on the inner side articulating with the scaphoid, and supporting the first metacarpal; (2) the **trapezoid**, articulating with the scaphoid and the centrale (see c), and supporting the second metacarpal; (3) the **os magnum**, a very small bone articulating with the semilunar and centrale, and supporting the third metacarpal; (4) the **unciform** (fourth and fifth distal carpals fused), articulating with the cuneiform, and supporting the fourth and fifth metacarpals.
 - (c) The **central bone** (centrale) between the semilunar and scaphoid, and appearing to belong to the distal row of carpals.
 - (d) The **pisiform**, a sesamoid bone on the posterior surface of the wrist, articulating with the ulna and the cuneiform.
4. The **hand**, with **five digits**, each composed of a **metacarpal** bone and three **phalanges**, except the thumb (pollex, which has only two), the last phalanx being modified to support a claw. Note several **sesamoid bones** developed in the tendons of the flexor muscles.

The **pelvic girdle**.

Remove each **os innominatum** from its muscular attachments and examine the following parts:—

- (a) The **ilium**, expanded anteriorly, narrowed posteriorly, articulating with the sacrum by a roughened crescentic surface on its sacral margin, and forming posteriorly about half the wall of the **acetabulum**.
- (b) The **ischium**, forming the posterior and dorsal part of the os innominatum, having its posterior part thickened to form the **ischial tuberosity**, and forming anteriorly about one-third of the wall of the acetabulum.
- (c) The **pubes**, the smallest bone of the three, meeting its fellow of the opposite side in the **symphysis pubis**, and sending a **ramus** backwards to meet the ramus of the ischium, and enclose the **obturator foramen**.

The **hind limb**.

Remove the muscles from the hind limb and study the following parts:—

1. The **femur**, an elongated bone, forming the skeleton of the thigh; its **head** articulating with the acetabulum, its lower end bearing two large **condyles** separated from each other by the **intercondylar notch**. Note, on the outer side of the head, the large rough **great trochanter**; on the inner side of the bone just below the head, the **lesser trochanter**; and opposite to this on the outer side, the **third trochanter**. Examine the knee-pan (**patella**), a large sesamoid bone sliding in the groove on the lower end of the femur: and also small sesamoid bones (**fabellæ**) at the back of the knee-joint.

2. The bones of the **leg**, unequal in size and fused together at their distal ends.
 - (a) The **tibia**, a stout straight bone, articulating at its upper end with the femur by two facets, at its lower end with the astragalus.
 - (b) The **fibula**, a slender bone, articulating at its upper free end with the outer surface of the head of the tibia, at its fixed lower end with the calcaneum.
3. The **ankle**, composed of two rows of tarsal bones.
 - (a) The **proximal row**, consisting of (1) the **astragalus**, on the inner side, articulating with the tibia; (2) the **calcaneum** (os calcis), on the outer side of the astragalus, articulating with the fibula and having its hinder end produced into a large **calcaneal process** or heel.
 - (b) The **distal row**, consisting of (1) the **meso-cuneiform**, a very small bone articulating with the navicular, (see c), and supporting the second metatarsal bone; (2) the **ecto-cuneiform**, on the outer side of the meso-cuneiform, articulating with the navicular and supporting the third metatarsal bone; (3) the **cuboid**, on the outer side, articulating with the calcaneum and navicular, and supporting the fourth and fifth metatarsal bones.
 - (c) The **central bone** (navicular) immediately in front of the astragalus, articulating with the second metatarsal, and sending a large **process** forwards along the ventral surface of the foot.
4. The **foot** with **four digits**, each composed of a long **metatarsal** bone, and three **phalanges**, the last phalanx being modified to support a claw. Note, on the outer side of the proximal end of the second metatarsal bone, a backwardly directed process, probably representing the metatarsal bone of the first (or lost) digit.

K. General Dissection of the Brain.

Remove the muscles of the neck from their attachment to the occipital part of the skull: remove the skin from the whole of the cranial portion: and with bone forceps and a stout blunt scalpel remove in pieces the bones of the skull and expose the surface of the brain, working from the foramen magnum forwards and taking special care not to injure the brain in the region of the ear bones. Cut through the spinal cord behind the medulla; and by help of the handle of a scalpel, moistened with water, lift up the brain, cutting through the various cranial nerves as far from the brain as possible.

1. Observe the **dura mater** covering the brain and dipping down between the cerebral hemispheres, forming the **falx cerebri**; and between the cerebrum and cerebellum, forming the **tentorium**. Remove the dura mater, and note the thin vascular **pia mater** closely enveloping the brain.
2. On the **dorsal aspect of the brain** note—
 - (a) The large smooth **cerebral hemispheres**.

- (b) The club-shaped **olfactory lobes**, projecting forwards from the cerebral hemispheres.
 - (c) The **corpora quadrigemina**, (**optic lobes**), only partly seen below the cerebral hemispheres posteriorly.
 - (d) The **pineal body**, above the corpora quadrigemina, and immediately posterior to the cerebral hemispheres.
 - (e) The **cerebellum**, large and tri-lobed. Turn back the anterior portion of the cerebellum in order to expose the corpora quadrigemina and the **valve of Vieussens**, a thin layer of nervous tissue stretching between the corpora quadrigemina and the cerebellum, and forming the roof of the anterior portion of the fourth ventricle. Note the **pathetic** (4th cranial) nerve arising from the dorsal surface of the valve of Vieussens near the middle line and looping round the brain towards the ventral surface. Note the **floccular lobes** at the outer aspect of the lateral lobes.
 - (f) The **medulla oblongata**, seen on turning forwards the cerebellum.
Note—
 - (1) The **choroid plexus** (**tele vasculose**) of the fourth ventricle, a portion of the pia mater covering the roof of the ventricle.
 - (2) The **dorsal pyramids**, on either side of the dorsal fissure of the spinal cord.
 - (3) The **restiform bodies**, external to the dorsal pyramids.
 - (4) The **fourth ventricle**, its posterior portion seen on removing the choroid plexus.
3. On the **ventral aspect of the brain** observe—
- (a) The **olfactory lobes**.
 - (b) The **cerebral hemispheres**, divided by a ventral longitudinal groove into a larger superior, and a smaller inferior, lobe. A slight depression on the ventral aspect of the superior lobe represents the **fissure of Sylvius**.
 - (c) The **optic tracts**, **optic commissure**, and **optic nerves**. Trace the optic tracts backwards towards the corpora quadrigemina.
 - (d) The **infundibulum**, a funnel-shaped projection to which the pituitary body is attached.
 - (e) The **corpus albicans** (**corpus mammillare**), a rounded mass immediately behind the infundibulum.
 - (f) The **crura cerebri**, or peduncles of the cerebrum, two broad bands diverging from the middle line posteriorly in front of the pons Varolii. Note the origin of the **oculo-motor** nerve (3rd cranial) from the ventral surfaces of the crura.
 - (g) The **pons Varolii**, two strong bands of transverse fibres running from the middle line outwards to the two halves of the cerebellum. Note the **trigeminal** (5th cranial) nerve arising by two roots from the outer posterior margin of the pons.

- (h) The **medulla oblongata**, broad anteriorly, but narrower posteriorly.

Note—

- (1) The **ventral pyramids**, on either side of the ventral fissure of the spinal cord.
 - (2) The **olivary bodies**, one on each side, external to the ventral pyramids.
 - (3) The **trapezoid bodies**, bands of transverse fibres, each at the external side of the ventral pyramids anteriorly. Note the **abducent** nerve (6th cranial), arising from the medulla close to the middle line, and just behind the pons Varolii; the **facial** (7th cranial), from the outer side of the corpus trapezoideum anteriorly; the **auditory** (8th cranial), immediately behind this; the **glosso-pharyngeal** and **pneumogastric** (9th and 10th cranial), from the side of the medulla by many small roots; the **spinal accessory** (11th cranial), behind this, arising by about ten small roots; and the **hypoglossal** (12th cranial) from near the middle line by several small roots.
4. The **cavities of the brain**, and **structures connected with them**. Make a longitudinal vertical section of the brain in the middle line, and observe—
- (a) The **corpus callosum** connecting the two cerebral hemispheres in the middle line.
 - (b) The **fornix** below the corpus callosum, continuous with the corpus callosum posteriorly, but separated from it anteriorly by the cavity of the "**fifth**" **ventricle**.
 - (c) The **third ventricle**, bounded above and in front by the **velum interpositum**. In connection with this ventricle note—
 - (1) The **anterior commissure**, a small transverse band of fibres in its anterior wall in front of the fornix.
 - (2) The **middle commissure**, a very thick band extending across the middle of the ventricle, and connecting the two **optic thalami**.
 - (3) The **posterior commissure**, a small transverse band of fibres in the posterior wall of the ventricle, immediately in front of the corpora quadrigemina.
 - (4) The **foramen of Monro**, which brings the anterior part of the ventricle into communication with the **lateral ventricles**. Remove horizontal slices of one cerebral hemisphere to expose the lateral ventricle, and observe the **grey** (cortical) **matter**, the **white** (medullary) **matter** of the hemisphere, and at a deeper level the **corpus striatum**.
 - (5) The **stalk of the pineal body**, an upward continuation of the third ventricle.

- (6) The **infundibulum**, the downward continuation of the third ventricle.
- (7) The **corpus albicans**, posterior to the infundibulum.
- (d) The **corpora quadrigemina**, now fully exposed.
- (e) The **pons Varolii**.
- (f) The **fourth ventricle**, its posterior triangular portion or **calamus scriptorius**, and the **aqueduct of Sylvius** (or **iter**) underneath the corpora quadrigemina, connecting its anterior extremity with the third ventricle.
- (g) The **roof of the fourth ventricle**, and the **cerebellum**. Make a longitudinal section of the cerebellum, and observe its arborescent structure.