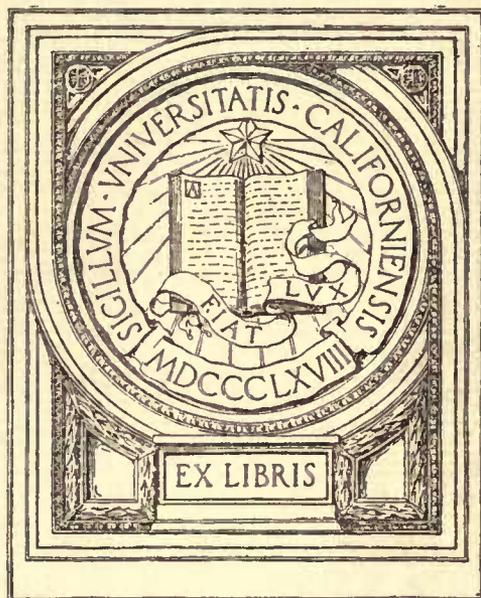


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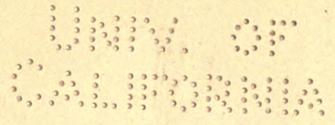


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A NOTE BOOK



FOR

# PRACTICAL BIOLOGY

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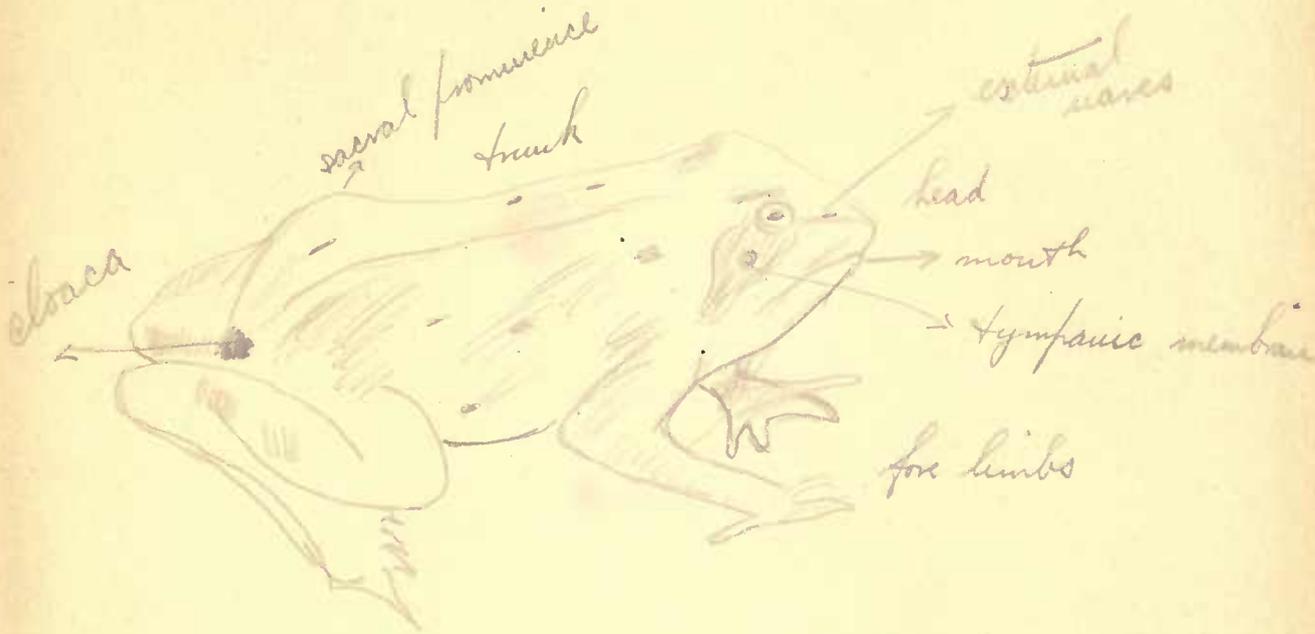
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1. Lateral view of the Frog: *head*; *trunk*; *fore-limbs*; *hind-limbs*; *sacral prominence*; *mouth*; *external nares*; *eye*; *tympanic membrane*; *cloaca*; bristle passed through the *tympanic membrane* and traced into the mouth by the Eustachian tube; bristle passed into the *external nares* and traced into the mouth by the internal nostril.

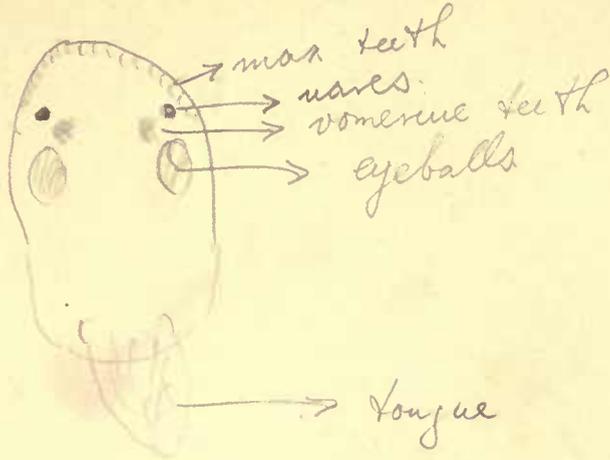


2. Enlarged drawings of the palmar surface of the fore-foot, or *manus*, with four digits (numbered 2-5), the præaxial (internal) digit with pad in the male; and of the plantar surface of the hind-foot, or *pes*, with five digits (numbered), webbed.

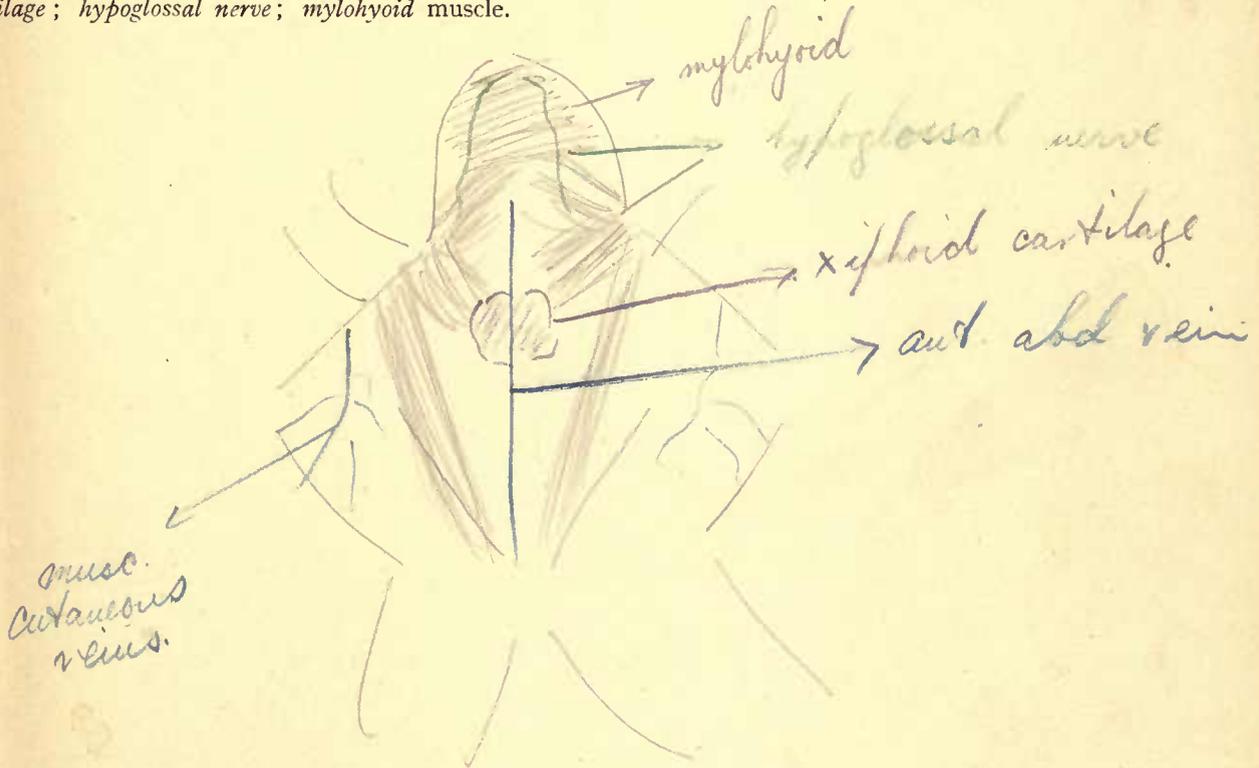


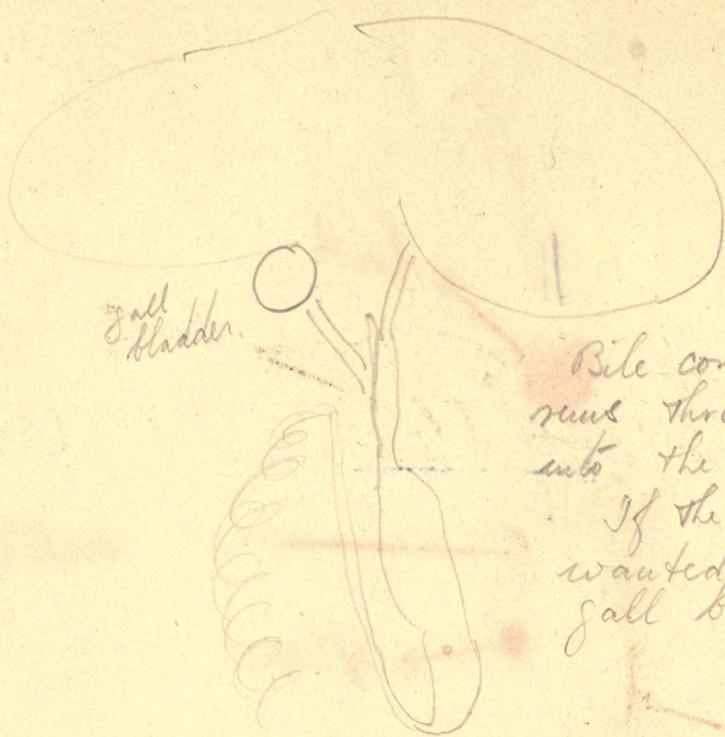


3. View of mouth widely opened: *maxillary teeth*; *vomerine teeth*; *posterior nares*; *eyeballs*; *Eustachian tubes*; *tongue*; *glottis*.



4. Ventral view of the same frog firmly pinned by its legs; the integument has been reflected from the body and throat; *anterior abdominal vein* seen through the muscular wall; *musculo-cutaneous veins*; *xiphoid cartilage*; *hypoglossal nerve*; *mylohyoid* muscle.

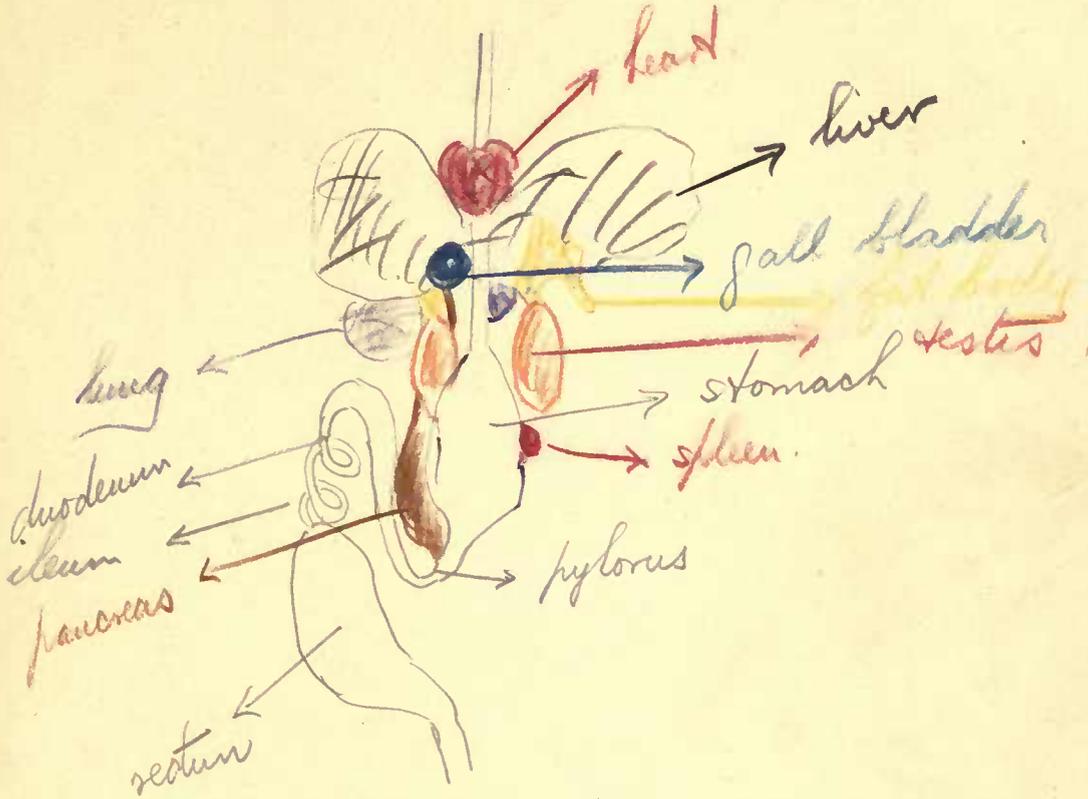


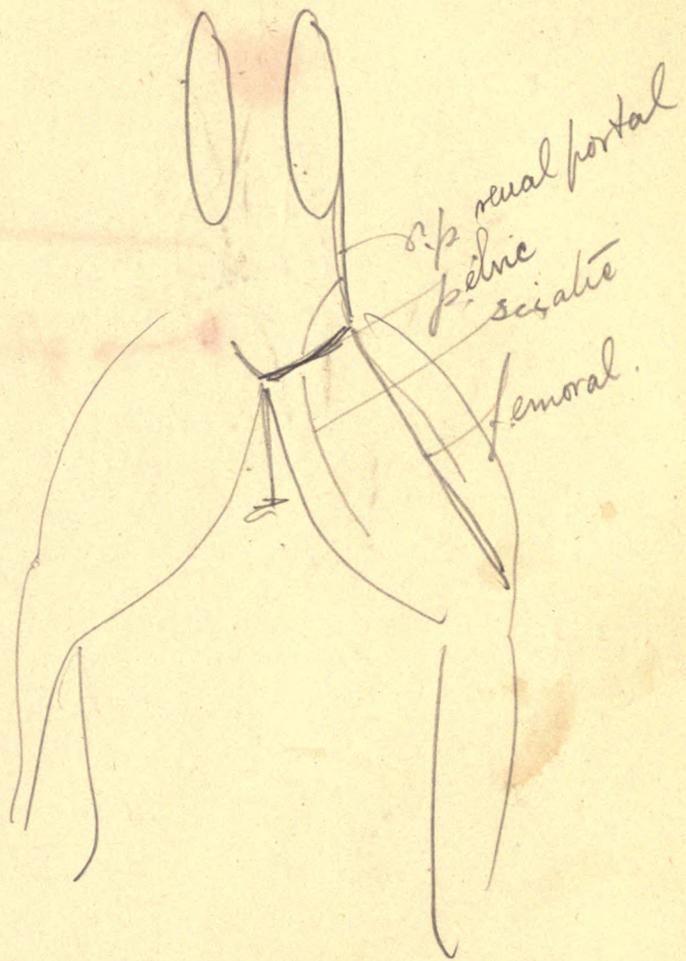


Bile comes from liver  
runs through the pancreas  
into the duodenum.

If the bile is not  
wanted, it fills the  
gall bladder.

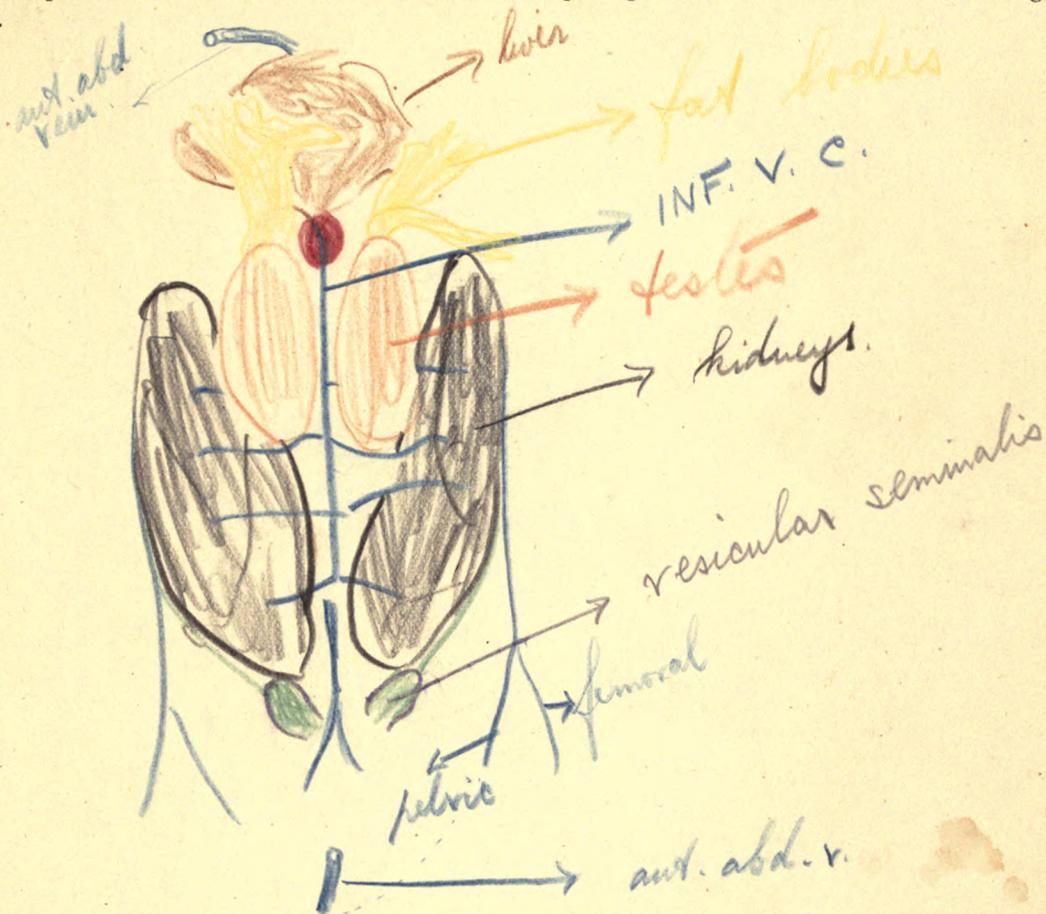
5. View of the ventral aspect of same frog, in which the muscular wall of the abdomen has been opened by a longitudinal cut a little to the left of the middle line so as to avoid the anterior abdominal vein; the pectoral girdle has been cut through a little to the left of the middle line; the cut abdominal and pectoral walls are pinned back on either side, and the anterior abdominal vein is doubly ligatured near where it enters the liver with thread and divided between the ligatures. The viscera are displaced so as to shew as much as possible. Heart; liver; gall-bladder; lung; stomach; spleen; duodenum and pancreas; hepato-pancreatic duct; intestine; rectum; testes or ovaries; fat-bodies; oviducts (in female); cloacal bladder.





6. View of the urinary and generative organs of a male from the ventral side. (The alimentary canal has been removed by cutting through the oesophagus, mesentery and rectum.) Fat-bodies; testes; vasa efferentia; kidneys; renal portal, femoral, sciatic, pelvic, anterior abdominal veins; urinogenital duct; vesicula seminalis; inferior vena cava; cloacal bladder.

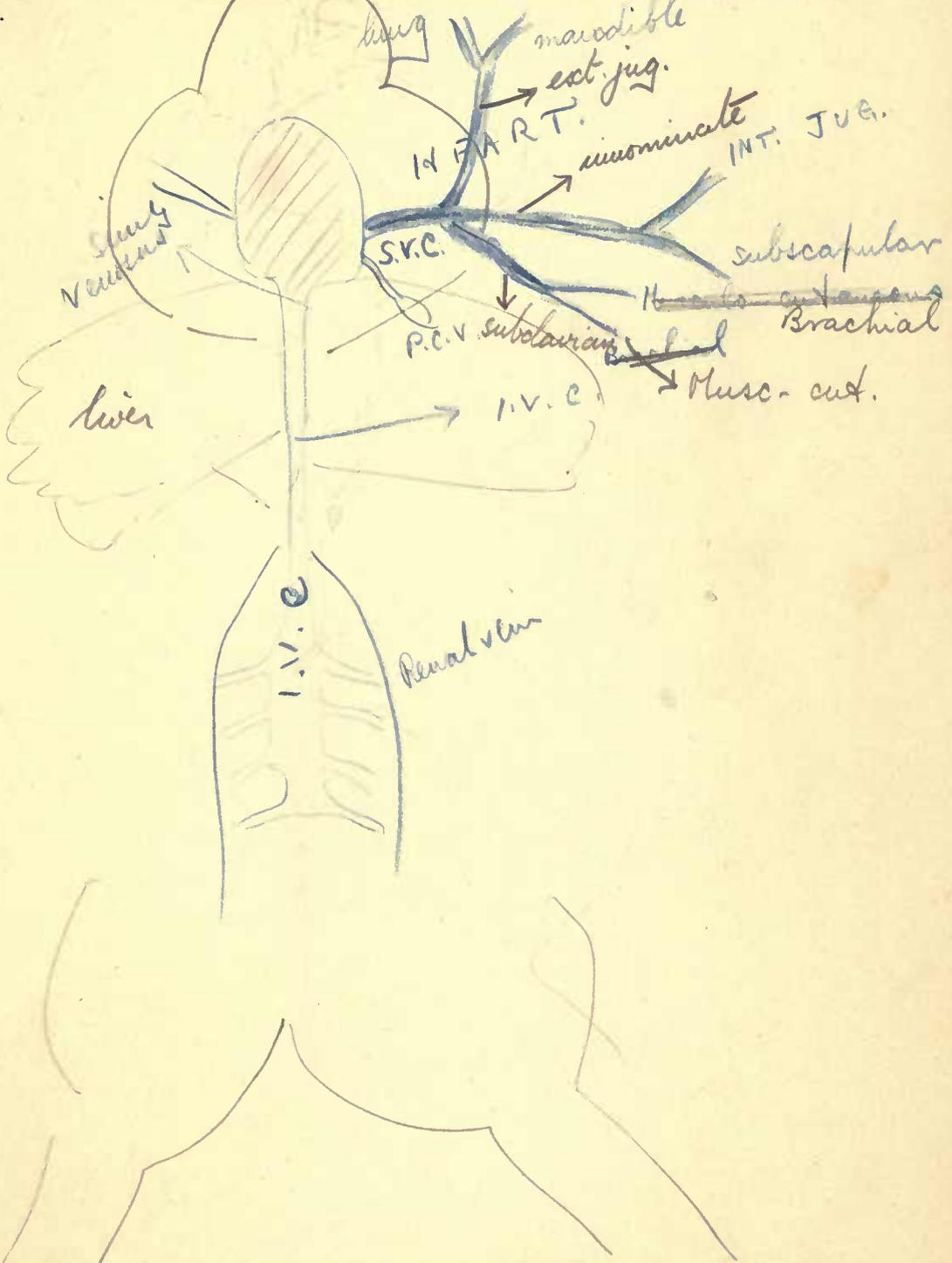
7. View of same parts in female: ovaries; oviduct; internal opening of oviduct; ureter; the other organs and veins as in 6.



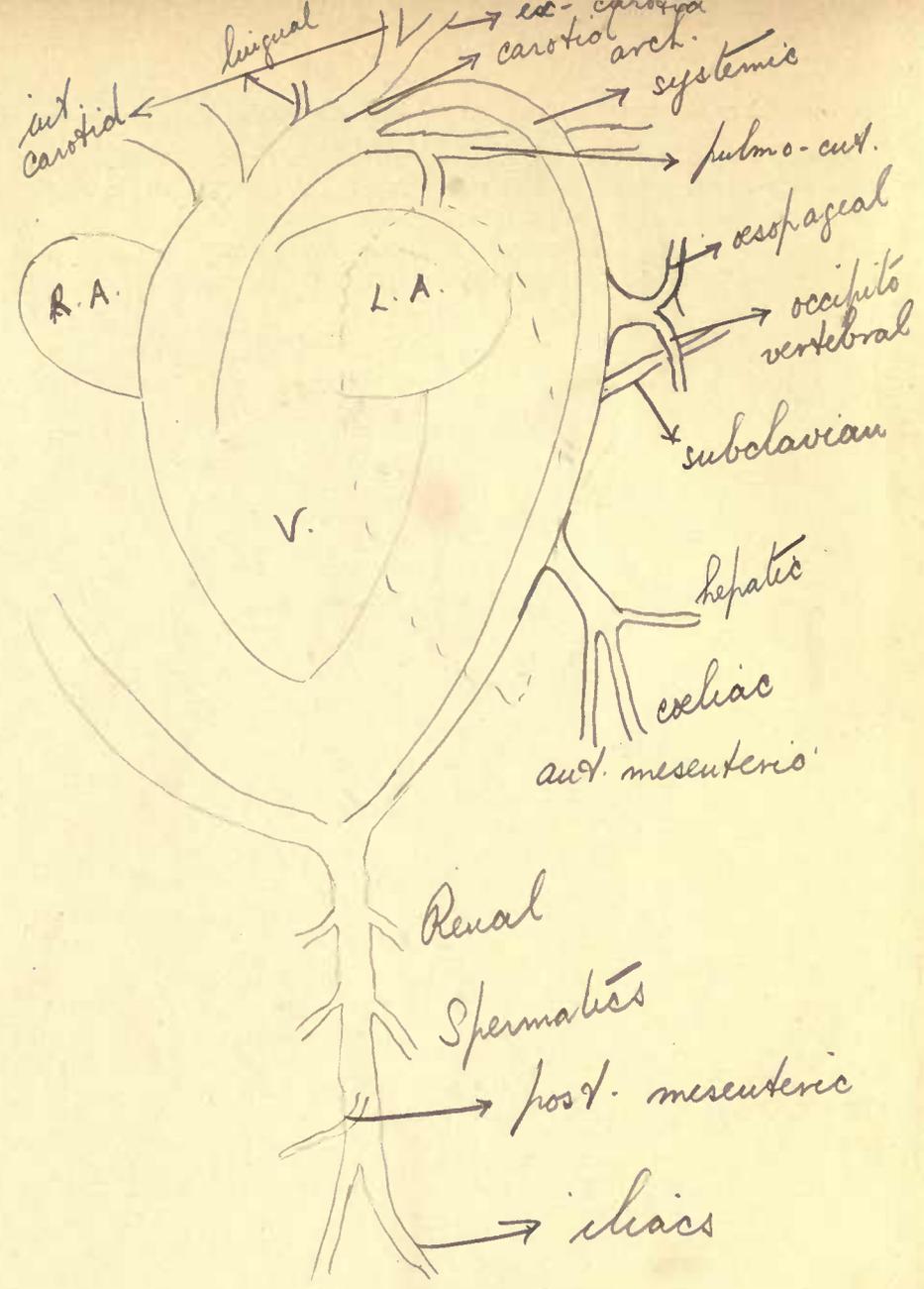


Open the abdominal cavity and expose the heart by cutting through the pectoral girdle as in 5.

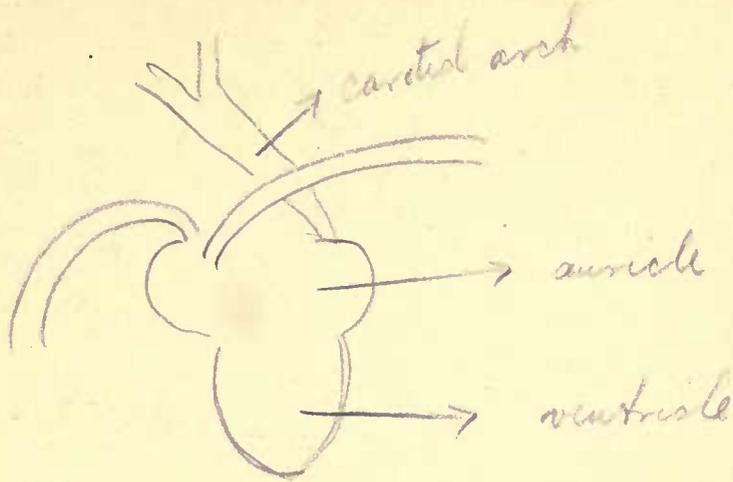
8. View of the great venous trunks converging to the heart. Remove the pericardium, draw the ventricle forward so as to expose the dorsal side of the heart, and cut through the ligament connecting the base of the ventricle to the dorsal wall of the pericardial cavity. Heart; sinus venosus; inferior vena cava; superior vena cava; external jugular, innominate, internal jugular, subscapular, subclavian, musculo-cutaneous, brachial veins. Note also the pulmo-cutaneous veins opening into the left auricle, and the hepatic veins opening into the inferior vena cava.



ARTERIAL SYSTEM OF FROG.



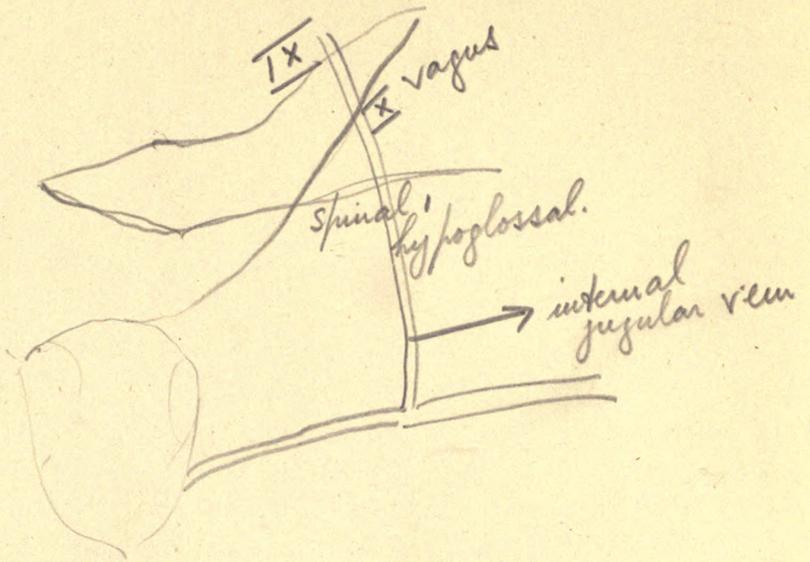
9. View of the heart and arterial arches, after removing the external jugular vein. *Ventricle; auricle; conus arteriosus; carotid arch; systemic arch; pulmo-cutaneous arch; lingual artery; carotid gland; common carotid artery; dorsal aorta; subclavian artery; celiaco-mesenteric artery; iliac artery.*



Ventral  
view.

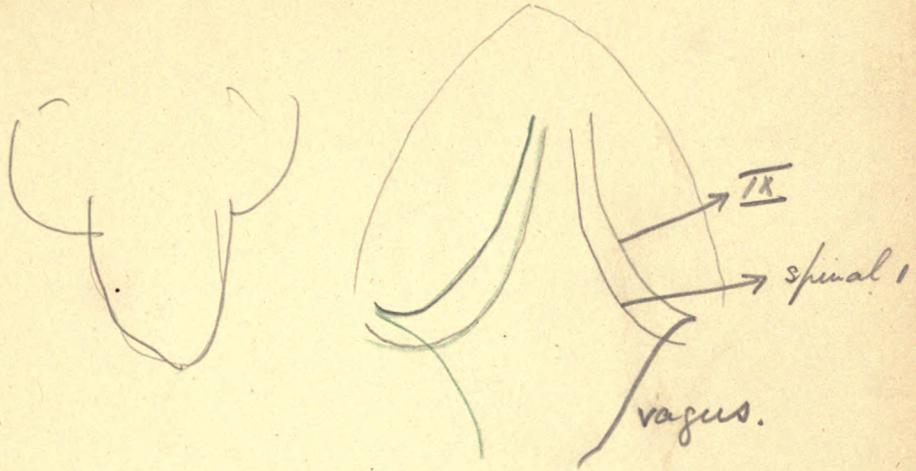


10. Plan (on opposite page) of the venous system of the Frog as determined by the preceding dissections: *sinus venosus; superior venæ cavæ; inferior vena cava; hepatic, hepatic-portal, gastric, mesenteric, renal, genital, renal portal, femoral, sciatic, pelvic, anterior abdominal veins.*

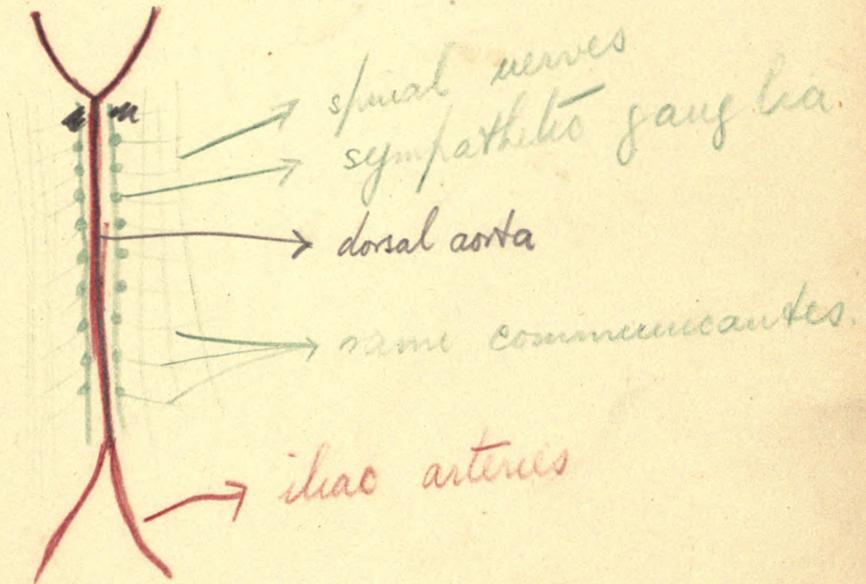


11. Open the abdominal cavity and expose the heart by cutting through the pectoral girdle.

Heart; glossopharyngeal nerve (cranial IX); vagus (cranial X); hypoglossal nerve (spinal I); internal jugular vein; brachial nerve.—(Trace the vagus to the heart)

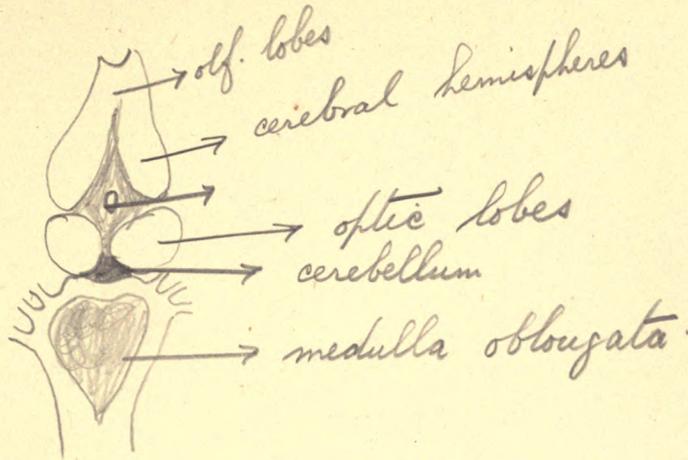


12. View of the hinder part of the body-cavity of the same frog from which the kidneys and generative organs have been removed without injuring the aorta: vertebral column; dorsal aorta; iliac arteries; calcareous concretions; spinal nerves; sympathetic ganglia; rami communicantes.

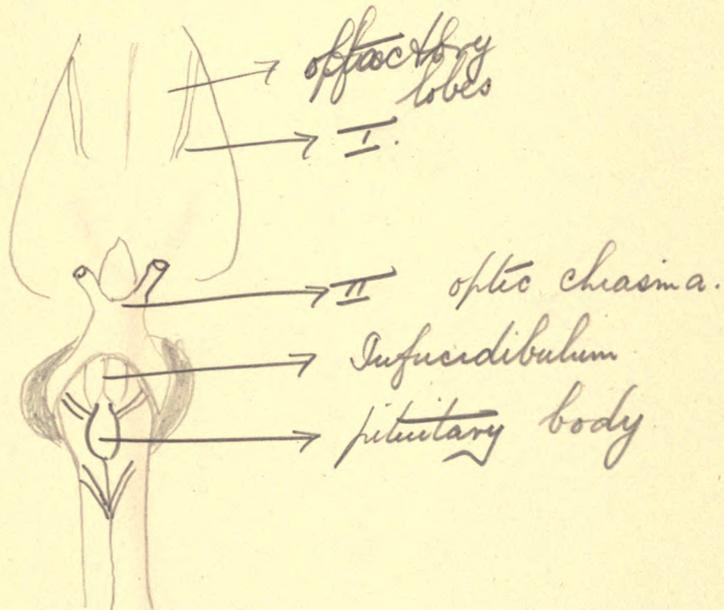


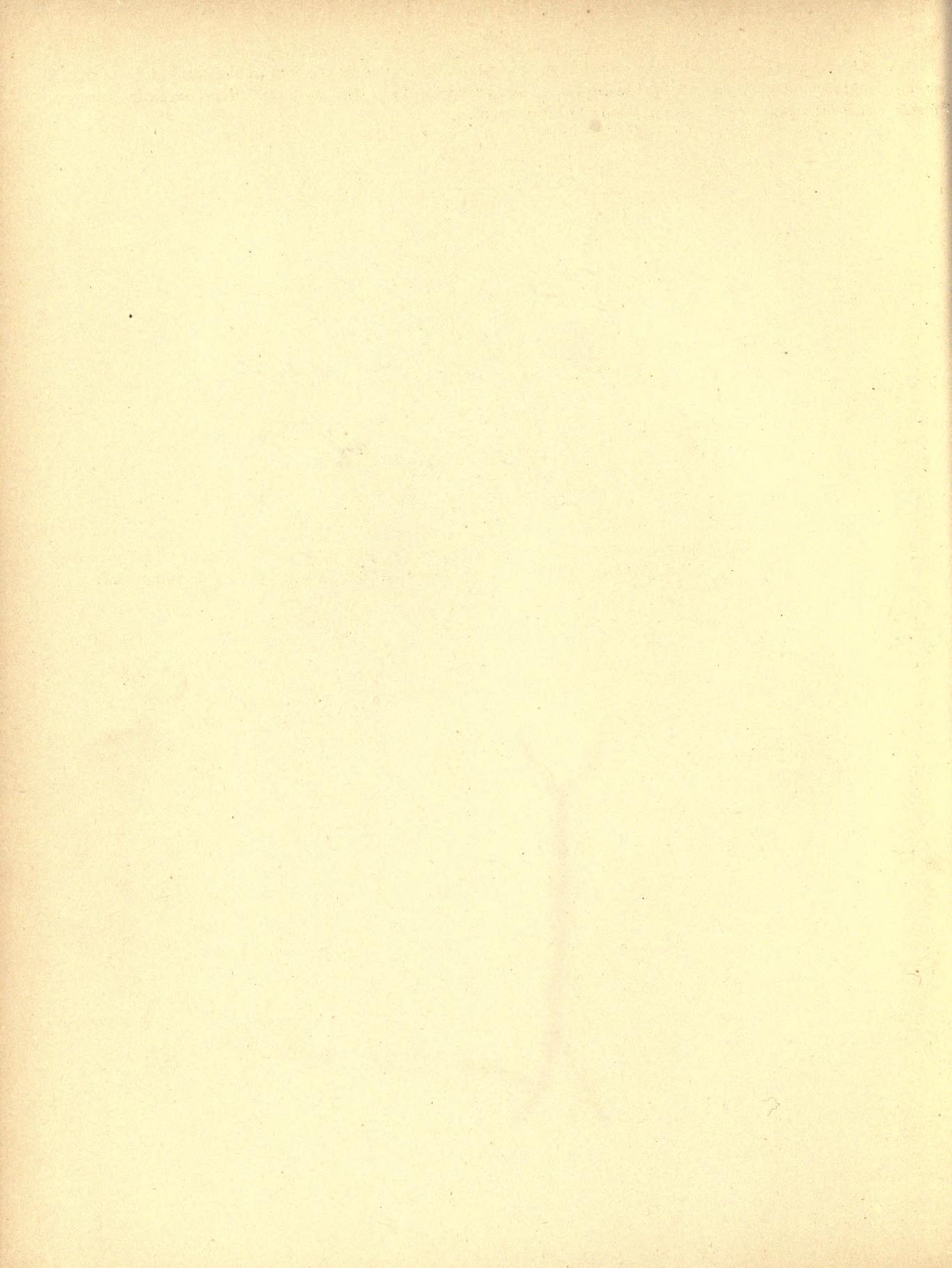


13. Central nervous system seen from above, as exposed by removing the roof of the skull and the neural arches: *olfactory lobes* (fused); *cerebral hemispheres*; *thalamencephalon*; *optic lobes*; *cerebellum*; *medulla oblongata*; *fourth ventricle*; *spinal cord*; *dorsal fissure of spinal cord*.

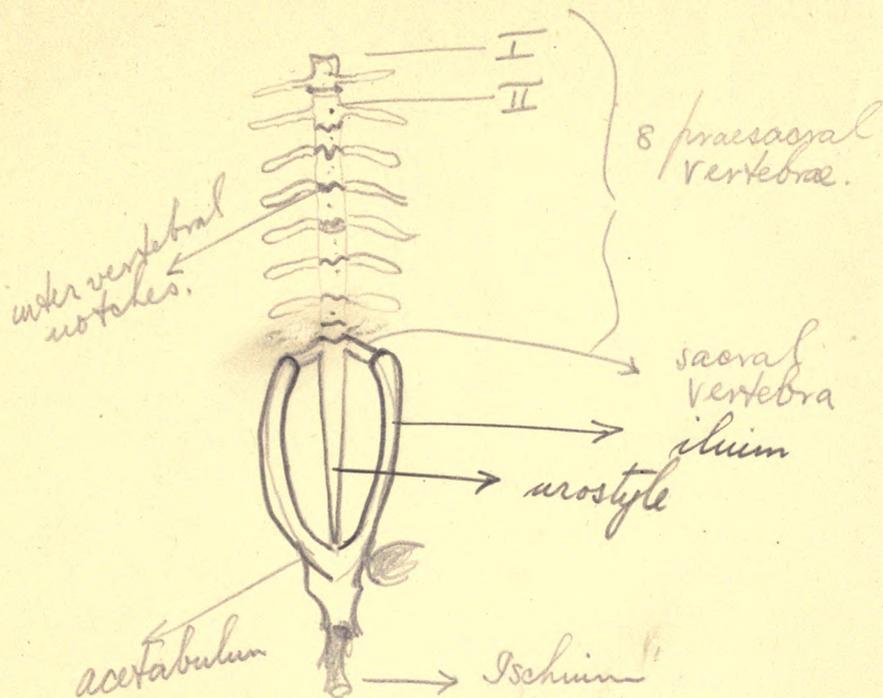


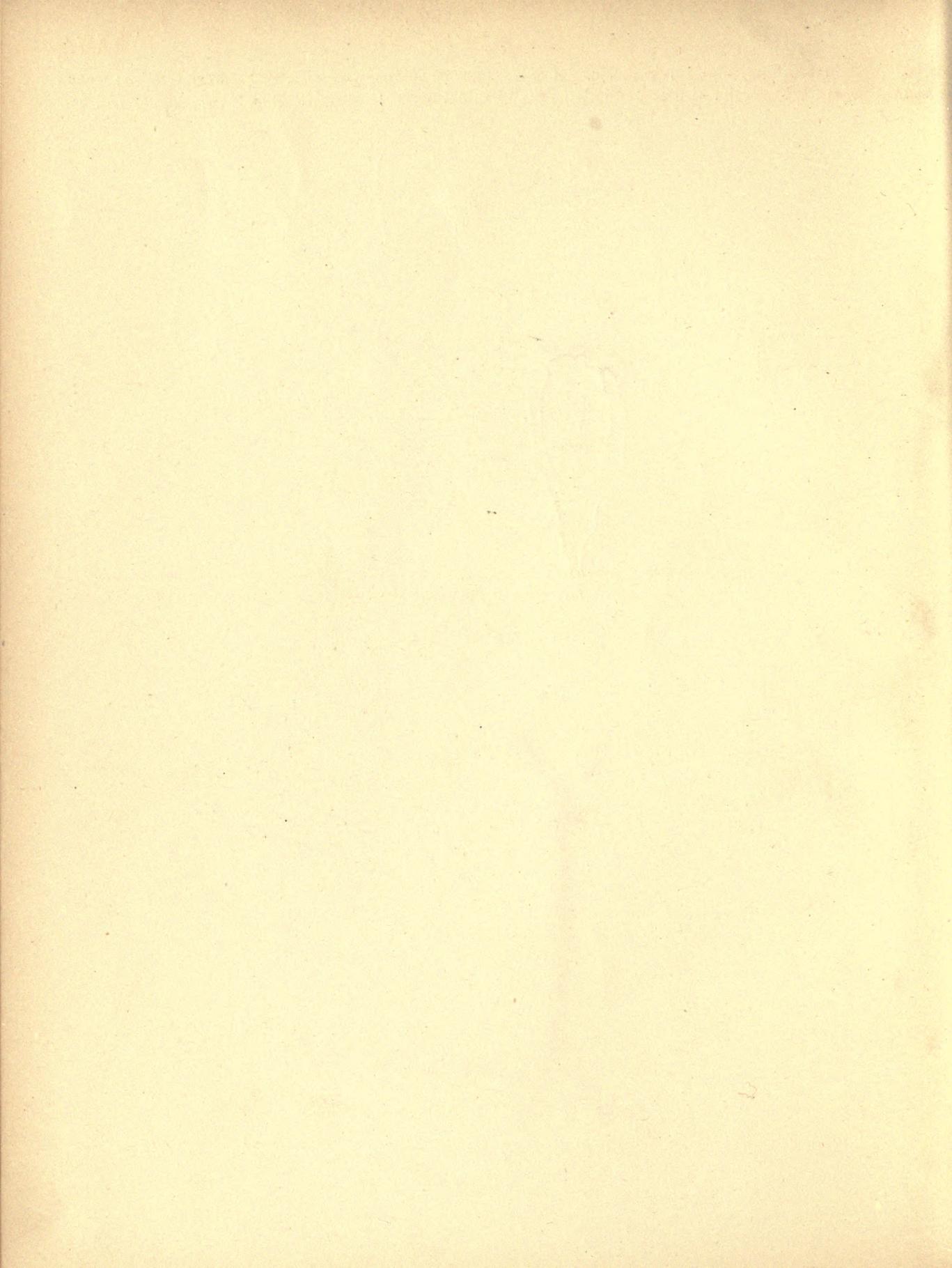
14. The same removed from the body and seen with its ventral side uppermost: *olfactory lobes*; *cerebral hemispheres*; *optic chiasma*; *infundibulum*; *pituitary body*; *crura cerebri*; *ventral fissure of spinal cord*.



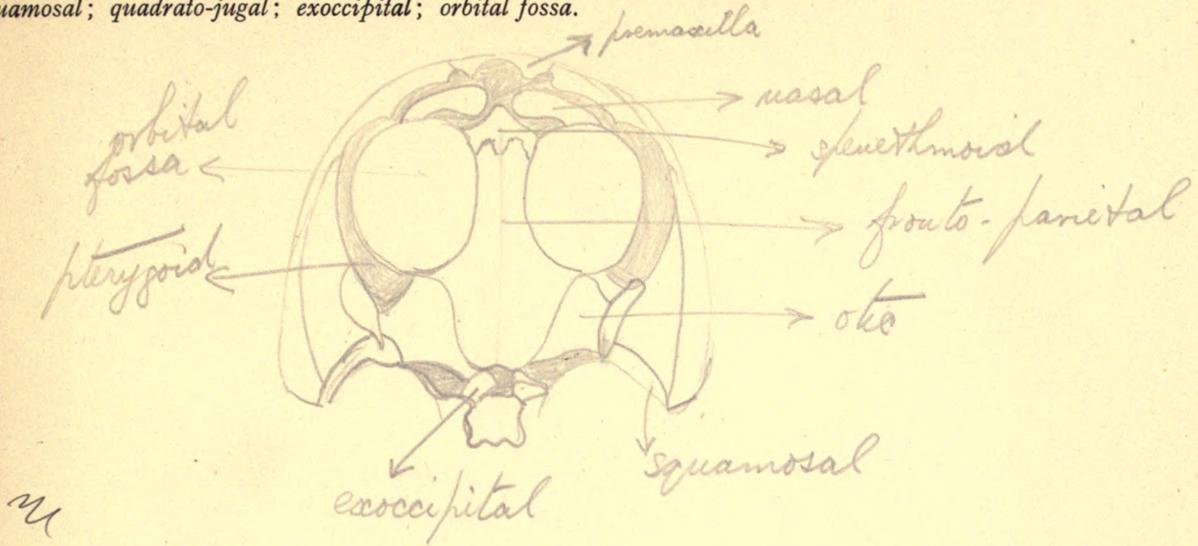


15. Vertebral column and pelvic girdle, dorsal aspect: eight *præsacral* vertebrae; *sacral* vertebra; *intervertebral* notches for the outlet of nine of the ten pairs of spinal nerves; *urostyle*; *ilium*; *acetabulum*; *ischium*.

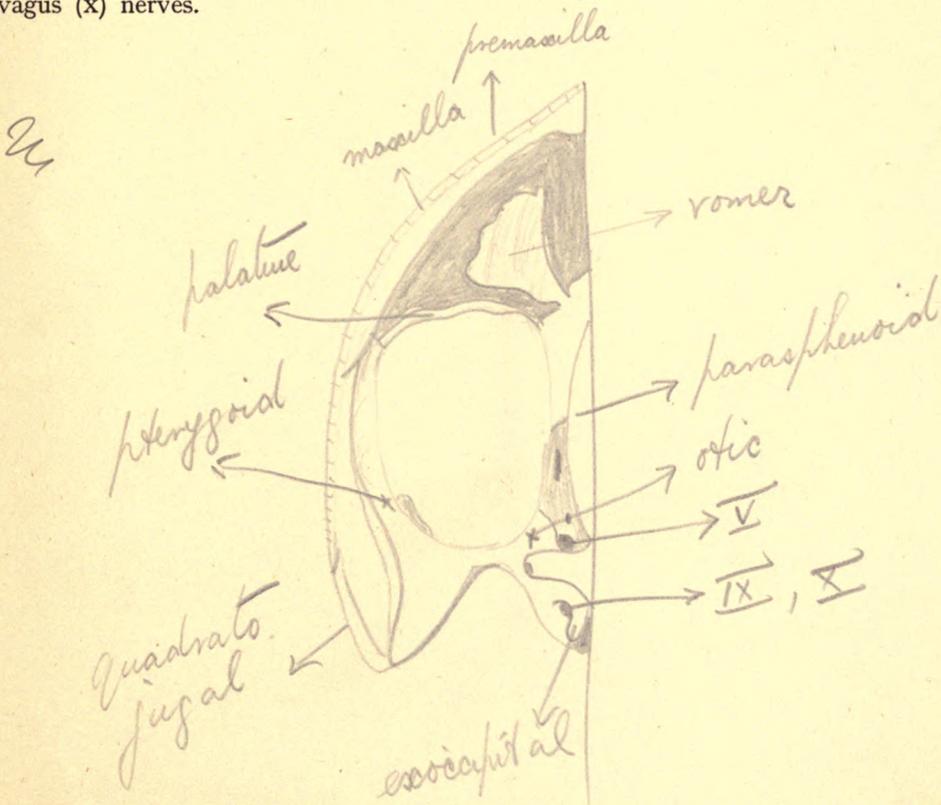


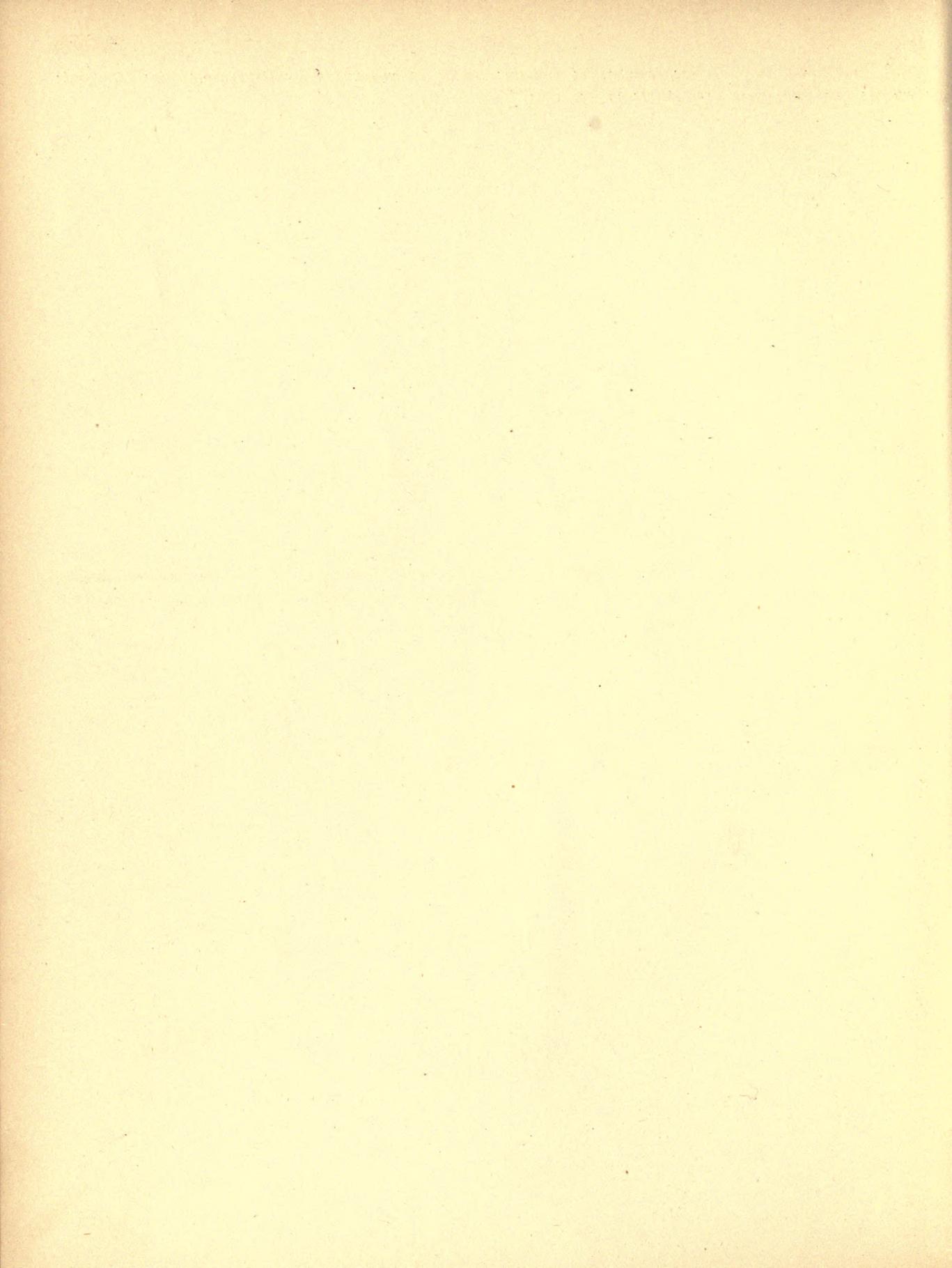


16. Skull viewed from above: *premaxilla*; *maxilla*; *nasal*; *sphenethmoid*; *fronto-parietal*; *otic*; *pterygoid*; *squamosal*; *quadrato-jugal*; *exoccipital*; *orbital fossa*.

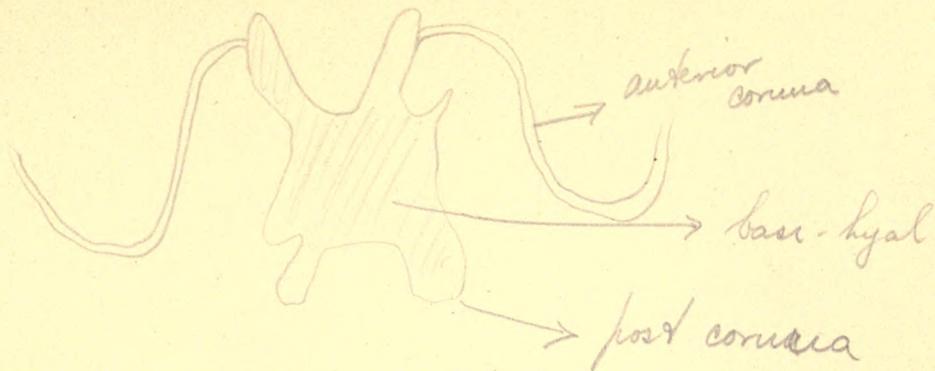


17. The same viewed from below: *premaxilla*; *maxilla*; *vomer*; *parasphenoid*; *palatine*; *sphenethmoid*; *pterygoid*; *quadrato-jugal*; *otic*; *exoccipital*; foramina of the optic (II), trigeminal (V), glosso-pharyngeal (IX), and vagus (X) nerves.

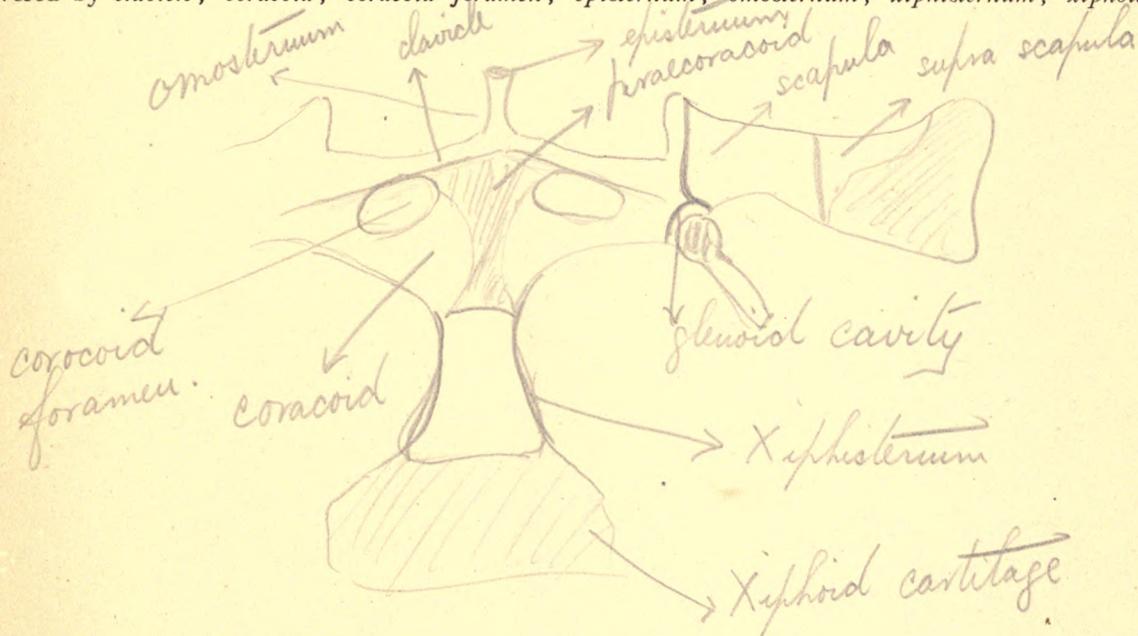


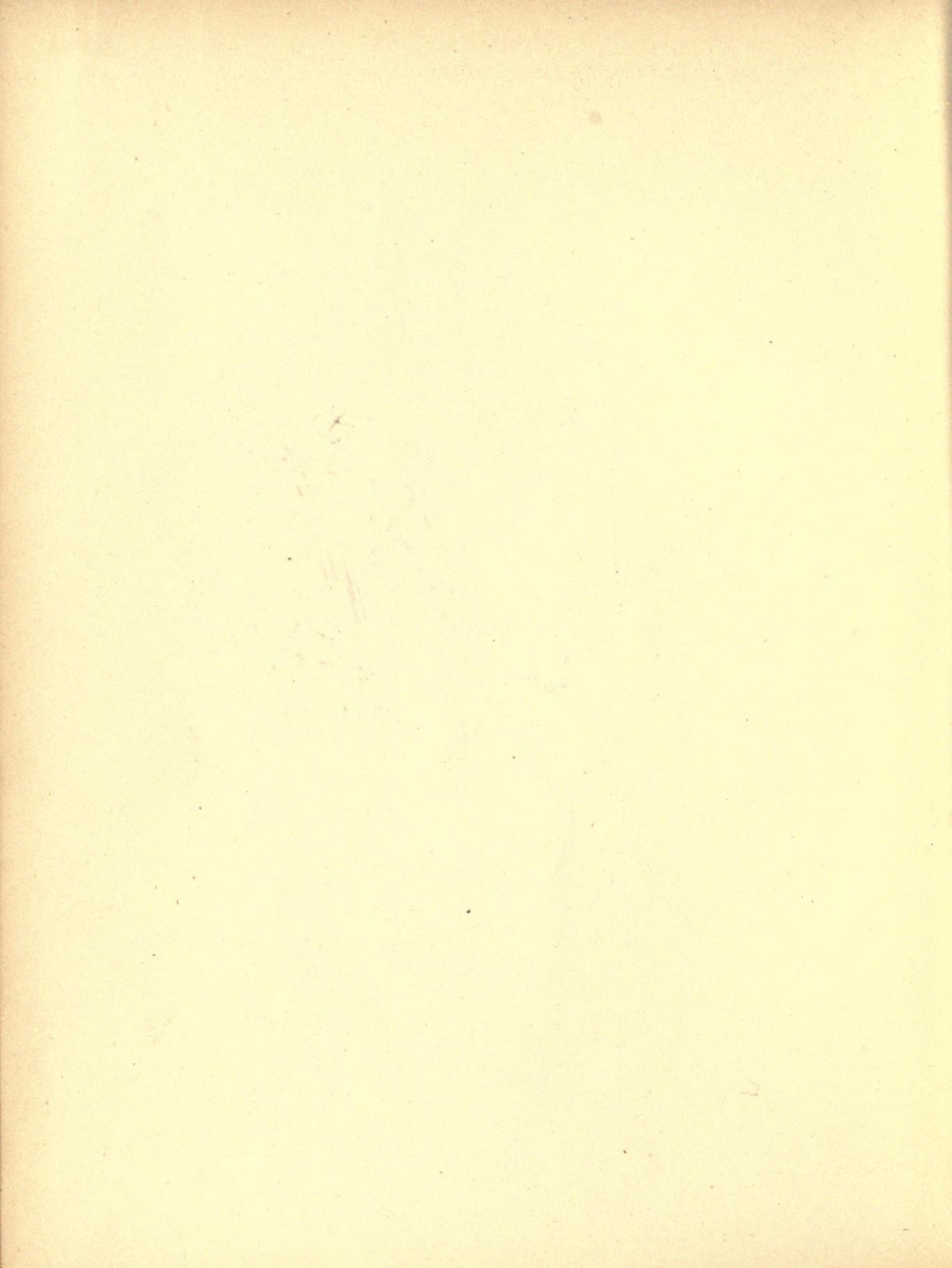


18. Hyoid cartilage: *basi-hyal*; *anterior cornua*; *posterior cornua*.

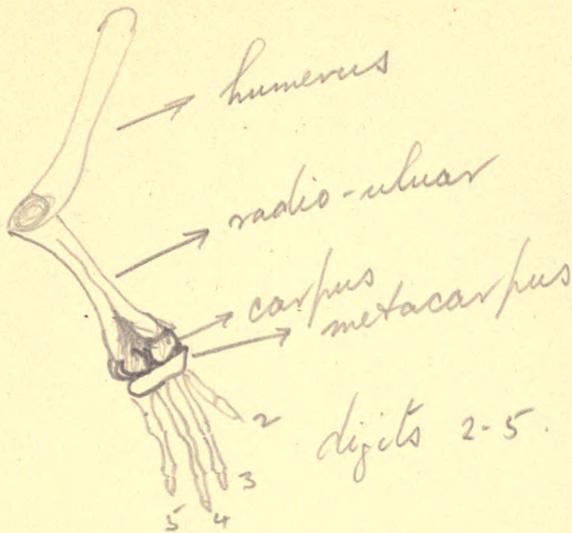


19. Pectoral girdle and "sternum," ventral view: *suprascapula*; *scapula*; *glenoid cavity*; *præcoracoid*, covered by *clavicle*; *coracoid*; *coracoid foramen*; *episternum*; *omosternum*; *xiphisternum*; *xiphoid cartilage*.

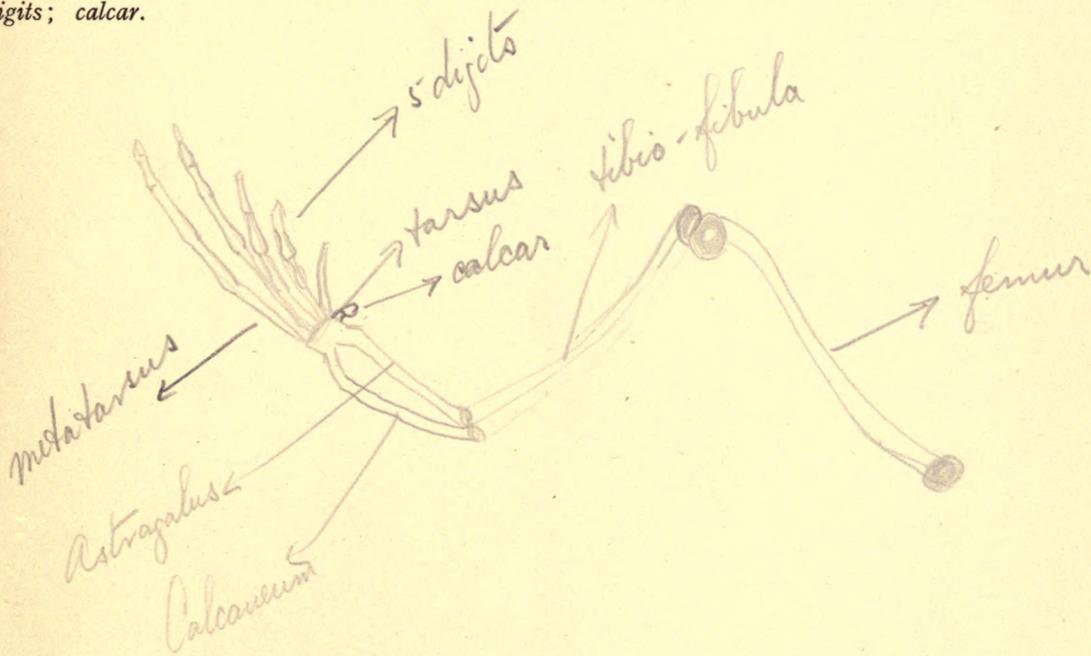




20. Fore-limb: *humerus*; *radio-ulna*; *carpus*; *metacarpus*; *phalanges*; *four digits (2-5)*.



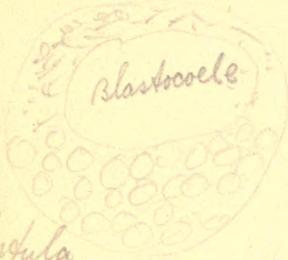
21. Hind limb: *femur*; *tibio-fibula*; *tarsus* with elongated *calcaneum* and *astragalus*; *metatarsus*; *five digits*; *calcar*.





22. Stages in the development: eggs; tadpoles; etc.

*Blastomeres.*



*Blastula*

→ *epiblast*

→ *gut  
archenteron*

→ *hypoblast*



1. **Frog's Blood.** Take a drop of the blood on a coverslip diluting with a drop of normal salt solution (75 %). Place on a slide and examine under the high power of the microscope. Draw the *red corpuscles* shewn in full face and in side view. Move the slide about to find *white corpuscles* (leucocytes).

Place a drop of acetic acid (1 %) at one side of the coverslip and allow it to diffuse under. Observe the *nuclei*.

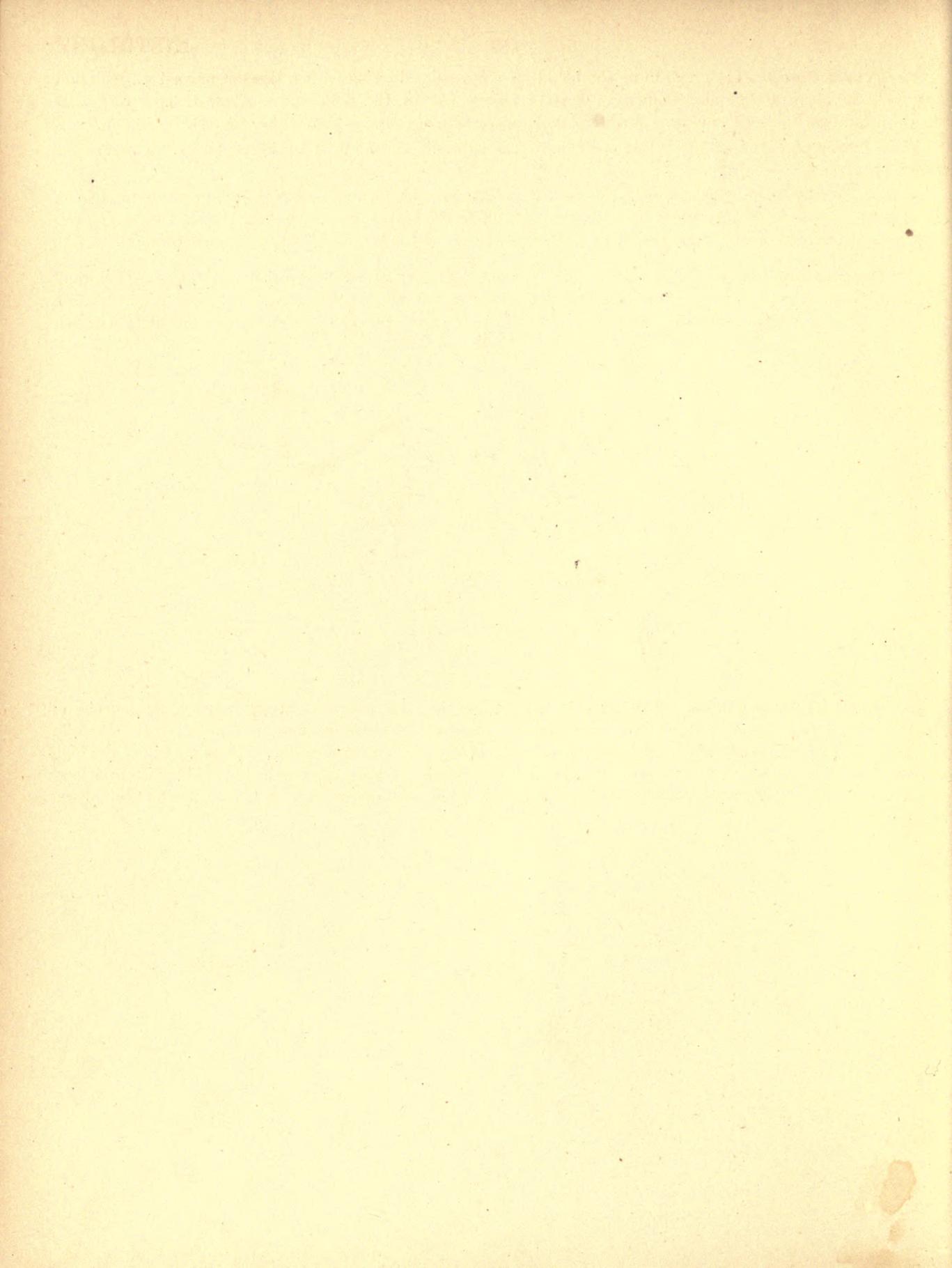
Make a film by thinly smearing one side of a coverslip with blood, and dropping it into absolute alcohol. Place for 3—4 minutes in methylene blue and examine under the high power. Observe the *red blood corpuscles* with *nuclei* clearly stained. Also the *leucocytes*, some *hyaline* and others with deeply stained *granules*.

2. **Mammalian Blood.** Draw a drop of blood from the finger with a clean needle and dilute with normal salt solution as before. Observe the *red corpuscles*, shewn in full face, in side view, and in rouleaux. Search for *white corpuscles*. Irrigate as before with acetic acid (1 %) and observe that the latter alone are nucleated.



3. **White Fibrous Tissue.** Pull up with fine forceps the thin connective tissue between the muscles of the frog's thigh and cut off a small piece with scissors. Spread out on a dry slide with needles, and carefully place over it a dry coverslip, allowing a drop of normal salt solution to diffuse under. Examine under the high power of the microscope. Observe the wavy bundles of *fibrillæ* crossing each other in every direction, and the *connective tissue cells*, which will be made clearer by irrigating with acetic acid (1 %), while the fibrillæ will disappear.



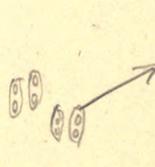


4. **Tendon.** Place on a slide a small piece of thin tendon from the end of one of the leg muscles of the frog. Keep moist by normal salt solution. Hold one end in position with a needle and fray out the fibres at the other end by passing a needle along them. Cover and examine fresh. Observe the *white fibres* in parallel bundles with *tendon cells* in rows between them. Irrigate with acetic acid (1%) and observe the *nuclei* of the tendon cells. Notice that the fibres swell up into a gelatinous mass.



5. **Pigment cells.** Take a piece of the web between the toes of a frog and spread it out on a slide. Observe under the high power the *pigment cells*, some with numerous branched processes, others rounded, their processes having been retracted.



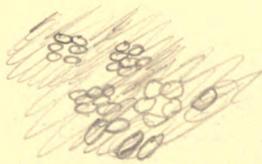


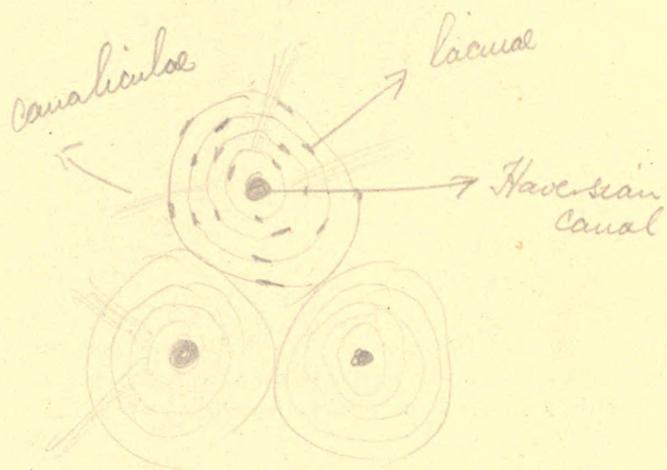
lacunae  
with cells.  
clear collagen.

A hand-drawn diagram consisting of five small, vertically-oriented oval shapes arranged in a slightly curved line. An arrow points from the right side of the second and third ovals towards the handwritten text.

6. **Adipose Tissue.** Take a piece of the mesentery of the rat and spread it out on a slide, mounting in normal salt solution. Observe the spherical highly refractive *fat-cells*. Irrigate with a drop of osmic acid and observe after half-an-hour that the fat has been stained black.

7. **Hyaline Cartilage.** Strip off the free edges of any of the thin cartilages of the sternum of a frog. Mount in normal salt solution and examine. Observe the *cells* lying in a *matrix* of collagen. Irrigate with acetic acid (1%) and notice that the cells are more distinct and that their *nuclei* are now visible.

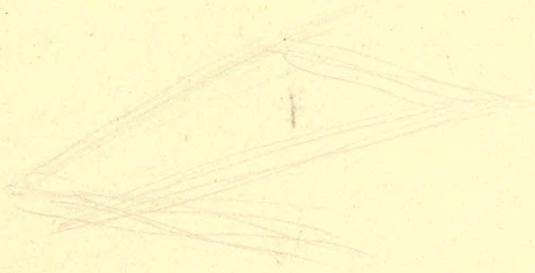




8. **Muscle Striated.** Cut through the skin covering the thorax, and remove one of the strands of tissue connecting the "sternum" with the skin. Lay it on a slide and tease out thoroughly. Crush some of the fibres by pressing a bristle across them. Place on coverslip and let a drop of normal salt solution pass underneath. Observe the *muscle sheath* of the *fibres* at the crushed spot and the alternate *dim* and *light bands*. Irrigate with acetic acid (1 %) and observe the scattered oval *nuclei*.



9. **Muscle Unstriated.** Take a piece of the bladder of a frog and spread its outer surface on a slide allowing its edges to dry and fix themselves to the glass. Rub off the internal epithelium with the finger. Put on one drop of 90 % alcohol and then one drop of eosin and methylene blue. Examine under the high power and observe the *unstriated muscle fibres* arranged in a plexus. Their *nuclei* are stained. Note also the *connective tissue cells* with stained *nuclei*.



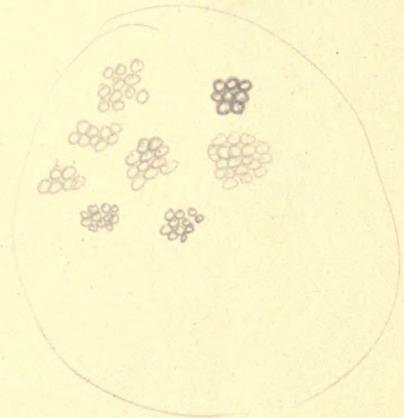


10. **Sciatic Nerve.** Cut out a quarter of an inch of the sciatic nerve of the frog. Hold one end on a slide by the blunt edge of a scalpel. Quickly tease out with a needle the other end into a fan. Add normal salt solution and put on a coverslip. Observe the *nerve fibres*, which are of double contour on account of their *fatty sheath*. At ends observe the transparent *outer sheath* of the fibres.

Place a drop of osmic acid on one side of the slide and draw it under the coverslip by absorbing the salt solution by blotting paper on the opposite side: then remove the blotting paper to prevent the osmic acid being absorbed. Leave for fifteen minutes and examine. Observe the *nodes of Ranvier* in the *fatty sheath* and the *nuclei* halfway between two nodes.



11. **Transverse Section of Sciatic Nerve** prepared with osmic acid. Observe the grouping of the fibres into *bundles* and the *fatty sheaths* as dark rings round the individual *fibres*.



0888

12. **Transverse Section of the Small Intestine of a Frog.** Observe that the cavity of the intestine is lined by a single layer of *columnar epithelial cells* which are raised on folds of *connective tissue*. This is abundantly supplied with *blood vessels* and *lymph spaces*, and is surrounded by a broad *circular* and a narrow *longitudinal* layer of *muscle fibres*.

13. **The same from a Frog fed with bacon.** Observe that the epithelial cells are crowded with *fat granules*.



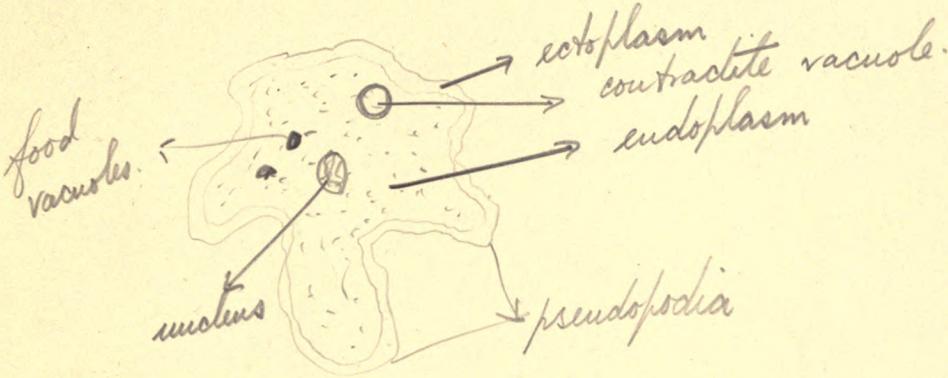
14. **Transverse Section of the Stomach of a Frog.** Observe the much greater thickness of all the layers as compared with the intestine. The epithelial cells instead of continuing as an even layer of cells over the ridges form the *gastric glands*. These are a series of branched tubes, the epithelium of which secretes gastric juice. Observe the subjacent *connective tissue* with *blood vessels* and the *muscle layers*.

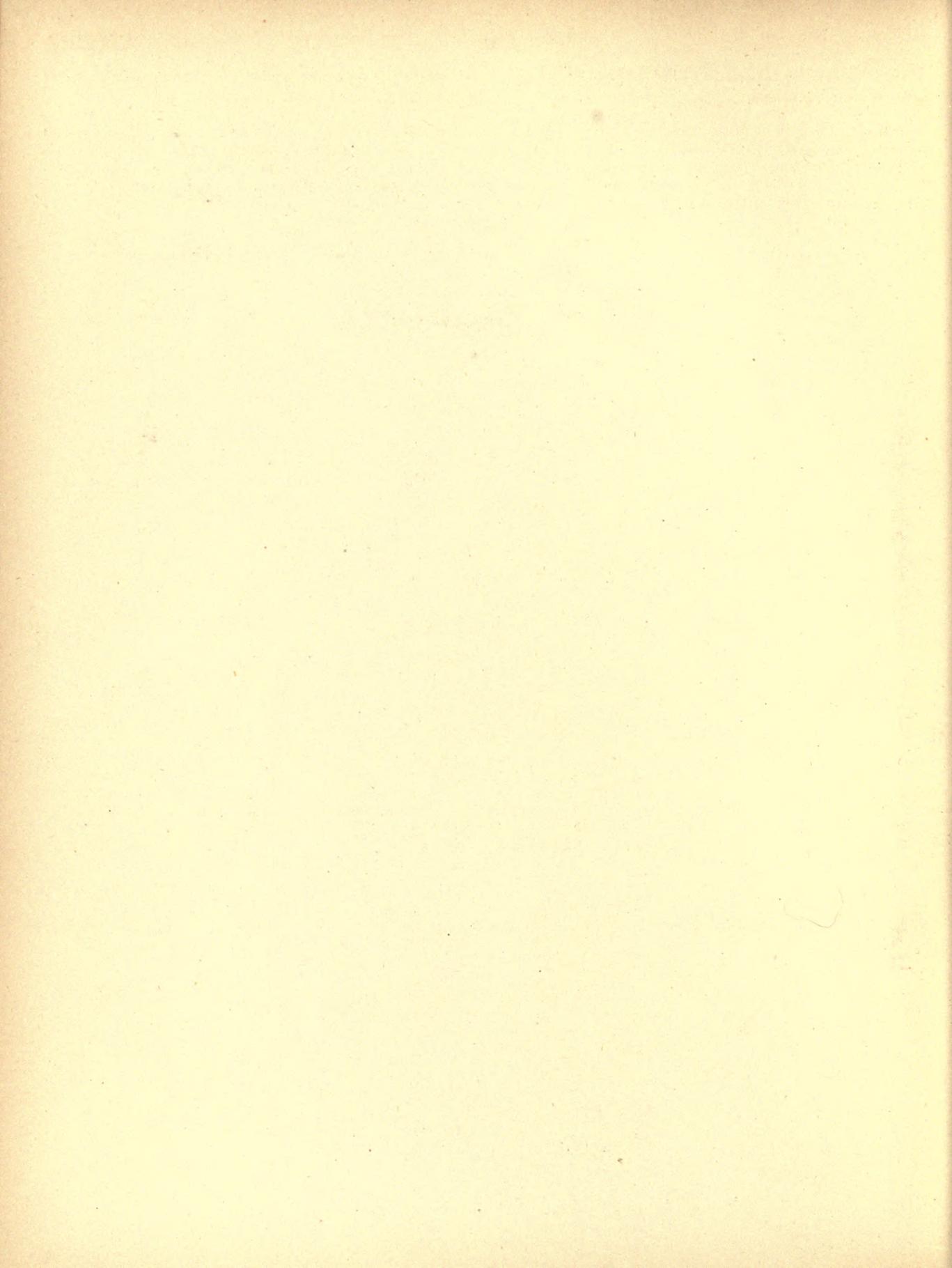




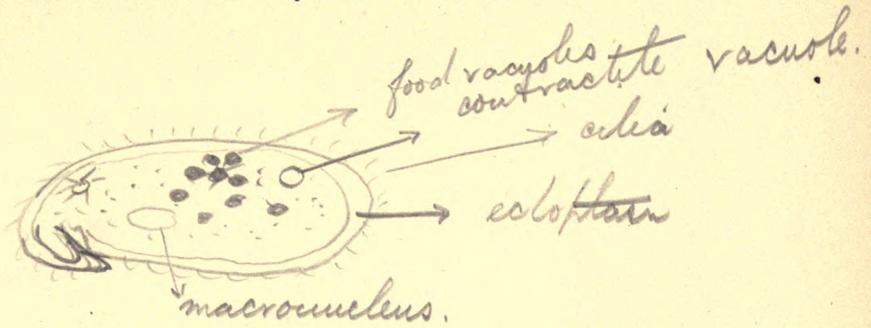
Sketches of the animal to shew changes of shape: *pseudopodia*; *ectoplasm*; *endoplasm*; *contractile vacuole*; *food vacuoles*; *nucleus*.

Kill and stain with picocarmine to bring out the nucleus. The introduction of the staining fluid under the coverslip should be effected by *irrigation*, i.e. by placing a drop of the fluid on the slide so that it just touches one side of the coverslip, and by drawing out fluid from the opposite side by means of a piece of blotting paper. The staining fluid will then pass in to replace the fluid taken up by the blotting paper. Care should be taken that there is always some fluid touching the coverslip, to replace that taken out by the blotting paper.

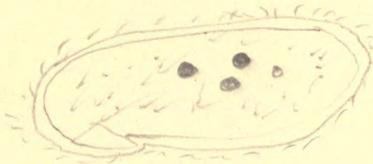




1. Sketches of the animal: *cuticle*; *ectoplasm*; *cilia*; *trichocysts*; *endoplasm*; *oral groove*; *gullet*; *food vacuoles*; *macronucleus*. Draw the two *contractile vacuoles* in *systole* and *diastole*.



2. Feed with Indian ink: *food vacuoles*. Watch the entrance of the food pellets into the endoplasm, the rotation of the food vacuoles, and the extrusion of their undigested contents by the *temporary anus*.



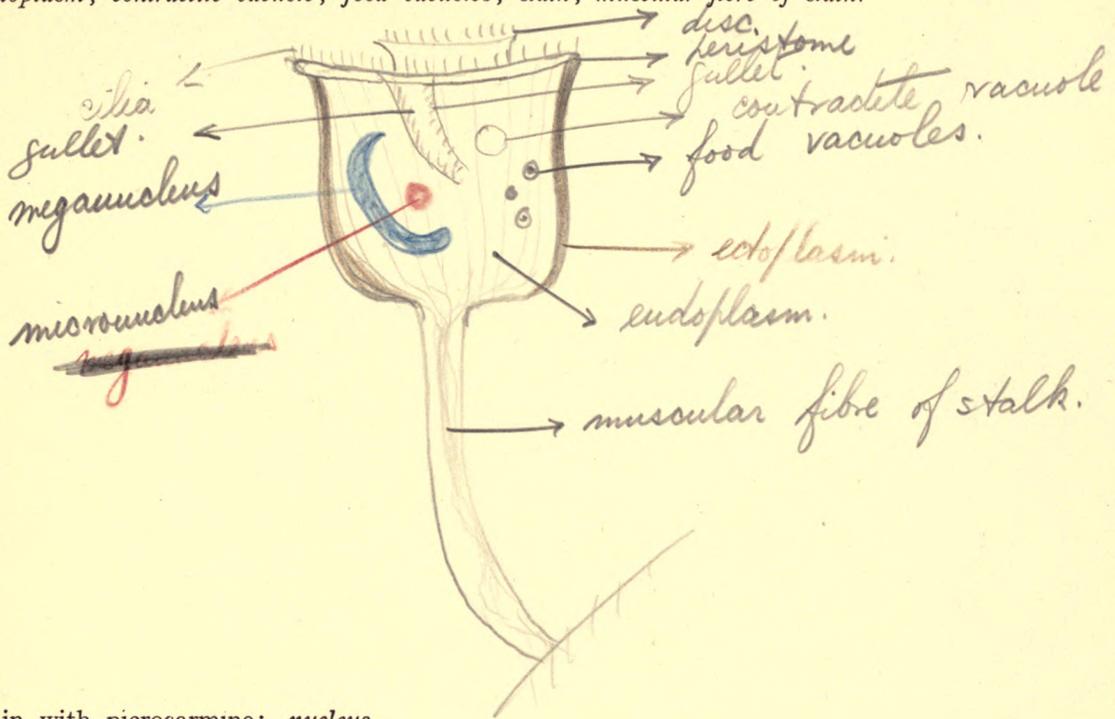
3. Stain with iodine: *macronucleus*; *miconucleus*; *trichocysts* discharged.





Find under the low power of the microscope. Sketch under the high power.

1. Enlarged drawing of the expanded body: *epistome*; *peristome*; *cilia*; *oral groove*; *gullet*; *cuticle*; *ectoplasm*; *endoplasm*; *contractile vacuole*; *food vacuoles*; *stalk*; *muscular fibre of stalk*.

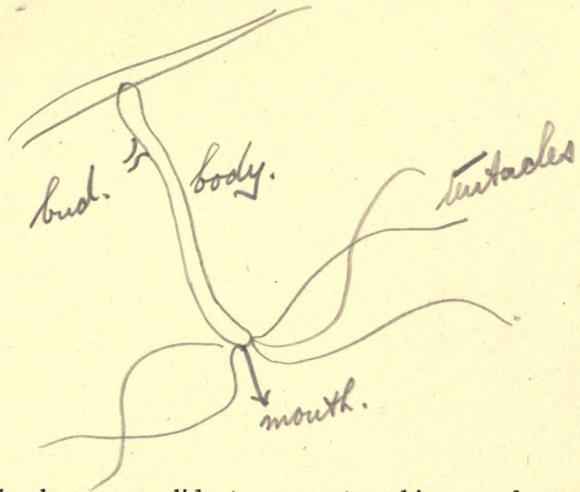


2. Stain with picocarmine: *nucleus*.

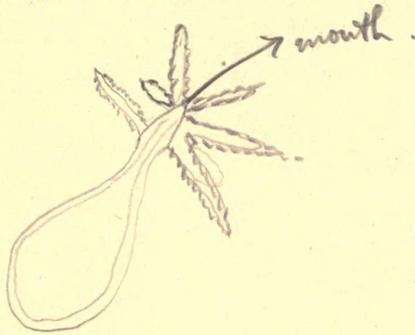
3. Feed with Indian ink. Observe the process by which the small particles accumulate at the bottom of the gullet, pass into the endoplasm, form small round masses which circulate in food vacuoles and are finally cast out into the oral groove through the *temporary anus*.



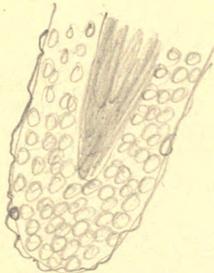
1. A view under hand lens of whole animal in watch glass: *body*; *tentacles*; *foot*; *testes* if present; *ovary* if present; *bud* if present.

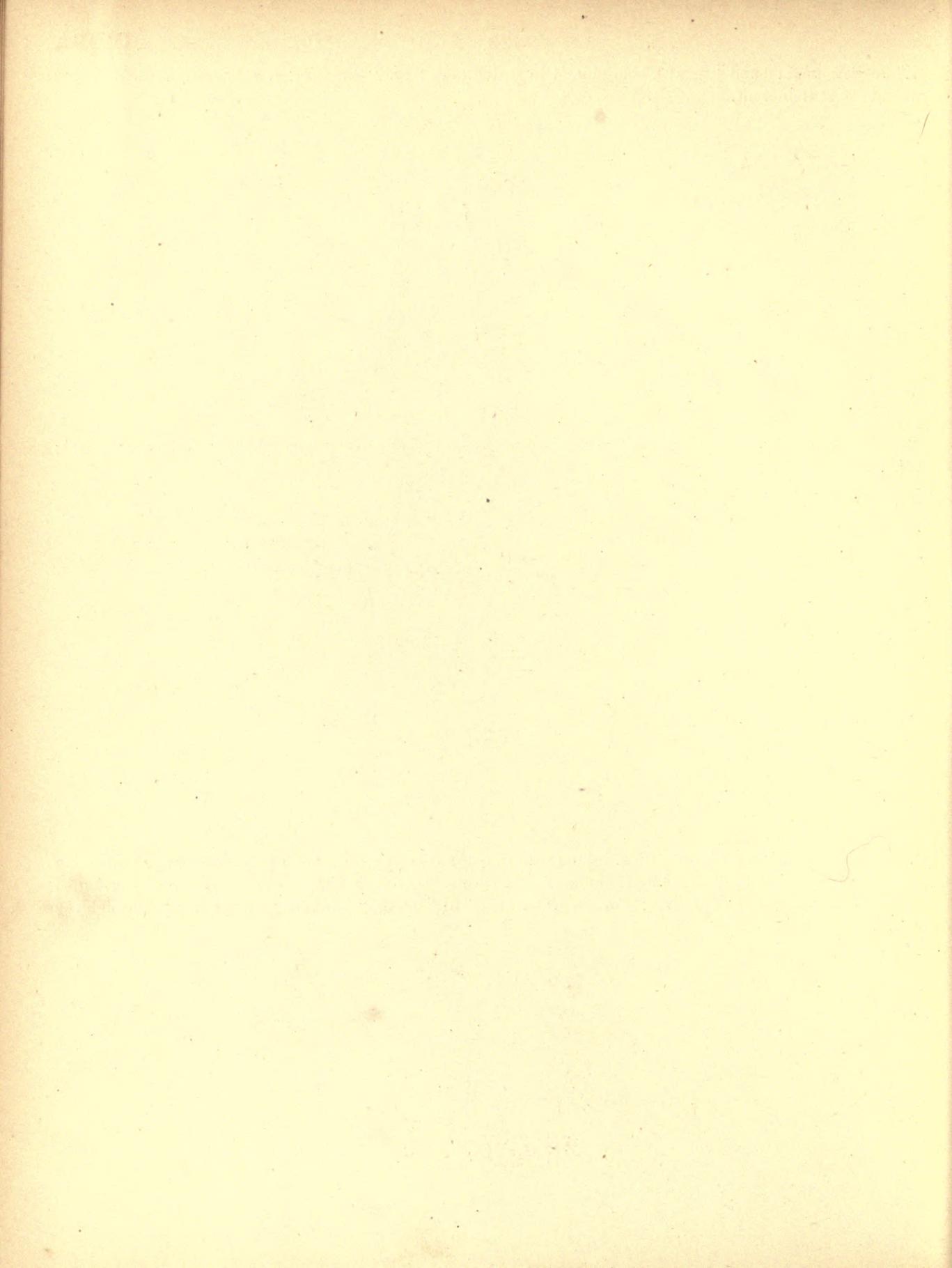


2. The same under low power, placing the watch glass on a slide to prevent rocking: *oral cone*; *mouth*; *tentacles*.



3. Mount the animal alive on a slide, taking care that the coverslip does not press too heavily by placing two slips of thin paper under it, and examine it first with a low power, then with a high. Draw portion of tentacle under high power: *ectoderm*; *thread-cells* arranged in batteries; *cnidocils*; *endoderm* seen through the ectoderm.

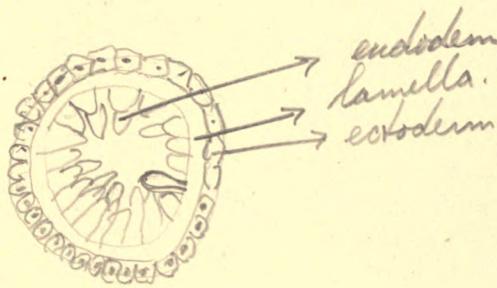




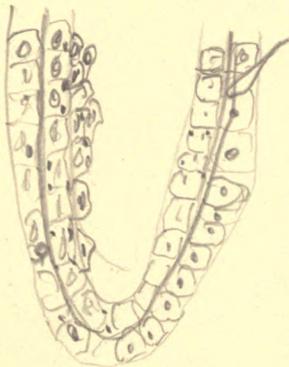
4. Irrigate the animal with 5 per cent. solution of common salt and watch the protrusion of the filaments of the nematocysts. Sketch detached *nematocyst* with the *cnidoblast* adhering to it.



5. Transverse section of the body; draw with low power, fill in details of small portion with high: *ectoderm*; *myo-epithelial cells*; *interstitial cells*; *nematocysts*; *basement membrane*; *endoderm*; *vacuoles*; *chloroplasts* if present; *digestive cavity*.

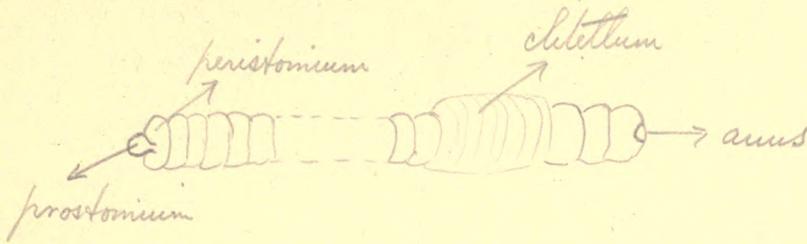


6. Longitudinal section of the body: parts as in 5.

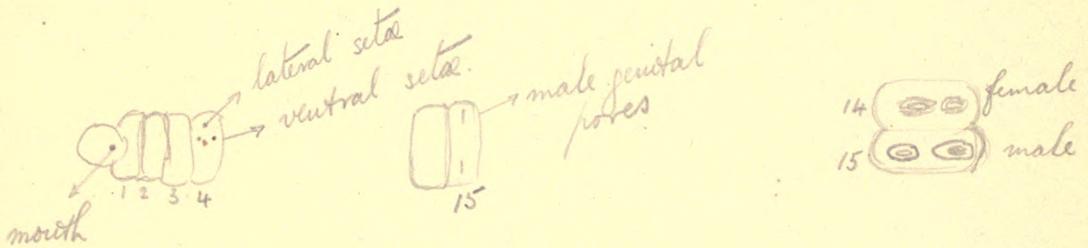




1. Dorsal view of the anterior part, enlarged: *prostomium*; *peristomium*; *clitellum* from segment 32 to 37 inclusive; *segments 2 to 40*.

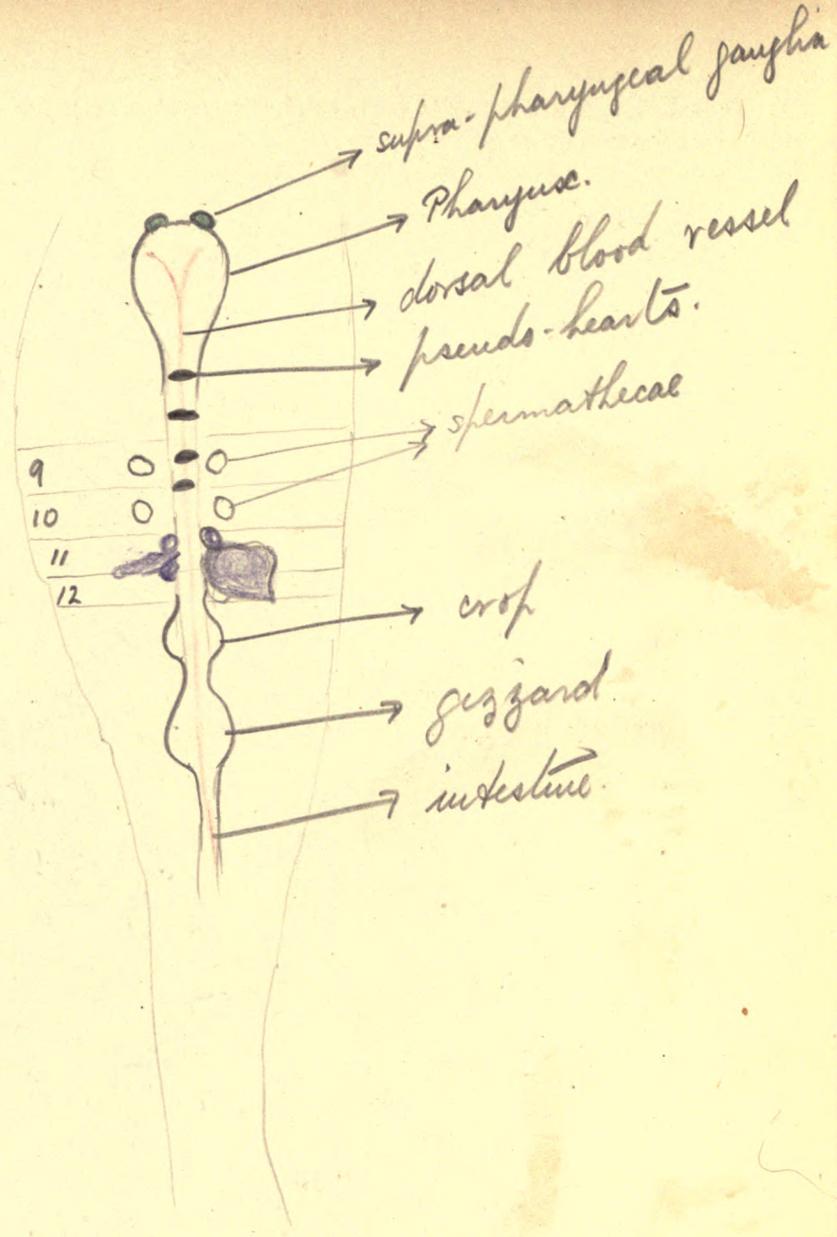


2. Ventral view: *mouth*; *ventral setae*; *lateral setae*; *male genital pores* (segment 15).

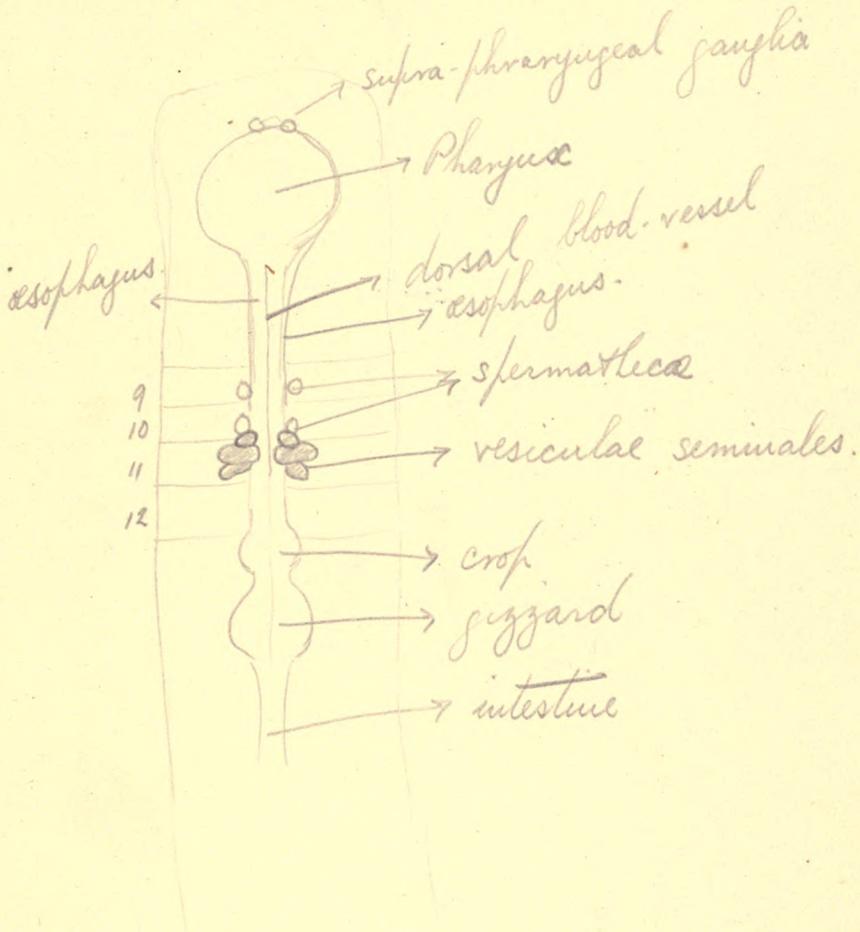


3. Extract a *seta* with forceps. Mount and sketch under low power.



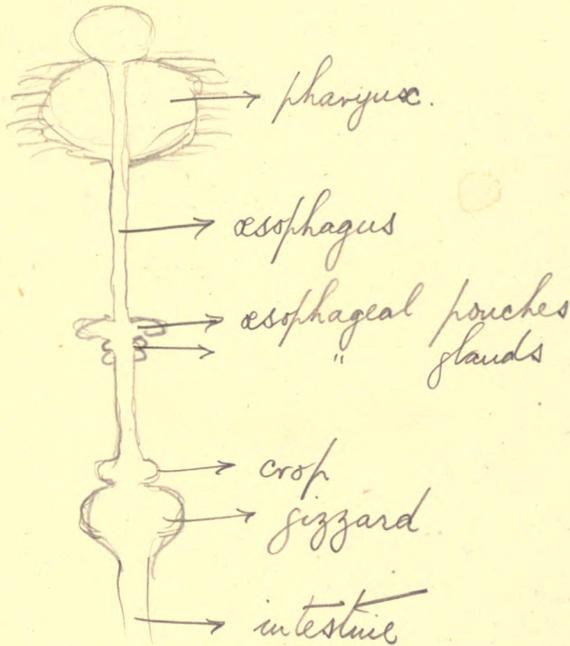


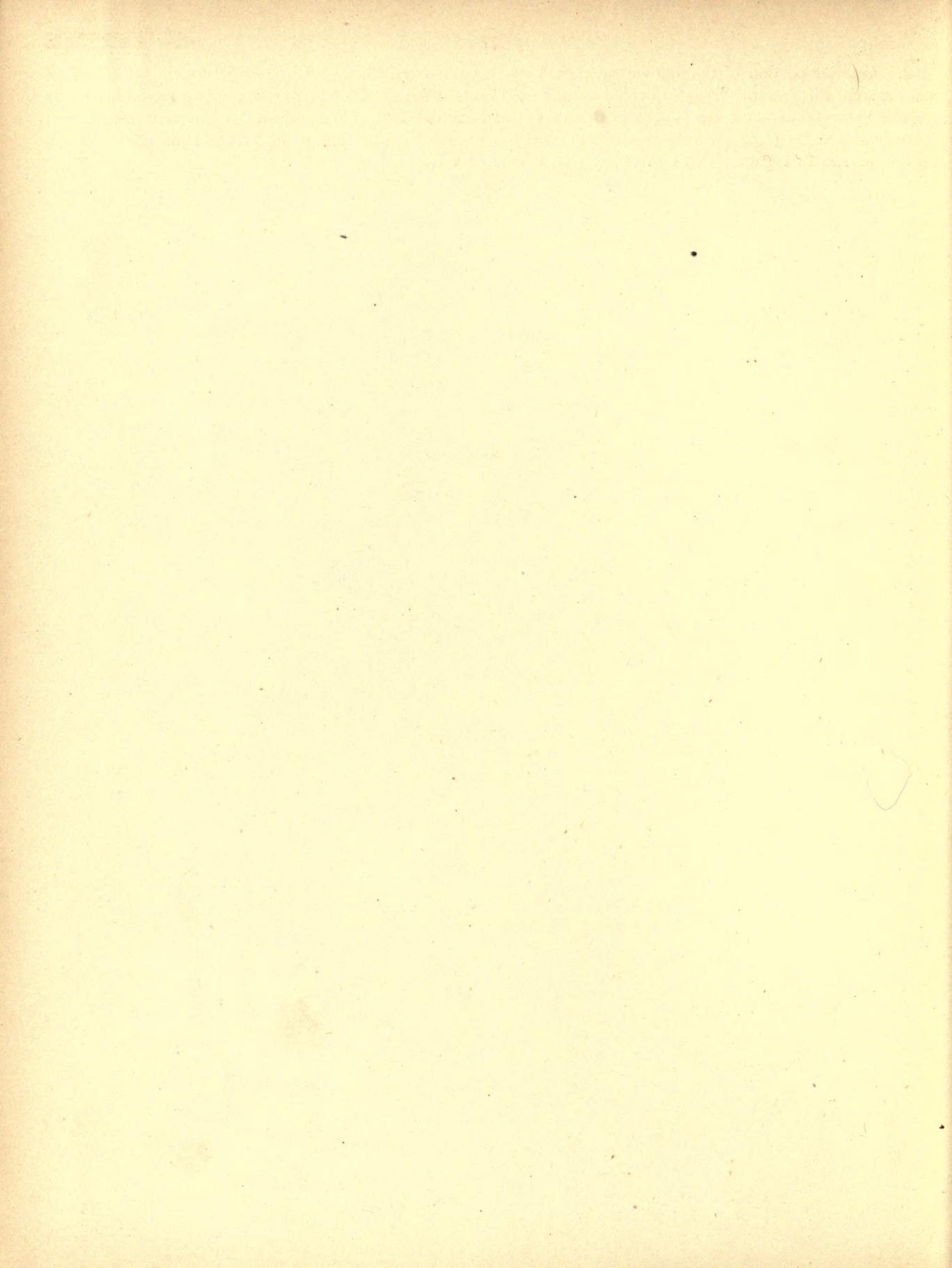
4. Pin the animal, ventral surface downwards, by two pins through the clitellum and two through the sides of the fourth segment. Stretch the body as much as possible. Open the body by a cut along the dorsal middle line from segment 20 to segment 2: fix the cut body-walls to the dissecting trough by pins on each side: *septa*; *nephridia*; *pharynx*; *supra-pharyngeal ganglia*; *oesophagus*; *vesiculæ seminales* in segments 9 to 12; *spermathecae* in segments 9 and 10; *crop*; *gizzard*; *intestine*; *dorsal blood-vessel*; *pseudo-hearts* in segments 7 to 11.



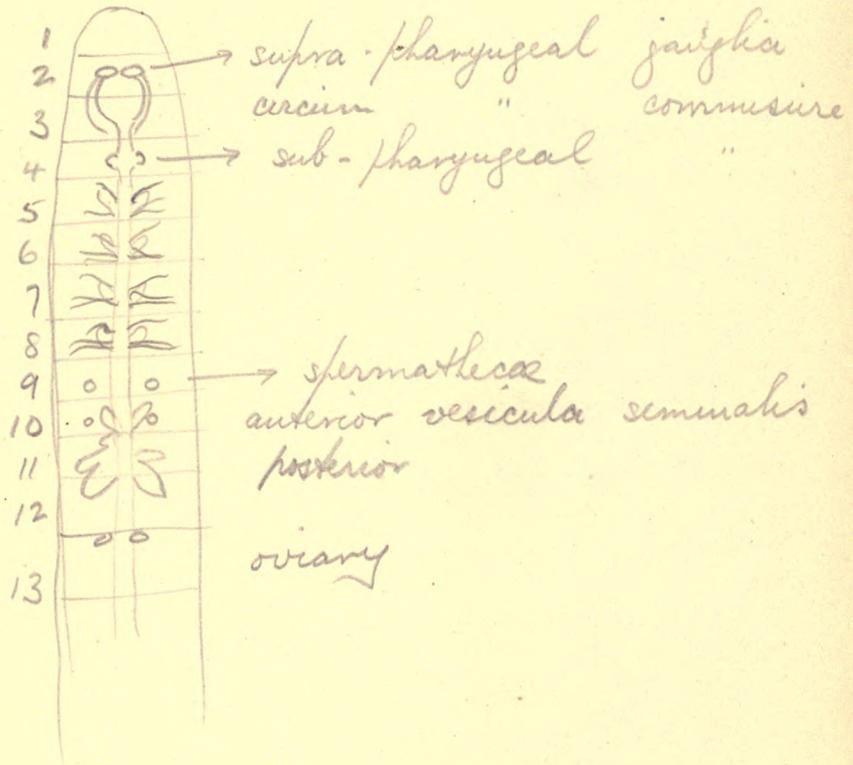


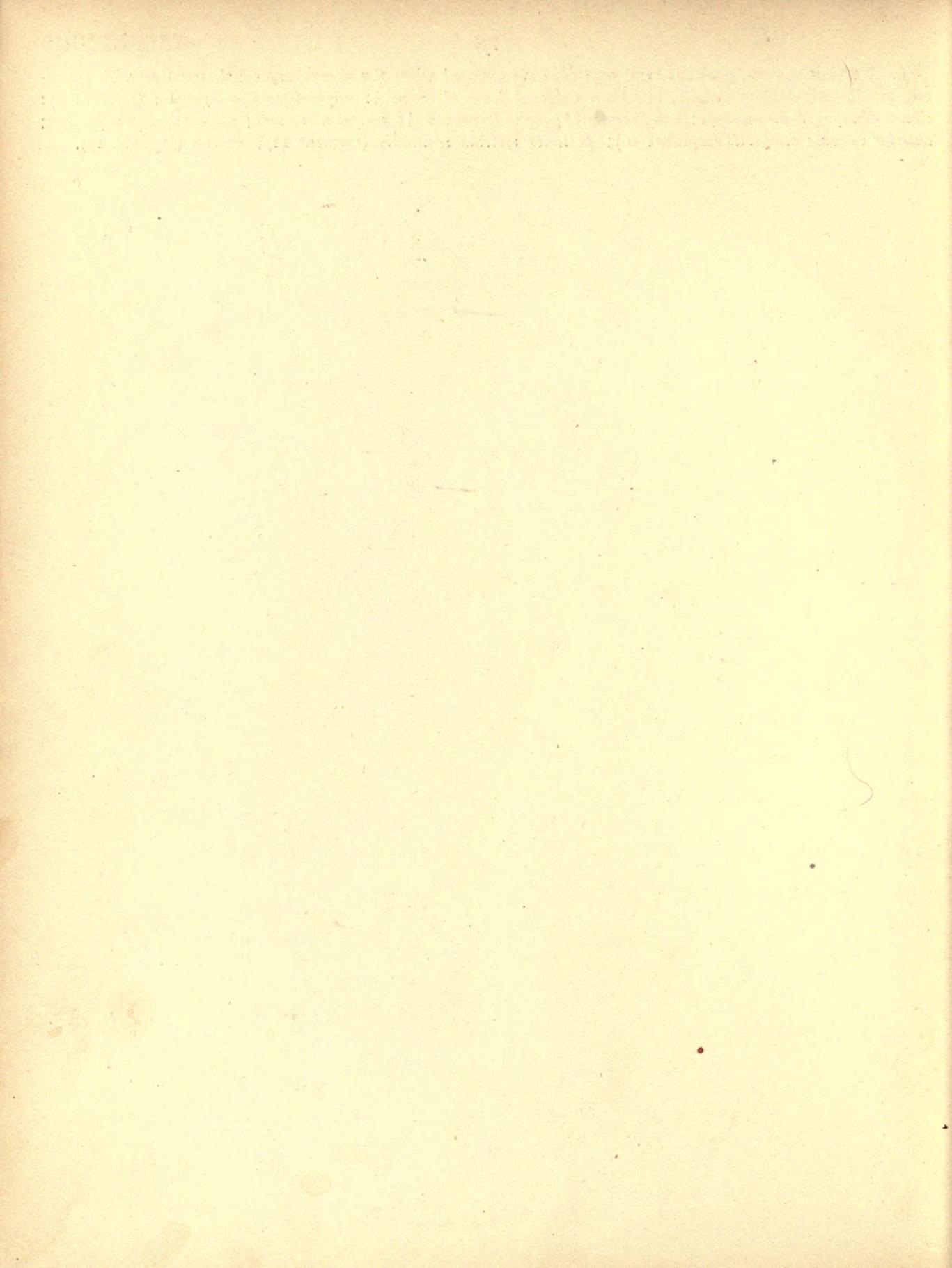
5. Anterior portion of the alimentary canal as seen when freed of surrounding structures in the following manner: cut through intestine just behind gizzard; lift up the gizzard with forceps and working forward separate the alimentary canal from the septa; pin down the alimentary canal as thus reflected: *pharynx*; *oesophagus*; *oesophageal pouches* (segment 10); *oesophageal glands* (segments 11 and 12); *crop*; *gizzard*; *intestine*. Look for the *ovaries* in segment 13 as the dissection is carried forward.





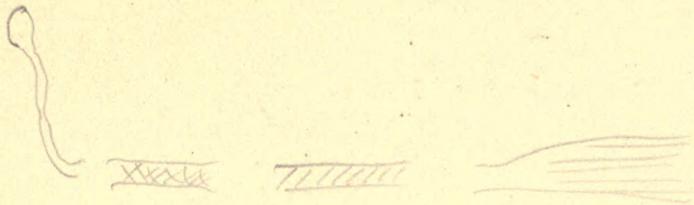
6. Nervous system, genitalia, and nephridia, as exposed when the alimentary canal, together with supra- and sub-intestinal blood-vessels, has been reflected forward as in 5: *supra-pharyngeal ganglia* (segment 3); *circum-pharyngeal commissure*; *sub-pharyngeal ganglia* (segment 4); *ventral nerve cord*; *spermathecae*; *nephridia*; *anterior vesicula seminalis* (segment 10); *posterior vesicula seminalis* (segment 11); *ovaries* (segment 13).





To make the observations under 7, 8, 9, 10 it will be necessary to use a worm which has been opened under 75 per cent. (normal) salt solution.

7. Nephridium removed and seen under low power: *nephrostome*; *glandular part*; *blood capillaries*; *muscular discharging part*.



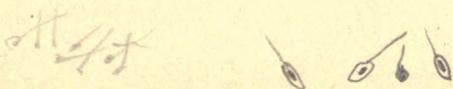
8. Ovary under low power: *immature ova*; *ripe ova*.



9. Place a drop of the contents of a seminal vesicle on a coverslip and fix at once with 90 per cent. alcohol. Wash gently with 70 per cent. alcohol, then with 50 per cent. alcohol. Place coverslip in watch glass containing picocarmine for 15 minutes. Wash in water and mount in dilute glycerine. Sketch various *stages of development of spermatozoa*.



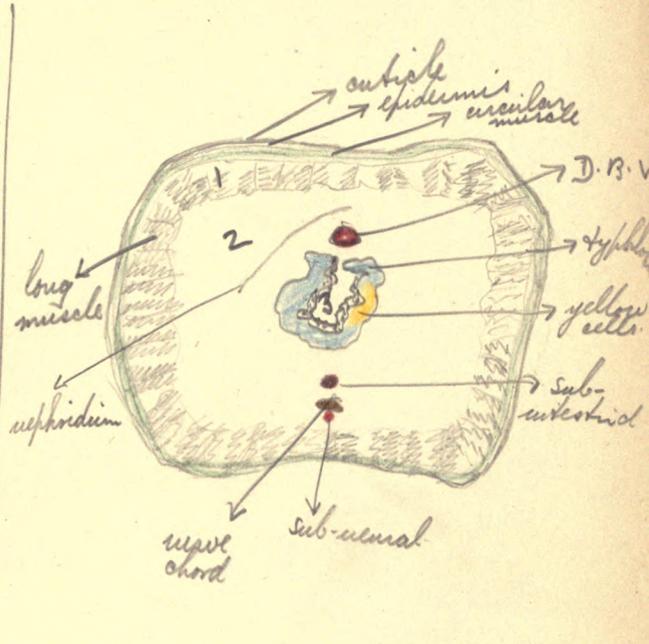
10. Treat a drop of the contents of a spermatheca as in 9. Sketch *ripe spermatozoa*.



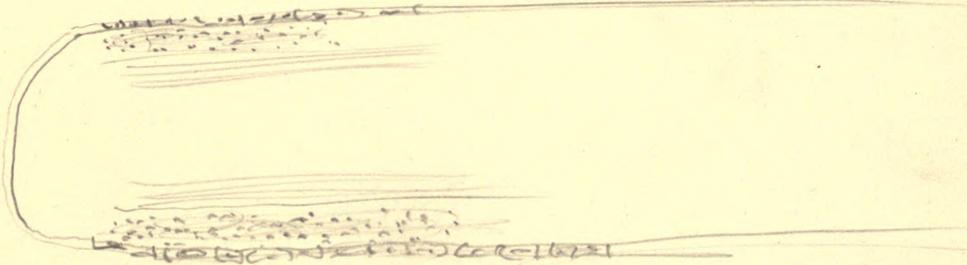


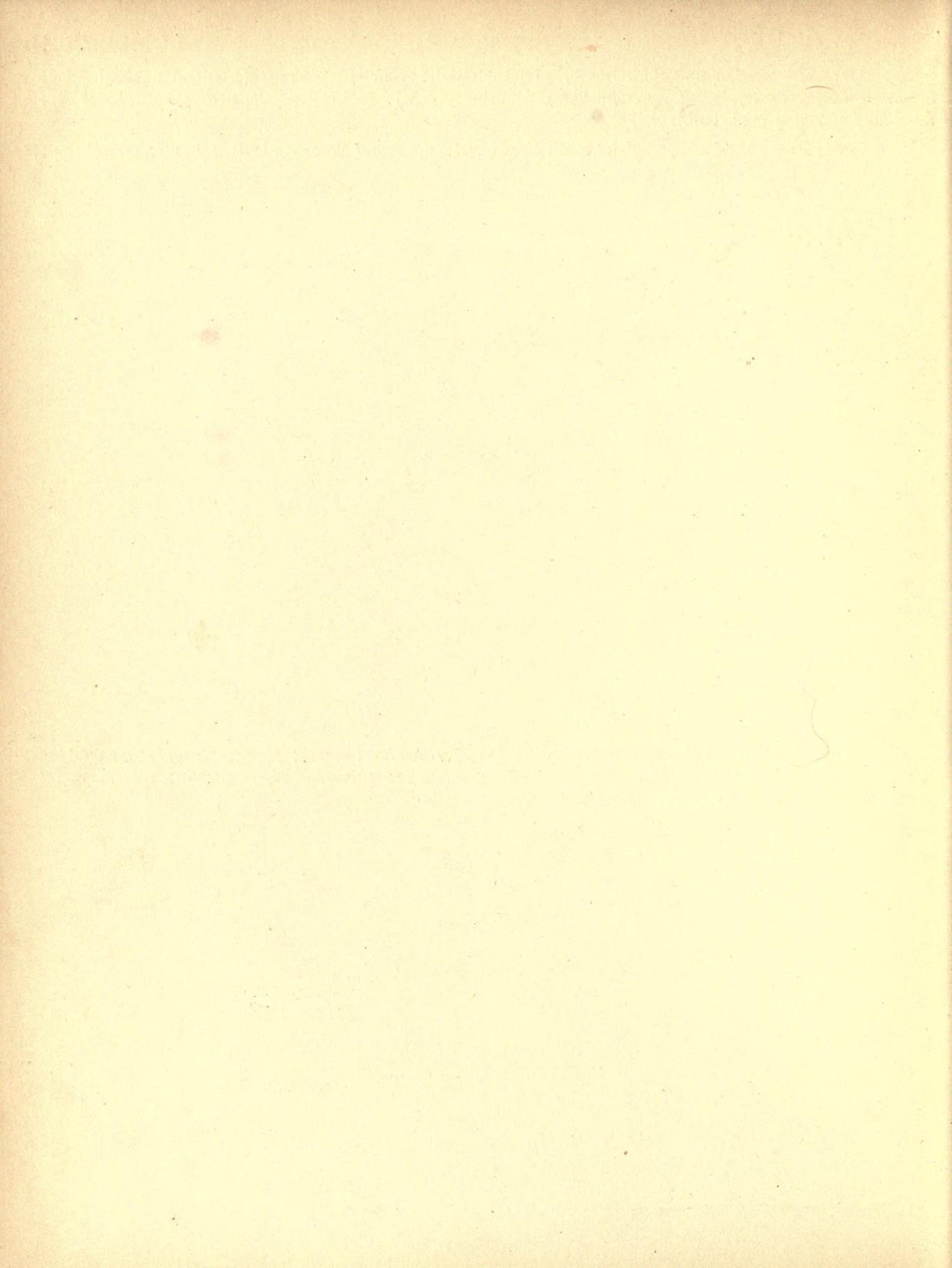
II. Transverse section under low power. (1) Body-wall: *cuticle*; *epidermis* (ectoderm); *circular and longitudinal muscular layers*. (2) Cœlom. (3) Alimentary canal: *typhlosole*; *yellow cells*; *muscular layers*; *intestinal epithelium* (endoderm).

*Nerve cord*; *dorsal blood vessel*; *sub-intestinal blood vessel*; *sub-neural blood vessel*; *lateral setæ*; *ventral setæ*; *nephridia*.

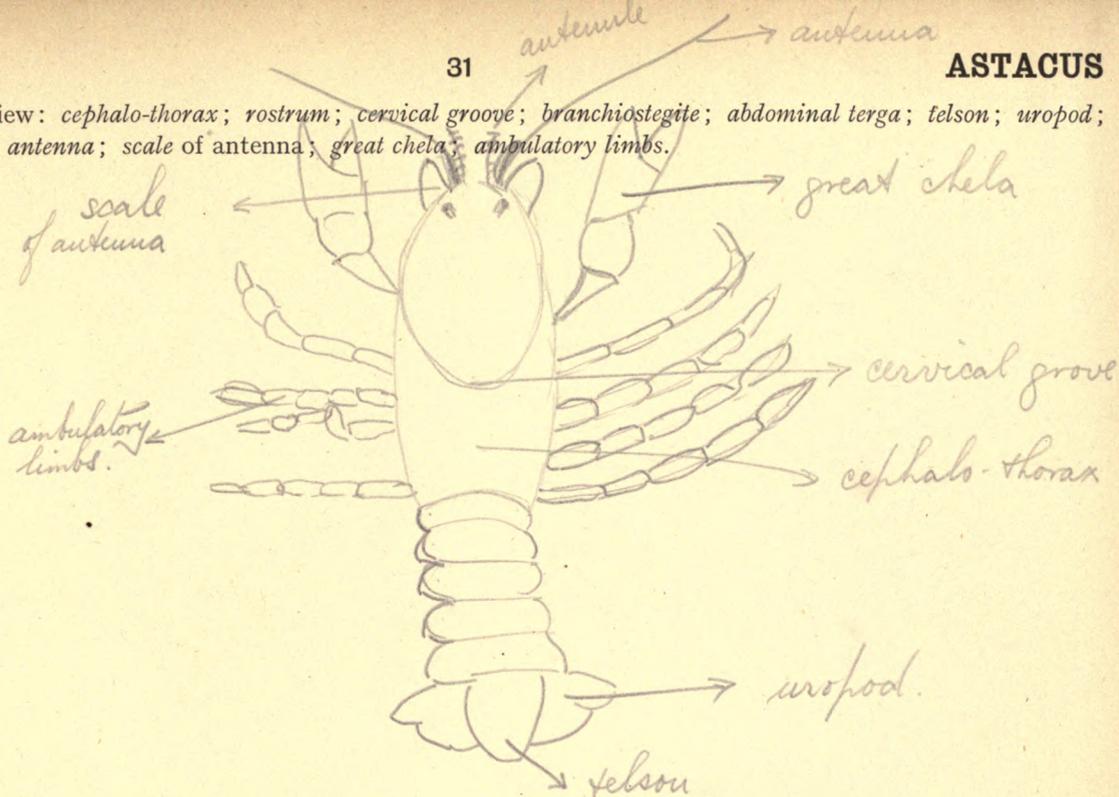


12. Longitudinal section of anterior end: *prostomium*; *peristomium*; *mouth*; *pharynx*; *œsophagus*; *œsophageal pouches and glands*; *anterior and posterior vesiculæ seminales*; *supra-pharyngeal ganglia*; *sub-pharyngeal ganglia*; *nerve cord*; *septa*; other names as in II.

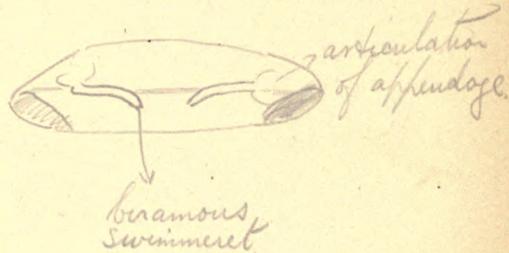
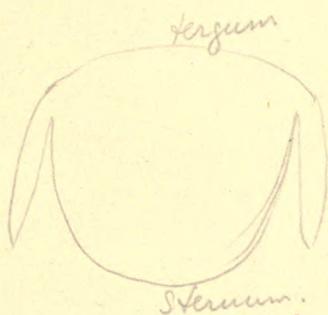




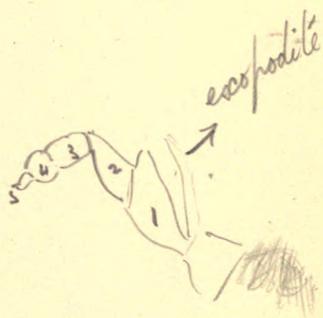
1. Dorsal view: cephalo-thorax; rostrum; cervical groove; branchiostegite; abdominal terga; telson; uropod; eye; antennule; antenna; scale of antenna; great chela; ambulatory limbs.



2. Fifth abdominal segment from behind: tergum; sternum; articulation of appendage; biramous swimmeret.

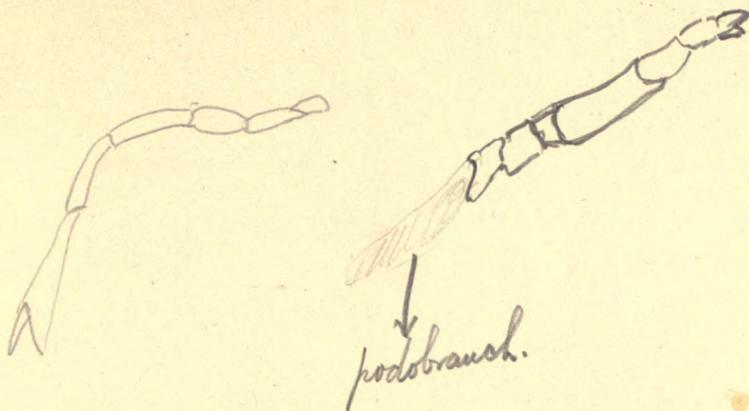


Mandible.



Remove all the appendages of one side from behind forwards, and pin them out on a sheet of paper. Sketch as required below.

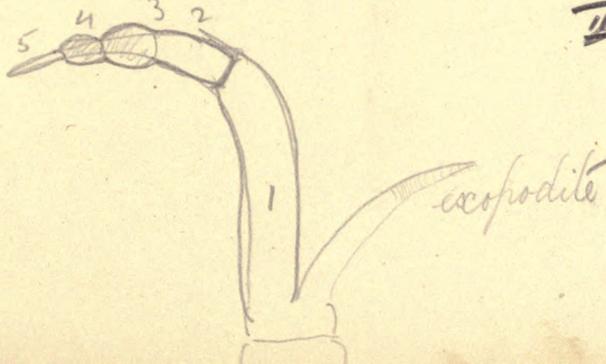
3. Third ambulatory limb. It is divided into *seven joints* of which the basal carries a *gill (podobranch)*.

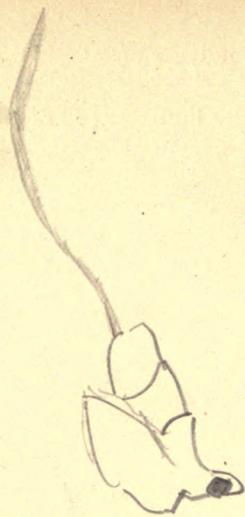


4. Mandible: *toothed edge*; two jointed *palp*; *basal end*; *tendon of muscle*.



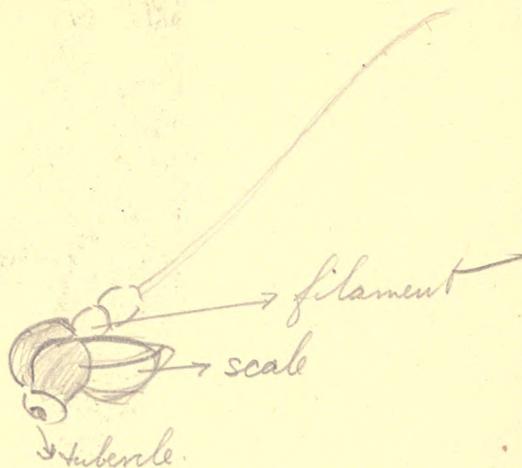
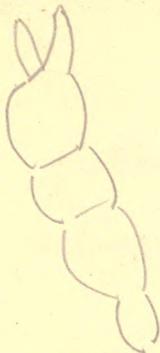
III Maxilliped





5. Antenna: two-jointed *basal portion*; *tubercle* carrying orifice of the green gland; *pointed scale*; *filament* of three large basal joints and a many-jointed continuation.

Great Chilae

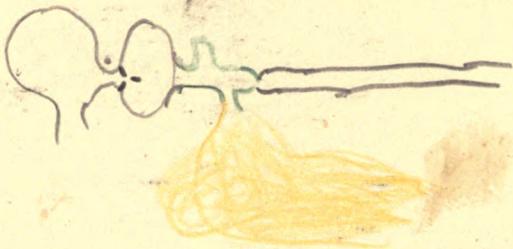


6. Antennule: three-jointed *basal portion*; outer and inner many-jointed *filaments*.



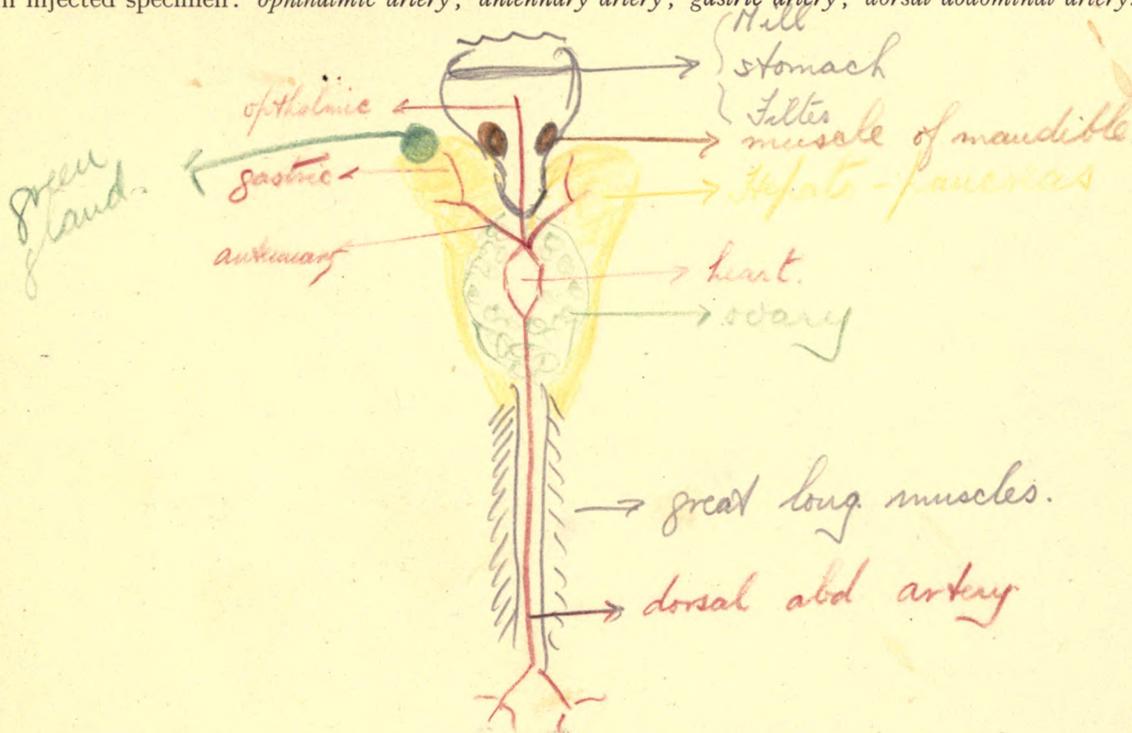
7. Enlarged view of dorsal aspect of the basal joint of same: opening of *statocyst*. Cut open the joint to see the statocyst, containing grains of sand.



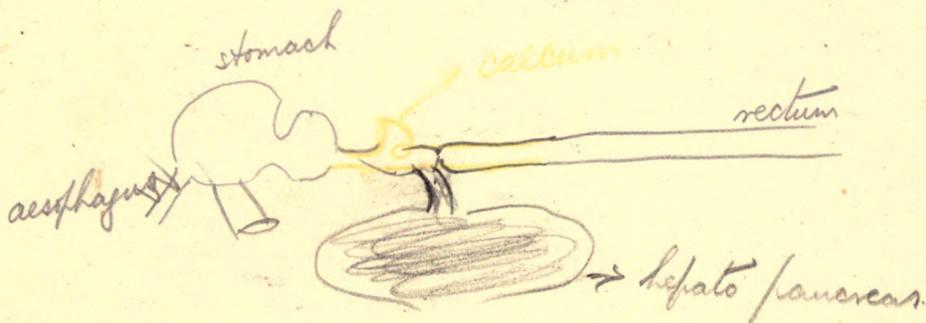


8. Dorsal aspect of a crayfish from which the carapace and the abdominal terga have been removed: heart, with two dorsal ostia; testis or ovary; stomach; hepato-pancreas; intestine; muscle of the mandible; great longitudinal muscles.

In injected specimen: ophthalmic artery; antennary artery; gastric artery; dorsal abdominal artery.

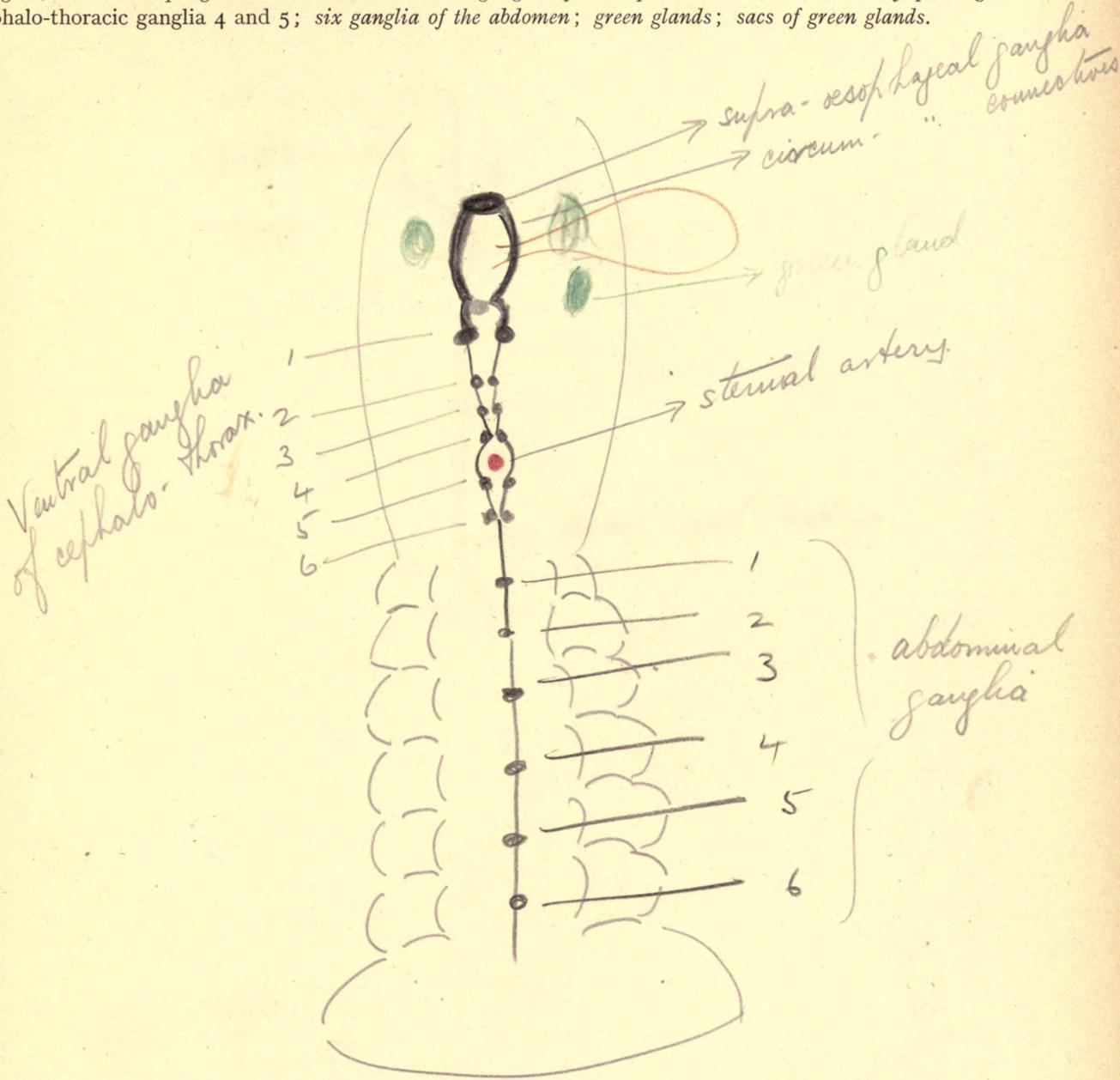


9. Alimentary canal removed from body and seen from the side: œsophagus; stomach; mesenteron; dorsal cœcum; hepato-pancreas; rectum.



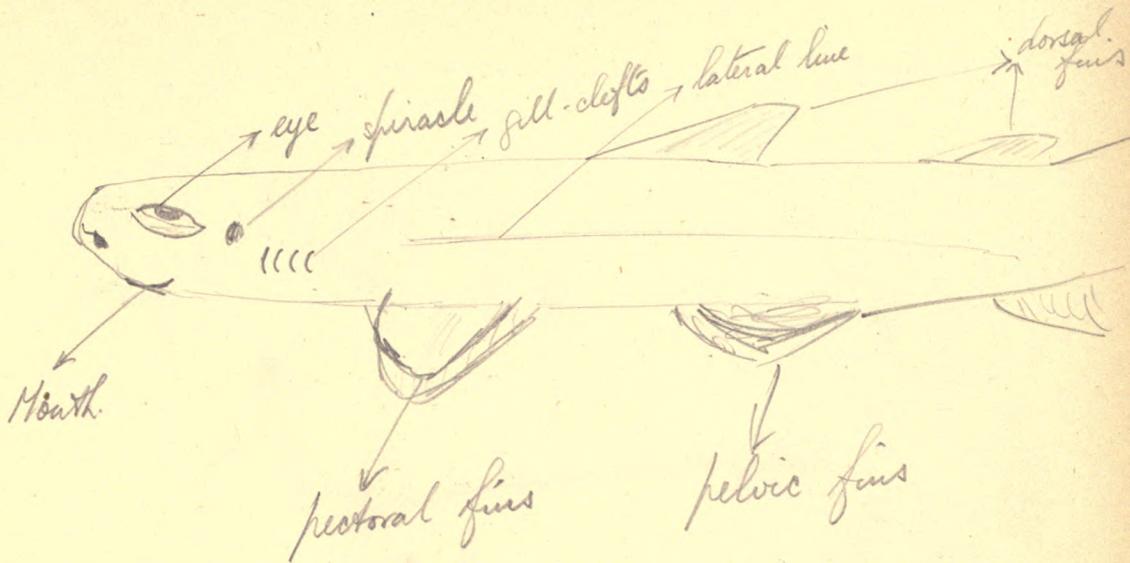


10. The same crayfish with all its viscera removed except the green glands which lie right and left of the mouth. The muscles of the tail and the false bottom of the thorax have also been removed. *Supra-oesophageal ganglia*; *circum-oesophageal connectives*; *six ventral ganglia of the cephalo-thorax*; *sternal artery* passing between cephalo-thoracic ganglia 4 and 5; *six ganglia of the abdomen*; *green glands*; *sacs of green glands*.

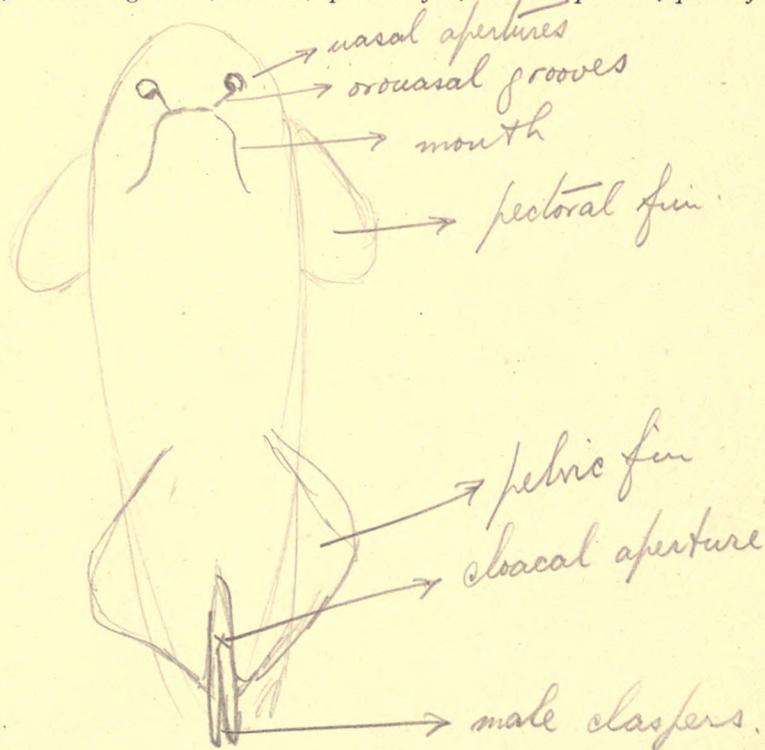


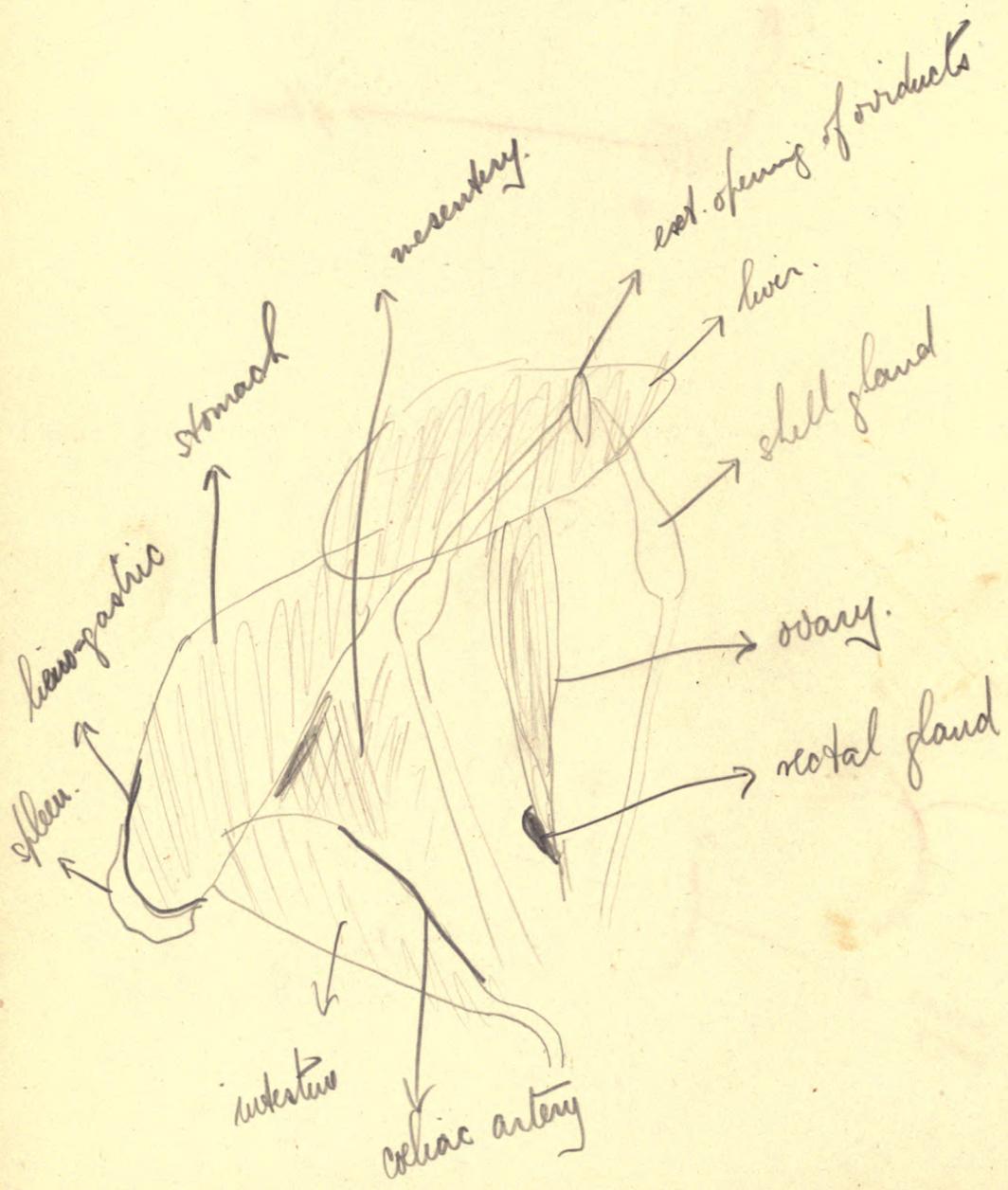


1. Side view: eye; mouth; spiracle; gill-clefts; lateral line; pectoral fins; pelvic fins; dorsal fins; anal fin; caudal fin. Strip off a small portion of skin to shew the myomeres.

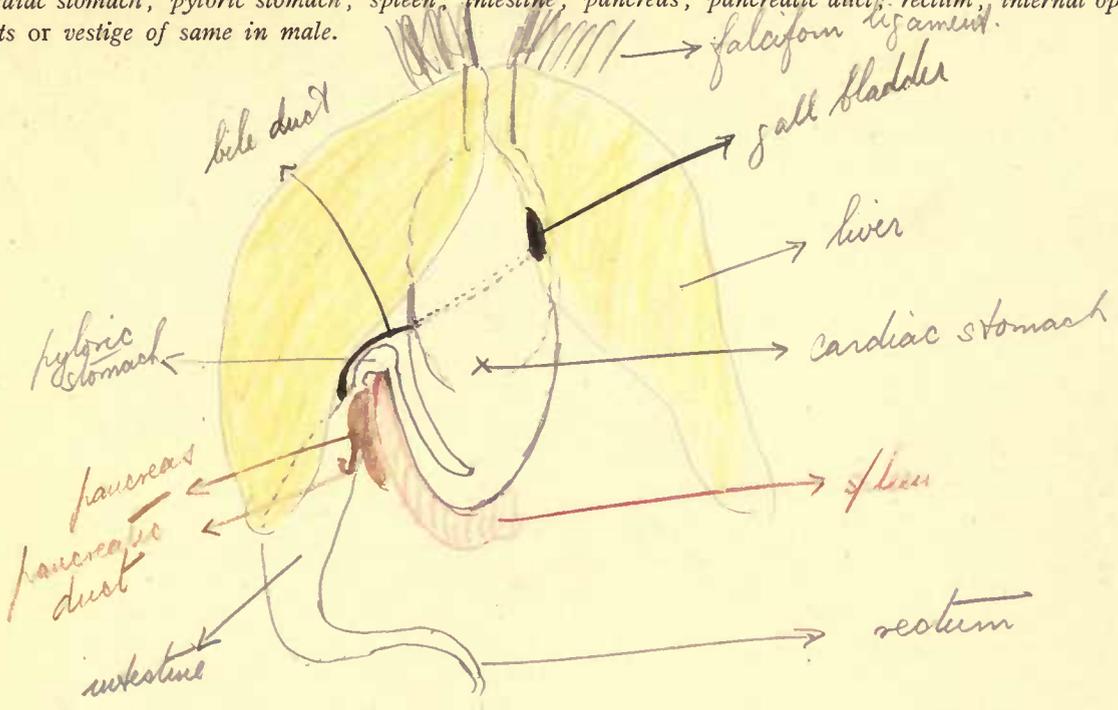


2. Ventral view: nasal apertures; oronasal grooves; mouth; pectoral fin; cloacal aperture; pelvic fins, with claspers in the male.

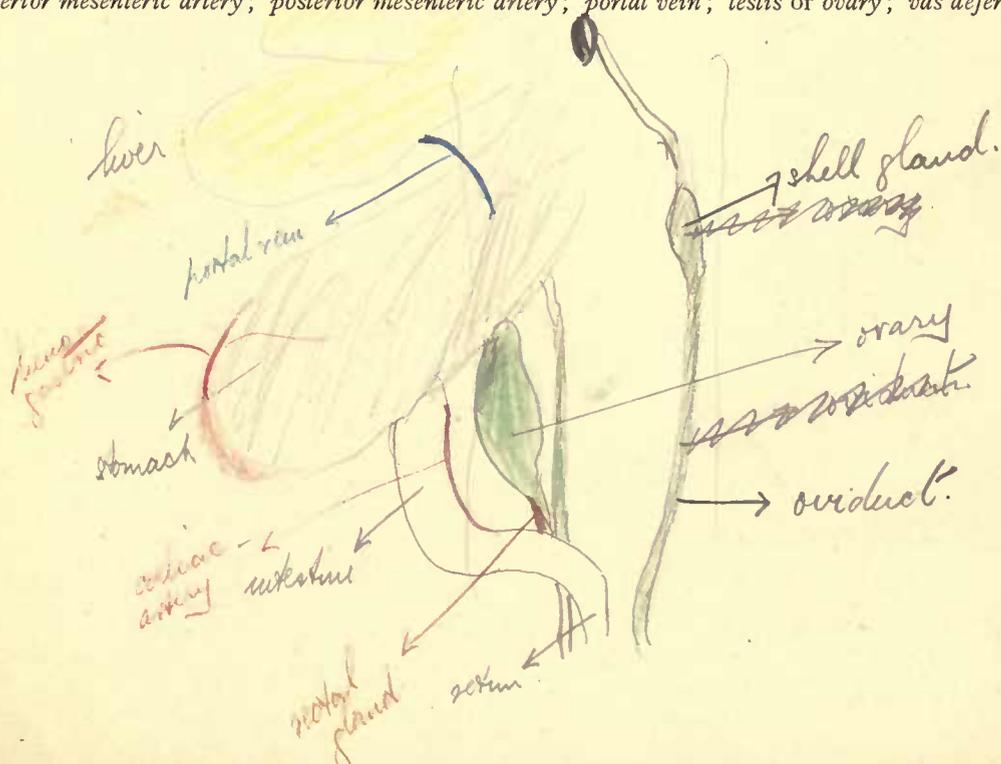




3. Ventral view of contents of body cavity: *falciform ligament*; *bilobed liver*; *position of gall bladder*; *bile duct*; *cardiac stomach*; *pyloric stomach*; *spleen*; *intestine*; *pancreas*; *pancreatic duct*; *rectum*; *internal opening of oviducts or vestige of same in male*.

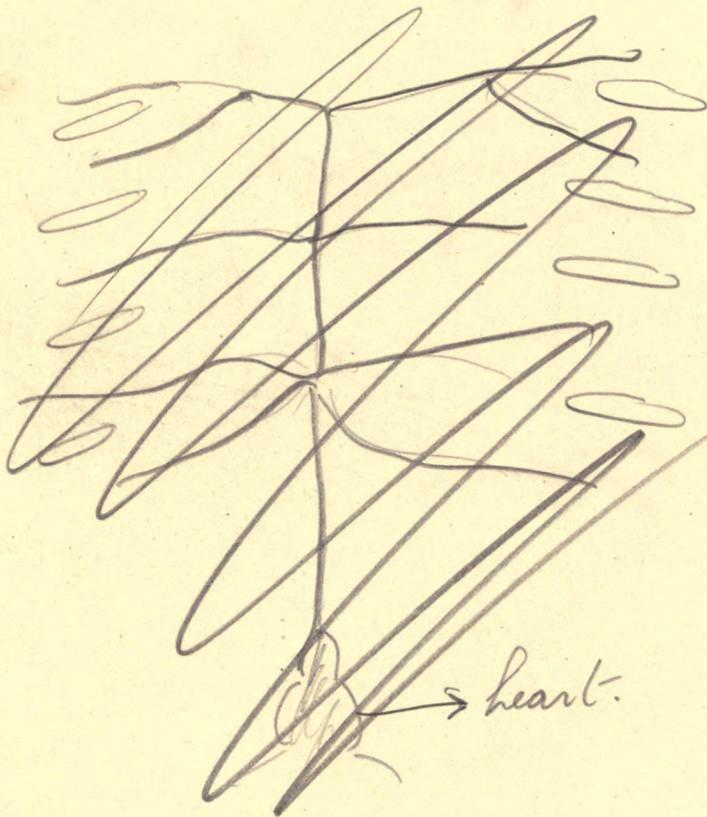


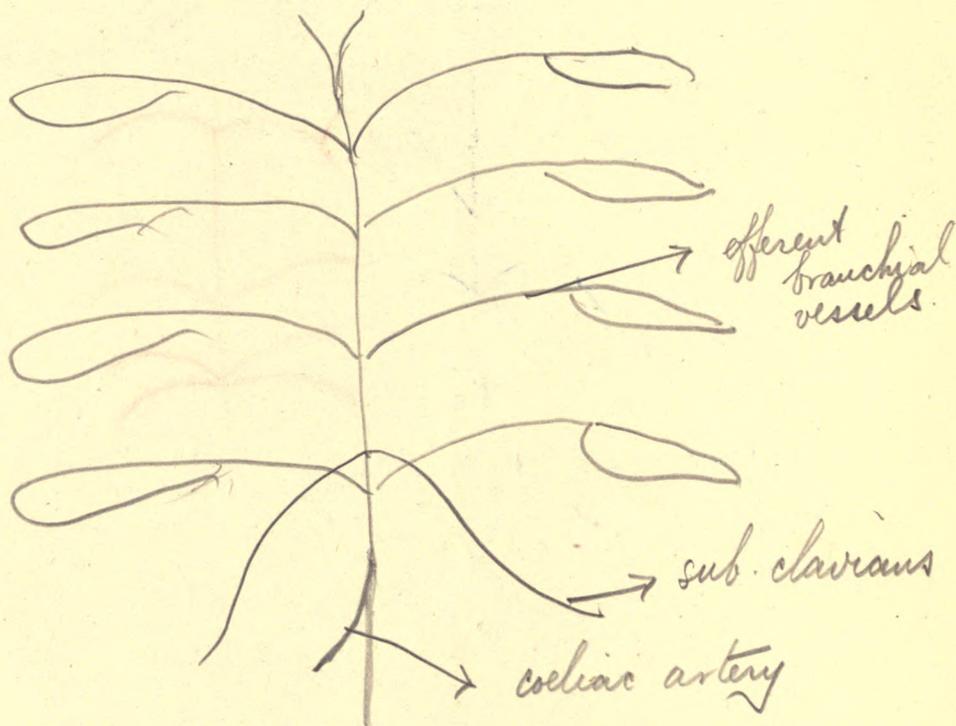
4. Contents of body cavity from right side, as seen after turning the liver forward and drawing the stomach downward: *falciform ligament*; *liver*; *stomach*; *intestine*; *rectum*; *rectal gland*; *coeliac artery*; *lieno-gastric artery*; *anterior mesenteric artery*; *posterior mesenteric artery*; *portal vein*; *testis or ovary*; *vas deferens or oviduct*.



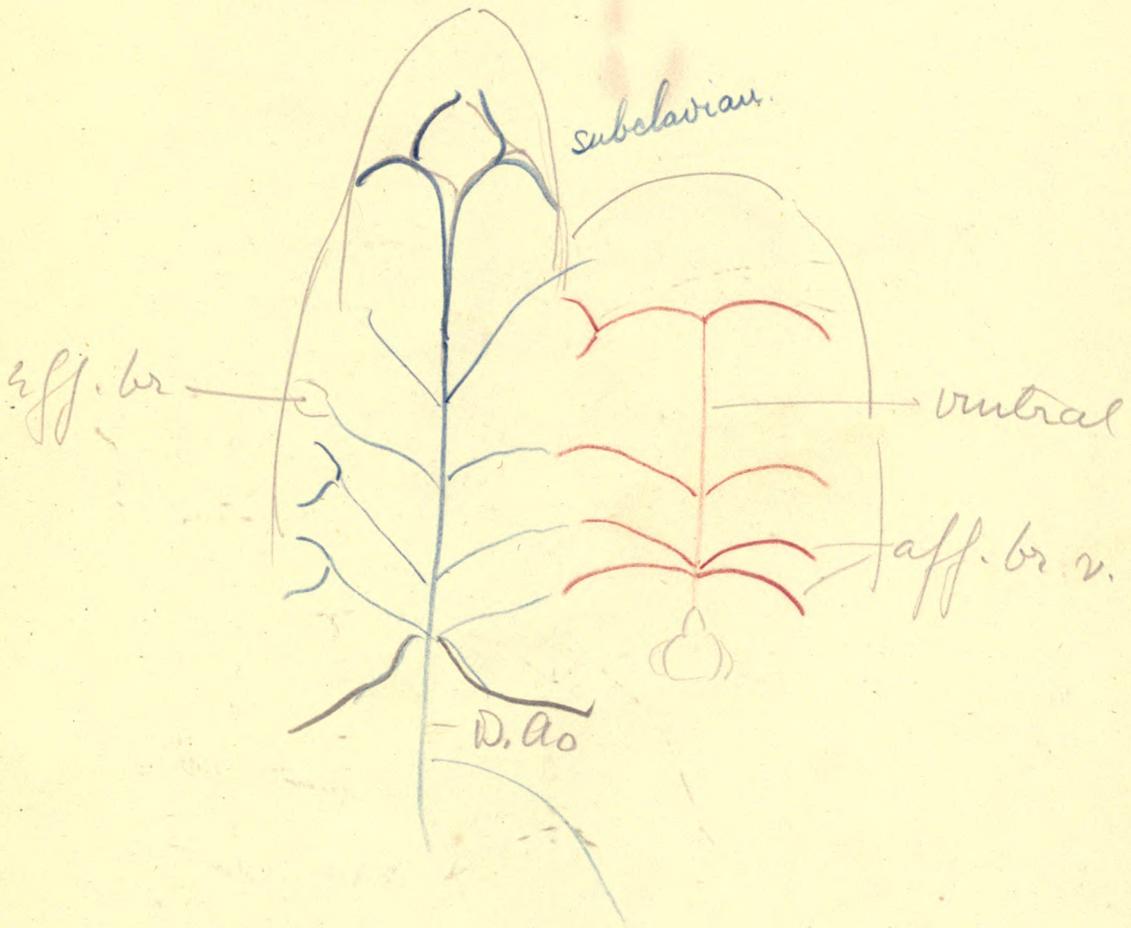


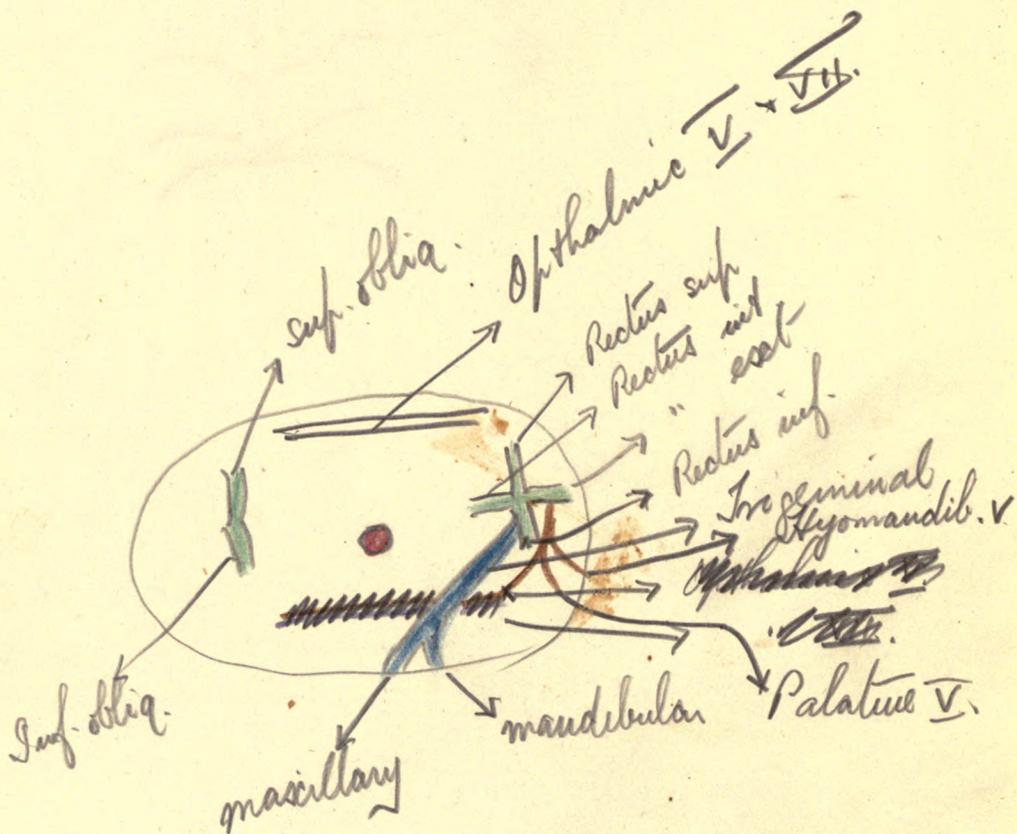
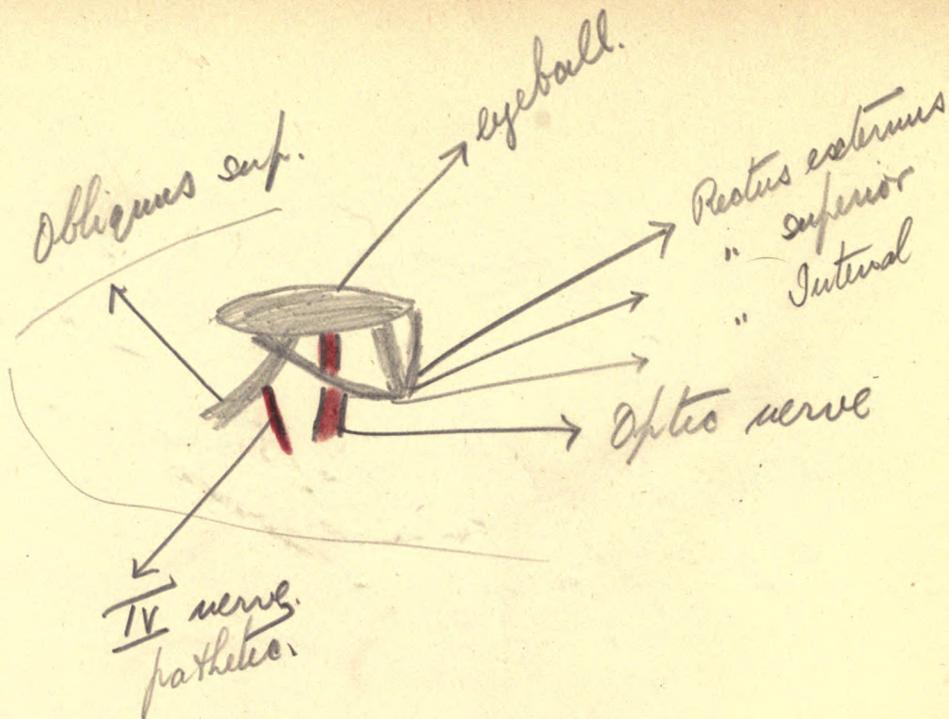
5. Ventral view of heart and great vessels as exposed by a cut in the middle ventral line from the mouth to the pericardium: *sinus venosus*; *auricle*; *ventricle*; *conus arteriosus*; *hepatic sinus*; *posterior cardinal sinus*; *anterior cardinal sinus*; *ductus Cuvieri*; *ventral aorta*; *afferent branchial vessels*; *thyroid gland*; *pericardio-peritoneal opening*; *gill clefts and gills*.



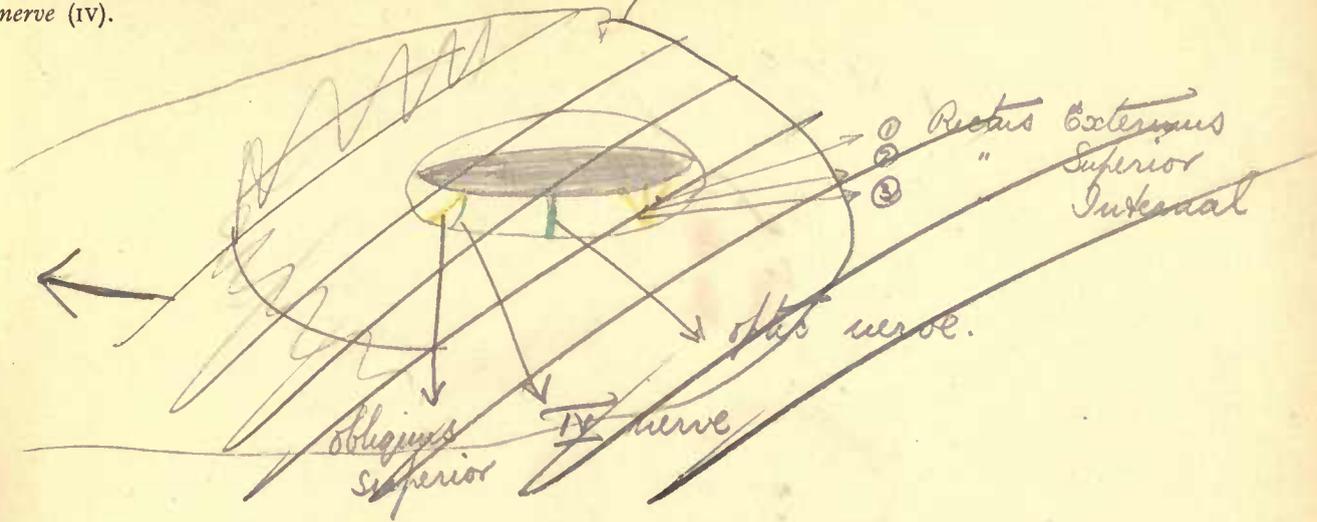


6. The efferent branchial vessels, carotid arteries and anterior portion of the dorsal aorta, as seen after cutting through the jaw and branchial arches on one side, turning the floor of the mouth outwards and removing the mucous membrane from the roof of the mouth: *efferent branchial vessels*; *dorsal aorta*; *subclavian artery*; *celiac artery*; *common carotid artery*; *external carotid*; *internal carotid*; *gill clefts and gills*.

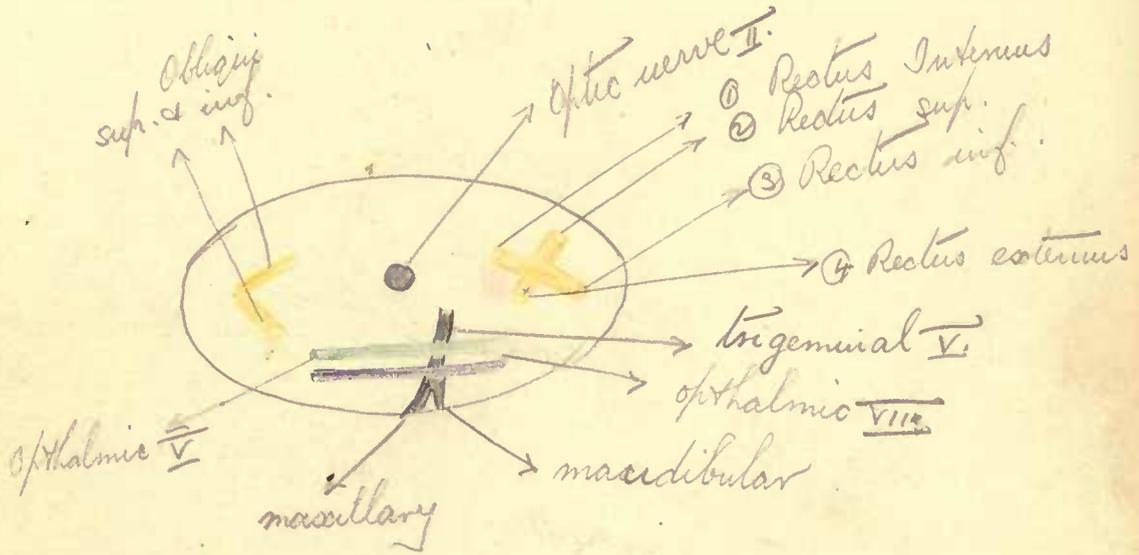


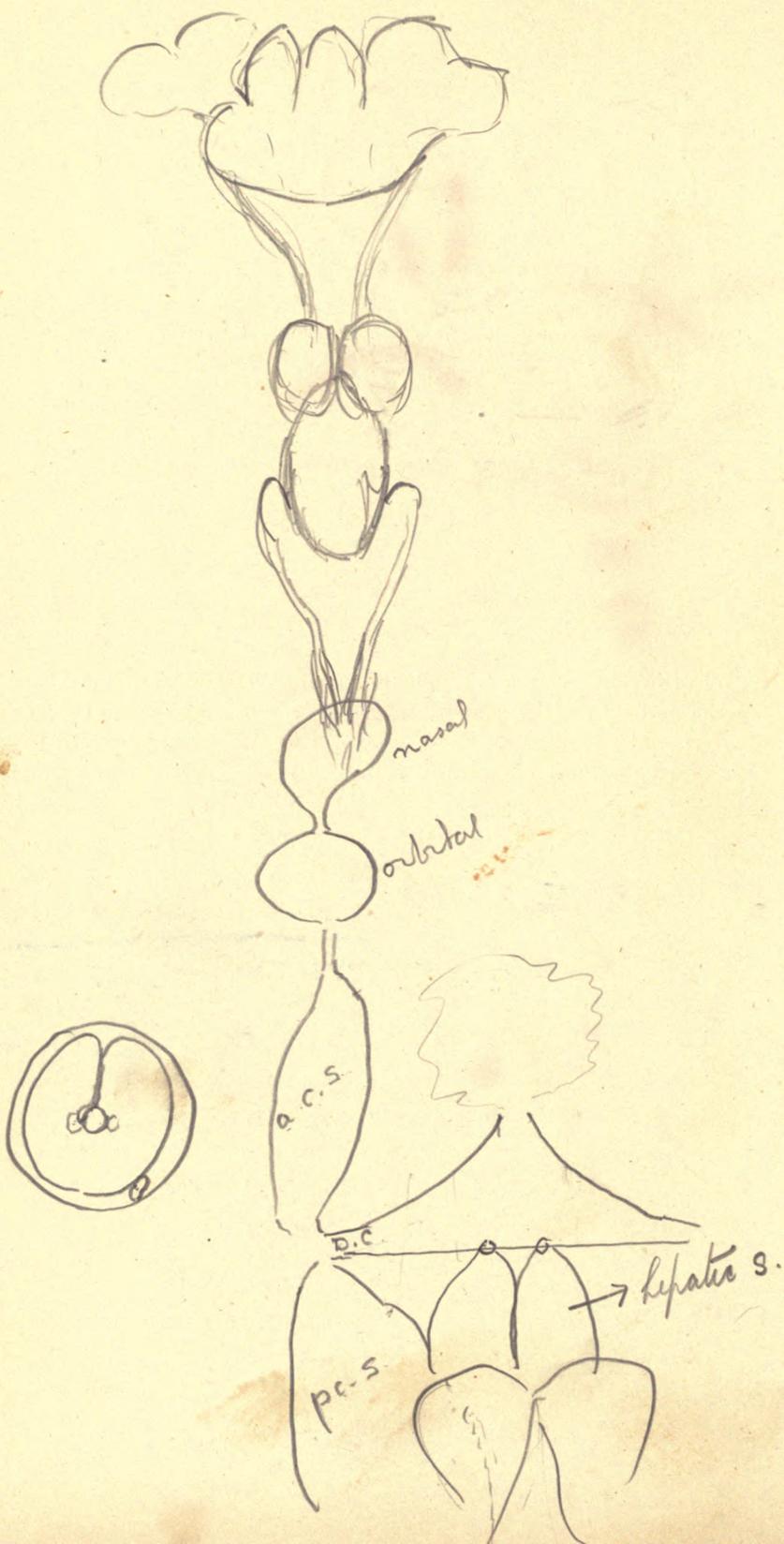


7. Dorsal view of orbit, as seen after cutting through the skin round the eye and pulling the eyeball outwards: eyeball; rectus externus; rectus internus; rectus superior; obliquus superior; optic nerve (II); pathetic nerve (IV).

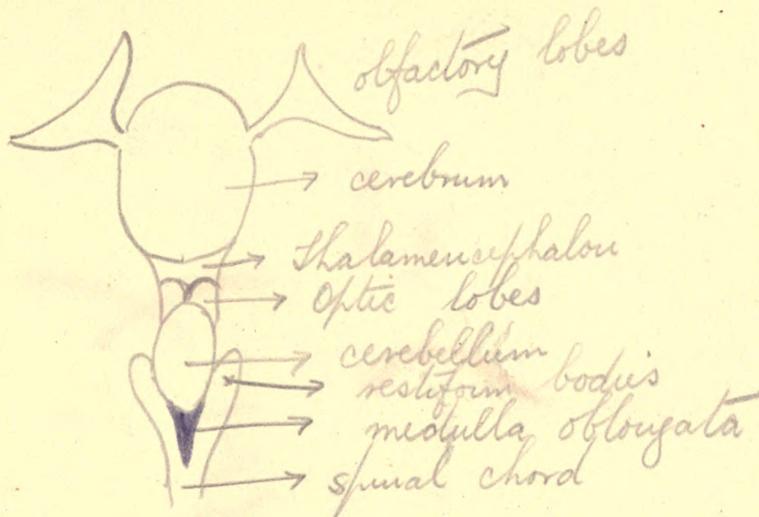


8. Contents of orbit after removal of eye by cutting through the six muscles and optic nerve close to the eyeball: recti externus, internus, superior and inferior; obliqui superior and inferior; optic nerve (II); oculo-motor (III); pathetic (IV); main trunk of trigeminal (V), dividing into maxillary and mandibular branches; ophthalmic branch of V; hyomandibular, palatine and ophthalmic branches of facial (VII).

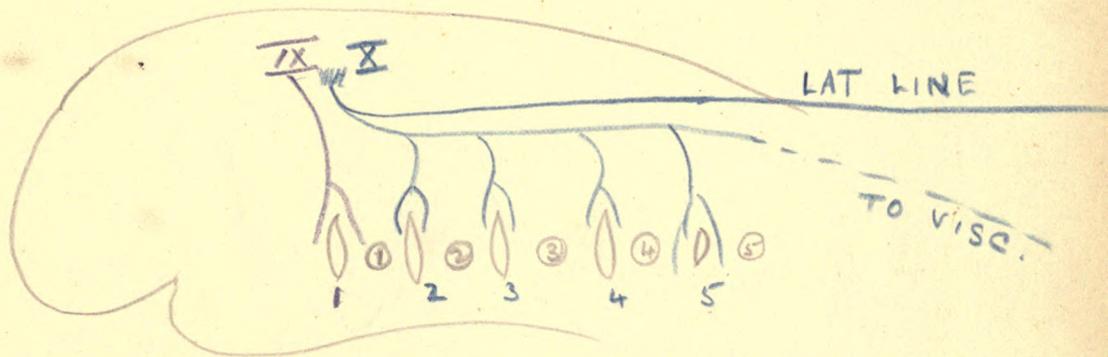


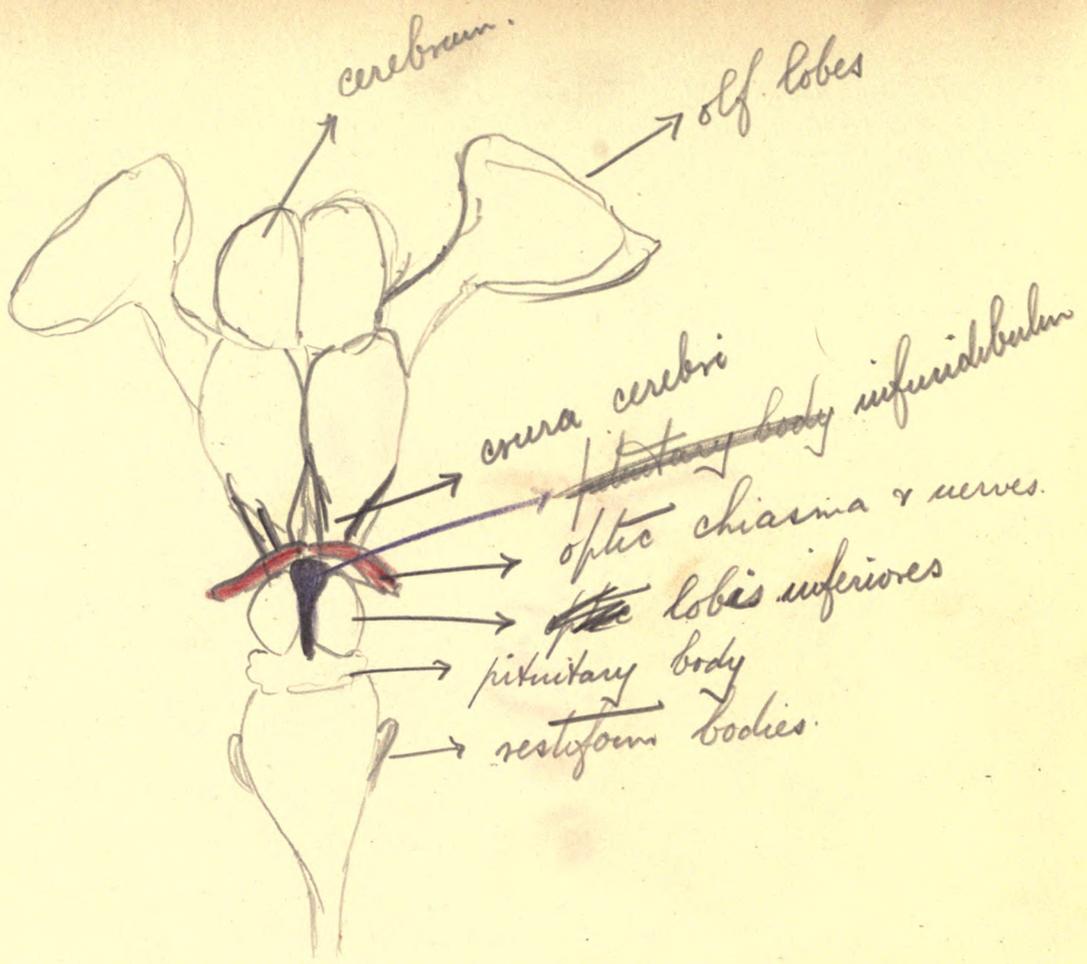


9. Dorsal view of brain and spinal cord: *olfactory lobes*; *cerebrum*; *thalamencephalon*; *optic lobes*; *cerebellum*; *medulla oblongata*; *restiform tracts*; *fourth ventricle*; *spinal cord*; *roots of cranial nerves II, III, IV, V, VII, VIII, IX and X*; *spinal nerves*.

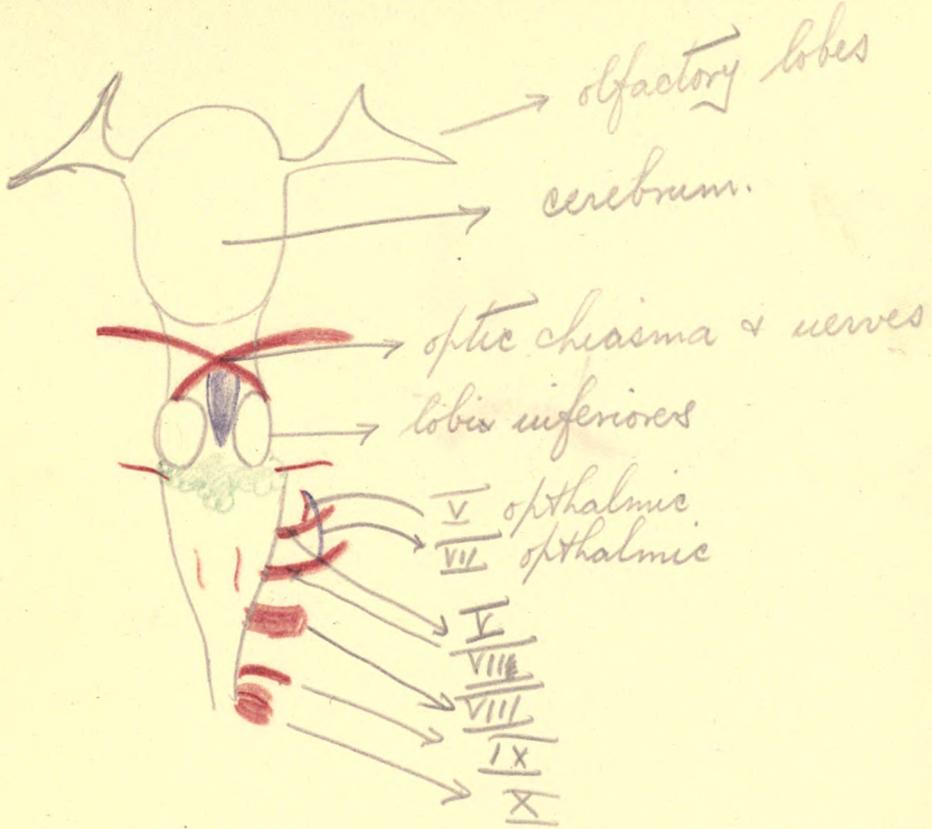


10. Glossopharyngeal (IX) and vagus (X) nerves as seen after slicing horizontally through the auditory capsule until the nerves are exposed and then slitting open the anterior cardinal sinus: *root of IX*; *branches of IX to hyoid and first branchial arches*; *root of X*; *branches of X to lateral line, to branchial arches 1 to 5, to heart and viscera*; *gill pouches*.

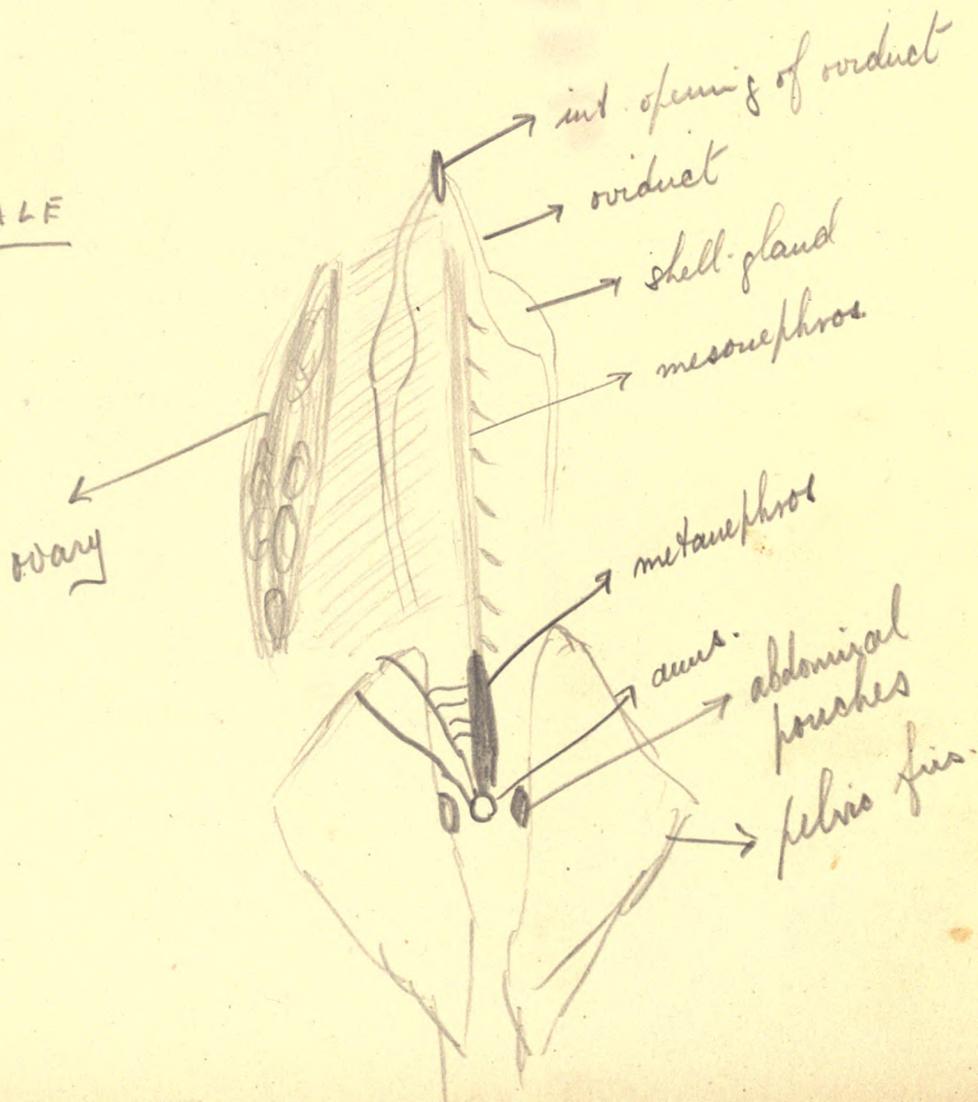




II. Ventral view of brain, removed from the skull: *olfactory lobes*; *cerebrum*; *optic chiasma* and *nerves*; *infundibulum*; *pituitary body*; *crura cerebri*; *medulla oblongata*; *restiform tracts*; *roots of cranial nerves III, V, VI, VII, VIII, IX and X.*



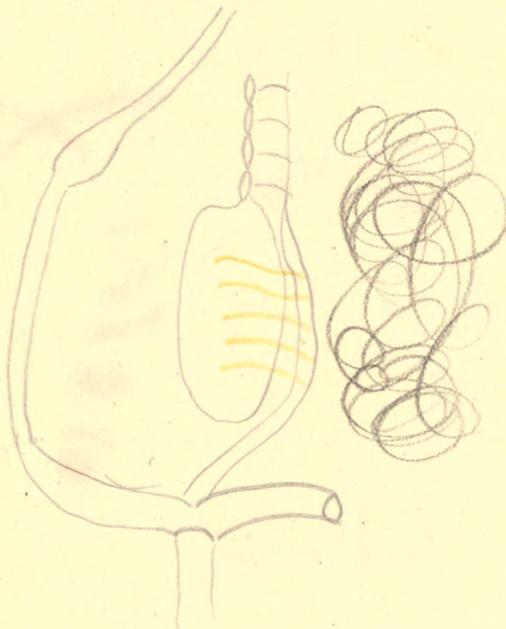
FEMALE

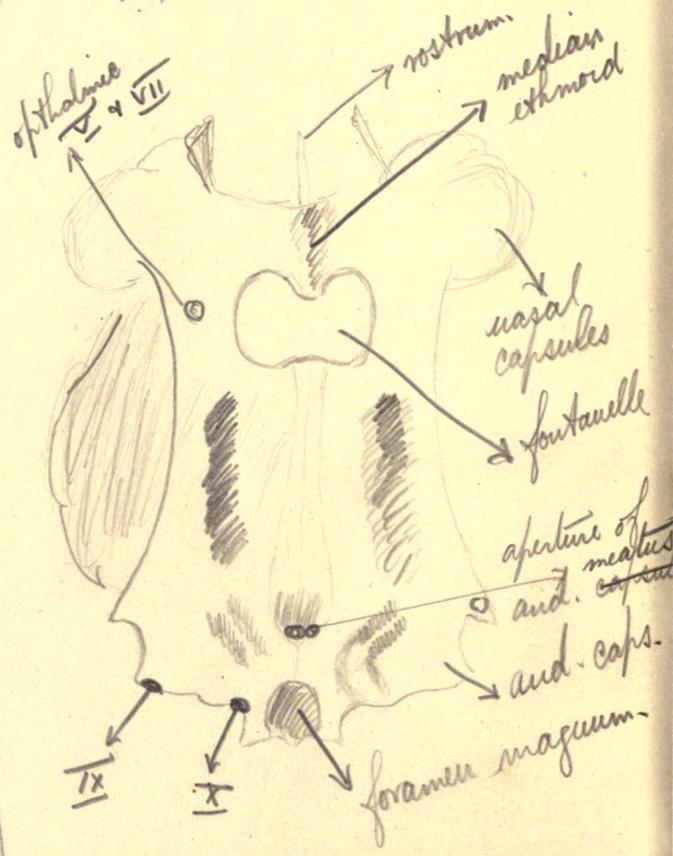
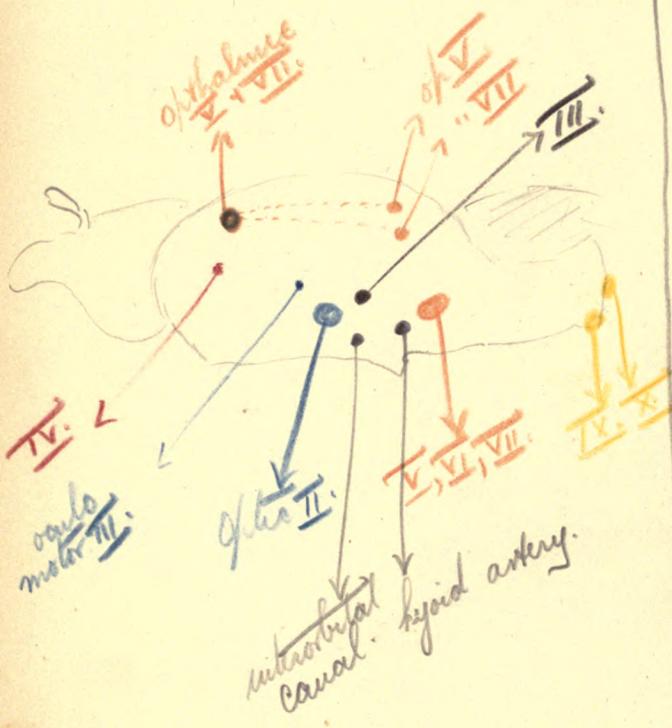
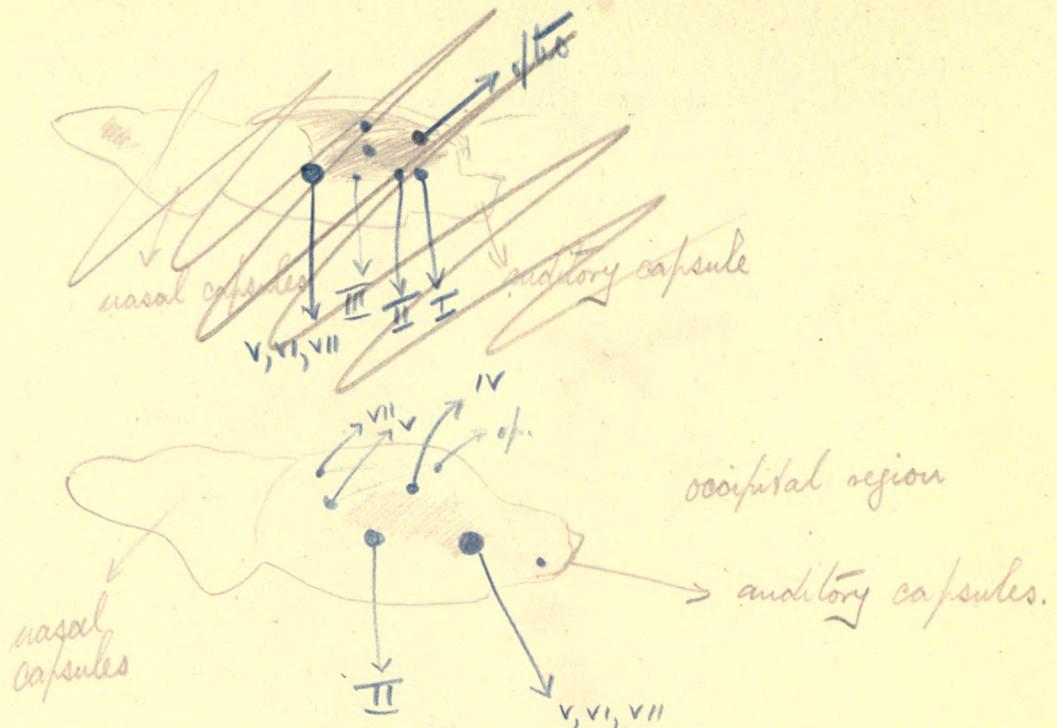


12. Ventral view of kidney and generative organs after slitting open the cloaca.

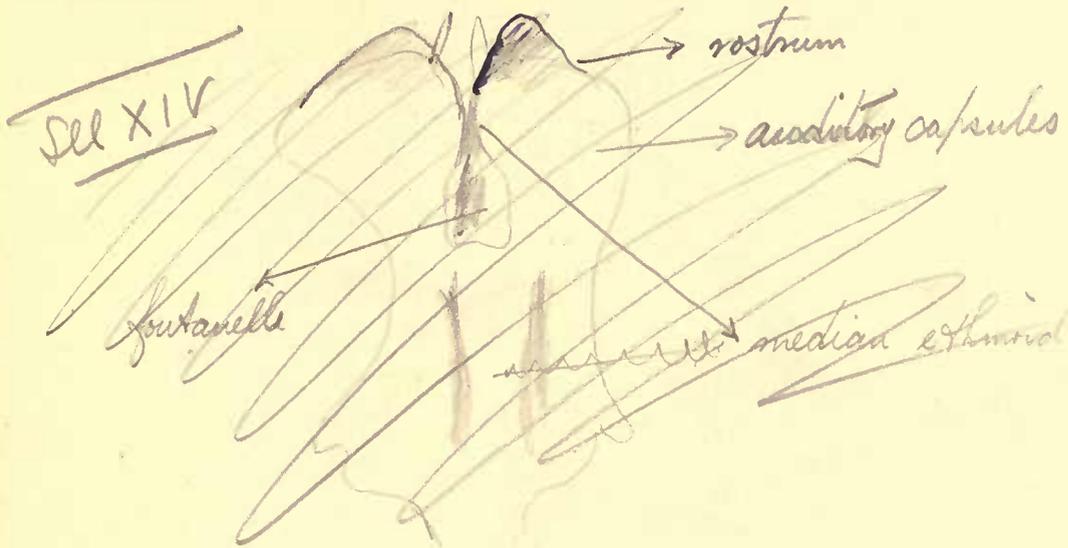
(a) Male: *testis*; *vasa efferentia*; *vas deferens*; *seminal vesicle*; *sperm sac*; *metanephros*; *ureter*; *cloaca*; *anus*; *urino-genital papilla*; *abdominal pouches*; *pelvic fins*.

(b) Female: *ovary*; *oviduct*; *internal opening of oviduct*; *shell gland*; *cloacal opening of oviduct*; *metanephros*; *cloaca*; *anus*; *urinary papilla*; *abdominal pouches*; *pelvic fins*.

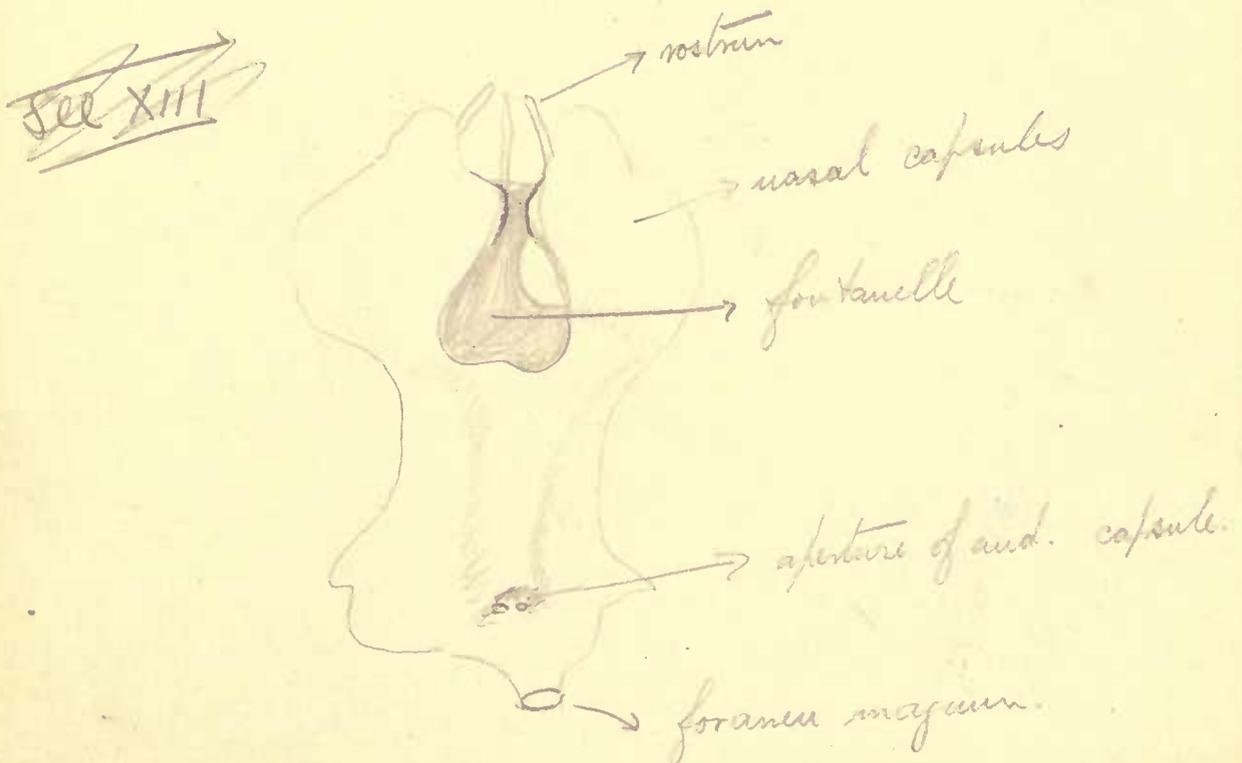


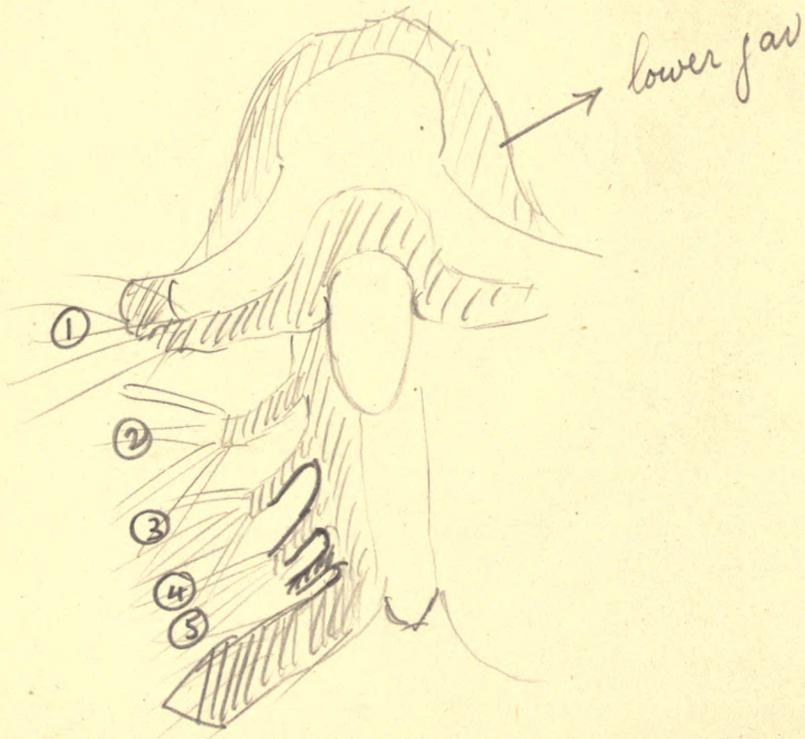
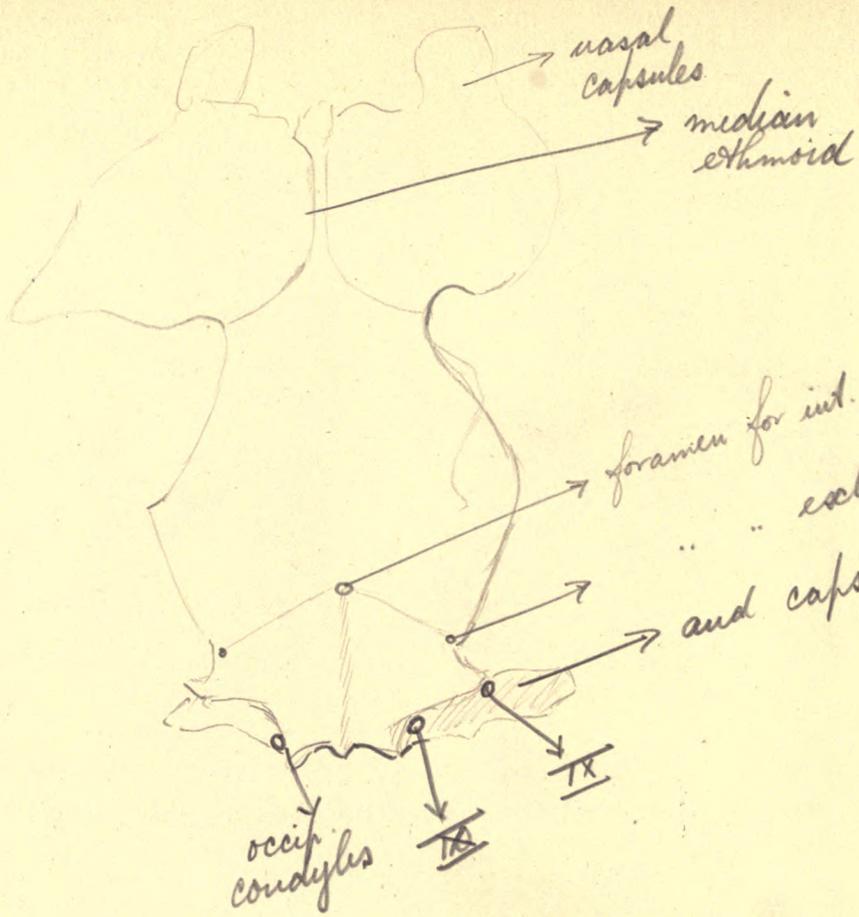


13. Cranium, side view: *ethmoidal region; nasal capsules; orbital region; auditory capsule; occipital region; foramina for optic (II), oculo-motor (III), patheticus (IV), main branches of trigeminal (V) and facial (VII) and also abducens (VI), ophthalmic branches of V and VII, glossopharyngeal (IX) and vagus (X); point of attachment of recti muscles; facet for hyomandibula.*

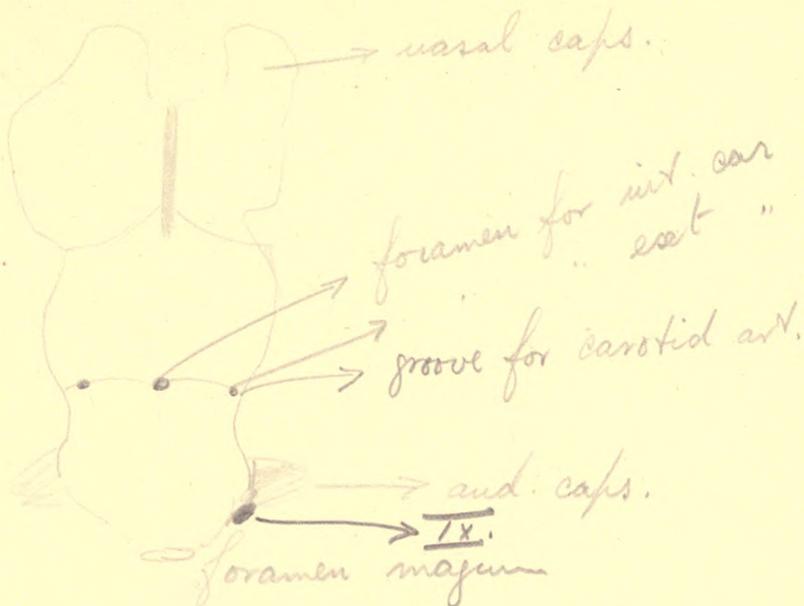


14. Cranium, dorsal view: *rostrum; nasal capsules; fontanelle; median ethmoid; aperture of auditory meatus; auditory capsule.*

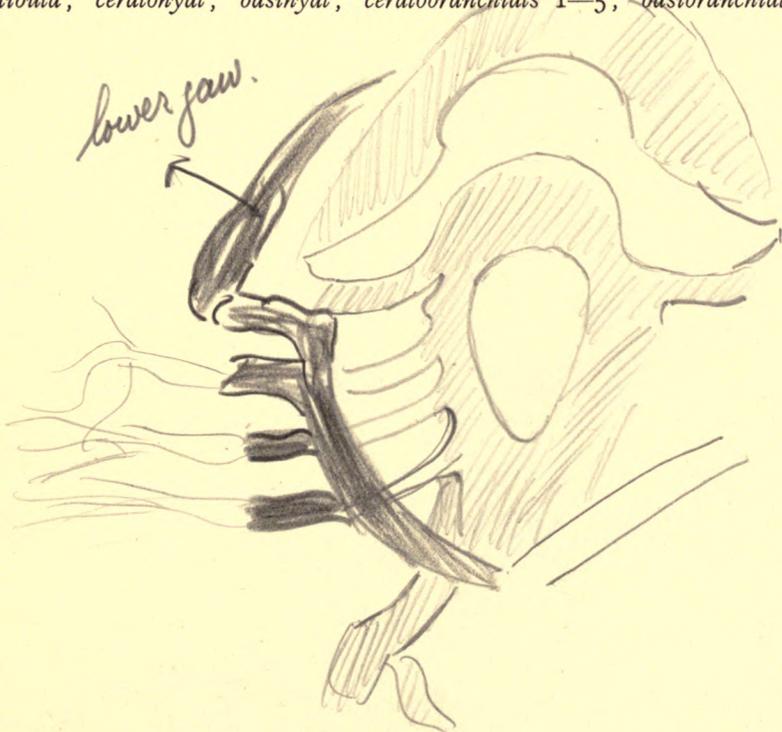




15. Cranium, ventral view: *nasal capsules; median ethmoid; groove for carotid artery; foramina for external carotid, internal carotid and nerves IX and X; auditory capsules; occipital condyles; foramen magnum.*

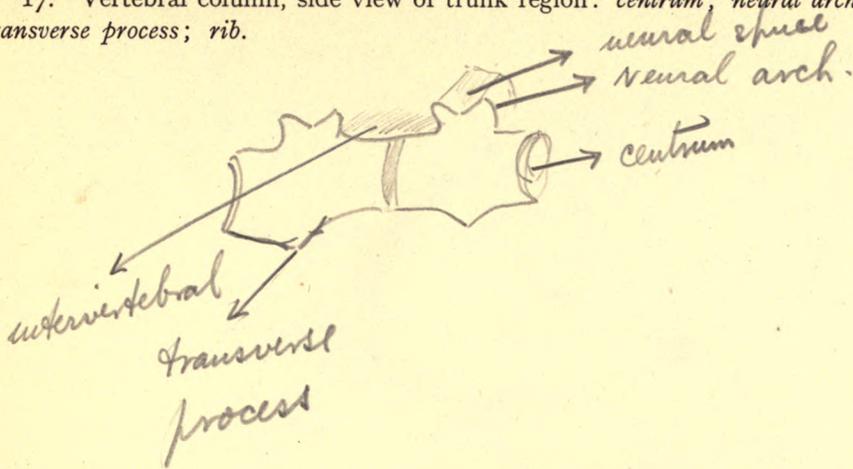


16. Jaws and branchial arches, ventral view: *palato-ptyergo-quadrate bar; lower jaw; ethmopalatine ligament; hyomandibula; ceratohyal; basihyal; ceratobranchials I-5; basibranchials.*

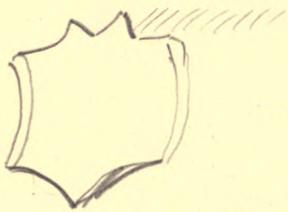




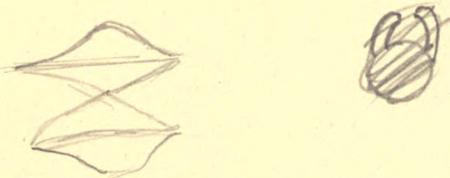
17. Vertebral column, side view of trunk region: *centrum*; *neural arch*; *neural spine*; *intervertebral plate*; *transverse process*; *rib*.



18. Vertebral column, side view of tail region: *centrum*; *neural arch*; *neural spine*; *intervertebral plate*; *haemal arch*; *haemal spine*.

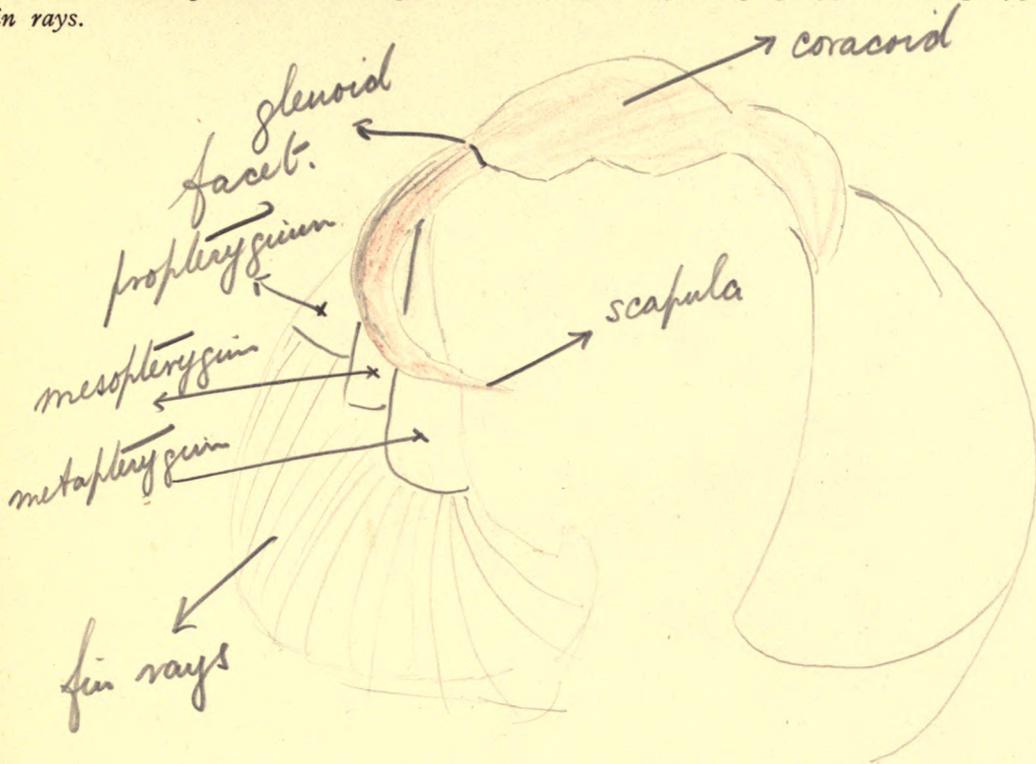


19. Vertebral column, longitudinal section of part: *centrum*; *notochord*; *neural spine*.

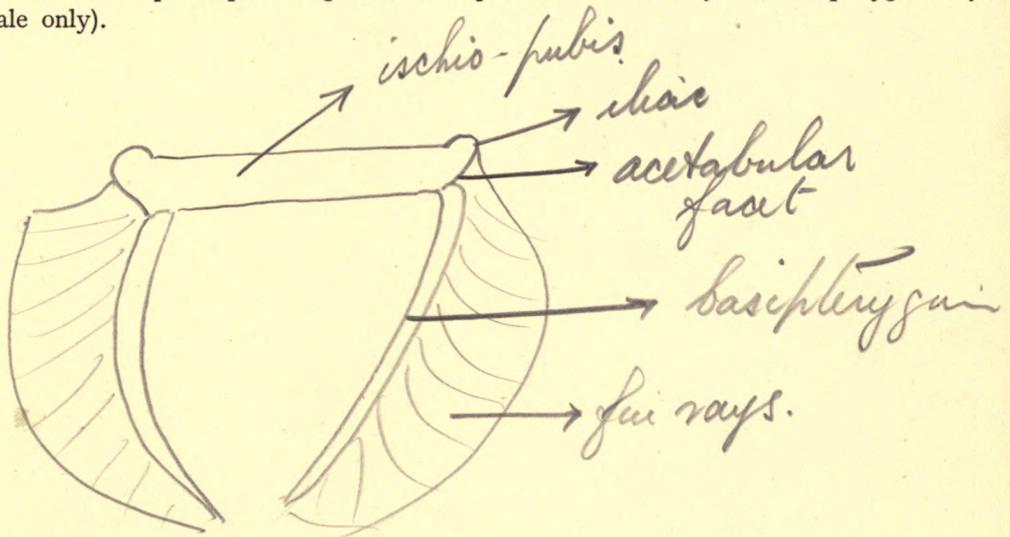


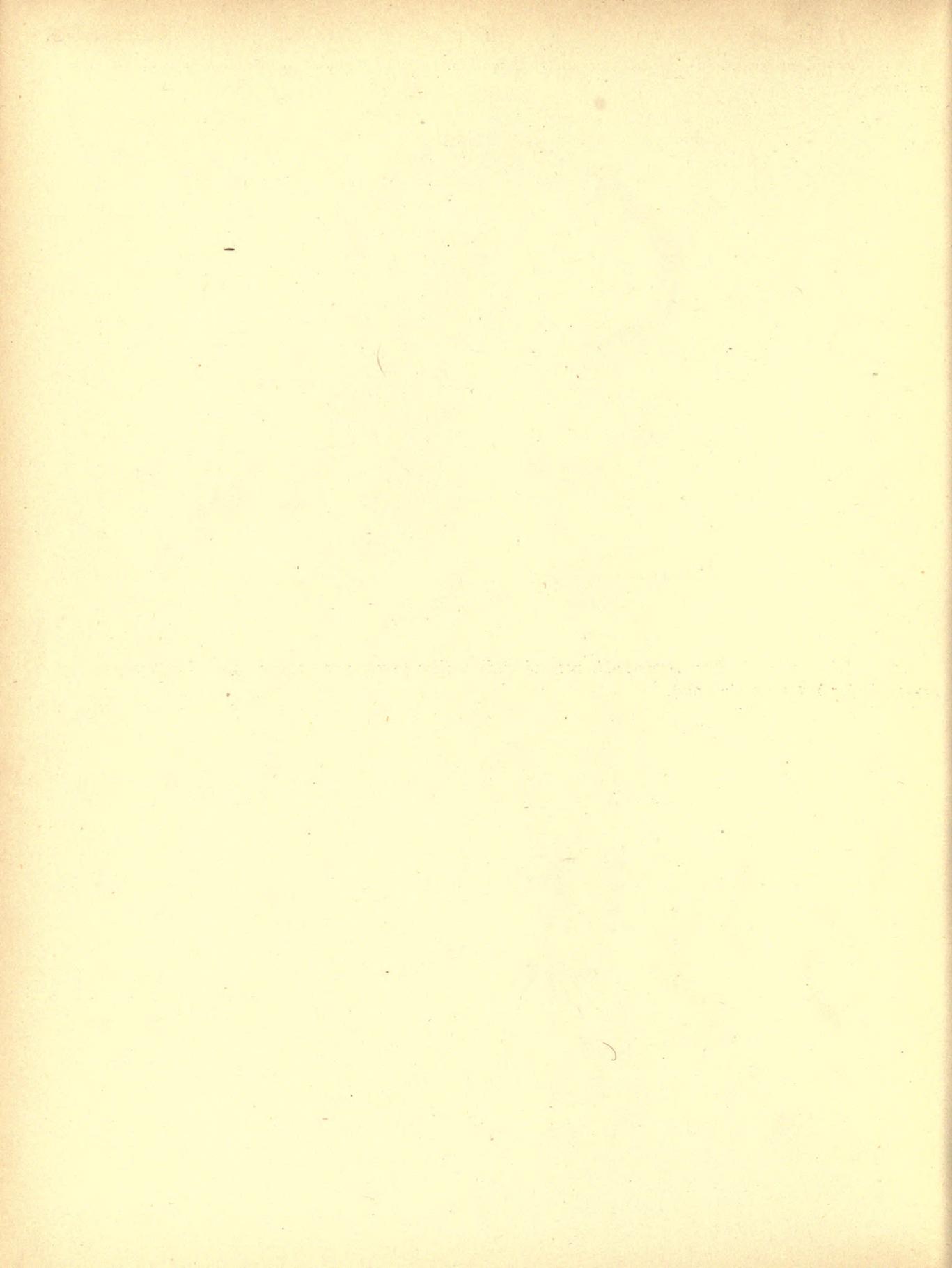


20. Pectoral girdle and fin: scapula; coracoid; glenoid facet; propterygium; mesopterygium; metapterygium; fin rays.



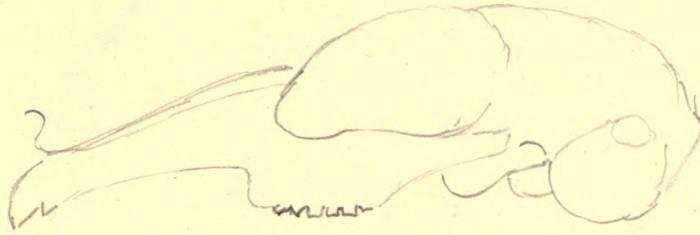
21. Pelvic girdle and fin: ischio-pubic part of girdle; iliac process; acetabular facet; basipterygium; fin rays; clasper rod (in male only).





## 1. Skull, side view:

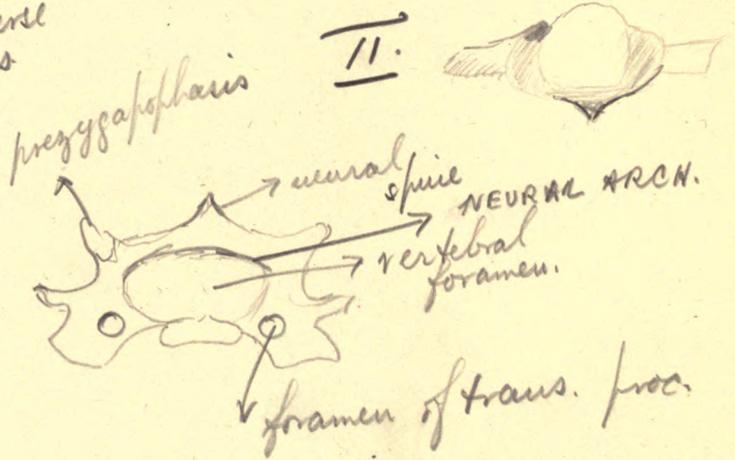
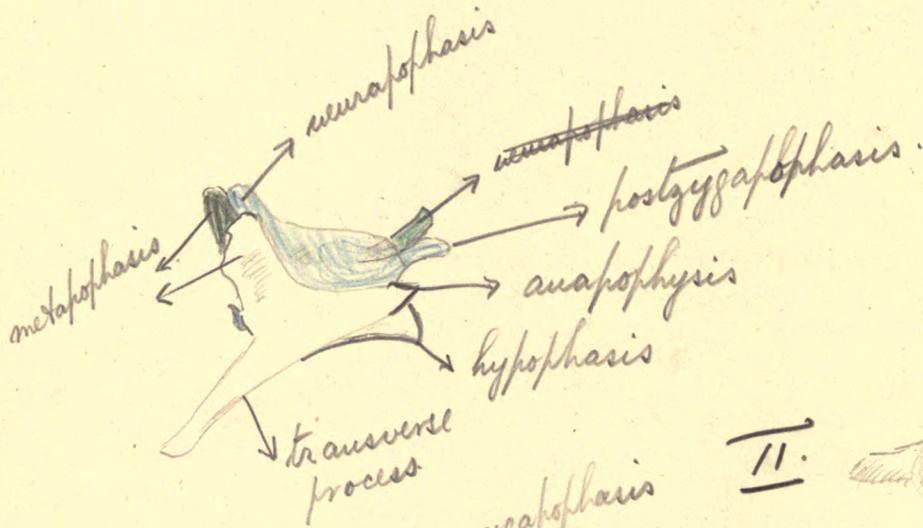
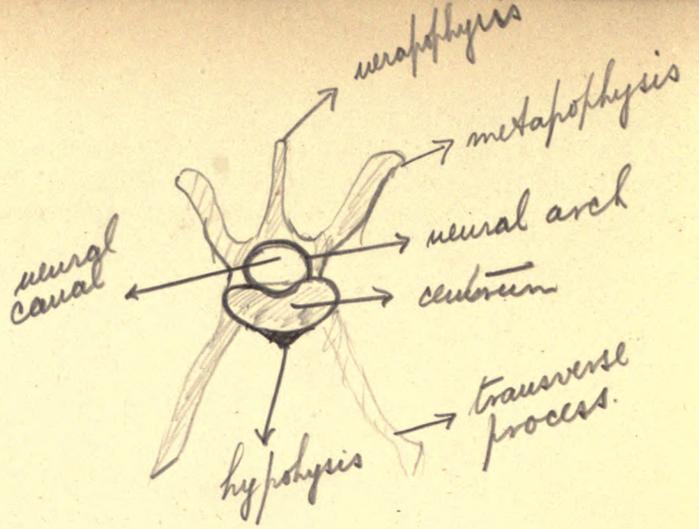
*premaxilla; nasal; frontal; parietal; supra-occipital; exoccipital; occipital condyle; maxilla; orbit; lachrymal; jugal; palatine; pterygoid; alisphenoid; squamosal; tympanic; external auditory meatus; mandible; mandibular condyle; coronoid process; mandibular angle; incisors  $\frac{3}{3}$ ; canines  $\frac{1}{1}$ ; premolars  $\frac{4}{4}$ ; molars  $\frac{2}{2}$ .*



## 2. Skull, ventral view:

*premaxilla; maxilla; palatine; vomer; pterygoid; alisphenoid; basisphenoid; basioccipital; tympanic bulla; exoccipital; occipital condyle; jugal; squamosal; glenoid fossa; incisors; canines; premolars; molars; foramina for nerves; foramen magnum.*





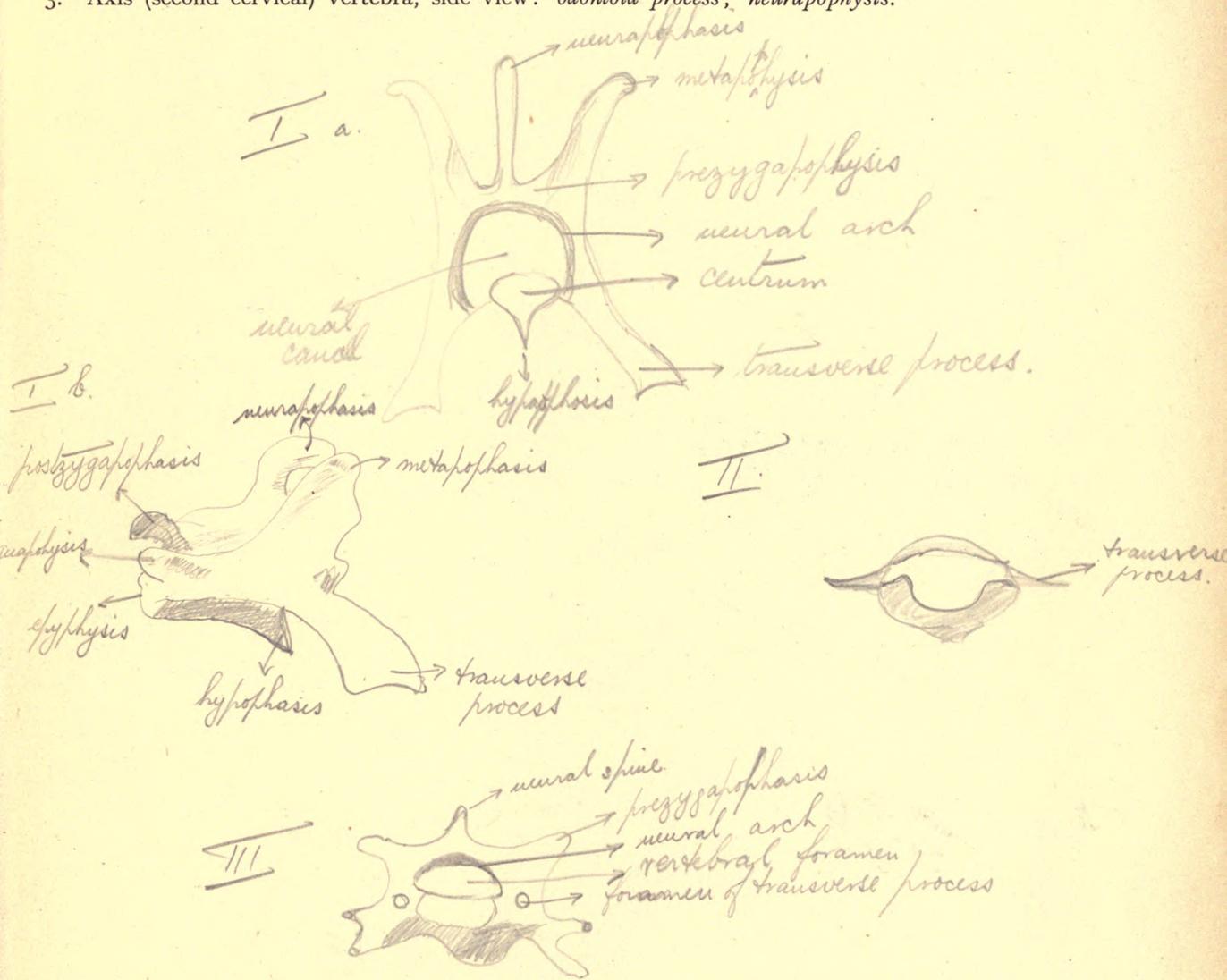
I. Second lumbar vertebra:

(a) front view: anterior epiphysis covering centrum; neural arch; neural canal; neurapophysis; metapophysis; transverse process; prezygapophysis; hypapophysis.

(b) side view: centrum; postzygapophysis; anapophysis; anterior epiphysis; posterior epiphysis; intervertebral notch (for exit of spinal nerves). Other names as in (a).

2. Atlas (first cervical) vertebra, front view: transverse process; prezygapophysis.

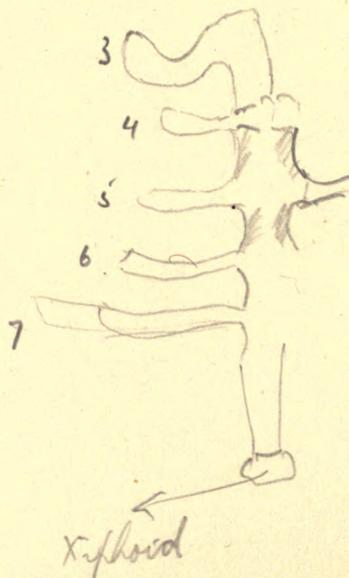
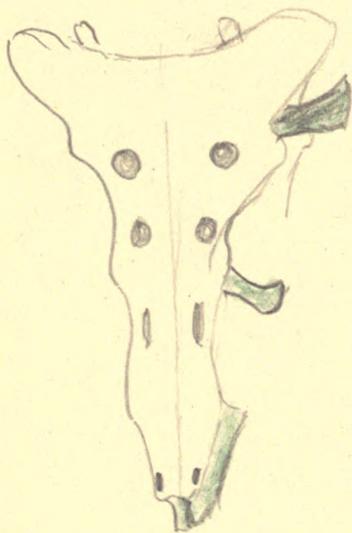
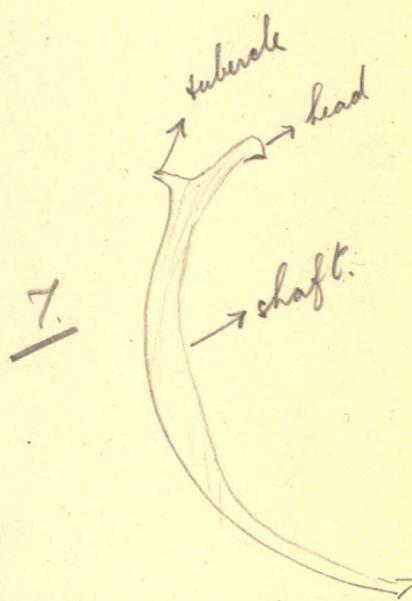
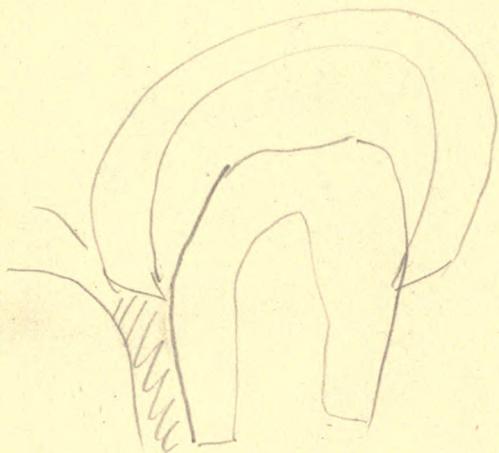
3. Axis (second cervical) vertebra, side view: odontoid process; neurapophysis.



Rabbit. I.  $\frac{2+2}{1+1}$  C  $\frac{0+0}{0+0}$  P.M.  $\frac{3+3}{2+2}$  M  $\frac{3+3}{3+3} = 28$

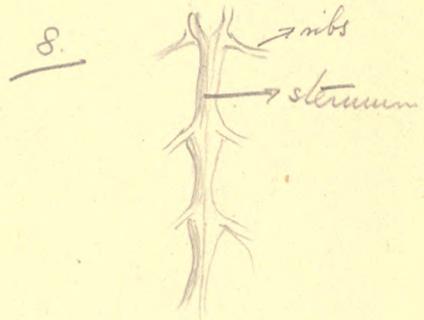
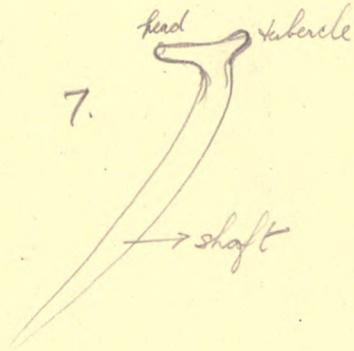
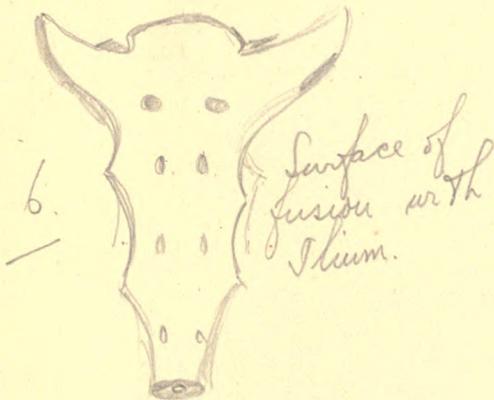
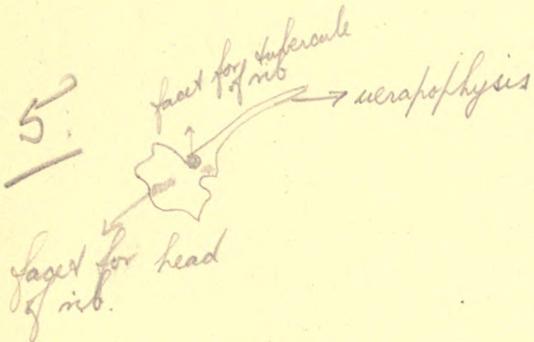
Lactial I  $\frac{2+2}{1+1}$  C  $\frac{0+0}{0+0}$  P.M.  $\frac{3+3}{2+2} = 16$

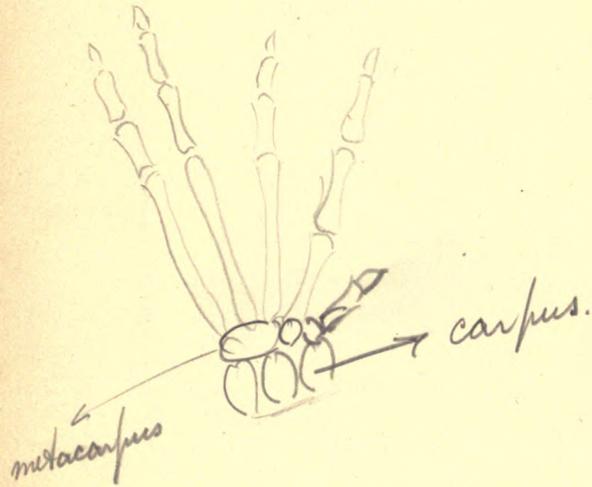
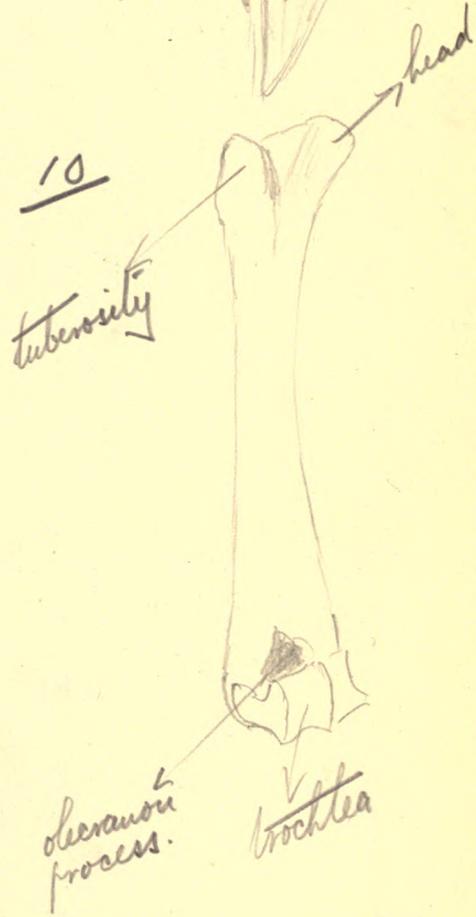
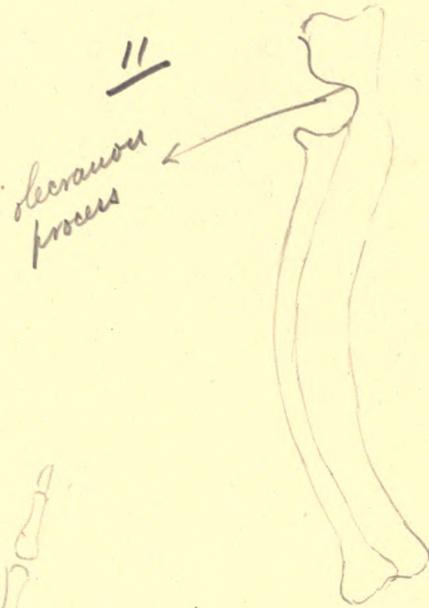
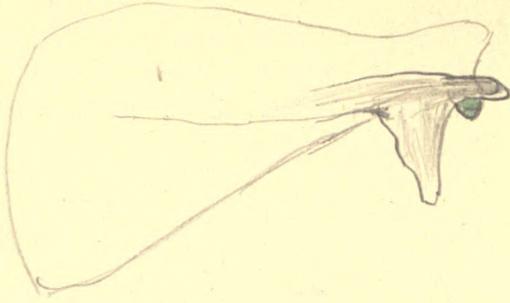
Man. I  $\frac{2+2}{2+2}$  C  $\frac{1+1}{1+1}$  P.M.  $\frac{2+2}{2+2}$  M  $\frac{3+3}{3+3} = 32$



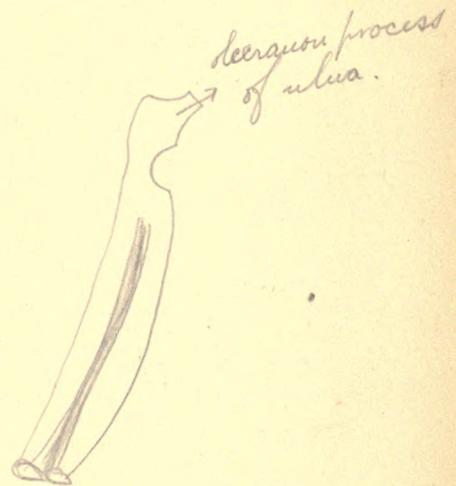
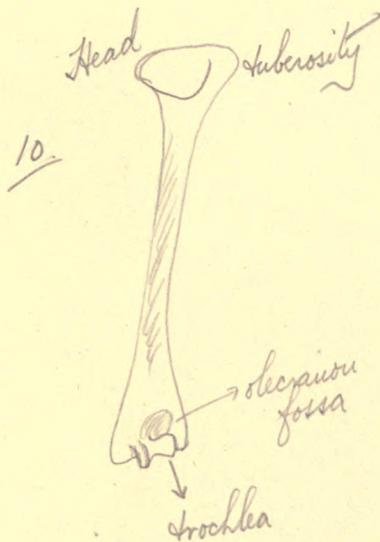
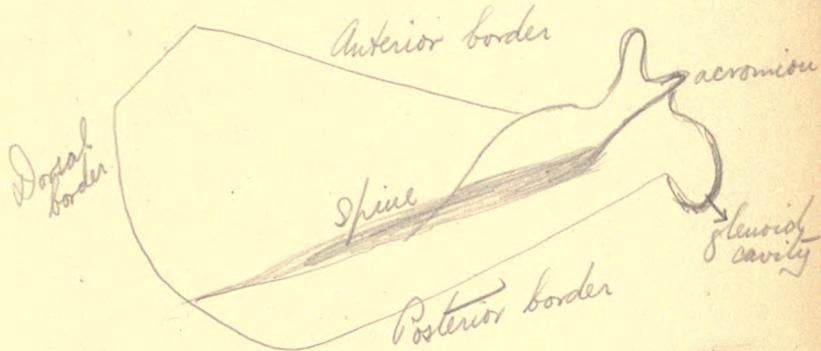
4. Third cervical vertebra, front view: *foramen for vertebral artery.*
5. Third dorsal vertebra, side view: *neurapophysis; facet for tubercle of rib; facet for head of rib.*
6. Sacrum, ventral view: *surface of fusion with ilium.*
7. Rib: *head; tubercle; shaft.*
8. Sternum with sternal ribs: *manubrium; sternebrae; xiphoid cartilage; sternal ribs.*

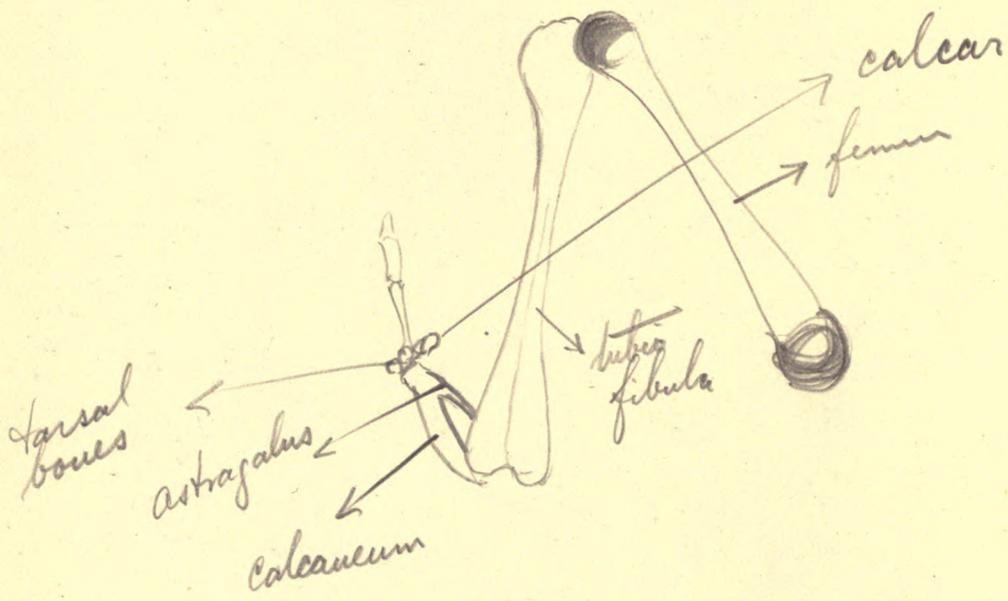
4.





9. Scapula, outer side: *blade*; *dorsal border*; *anterior border*; *posterior border*; *spine*; *acromion*; *coracoid process*; *glenoid cavity*.
10. Humerus, hind view: *head*; *tuberosity*; *trochlea*; *olecranon fossa*.
11. Radius and ulna: *olecranon process of ulna*.
12. Carpus, front view: *radiale* (scaphoid); *intermedium* (semilunar); *ulnare* (cuneiform); *centrale*; *carpale 1* (trapezium); *carpale 2* (trapezoid); *carpale 3* (os magnum); *carpalia 4 and 5* (unciform).
13. Manus: *digits 1-5*; *metacarpals*; *phalanges*; *pollex*.





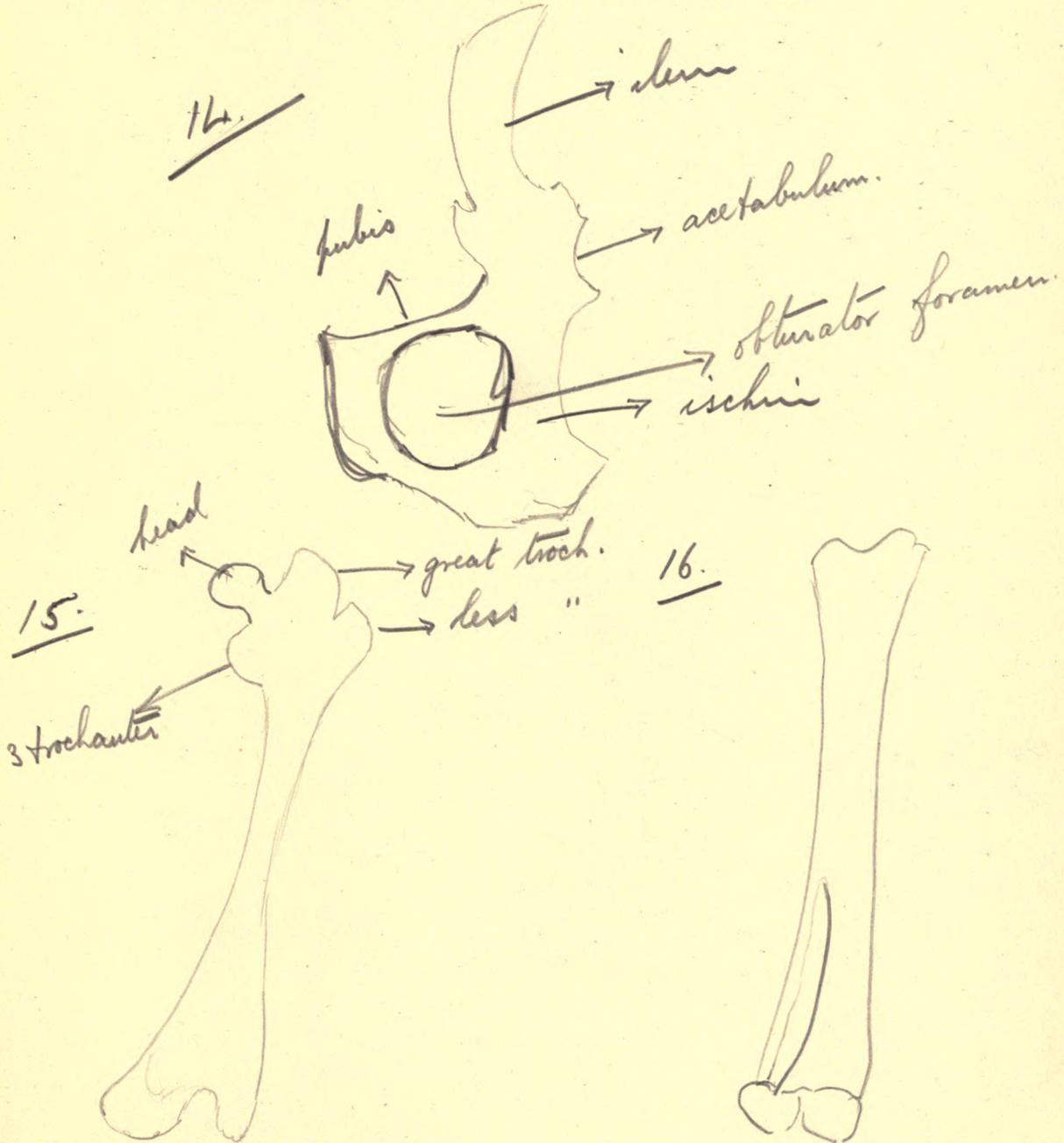
14. Pelvic girdle, outer side: *ilium*; *ischium*; *pubis*; *acetabulum*; *obturator foramen*.

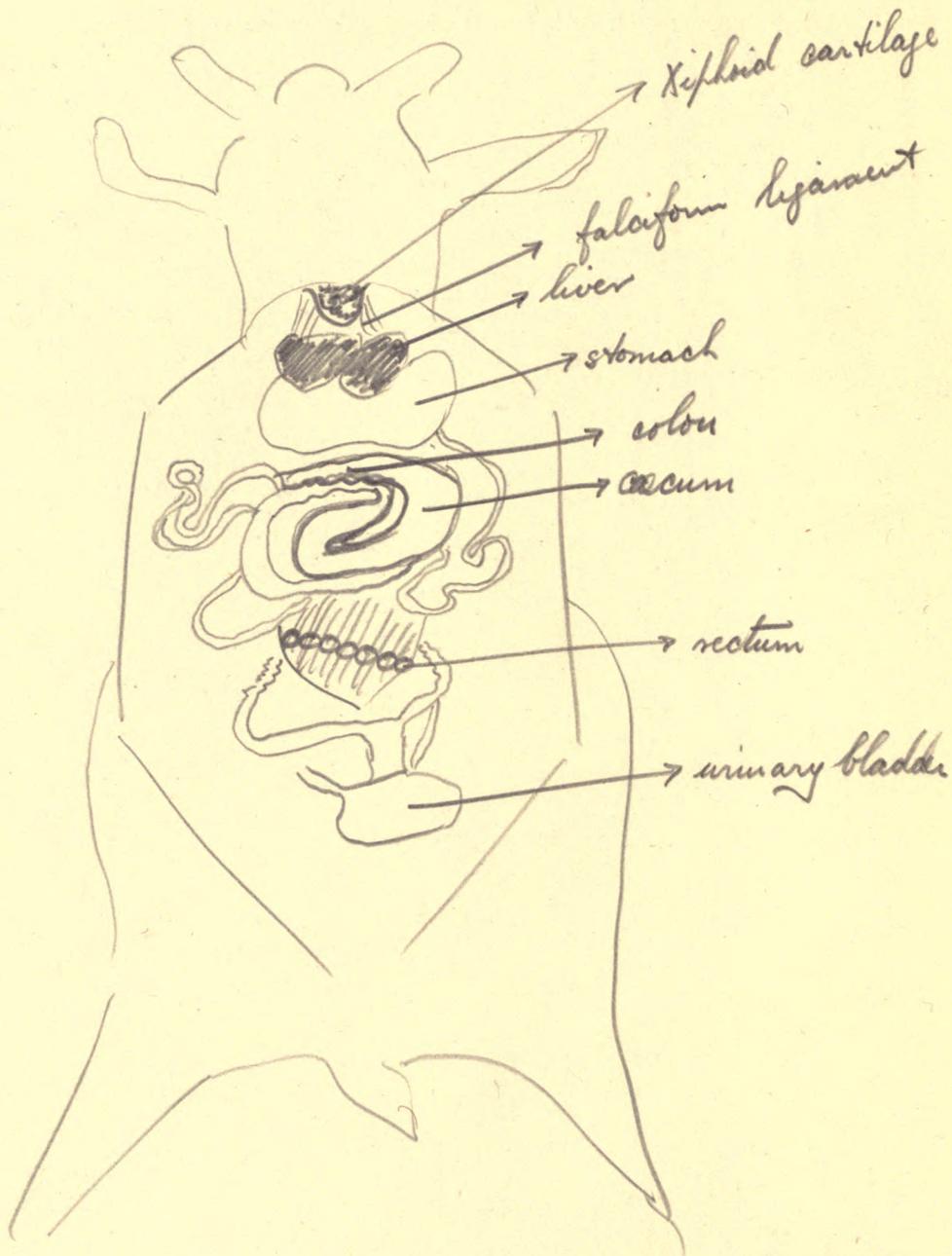
15. Femur: *head*; *great trochanter*; *lesser trochanter*; *third trochanter*; *condyles*.

16. Tibia, fibula and patella: *cnemial ridge of tibia*.

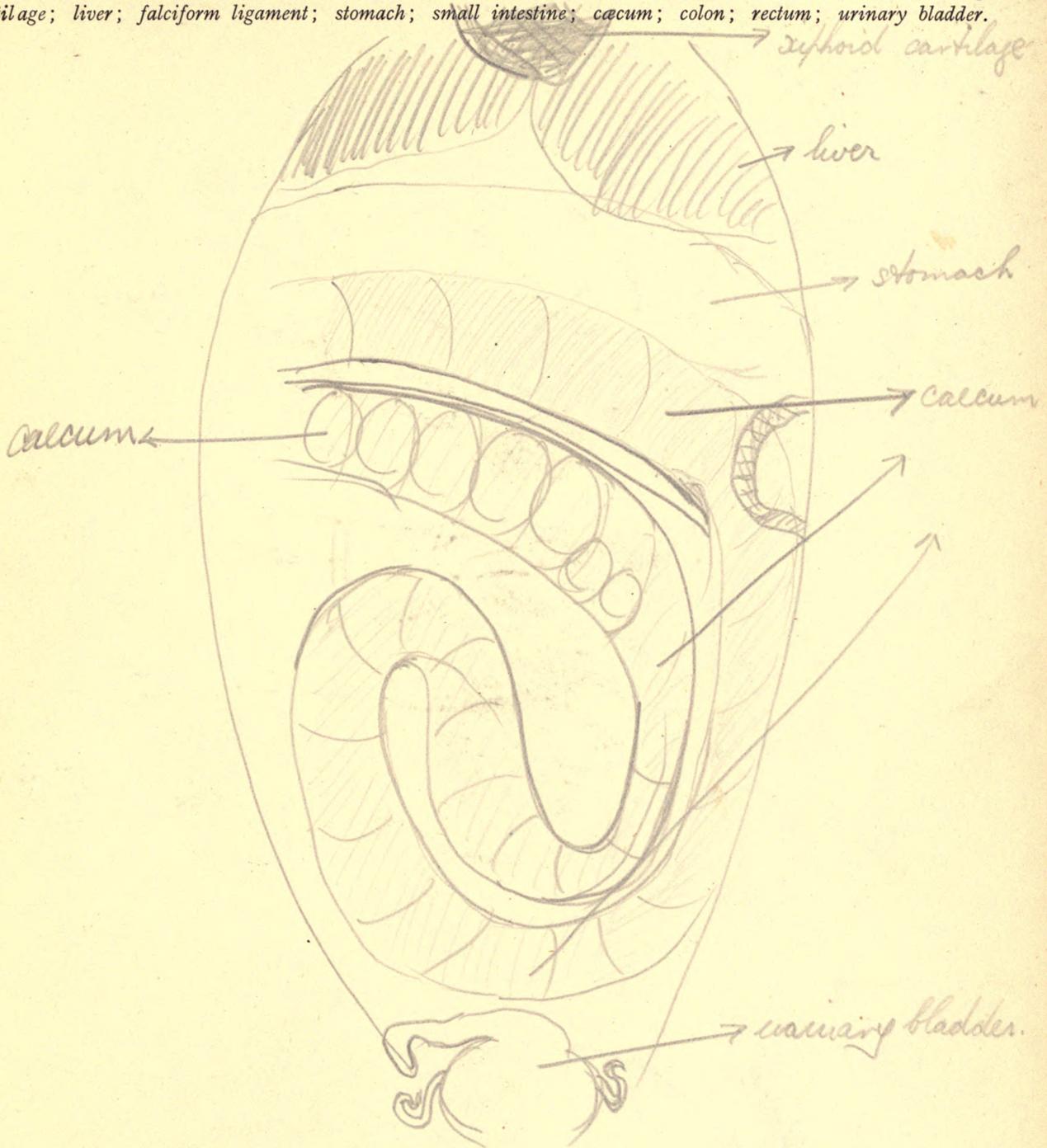
17. Tarsus, front view: *tibiale* and *intermedium* fused (*astragalus*); *fibulare* (*calcaneum*); *centrale* (*navicular*); *tarsale 2* (*mesocuneiform*); *tarsale 3* (*ectocuneiform*); *tarsalia 4 and 5* (*cuboid*).

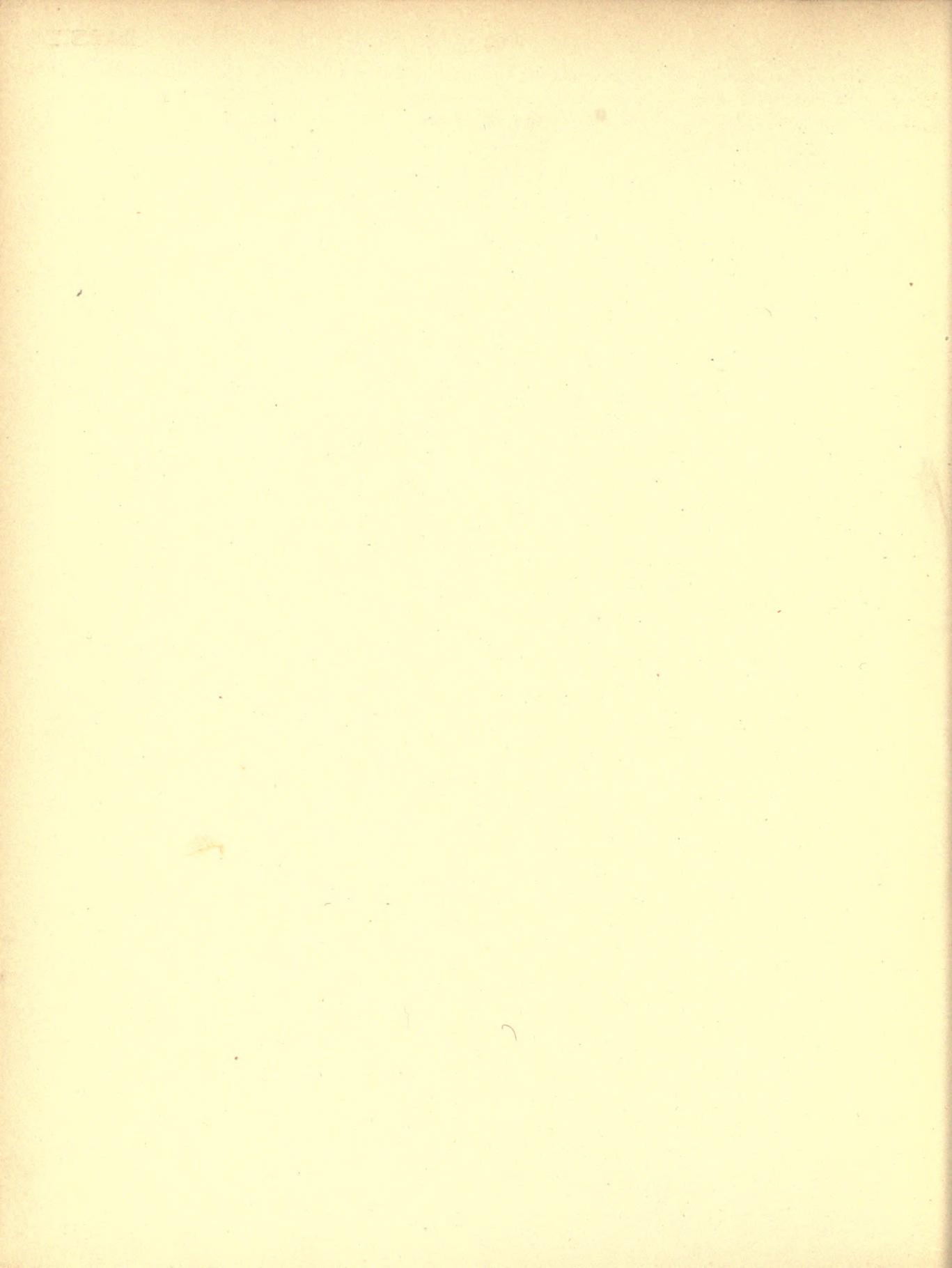
18. Pes: *digits 2—5* (first digit or *hallux* is absent); *metatarsals*; *phalanges*.



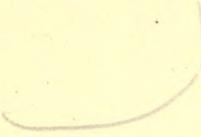


19. View of the abdominal viscera as seen when the animal is fixed on its back and the skin dissected from the muscular wall, which is opened by one median and one or more transverse cuts and then reflected: *xiphoid cartilage*; *liver*; *falciform ligament*; *stomach*; *small intestine*; *cæcum*; *colon*; *rectum*; *urinary bladder*.



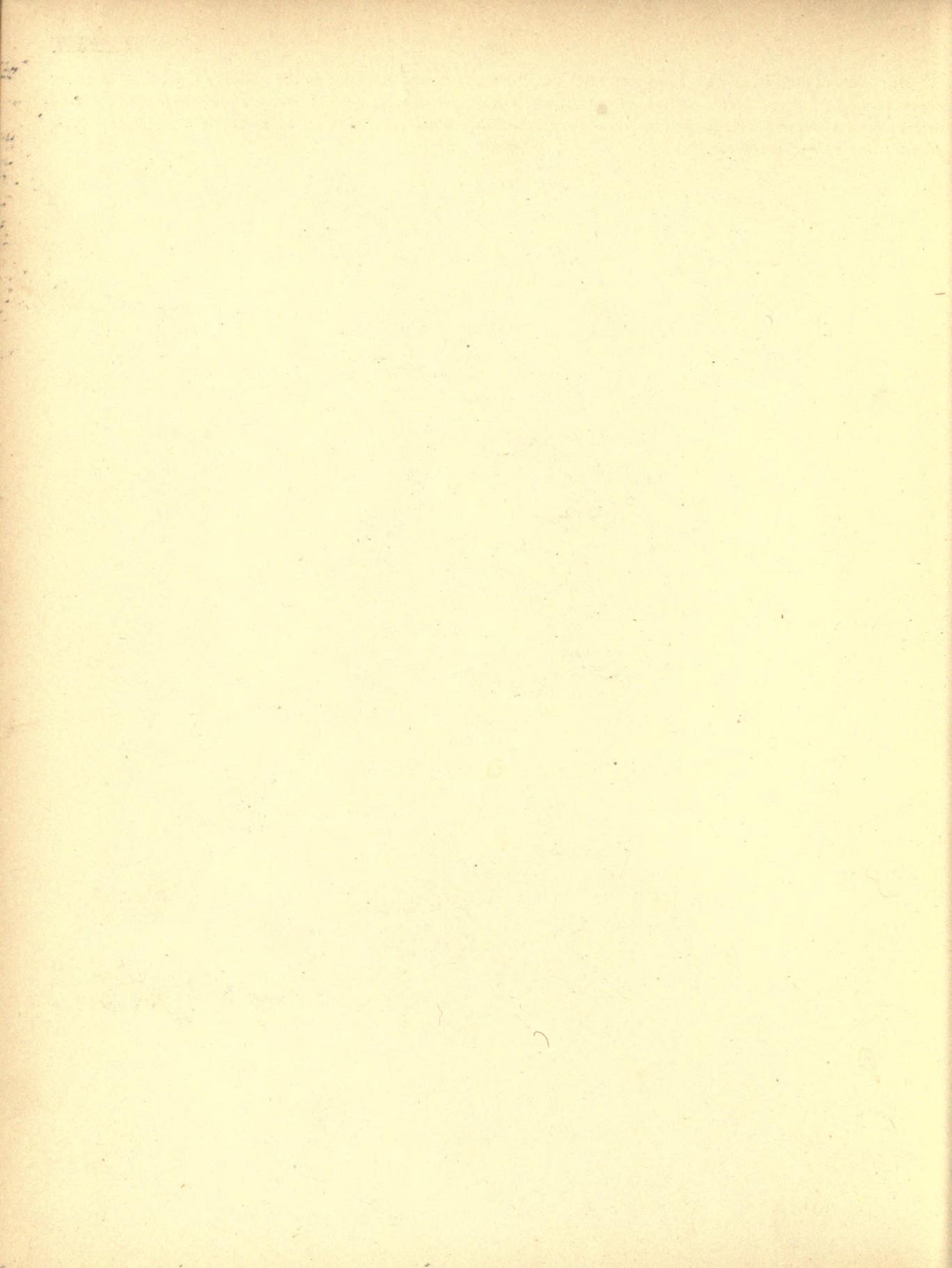


20. View of the stomach and commencement of the small intestine, as seen by turning up the liver and spreading out the duodenum: *oesophagus; liver; gall bladder; bile duct; portal vein; cardiac region of stomach; pyloric region of stomach; pyloric sphincter; duodenum; pancreas; pancreatic duct; spleen.*

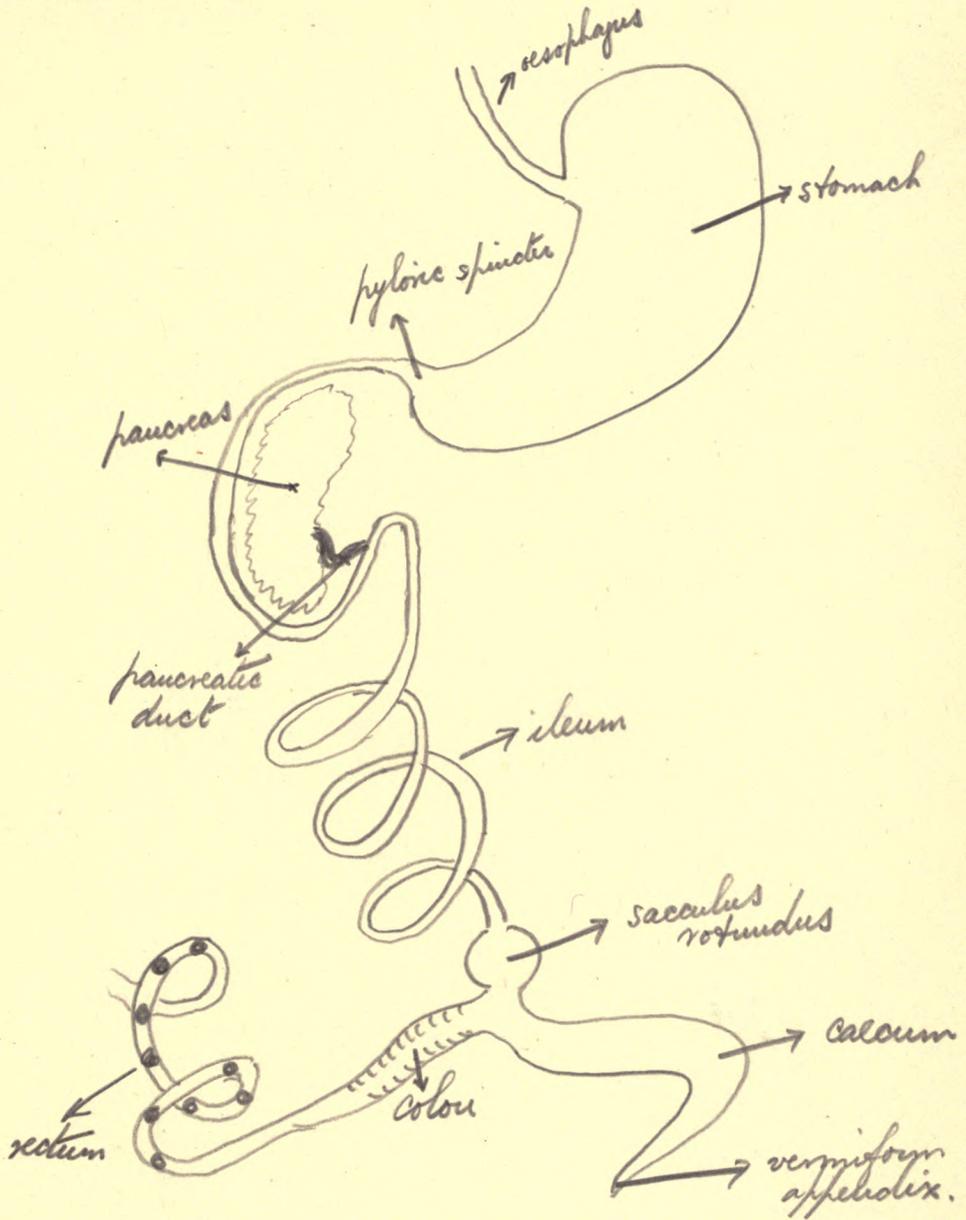




21. View of abdominal viscera as seen after turning stomach and intestine to the animal's right side: *kidney; suprarenal body; dorsal aorta; celiac artery; hepatic artery; lienogastric artery; anterior mesenteric artery; renal artery; posterior mesenteric artery; inferior vena cava; left renal vein; left vagus nerve on œsophagus; solar plexus; left splanchnic nerve.*

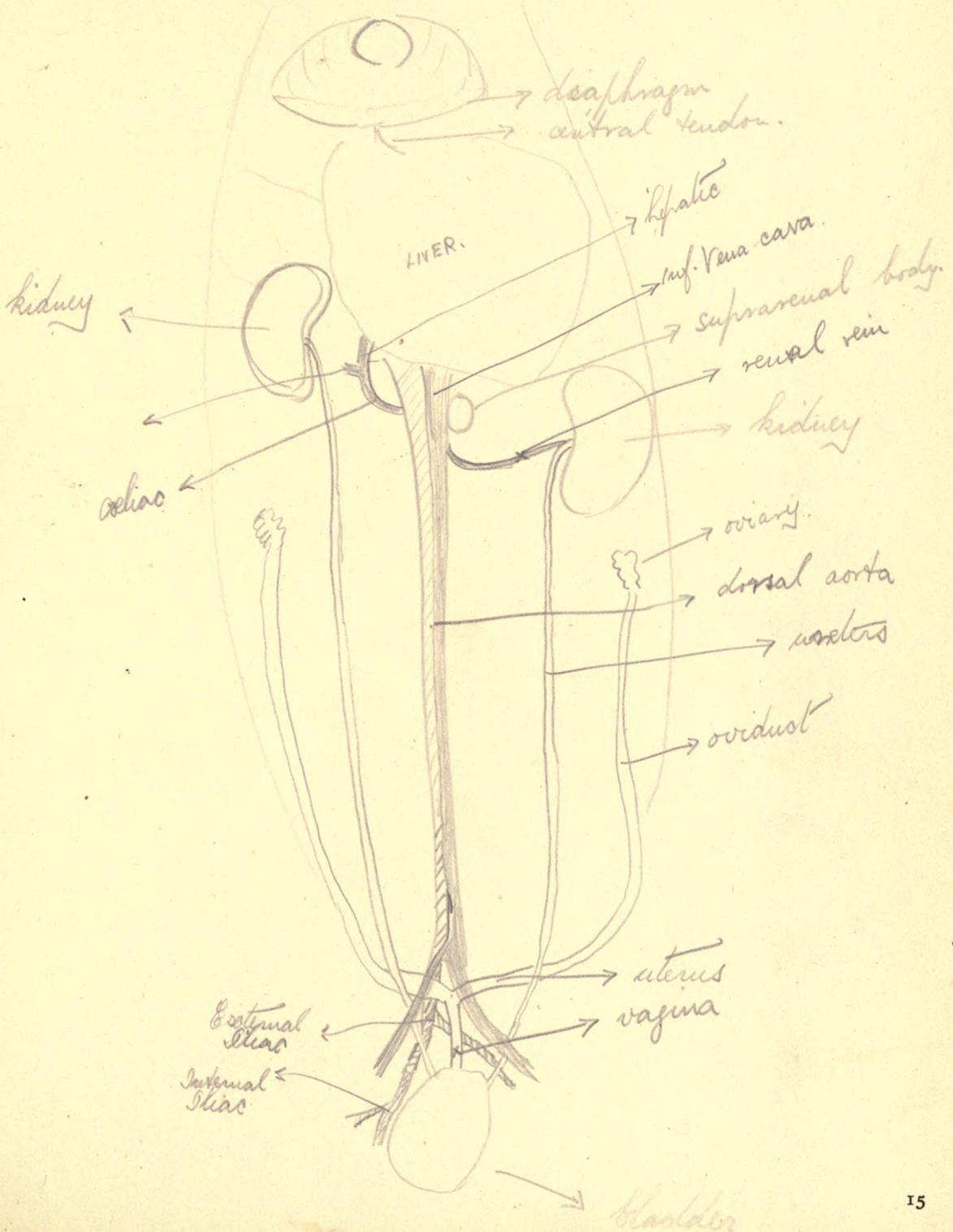


22. Alimentary canal unravelled after removal from body in the following manner: the portal vein has been ligatured in two places and cut between the ligatures, the œsophagus ligatured and cut above the ligature, the rectum ligatured and cut below the ligature; the mesentery has been cut and the whole canal has been spread out on the dissecting board: *œsophagus*; *stomach*; *pyloric sphincter*; *small intestine*; *sacculus rotundus*; *cæcum*; *vermiform appendix*; *colon*; *rectum*.





23. View of the abdominal cavity after removal of the alimentary canal: central tendon of diaphragm; muscular portion of diaphragm; œsophagus; kidneys; suprarenal bodies; ureters; bladder; dorsal aorta; celiac, anterior mesenteric, renal, genital, posterior mesenteric and common iliac arteries: inferior vena cava; renal, genital, external iliac and internal iliac veins; (a) in male: testis pulled out of scrotal sac; epididymis; vas deferens; uterus masculinus; genital cord; (b) in female: ovaries; oviducts; internal openings of same; uteri; vagina; genital cord.





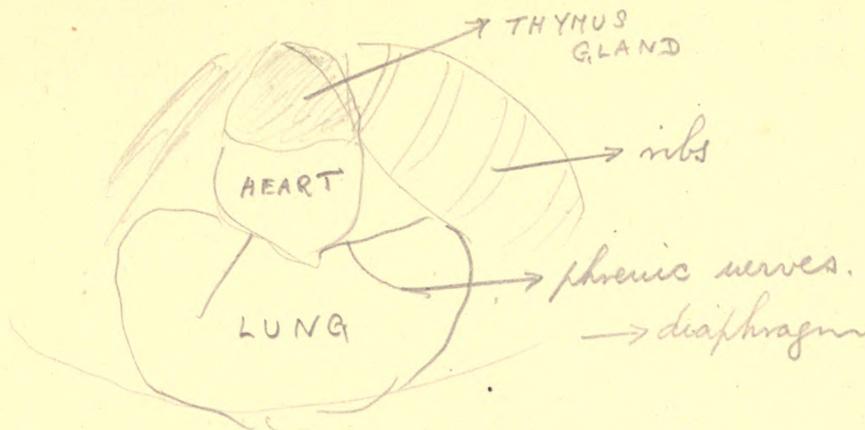
24. Genital organs in side view after the symphysis pubis has been divided and one side of it removed:

(a) male: *rectum; bladder; ureter; vas deferens; uterus masculinus; urethra; perineal gland.*

(b) female: *rectum; bladder; ureter; vagina; vestibule; perineal gland.*



25. Thoracic organs as exposed by cutting through the ribs and removing the sternum: *ribs*; *thymus gland*; *heart*; *lungs*; *phrenic nerves*; *diaphragm*.



26. The heart and great vessels as seen after the thymus gland has been removed and the heart turned towards the animal's right side: *left auricle*; *left ventricle*; *apex of heart*; *pulmonary artery*; *arch of aorta*; *innominate*, *right subclavian*, *right common carotid*, *left common carotid* and *left subclavian* arteries; *aorta* passing through *diaphragm*; *left superior vena cava*; *left subclavian*, *external jugular* and *pulmonary veins*; *inferior vena cava*; *oesophagus*.



27. Vessels, nerves and other organs of neck and floor of mouth after removal of the skin and neck muscles; *posterior cornua of hyoid bone; larynx; trachea; thyroid gland; œsophagus; common carotid, external carotid and internal carotid arteries; external and internal jugular veins; submaxillary gland; main trunk of vagus nerve; superior laryngeal, depressor, inferior (recurrent) laryngeal and hypoglossal nerves; cervical sympathetic nerve; superior cervical ganglion.*



28. Heart and great vessels removed from the body, ventral view—the vessels should be cut through at some little distance from the heart: *apex*; *left* and *right auricles*; *left* and *right ventricles*; *arch of aorta*; *pulmonary artery*; *left* and *right superior venæ cavæ*; *pulmonary veins*.

29. Dorsal view of same: names as in 28.



30. Head with skin removed, side view: *external auditory meatus; masseter muscle; facial nerve; parotid gland; eyeball; lachrymal gland; infraorbital gland.*

31. Mouth, view of interior as seen when opened widely after cutting through the muscles at its sides: *upper incisor teeth (4); upper premolar teeth (6); upper molar teeth (6); lower incisor teeth (2); lower premolar teeth (4); lower molar teeth (6); rugæ of hard palate; soft palate; posterior nares; pharynx; orifice of œsophagus; glottis; epiglottis; tongue.* After making the above sketch the soft palate should be slit open to expose the orifices of the *Eustachian tubes.*

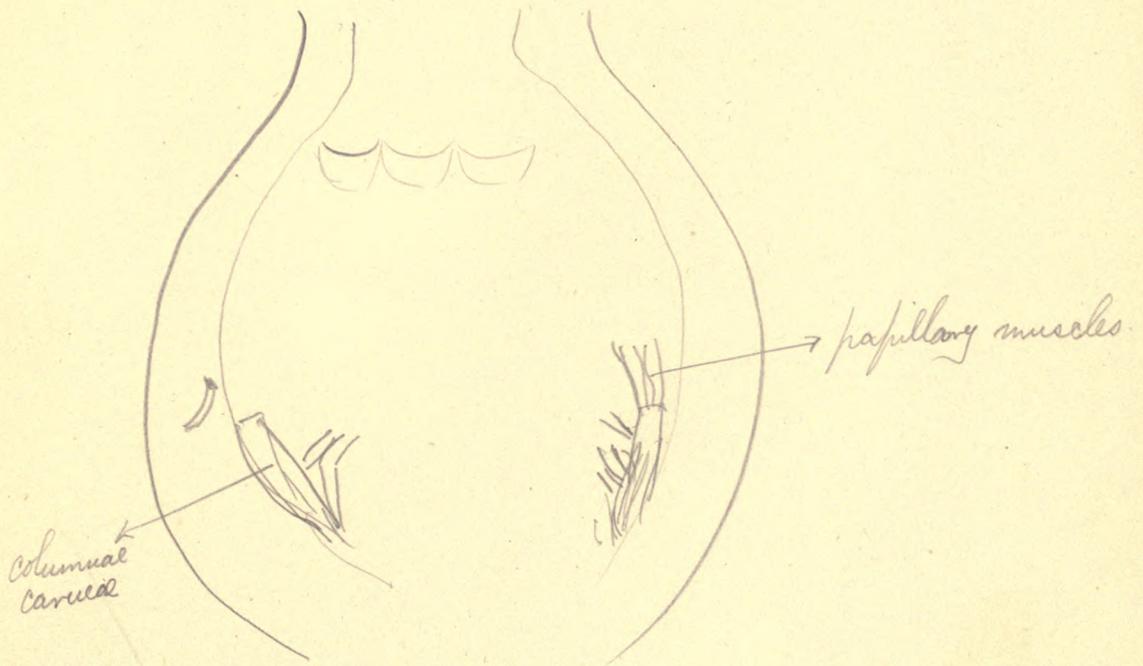


32. Brain removed from skull, dorsal view: *olfactory lobes; cerebral hemispheres; cerebellum; medulla oblongata; fourth ventricle.*
33. Brain as last, one cerebral hemisphere pulled outwards: *corpus callosum; optic thalami; optic lobes.*
34. Brain, ventral view: *olfactory lobes; temporal lobes; optic chiasma; optic nerve (II); Sylvian fissure; infundibulum; pituitary body; crura cerebri; pons Varolii; medulla oblongata; III—XII roots of third to twelfth cranial nerves.*



35. Sheep's heart, interior of right side after exposure by a longitudinal cut through the ventral wall of the right auricle and ventricle: *wall of right auricle*; *interauricular septum*; *fossa ovalis*; *Eustachian valve*; *wall of right ventricle*; *columnæ carneæ*; *interventricular septum*; *flaps of tricuspid valve*; *chordæ tendineæ*; *papillary muscles*; *moderator band*.

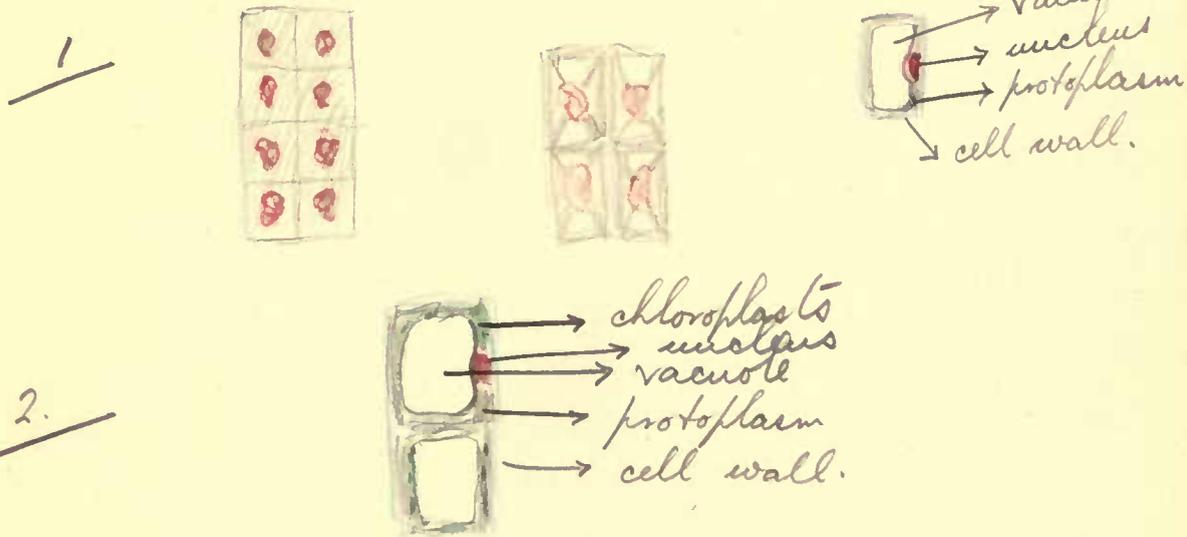
36. Sheep's heart, interior of left ventricle and root of aorta after exposure by a longitudinal cut through the aorta and ventral wall of the left ventricle: *wall of ventricle*; *columnæ carneæ*; *flaps of mitral valve*; *chordæ tendineæ*; *papillary muscles*; *semilunar valves of aorta*; *orifices of coronary arteries*.





**Typical Cells of Plant.**

1. Examine the fixed and stained section of the young growing portion of the root of the bean plant under the high power. Find and draw (a) cubical cells with very thin *cell-walls* completely filled with *protoplasm* each containing a large round *nucleus* shewing the deeply staining (chromatin) nuclear network, (b) oblong cells in which a *vacuole* has appeared in the protoplasm, the nucleus remaining in a central position, (c) much longer oblong cells in which the protoplasm forms a thin layer on the cell-wall: in this layer the nucleus is enclosed, bulging out the protoplasm into the vacuole, which now fills the whole of the centre of the cell, occupying much the greater portion of its volume.

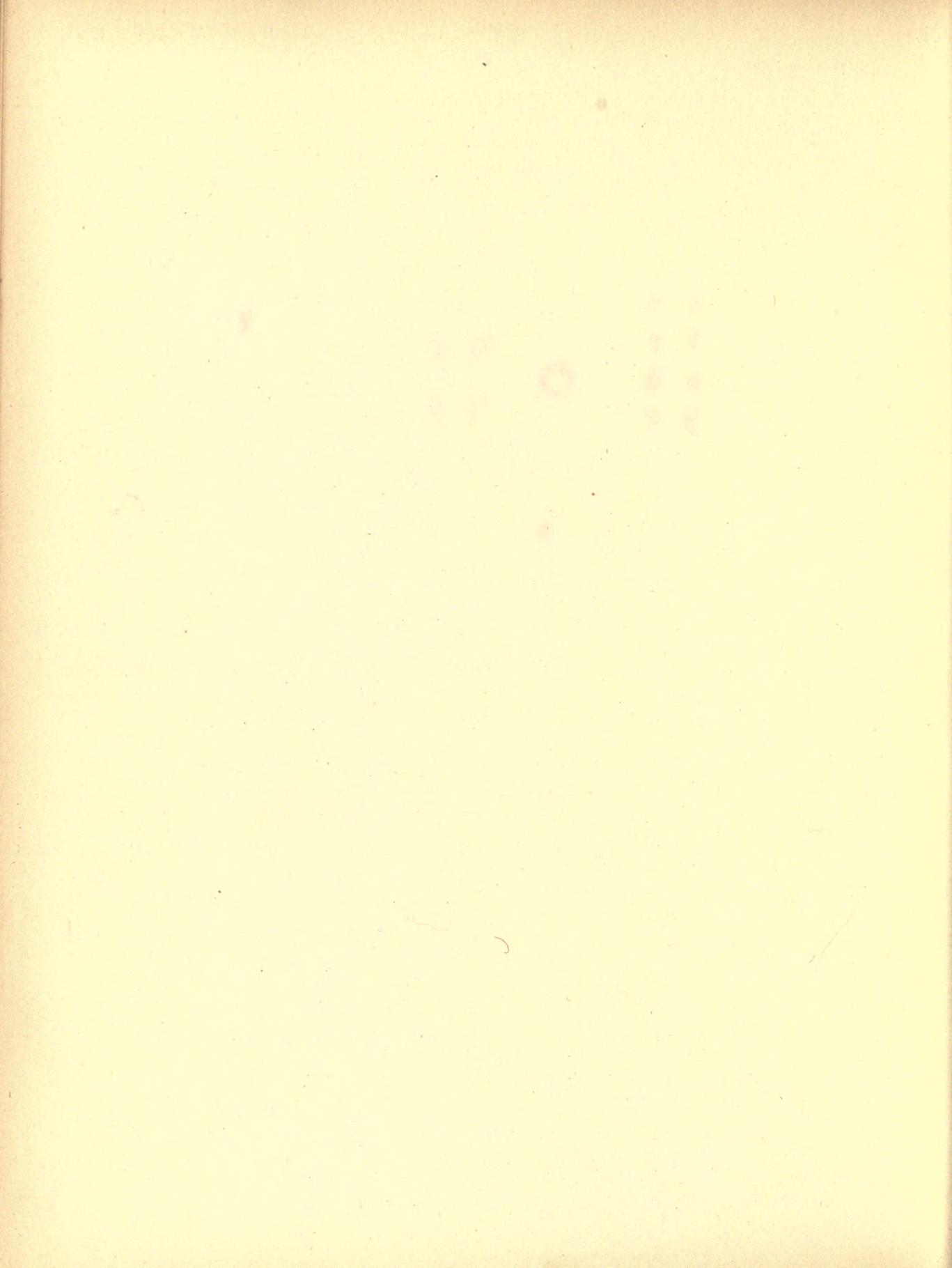


2. Mount a leaf of *Elodea* in water. Examine under a low power and note that the leaf consists of numerous *cells*. Sketch a single cell under the high power, shewing the *cell-wall*, *protoplasm*, *chloroplasts*, *nucleus*, and *vacuole*. The nucleus is often somewhat difficult to find.

**Movement of plant protoplasm.**

Observe the *circulation of the protoplasm* especially in the cells along the middle of the under surface of the leaf. The green *chloroplasts* are carried round and round the cell by this circulation. Indicate in your sketch the course of the circulation by means of arrows.



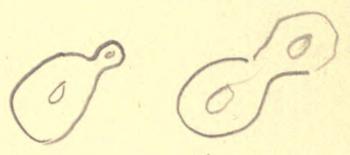
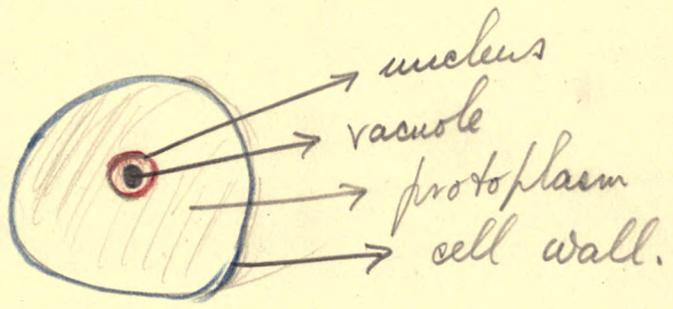


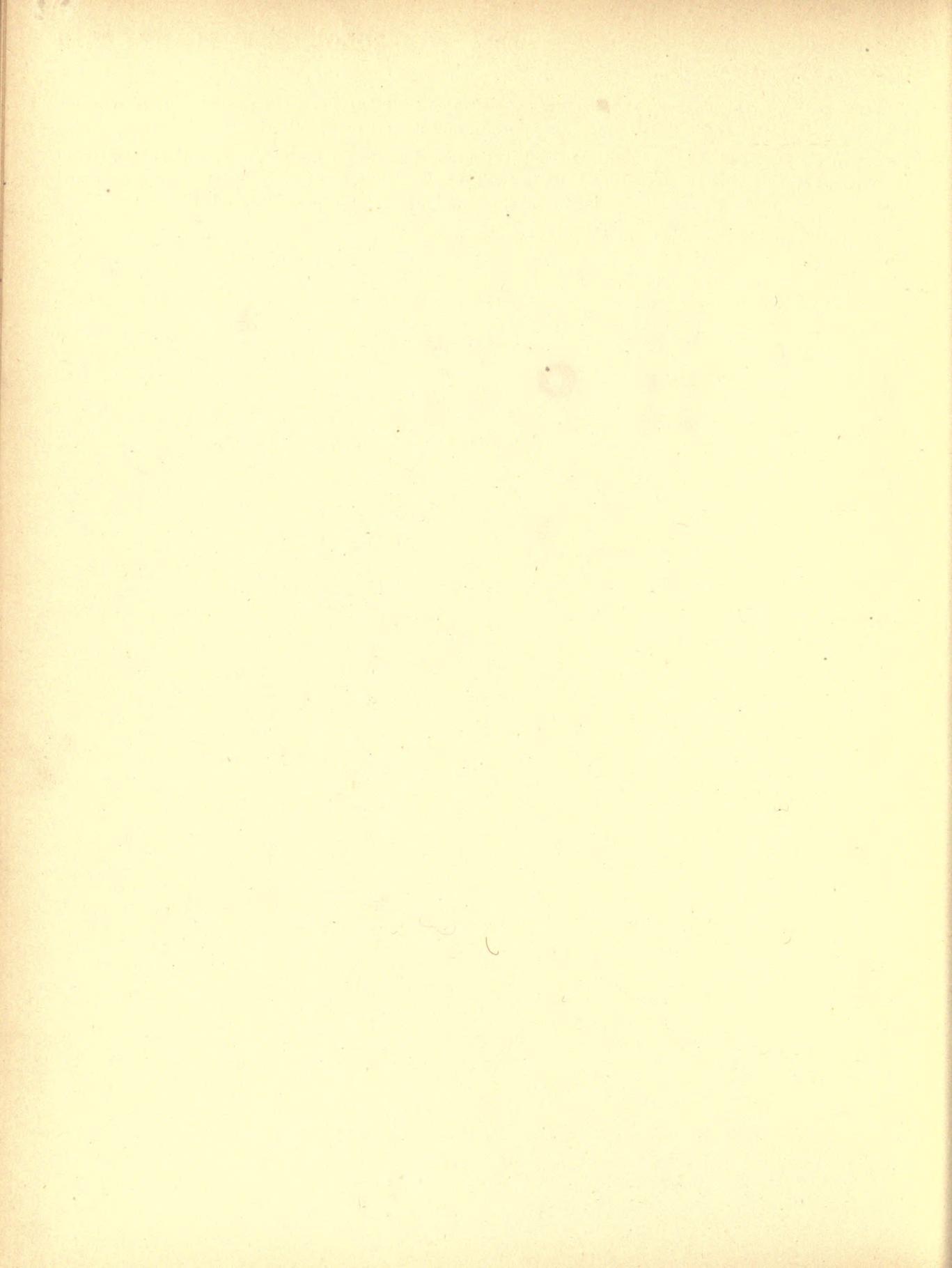
**Yeast** (*Saccharomyces Cerevisiae*).

A. Yeast cell under high power, shewing the *cell-wall*, the *protoplasm*, and the *vacuoles*. Run in iodine solution; the protoplasm and cell-wall are stained brown, and are seen more clearly.

[NOTE.—In the yeast cell the large central vacuole is contained *within* the nucleus, most of the chromatin of which is situated at one end of the vacuole and closely applied to it. These relations, which are quite exceptional in plant-cells, cannot be clearly seen except in stained specimens prepared by special methods.]

B. Yeast cells in different stages of *budding*.





A. **Bacteria in pea extract.** Mount a drop of the turbid liquid (pea infusion that has been exposed to air for a fortnight), put on a coverslip and observe the numerous bacteria in motion. The preparation must be very carefully focussed with the high power.

B. **Bacteria in air.** Remove the cover from the dish of sterilised gelatine provided, thus allowing the dust of the air to settle on it. Replace the cover after an hour and label the dish with your name. After a week or two the number of bacterial and fungal colonies arising from the bacterial and fungal spores deposited from the air can be counted.

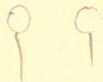
C. **Bacillus subtilis.** Examine the stained preparation provided. Notice and draw the abundant rod-shaped bacteria. Compare their size with that of a yeast cell.

D. Examine the stained slides of various pathogenic (disease) bacteria shewing different bacterial forms, spore formation, etc.

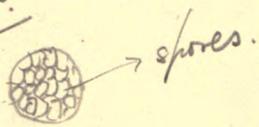
A.



B.



C.



**White Mould (*Mucor*).**

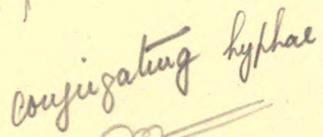
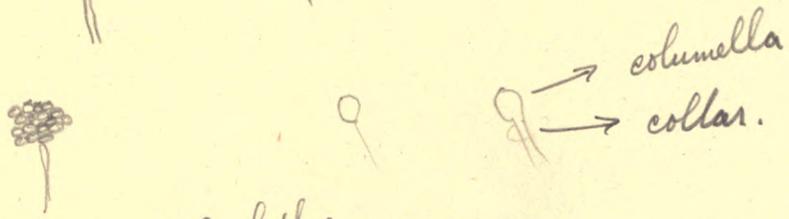
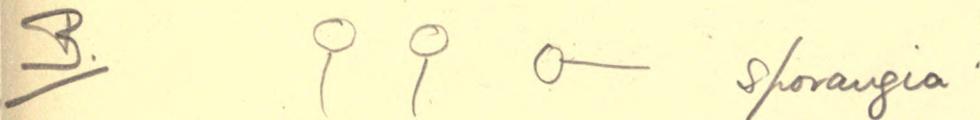
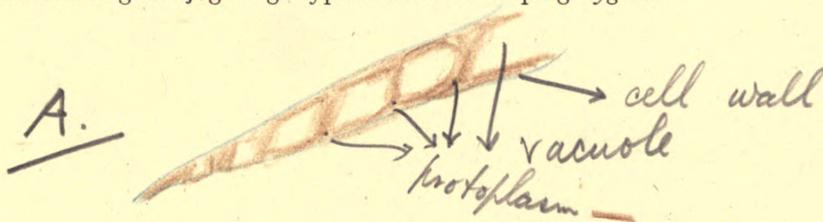
A. Mount a small piece of young *Mucor* (grown on gelatine) in water. Sketch a portion of a young *hypha*, shewing the *cell-wall* and the *protoplasm* containing numerous *vacuoles*, which are smaller towards the growing tip of the hypha.

B. An older mycelium of *Mucor* growing in gelatine. Place the watch-glass containing the gelatine and the fungus on the stage of the microscope, and examine under a low power, noting *sporangia*.

C. Draw young *sporangia*, some shewing *spores*, and some in an earlier stage of development, seen under high power.

D. Examine the still older *Mucor* growing on bread and sketch a *sporangium* which has burst, shewing (a) the *columella*, to which some spores may be found adhering, (b) the *collar* or remains of the sporangium wall at the base of the *columella*.

E. Examine the slide shewing conjugating hyphae and developing zygotes.



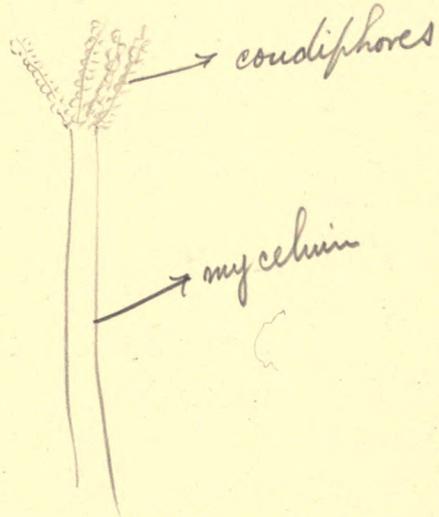


**Blue Mould (*Penicillium*).**

Examine the blue mould under the low power in air. Note the brushes of radiating *conidiophores* rising erect from the mycelium (vegetative body of the plant). Now remove a small piece of the mould, place it in a watch-glass of spirit and transfer to a drop of dilute glycerine on a slide. Put on a coverslip, and examine the septate hyphae; also the conidiophores and note the row of spores (*conidia*) cut off from the end of each branch.

**Types of Higher Fungi.**

Examine the demonstration specimens of higher fungi parasitic on leaves, etc.; also the mushroom (fruit body of a fungus living in richly manured soil).



SPORES.

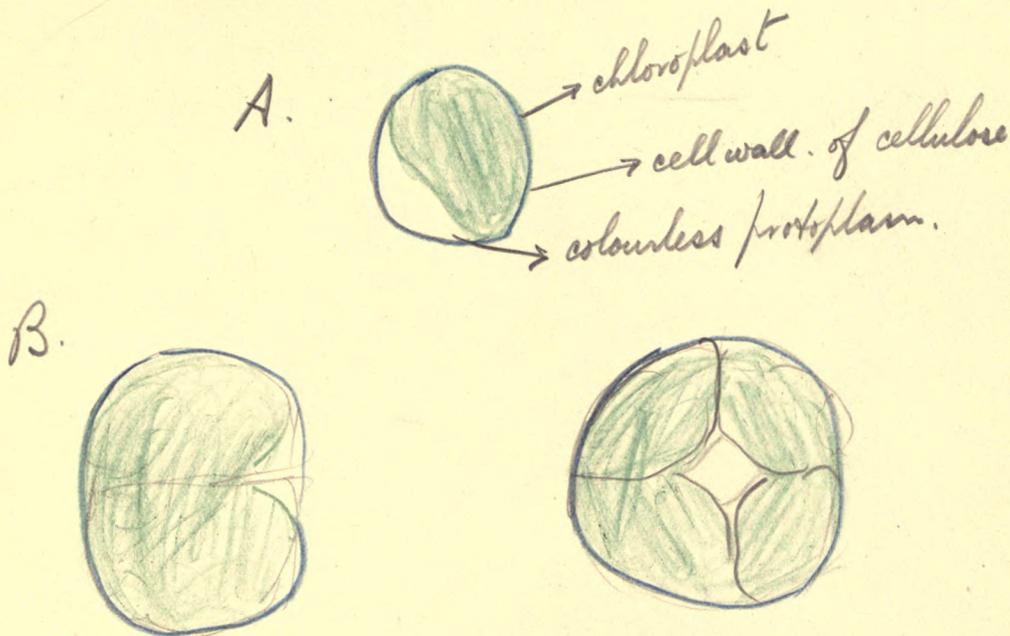


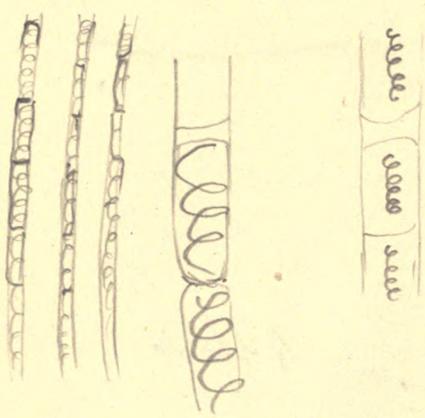


**Pleurococcus.**

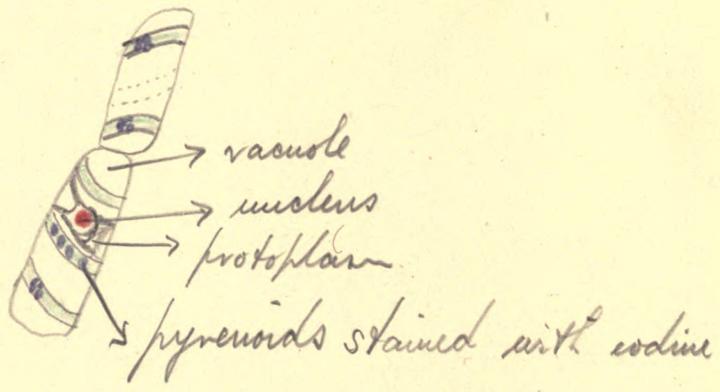
A. Remove a small quantity of the green powder from the piece of bark provided, and mount in a drop of water. Examine under a high power and sketch a single *Pleurococcus* cell, shewing the *cell-wall* and the *chloroplast* which occupies most of the cell cavity, often appearing completely to fill it. Look for cells in which colourless protoplasm can be seen at one side of the cell. The nucleus can rarely be distinguished.

B. Mount some of the *Pleurococcus* from the watch-glass of water and draw groups of cells illustrating different stages of *division*.





Plasmolysis



**Spirogyra.**

A. Make a diagrammatic sketch of part of a filament under a low power, shewing the single row of similar cells, containing the green spiral chloroplasts.

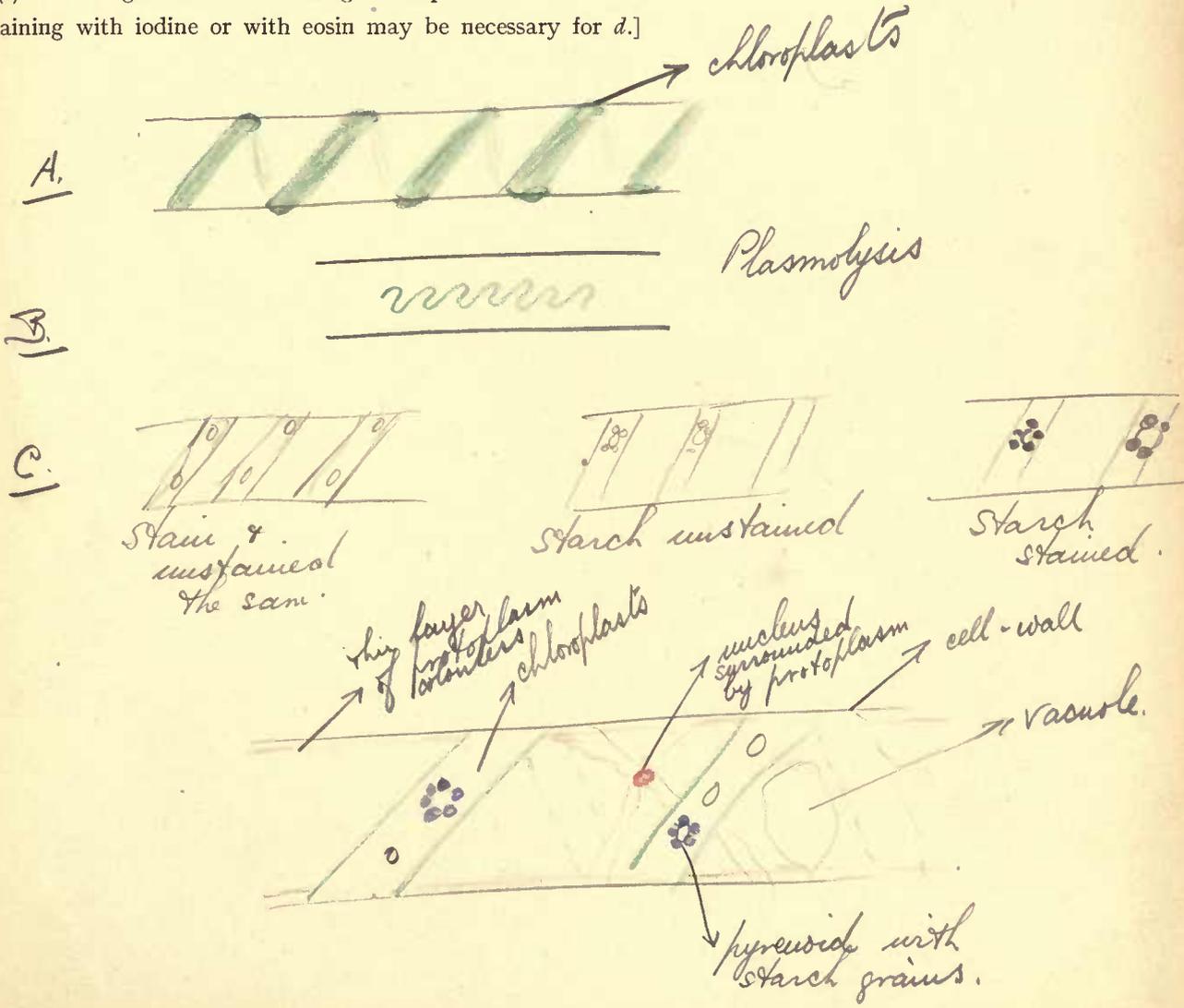
B. Treat a fresh specimen with 5 % salt solution (by drawing a drop under the coverslip with blotting-paper) and observe the shrinking of the protoplasmic lining. This phenomenon is known as *plasmolysis*. Sketch a contracted cell. Draw water through with blotting-paper and observe the cell reassume its *turgid condition*.

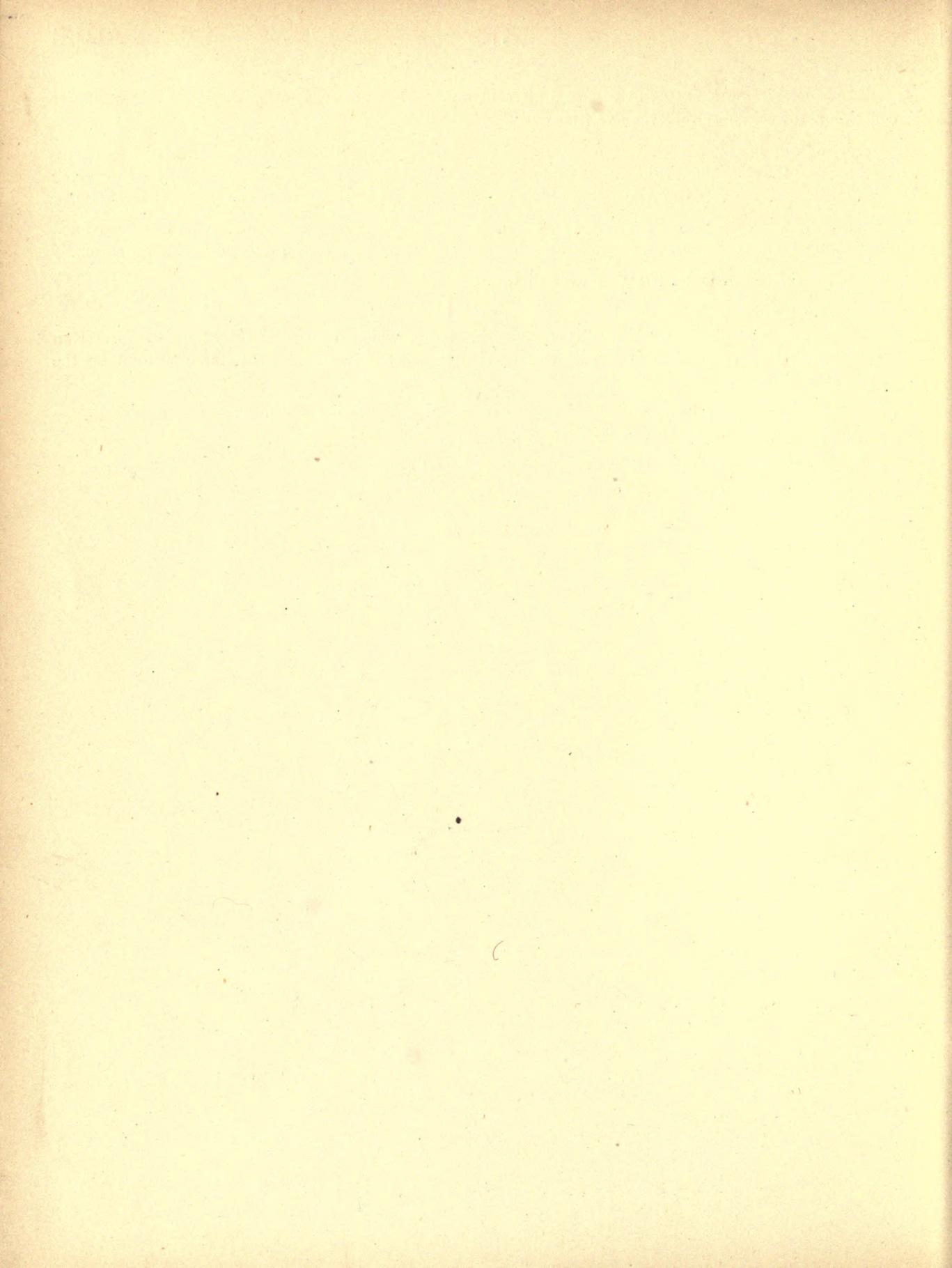
C. Mount the two preserved filaments of *Spirogyra* provided and stain with iodine. One has been fixed after illumination and contains much starch, the other, kept for two days in the dark, contains no starch.

D. Sketch a single cell under a high power shewing

- (a) the cell-wall ;
- (b) the spirally wound chloroplast with the pyrenoids, each of which is surrounded by starch-grains. Run in iodine (by drawing a drop under the coverslip with blotting-paper) and notice that the starch surrounding the pyrenoids is stained dark blue ;
- (c) the thin layer of colourless protoplasm closely pressed against the cell-wall ;
- (d) the nucleus suspended by strands of protoplasm ;
- (e) the large vacuole containing cell-sap.

[Staining with iodine or with eosin may be necessary for d.]



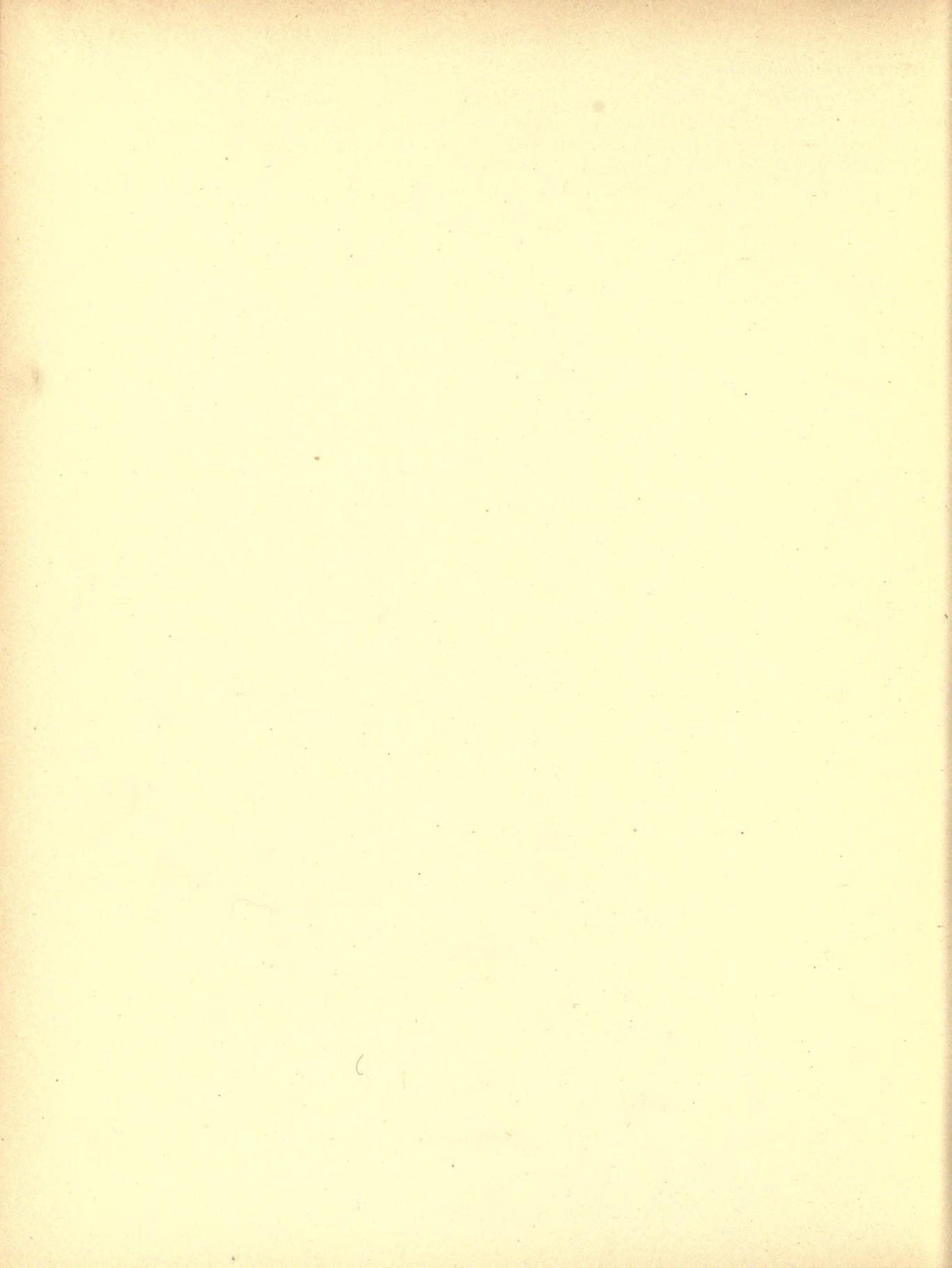


**Spirogyra** (continued).

E. *Conjugating cells* of *Spirogyra* filaments. Examine the slides of red-stained material provided and select examples, from which to draw (a) the *lateral protuberances* of cells in an early stage of conjugation, (b) meeting of protuberances, (c) *passage of protoplasm* through *conjugation canal*, (d) *young zygote*, (e) *older zygote* with thick wall. Draw as many distinct stages as you can distinguish.

(N.B. In some forms of *Spirogyra* conjugation takes place between *adjacent cells of the same filament*.)

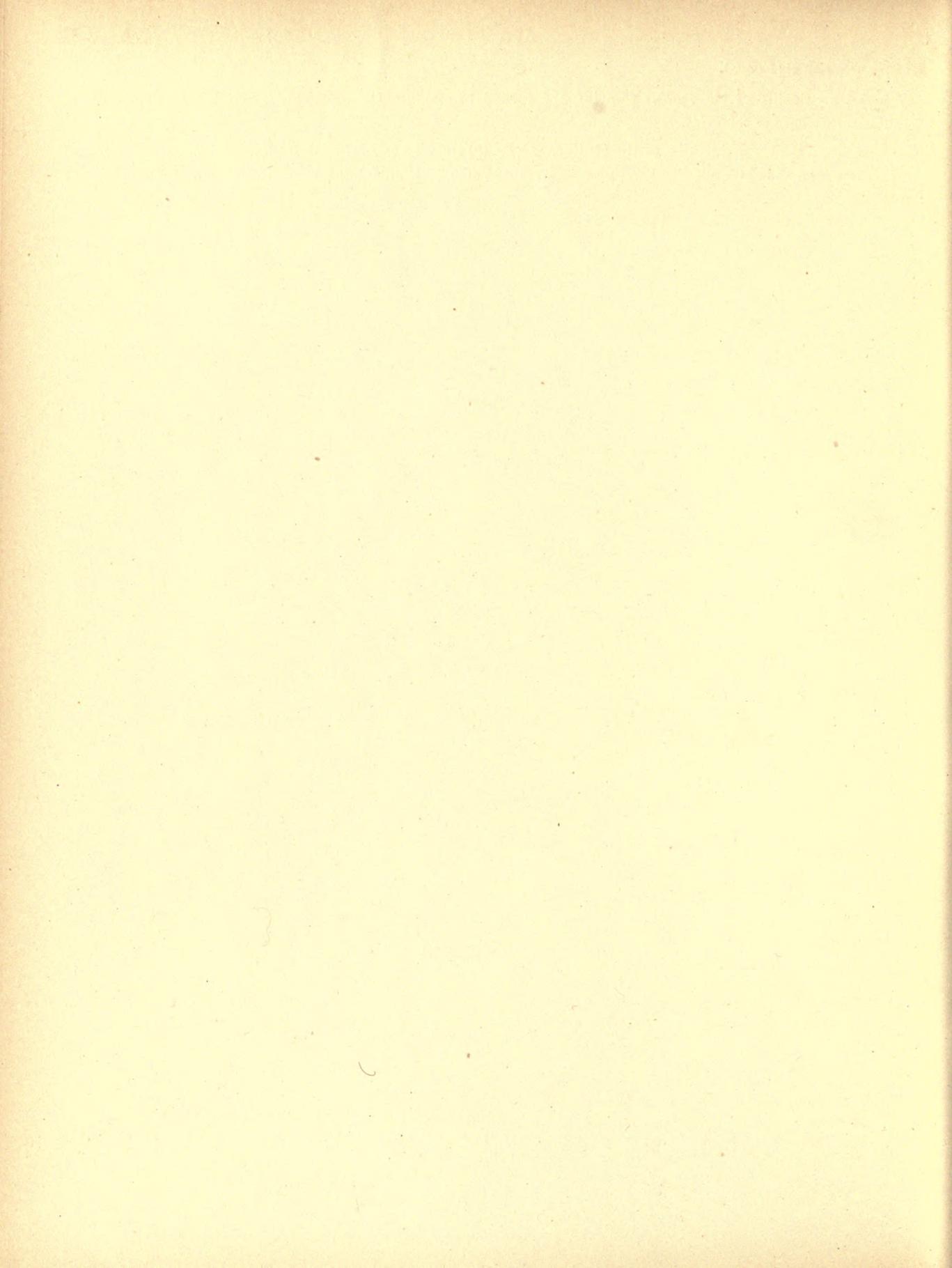




**Bladder-wrack** (*Fucus*).

A. Make a drawing of the *thallus* shewing the forked branching, the *attachment*, and the swollen ends of the branches bearing *conceptacles*.

B. Examine a transverse section of the thallus. Draw (a) the closely packed *assimilating cells* with *phæoplasts* on the surface, (b) the thin-walled *conducting cells* in transverse section, (c) the thick-walled *fibres* in transverse section.

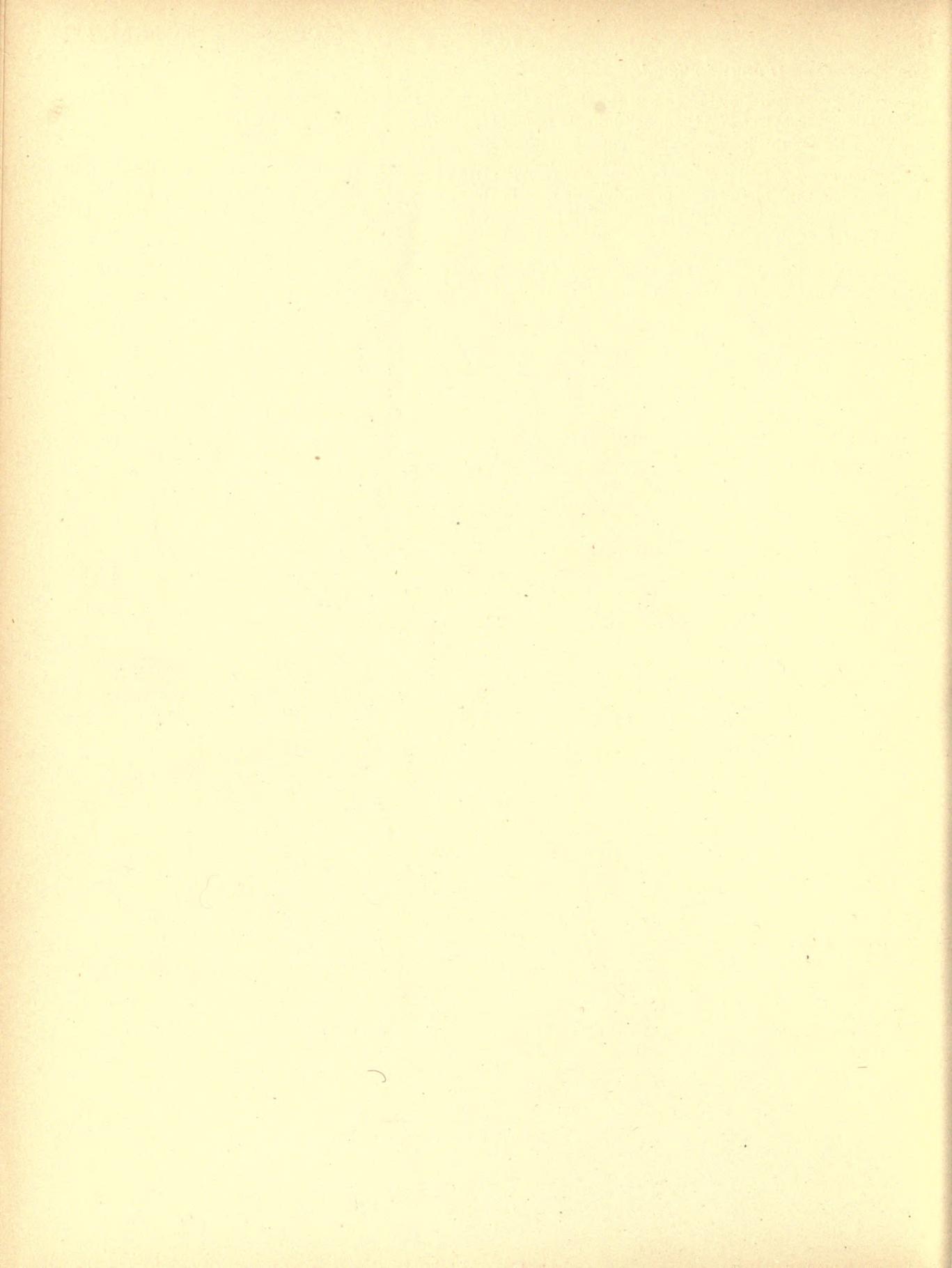


**Bladder-wrack** (*Fucus*) *continued*.

C. Examine a longitudinal section of the stalk of the thallus. Draw (a) the surface layer of square or oblong cells with brown phæoplasts, (b) the longitudinally running *conducting cells* with abundant contents and perforated cross walls, and (c) the longitudinally running thick-walled *fibres*.

D. Examine a transverse section through the reproductive part of the thallus. Note the assimilating cells on the surface and the loose tangle of conducting cells in the centre. Draw a *conceptacle* containing (a) *oogonia*, with eight egg-cells when ripe, (b) the *antheridial branches*, bearing the long oval *antheridia* with dense contents, (c) the sterile hairs.

E. In fresh material notice the *antherozoids* (*sperms*) and *egg-cells* (*ova*) extruded from the mouth of the *conceptacle*. Mount some of these in sea-water and observe the movements of the *sperms*.



**Pellia.**

A. Examine a plant of *Pellia* (a common Liverwort). Sketch the form of the flat green branching *thallus*, with a thickened *midrib* attached by *rhizoids* to the soil.

B. Draw a transverse section through the thallus, shewing the uniform parenchymatous thin-walled tissue, containing numerous *chloroplasts*, especially towards the upper surface, and starch grains; also *rhizoids* arising from the lower surface and penetrating the soil.

C. Examine and draw a section through the *spore capsule* shewing *capsule wall*, *spores* and *elaters*.

D. Examine a ripe spore-capsule. Note the four valves into which the capsule splits. Examine some of the brown spores in dilute glycerine under the high power.





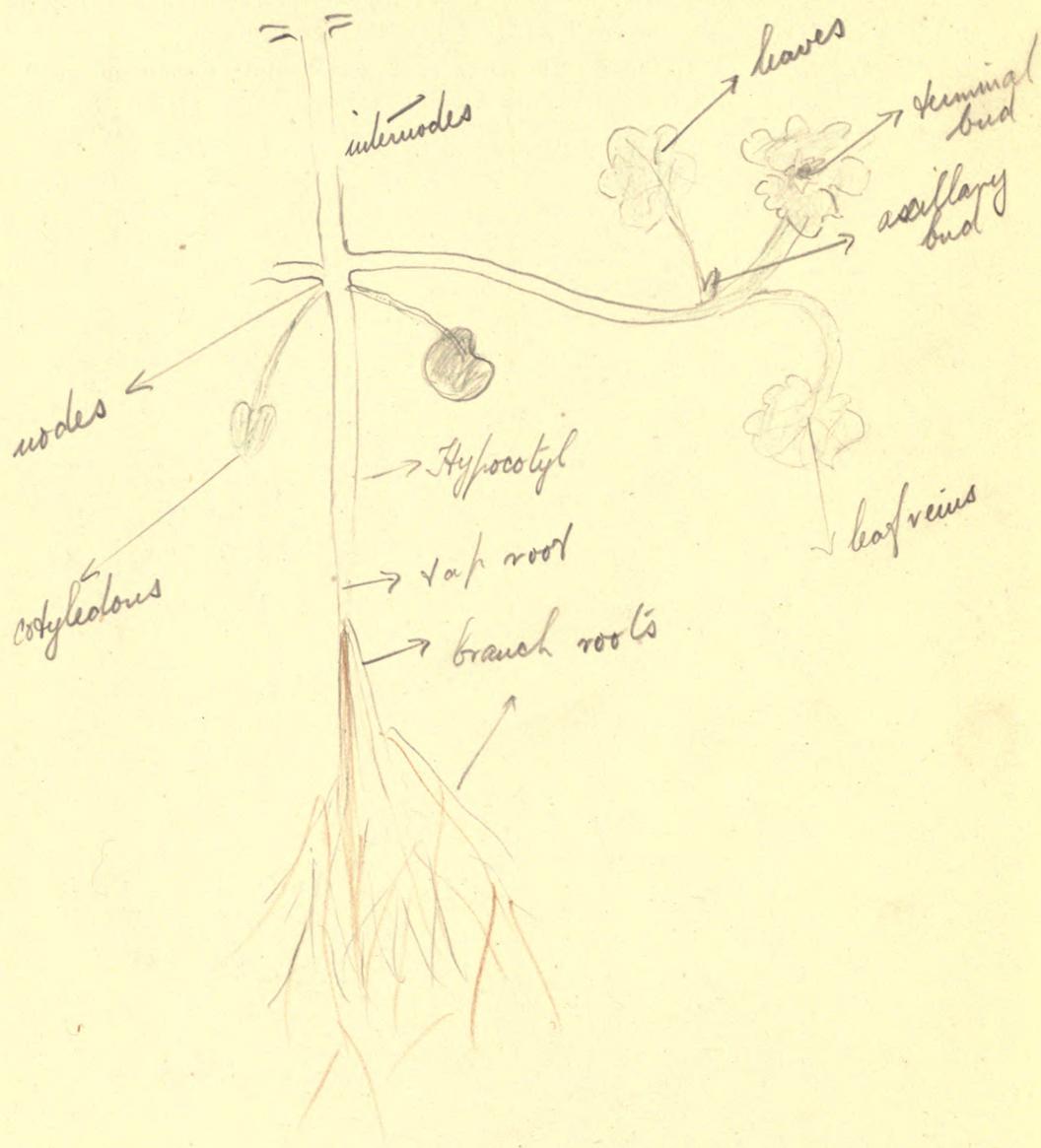
**Funaria.**

A. Examine a single plant of *Funaria* (a common Moss) under the dissecting microscope. Make a sketch illustrating the differentiation of the plant-body into (a) a slender axis, bearing (b) delicate green leaves, and (c) brown rhizoids in a tuft on the lower part of the axis. The leafy axis bears a slender stalk terminating in a pear-shaped *capsule* containing spores similar to the spores of *Pellia*.

B. Detach a single leaf and examine it in water under a low power. Observe that it consists of a single layer of cells all alike and that there are no veins. Under the high power draw some of the cells shewing the thin cell-wall, protoplasm with numerous disc-shaped chloroplasts embedded in it and the large vacuole occupying most of the cell-cavity, as in *Elodea*.

C. Examine some of the brown rhizoids under the high power and observe that they consist of threads of cells, branching at intervals. The end walls of the cells are very oblique.

D. Examine the transverse section of the stem of *Mnium* (another common Moss). Distinguish in a drawing the narrow thin-walled *water-conducting cells*, the larger *cortical cells* and the thick-walled *protective cells* on the surface.

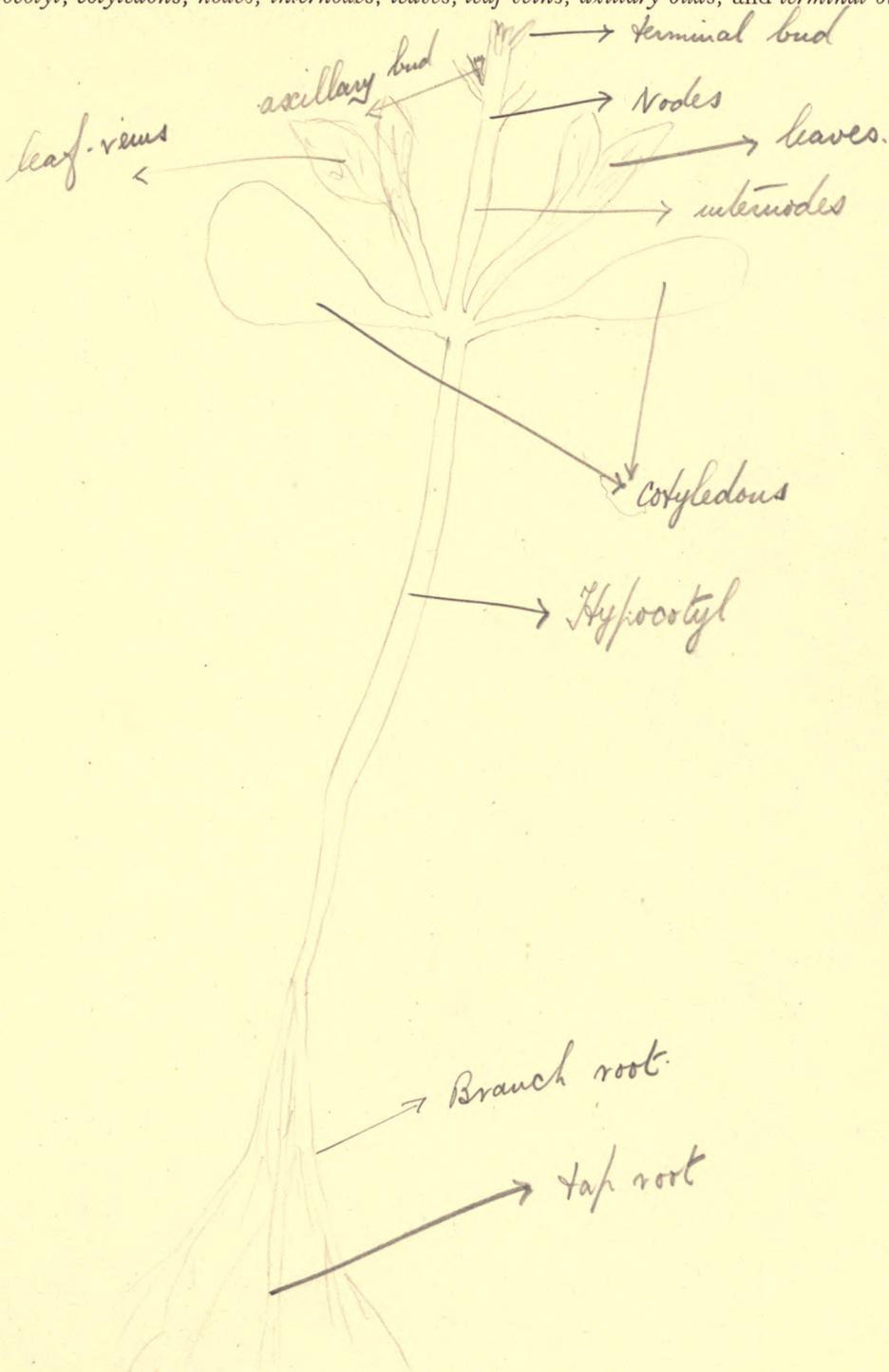


**Vegetative organs.**

ARRANGEMENT OF LEAVES, STEMS AND ROOTS IN DIFFERENT TYPES

**I. Erect herbaceous plant.**

A. Examine the upright herbaceous plant. Make a sketch shewing the relations of the following parts: tap-root, branch roots, hypocotyl, cotyledons, nodes, internodes, leaves, leaf-veins, axillary buds, and terminal buds.





**Vegetative organs** (*continued*).

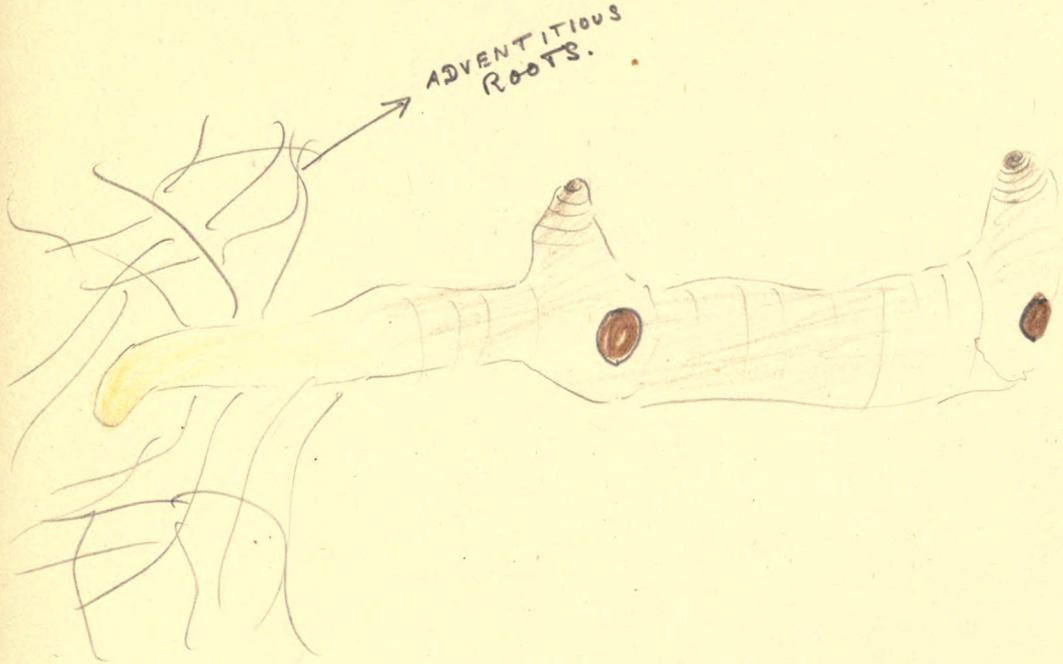
## ARRANGEMENT OF LEAVES, STEMS AND ROOTS IN DIFFERENT TYPES

**II. Rhizome.**

B. Examine the creeping underground stem of Solomon's Seal (*Polygonatum*). The main stem is a horizontal rhizome remaining below the ground, bearing leaf scales at its nodes, and adventitious roots.

The apical bud of this rhizome turns vertically upwards and grows out into the leafy flowering shoot. This dies down in the autumn and the plant remains below ground with food stored in the fleshy rhizome.

Growth is continued by a bud arising in the axil of a scale leaf on the rhizome.





Vegetative organs (continued).

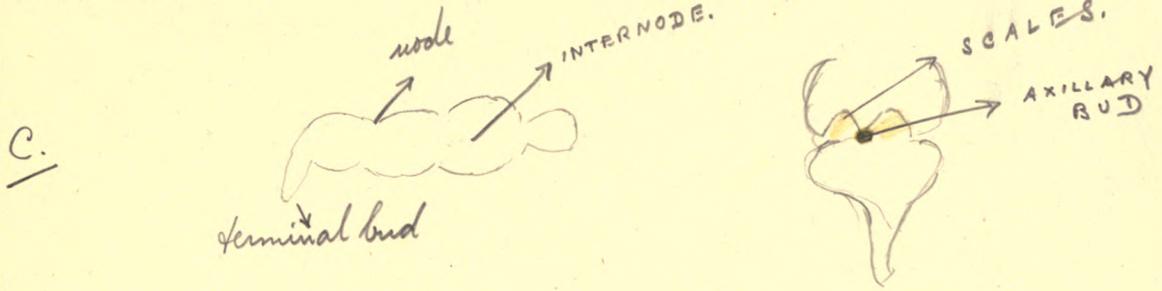
ARRANGEMENT OF LEAVES, STEMS AND ROOTS IN DIFFERENT TYPES

III. Tuber.

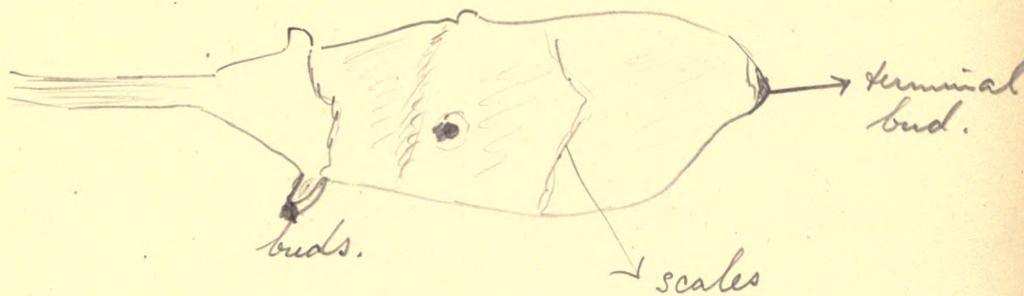
C. Make a sketch of the tuberously thickened underground stem of the Chinese artichoke (*Stachys tuberifera*), marking nodes, scales, axillary buds, internodes, upwardly turned terminal bud.

D. Jerusalem artichoke (*Helianthus tuberosus*). Sketch the tuber as seen from the side, marking scales, axillary buds, and terminal bud.

E. Sketch the sprouting potato (*Solanum tuberosum*): shewing tuber, leafy shoots, and adventitious roots arising from their base.



D.



E.





Vegetative organs (*continued*).

## ARRANGEMENT OF LEAVES, STEMS AND ROOTS IN DIFFERENT TYPES

IV. **Corm.**

*F.* *Crocus* corm (autumn—resting stage). Cut the corm longitudinally through the middle and sketch the section, marking *scar* left by falling off of flowering shoot, *protective scales*, *buds* in their axils, which will form new flowering shoots.

*G.* *Crocus* plant (spring stage). The buds in *F* have grown out into flowering shoots, whose bases are thickening to form new corms.

Identify the scar of last year's flowering shoot.





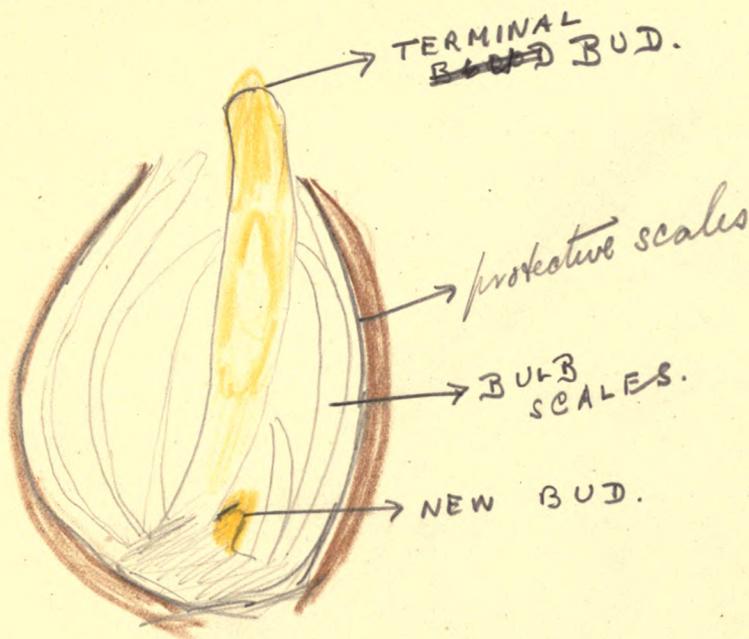
## Vegetative organs (continued).

## ARRANGEMENT OF LEAVES, STEMS AND ROOTS IN DIFFERENT TYPES

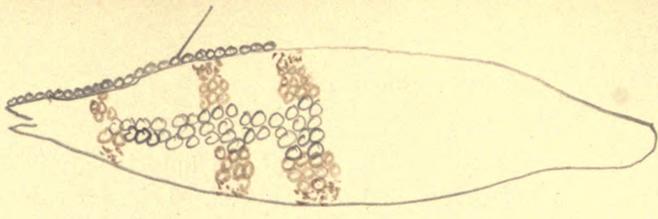
## V. Bulb.

*H. Tulip* bulb (autumn—resting stage). Cut through the middle of the bulb longitudinally and make a drawing of the section, marking *protective scales*, *bulb scales*, and *terminal bud*. Look for axillary bud which will form next year's bulb.

*I. Tulip* plant (spring stage). The terminal bud in *H* has grown out into the flowering shoot. Cut through the old bulb longitudinally and draw the section, shewing the *new bulb* arisen from an axillary bud formed in the autumn, *roots*, etc.

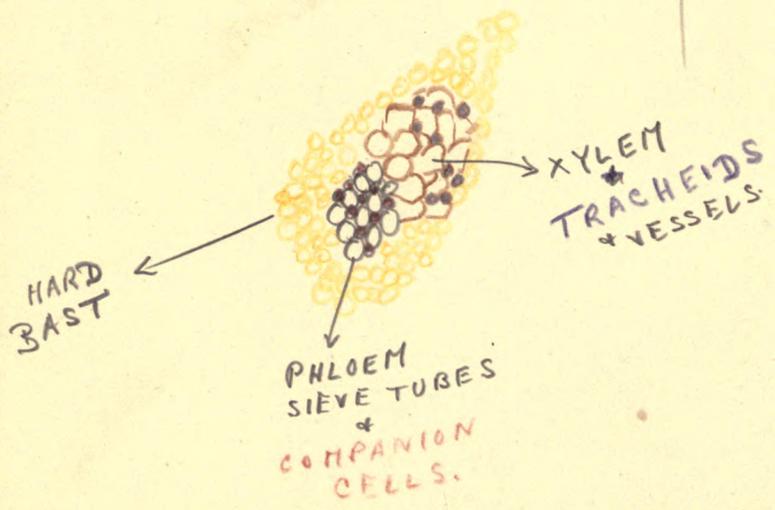
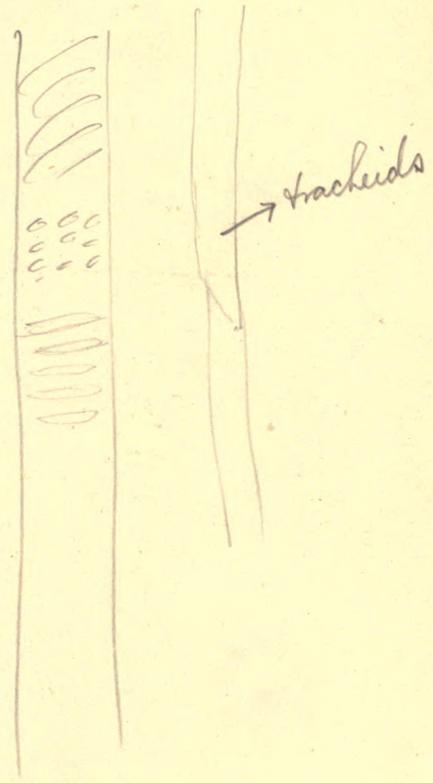
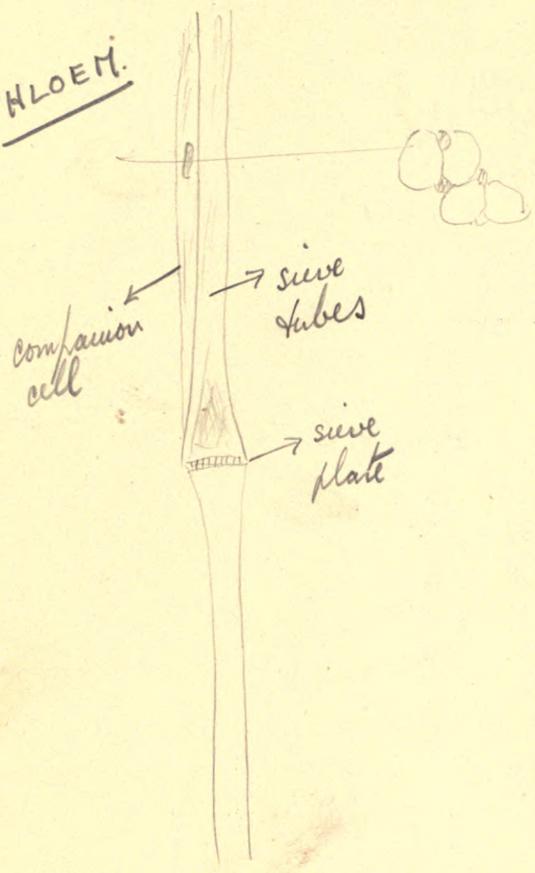


F



PHLOEM.

XYLEM



**Leaves.**

A. Examine the transverse section of the leaf-lamina provided. Make a drawing of the structure, shewing (a) the *epidermis* and *cuticle* of the upper surface, (b) the *palisade cells* of the *mesophyll*, (c) the *spongy tissue* of the mesophyll with large *intercellular air-spaces*, (d) the *lower epidermis*, its *stomata* and *cuticle*. Note also (e) the vascular bundles.

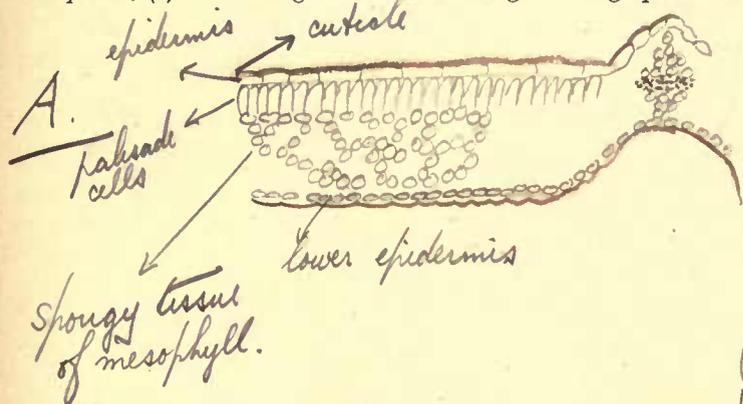
B. Mount another section in Schulze's solution. Note that the cuticle turns yellow while the cellulose-walls and starch grains turn blue.

C. Examine the leaf of geranium (*Pelargonium*) in the glass of coloured solution. Cut across the leaf-stalk and veins and observe that the coloured solution has been sucked up in the wood elements of the vascular bundles.

D. Strip off a piece of the epidermis from the lower surface of a leaf of *Iris*; mount it in water and sketch under a high power (a) a few of the epidermal cells, without chloroplasts, and (b) the guard cells, containing chloroplasts, surrounding the pore of each stoma. Treat the upper epidermis similarly and note that stomata are absent.

E. Examine a transverse section of the leaf of *Iris*, and draw a vascular bundle, distinguishing (a) *xylem* with *tracheids*, (b) *phloem* with *sieve-tubes* and *companion-cells*, (c) *hard bast* of *fibres*. Stain with aniline chloride. This turns lignified tissues bright yellow.

Examine also and draw a *stoma* in transverse section distinguishing (a) *guard-cells* with cell cavities containing chloroplasts, (b) *cuticle* of guard-cells and neighbouring epidermal cells, (c) *vestibule*, (d) *pore* of stoma.



D.

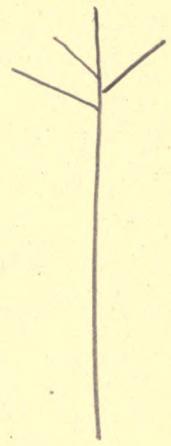
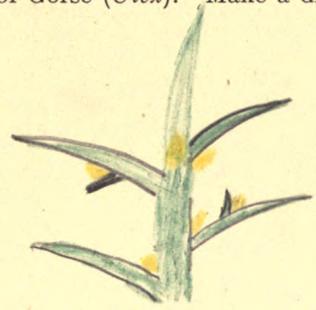




**Leaves** (*continued*).

F. Place the lamina of a fresh leaf (*e.g. Limnocharis*) in water, then suck the end of the leaf-stalk and note the dark patches that appear on the leaf-blade. These are due to water having been sucked through the stomata into the intercellular spaces.

G. Examine the shoots of Gorse (*Ulex*). Make a diagrammatic sketch to shew the arrangement of "leaf-spines" and "stem-spines."





**Roots.**

A. Draw a single mustard seedling under the dissecting microscope to shew the numerous *root-hairs*. Notice that the hairs are shorter towards the root apex.

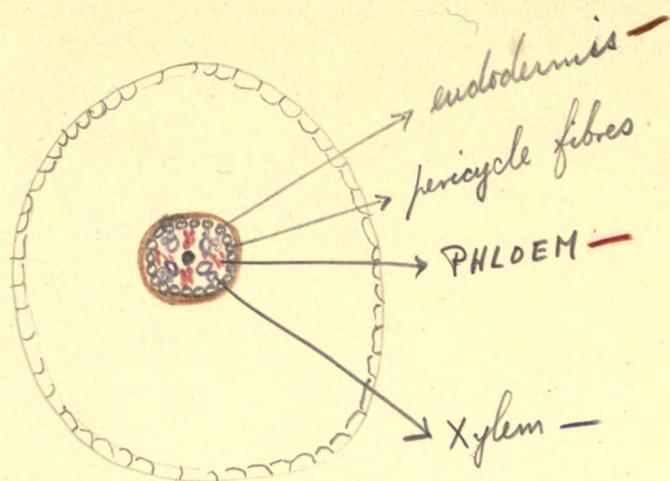
B. Mount the root of the seedling in water, and flatten it out under a coverslip. Draw some *root-hairs* to illustrate *their origin from single superficial cells*.

C. Examine the fresh Bean root, observe the root-cap at the growing point and the four or more longitudinal rows of lateral roots. Cut the root across and make out with a lens the endogenous origin of the lateral roots.

D. Separate the cortex from the *stele* by twisting the root to break the cortex and pulling it off like a sheath.



F.

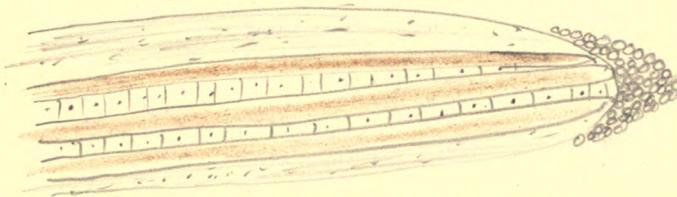


**Roots** (*continued*).

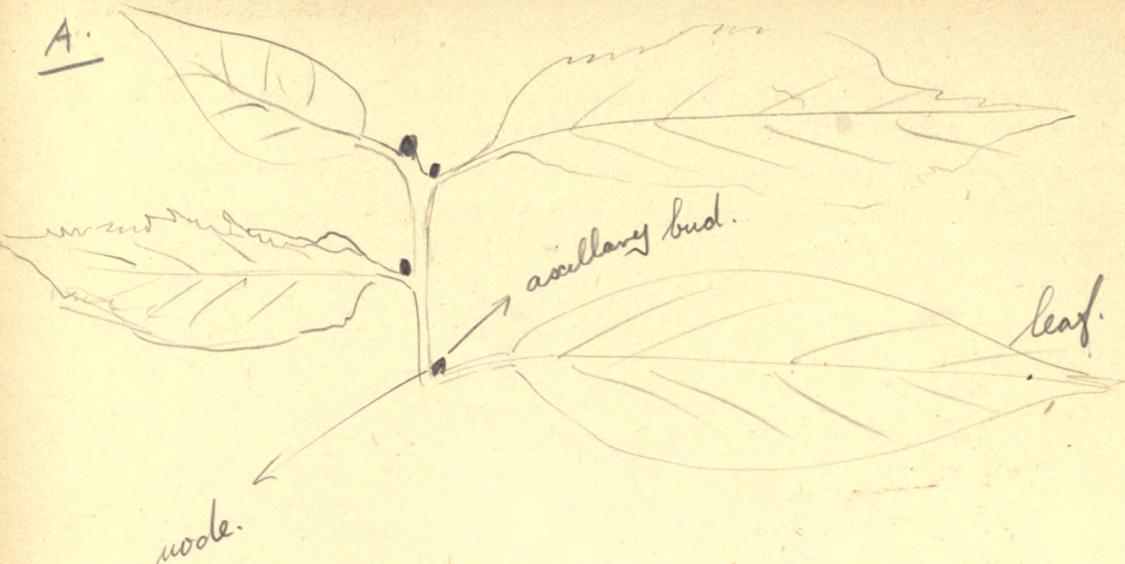
E. Make a drawing of a transverse section of the *stiele* of the root of a Buttercup. Shew the well-marked *endodermis*, the *pericycle*, and the four alternating *xylem* and *phloem* strands.

F. Examine the transverse section of young bean root, noting especially the piliferous layer with *root-hairs*

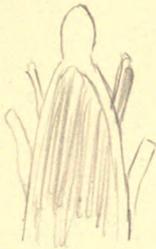
G. Draw the longitudinal section through the apex of a root (Maize) shewing (a) the growing point, (b) root-cap, (c) young *stiele*.

G.

A.



B.



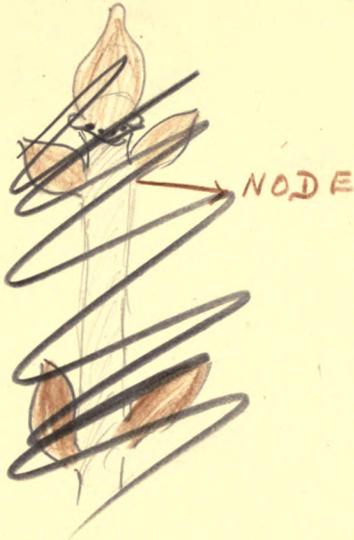
**Herbaceous Stems.**

A. Draw the piece of stem provided which bears leaves and axillary buds at the *node*. Note the arrangement of the vascular bundles in the cut stem and cut leaf-stalk.

B. Dissect the growing-point of the stem and sketch the rudimentary leaves of a Brussels sprout.

C. Make a diagram of the growing region of the stem of the Brussels sprout as seen in longitudinal section, shewing (a) *growing-point* (primary meristem), (b) the *youngest leaves*, (c) older leaves with buds in their axils, (d) young vascular bundles.

A.



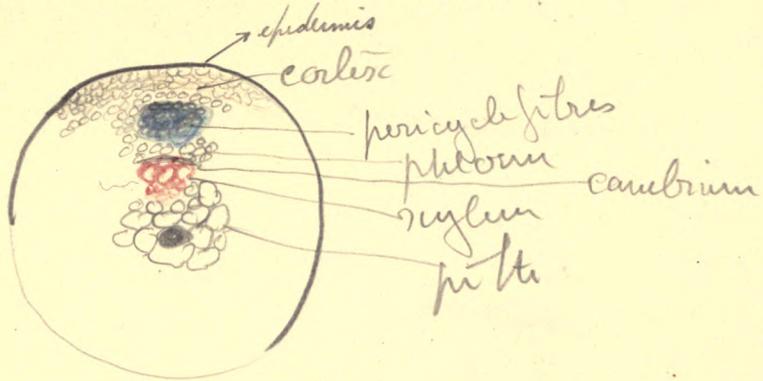


**Herbaceous Stems** (*continued*).

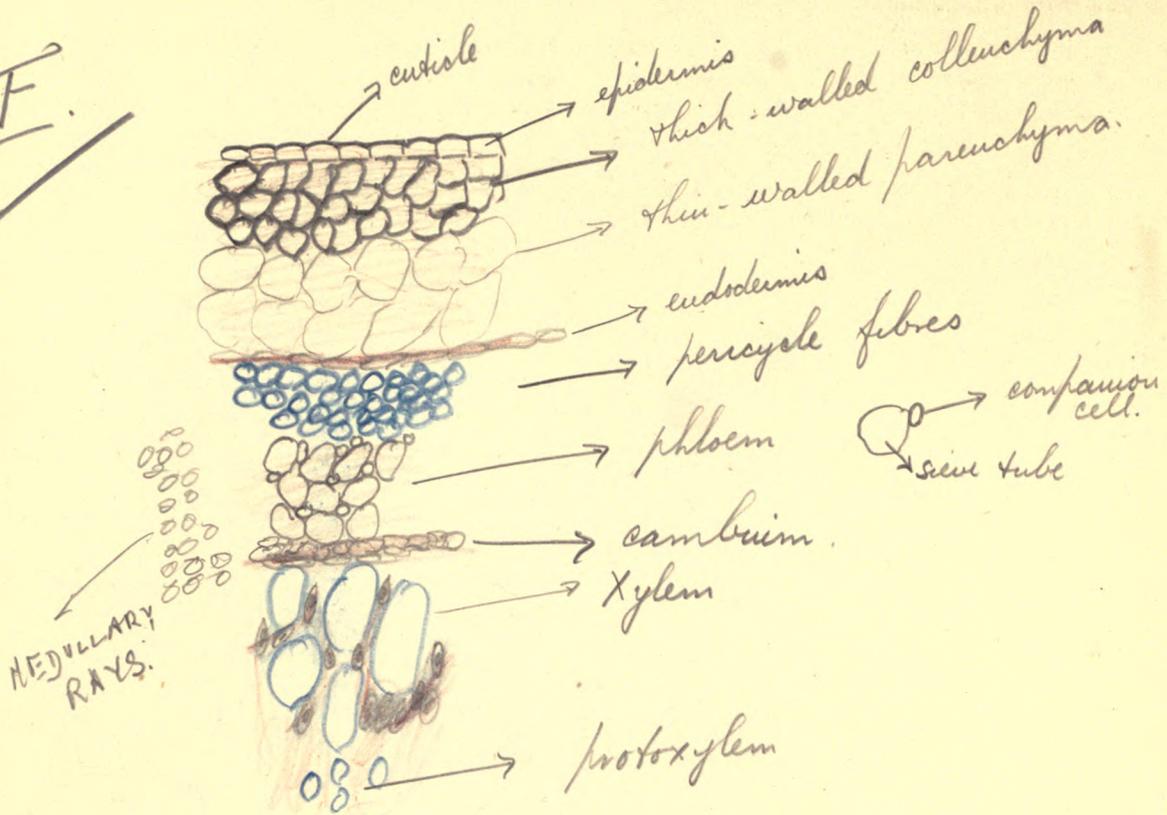
D. Examine in water, a transverse section of the stem of the Sunflower and draw a *diagram* indicating the following tissues and system of tissues; *epidermis*, *outer cortex*, *inner cortex*, *endodermis* (starch sheath) and *central cylinder* (stele) consisting of (i) *pericycle* (fibrous opposite bundles, parenchymatous between), *rays*, *pith*, and (ii) *vascular bundles*, shewing *xylem*, *phloem* and *cambium*.

Add a drop of Schulze's solution, and observe that the cell-walls of most of the tissues turn *blue* (cellulose) while those of the pericycle fibres and most of the xylem turn *yellow* (lignified).

D.



F.

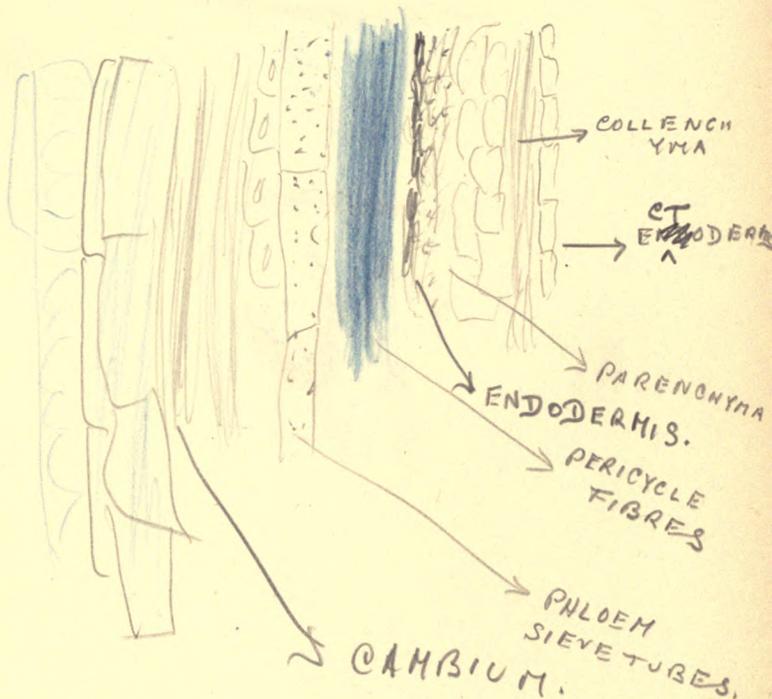


**Herbaceous Stems** (continued).

E. From the stained section provided make a careful high-power drawing of a few cells of each of the following tissues: (a) epidermis with cuticle; (b) outer cortex consisting of thick-walled cells (*collenchyma*); (c) inner parenchymatous cortex; (d) endodermis; (e) pericycle fibres; (f) phloem, including sieve-tubes, companion-cells and parenchyma; (g) cambium; (h) xylem, including large (pitted) vessels, xylem fibres, parenchyma, and (i) protoxylem; (j) cells of the medullary rays which are beginning to form the interfascicular cambium.

F. Examine the radial longitudinal section and draw under the high power a few cells of each of the following tissues: (a) phloem showing *sieve-tubes* and *companion-cells*; (b) *metaxylem* showing part of a *pitted vessel*, some adjoining parenchyma and fibres, and (c) *protoxylem* showing *spiral vessels* and adjoining *thin-walled parenchyma*.

F.

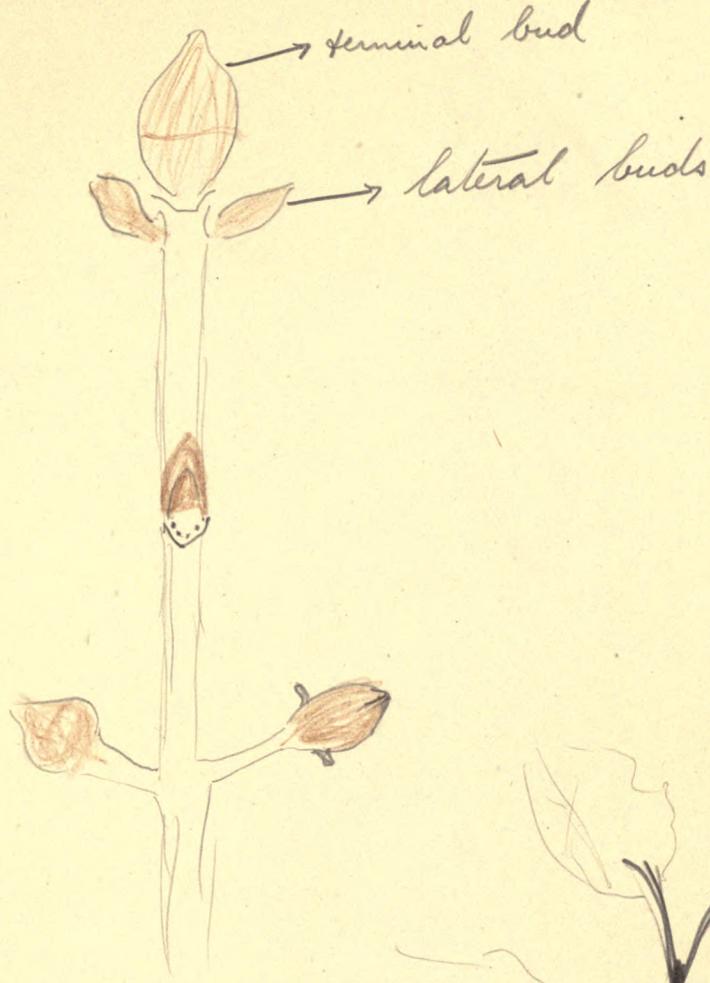


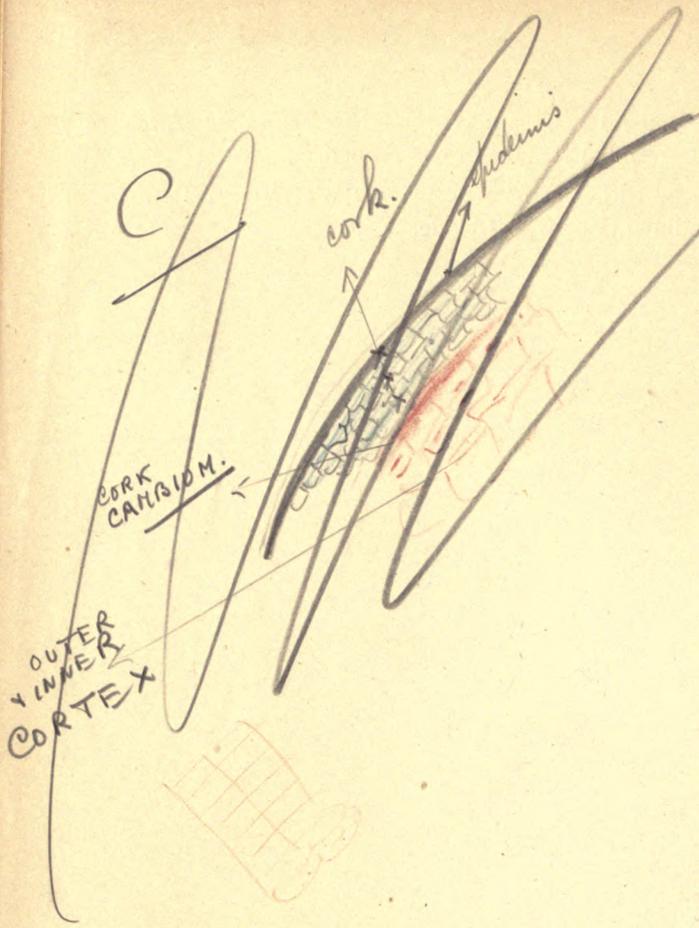


**Woody (Arboreal) Stems.**

A. Draw a winter branch of Horse-chestnut shewing several years' growth. Mark *terminal buds*, *lateral buds*, covered with bud scales, *leaf scars*, *bud-scale scars*. Determine the age of the branch.

B. Make a diagram of the structure of the sprouting bud of Sycamore, shewing the arrangement of the bud scales and foliage leaves. Draw scales which bear rudiments of a leaf-blade.

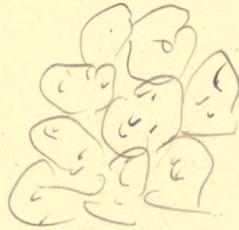
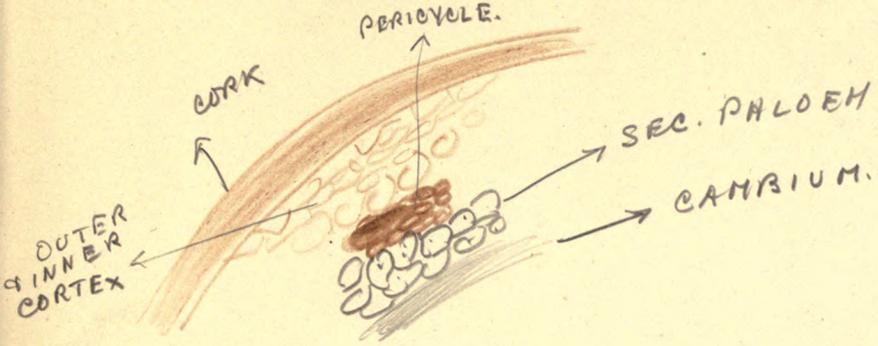


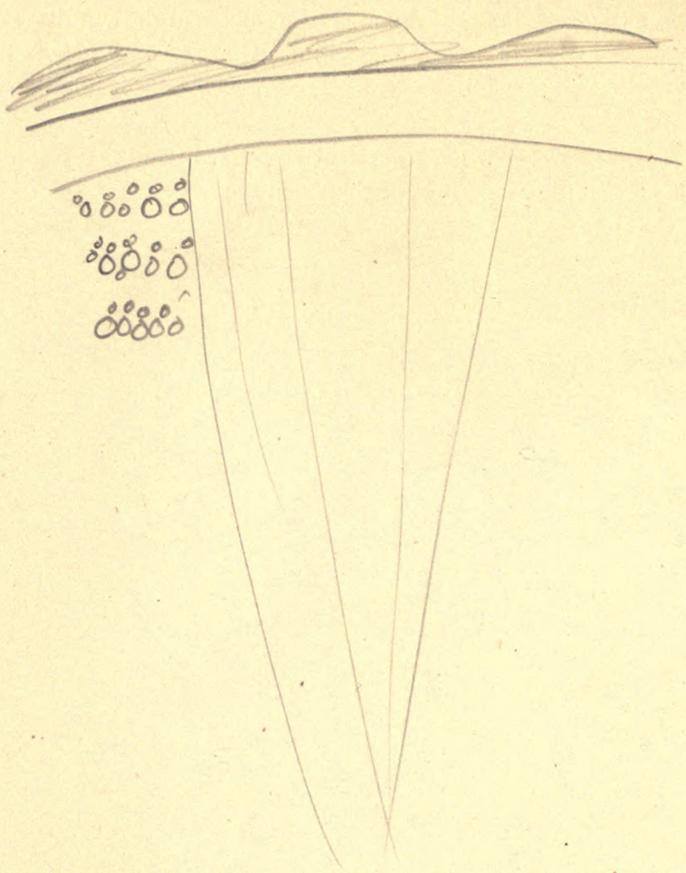


**Woody (Arboreal) Stems** (continued).

C. Examine the transverse section of a Maple branch three years old and draw a diagram shewing (1) the cork ; (2) the outer cortex ; (3) the inner cortex ; (4) the pericycle ; (5) the secondary phloem ; (6) the cambium ; (7) the secondary xylem with three annual rings ; (8) the principal secondary rays ; (9) the primary xylem, and (10) the pith.

D. Examine the branch of Portugal Laurel that has been kept with its cut end in a coloured solution. Split it longitudinally and note that the solution is carried up in the wood only.





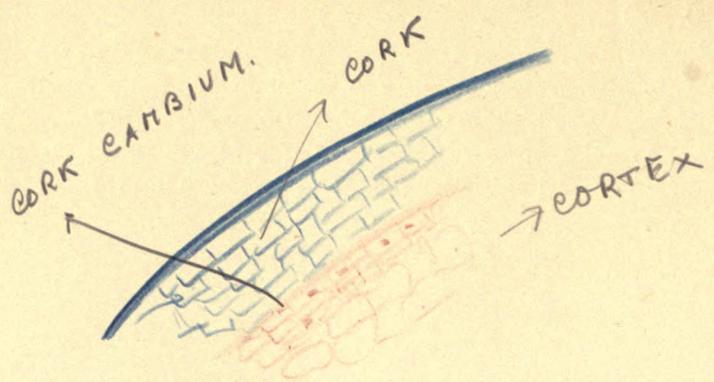
PHLOEM.

XYLEM.

**Woody (Arboreal) Stems** (*continued*).

E. Make a diagrammatic sketch of the different faces of the block of Oak, including: (i) the transverse section shewing the *annual rings*, the large *spring-vessels*, which appear as small holes in the wood, the broad *medullary rays* crossing the line of *cambium*, *inner bark* (yellow-brown) consisting of *secondary phloem* and *outer bark* (red) with irregular bands of dark *cork*; (ii) radial face, shewing the *wood* and broad *medullary rays* ('silver grain'); (iii) tangential face, shewing the ends of the *medullary rays* as seen in the cut surface of the wood.

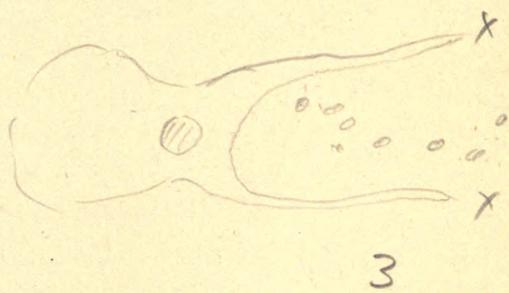
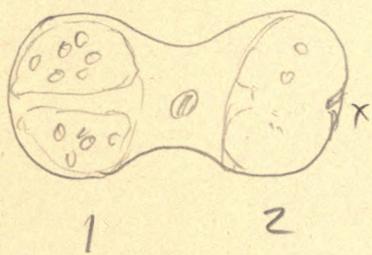
Note on the transverse and radial faces the distinction between *sapwood* and *heartwood*.



**Woody (Arboreal) Stems** (*continued*).

F. Draw a portion of the outer tissues of a transverse section of the twig of *Ailanthus* under the high power to shew the development of *cork* from the *cork-cambium*.

G. Examine the piece of willow branch provided. Observe the *lenticels* seen on its surface. Peel it and note that the outer part separates at the line of the *cambium*.



**Morphology of the Flower.**

**Buttercup (*Ranunculus*).**

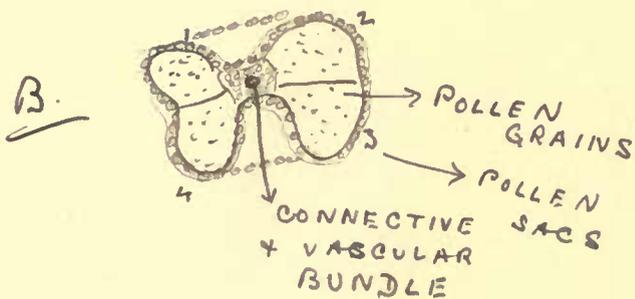
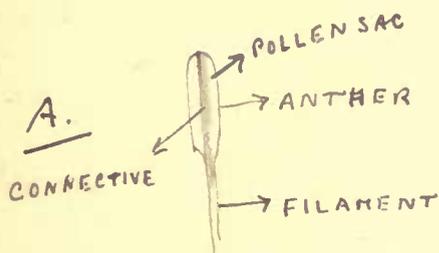
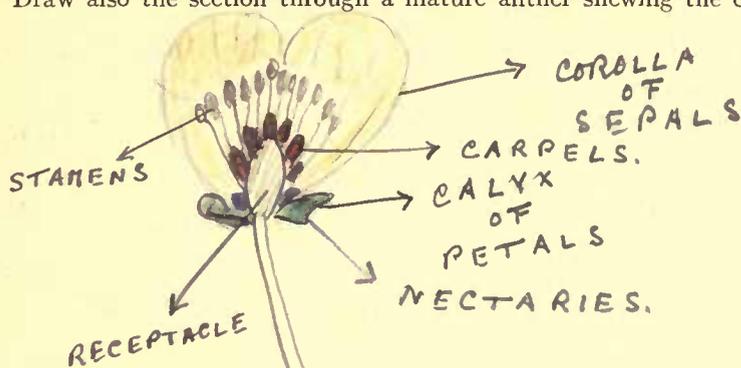
Sketch a single flower cut in half longitudinally exactly down the middle with a razor or very sharp knife, shewing (a) *receptacle*, (b) *calyx* of *sepals*, (c) *corolla* of *petals*, (d) *stamens*, (e) *carpels*, (f) *nectaries* on the petals.

**STAMENS.**

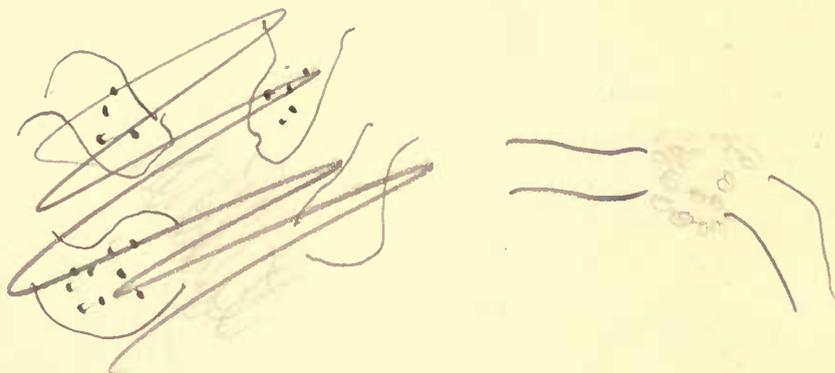
A. Sketch under a lens, a single stamen shewing (a) the *filament*, (b) the *anther* with its two pairs of *pollen-sacs*, (c) the *connective* or continuation of the filament between the pollen-sacs, and (d) the line of dehiscence of the anthers.

B. Examine transverse section through a young anther and draw (a) the four *pollen-sacs* containing *pollen-grains*, (b) the connective traversed by a vascular bundle, (c) the *fibrous layer* below the epidermis.

C. Draw also the section through a mature anther shewing the dehiscence.



C.





Morphology of the Flower (continued).

CARPELS.

A. Remove a carpel from the old flower or young fruit of *Caltha* (Marsh marigold), draw the side view and then split down the ovary to shew the many ovules inside, attached in two rows along the inner edge, corresponding with the joined margins of the carpellary leaf.

B. Draw under a low power the transverse section of the ovary of *Yucca* provided, shewing the three joined carpels, midrib and edges (*placentae*) of each, the ovules with (i) *funicle* and vascular bundle traversing it, (ii) *inner* and *outer coats*, (iii) *micropyle*, (iv) *nucellus*, (v) *embryo-sac*.

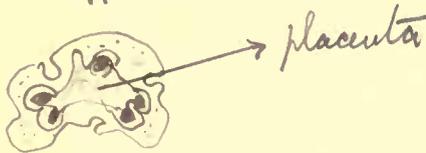
C. Draw under a low power a diagram of the transverse section of the carpel of *Aquilegia* (Columbine) shewing (i) *midrib* of carpellary leaf, (ii) edges (*placentae*) to which ovules are attached, (iii) *cavity of ovary*, (iv) ovules.

D. In the same section draw under the high power (a) the *synergidae* and the *egg-cell*, (b) the *antipodal cells*, (c) the *nucleus* and *vacuolated protoplasm* of the *embryo-sac*, (d) the *nucellus*, (e) the coats of the ovule and if possible indicate (f) the *micropyle* (very narrow and not traversed in most sections).

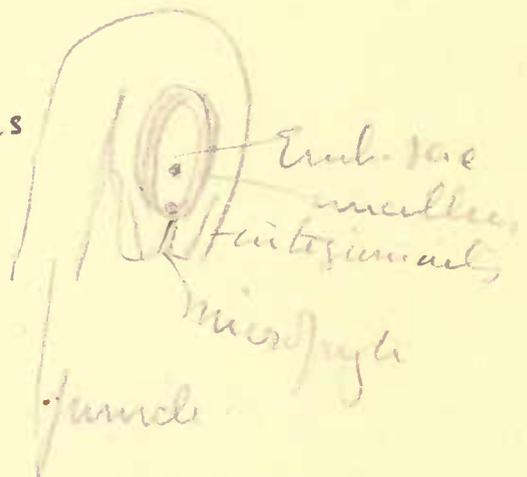
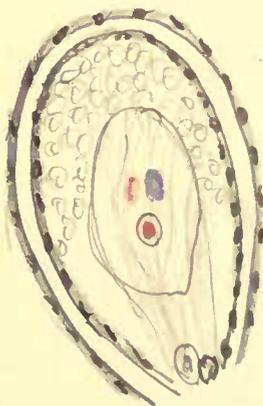
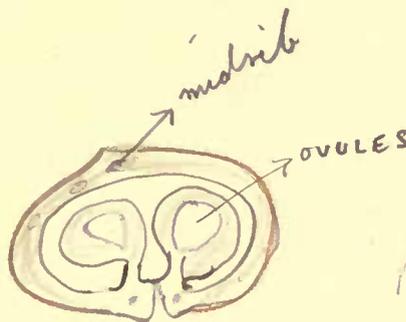
A.



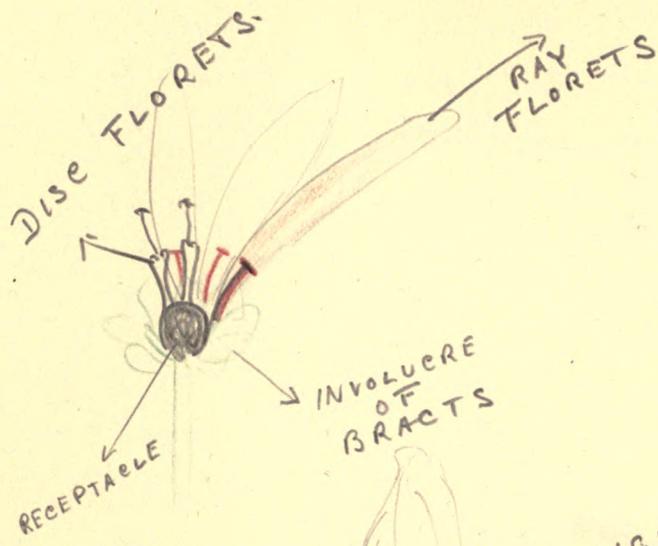
B.



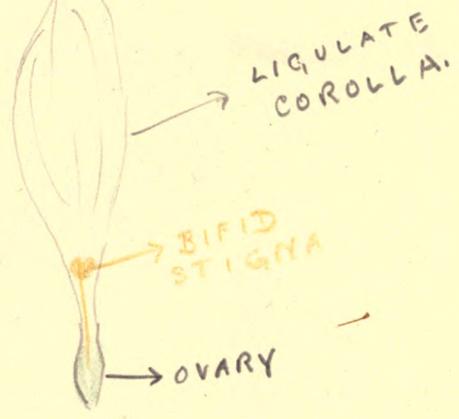
C.



11 A.



B.



C.



**Types of Flower.****I. CYTISUS. (*Papilionatæ*.)**

A. A general sketch of the flower illustrating the form of a *papilionaceous flower*.

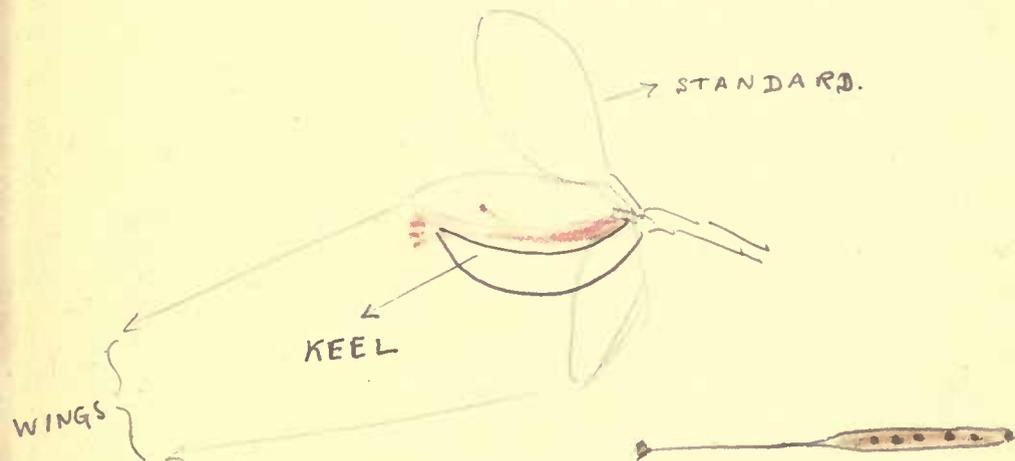
B. Dissect the flower and make sketches of (a) the *calyx*, (b) the *corolla*, consisting of five *petals*—the *standard*, the two *wings*, the two coherent petals forming the *keel*, (c) the *andrecium*, consisting of *ten stamens*, which are *joined together* by their filaments. Slit open the staminal tube to expose (d) the single *carpel*; the basal swollen part of *pod* is the *ovary*, the elongated portion the *style* ending in the *stigma*.

**II. DOG DAISY (*Chrysanthemum* sp.). (*Compositæ*.)**

A. Sketch the *inflorescence* of a Daisy cut in half, shewing (a) the *receptacle*, (b) *involucre of bracts*, (c) *ray-florets*, (d) *disc-florets*.

B. Carefully remove and sketch a single ray-floret, shewing (a) *ligulate corolla*, (b) *bifid stigma*, (c) *ovary*.

C. Carefully remove a disc-floret (including the inferior ovary), and examine in water under the low power of the microscope. Make a drawing shewing (a) *tubular corolla* with five lobes, (b) *ovary*, (c) *anthers forming a tube* round the gynæceum, (d) the *bifid stigma* projecting beyond the *anther-tube*. Slit open a corolla, and make a drawing of the *free filaments* of the five stamens, and the *united anthers*. Notice the *arrangements for cross-pollination*.





**Types of Flower** (*continued*).

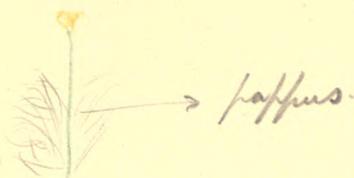
D. Make a sketch of a *disc-floret* of another Composite (*e.g.* Groundsel) to shew the *pappus*.

E. Mount a few *pollen-grains* from a fresh flower of *Chrysanthemum* in a drop of water; examine under a high power and sketch a single pollen-grain shewing the character of the outer coat.

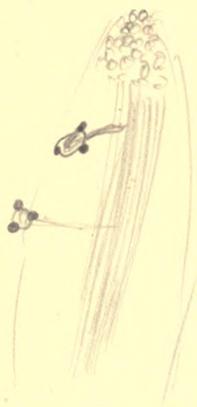
F. Examine the preparation of sprouting pollen-grains shewing the formation of the pollen-tube.

G. Sketch the longitudinal section through a stigma [*e.g.* the Evening Primrose (*Enothera*)] shewing the *pollen-grains* and *pollen-tubes* in the tissue of the style.

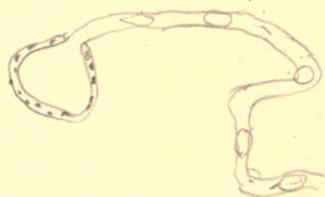
D.



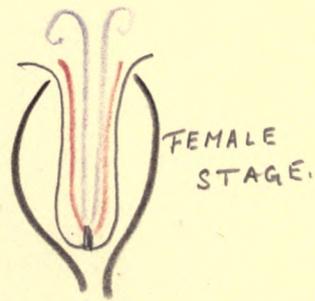
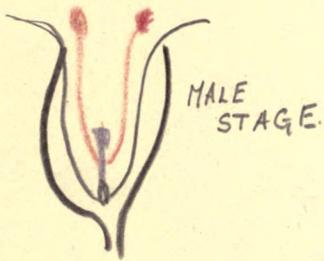
G



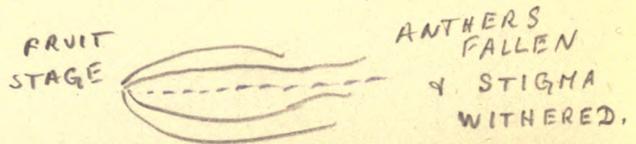
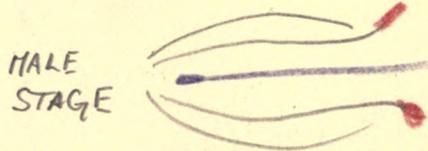
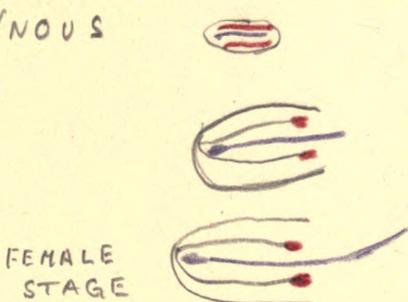
E, F.



LYCHNIS. ~~PROTANDROUS~~. PROTANDROUS.



PROTOGYNOUS



**Types of Flower** (*continued*).III. CAMPION (*Melandrium*), *protandrous*.

A. Sketch the appearance of (a) a flower in the *male* stage, (b) one in the *female* stage.

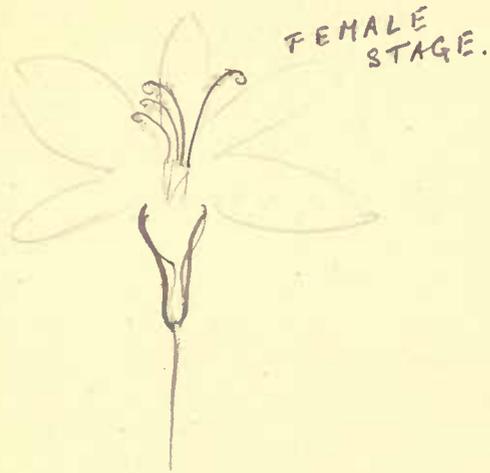
B. Cut longitudinally a flower in the male stage and make a sketch to shew that the styles are immature and not fully grown.

IV. PLANTAIN (*Plantago major*), *protogynous*.

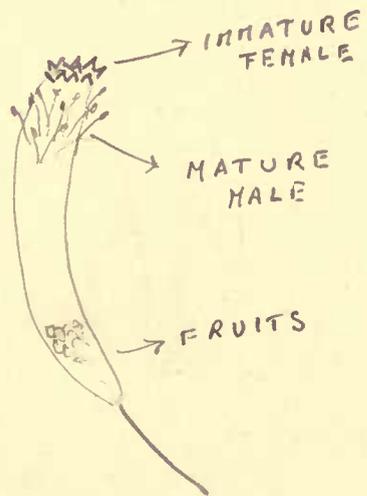
A. Sketch the inflorescence of crowded flowers shewing the projecting styles and the drooping stamens. Note that the flowers open at the *bottom* of the inflorescence first.

B. Draw a flower from the upper part, in the young (female) stage, with the unripe stamens hidden in the corolla; also a flower in the later male stage from the lower part.

III



IV.





Floral diagram  
OF  
PEA.

Fruits.

I. SWEET PEA (*Lathyrus odoratus*) (*Papilionatae*).

Sketch the young fruit (pod) shewing the remains of the *stigma* and the persistent *calyx*. Split it longitudinally and draw the young seeds attached to one ridge of the fruit wall. Compare it with your drawing of the flower of *Cytisus*. In the older pod draw the row of nearly ripe seeds.

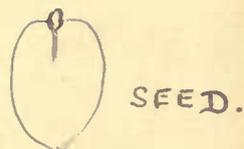
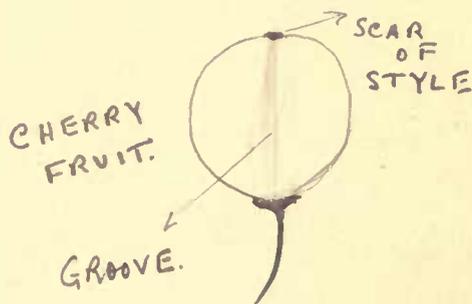
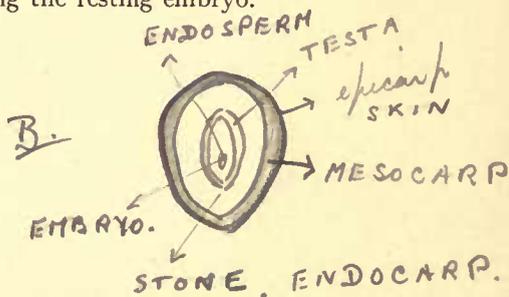
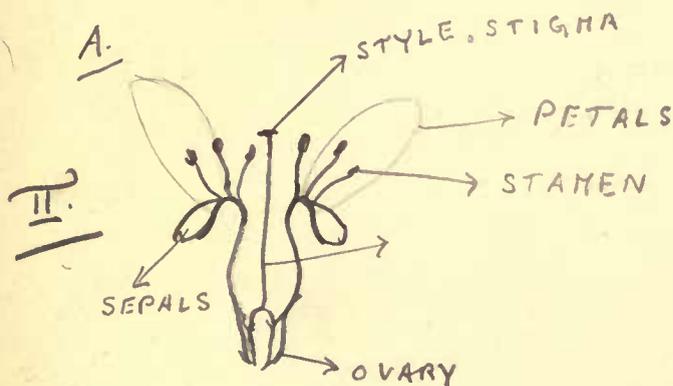
II. CHERRY (*Prunus cerasus*) (*Rosaceae*).

A. Sketch a flower cut open longitudinally, shewing the receptacle and the arrangement and manner of attachment of (a) the *sepals*, (b) *petals*, (c) numerous *stamens*, (d) *single carpel*.

B. Cut a longitudinal section of a very young Cherry fruit. Observe the *pericarp* (fruit wall) consisting of *epicarp* (skin), *mesocarp* (flesh) and the thickening *endocarp* (stone); also the *testa* and *endosperm* and *embryo* of the young *seed* (kernel).

C. Sketch a ripe Cherry fruit shewing the *scar of the style* and the *longitudinal groove* representing the *suture* (joined margins) of the *carpel*. Remove the stalk and notice on it the scar of the attachment of the receptacle-tube.

D. Break the stone and examine the 'kernel' or *seed* containing the resting *embryo*.









Fruits (continued).

IV. SYCAMORE (*Acer pseudo-platanus*).

- A. Make a sketch of the ripe dried fruit.
- B. Dissect one of the fresh half-fruits to shew the thin *testa* and the green coiled *embryo*.
- C. Make a drawing of a section through the ripening ovary of the flower of Sycamore. Note the *two ovules* in each *loculus*, and also the outgrowths which become the *wings* of the fruit.

V. DANDELION (*Taraxacum officinale*) (*Compositæ*).

Sketch a fruit of Dandelion to shew the *pappus*.

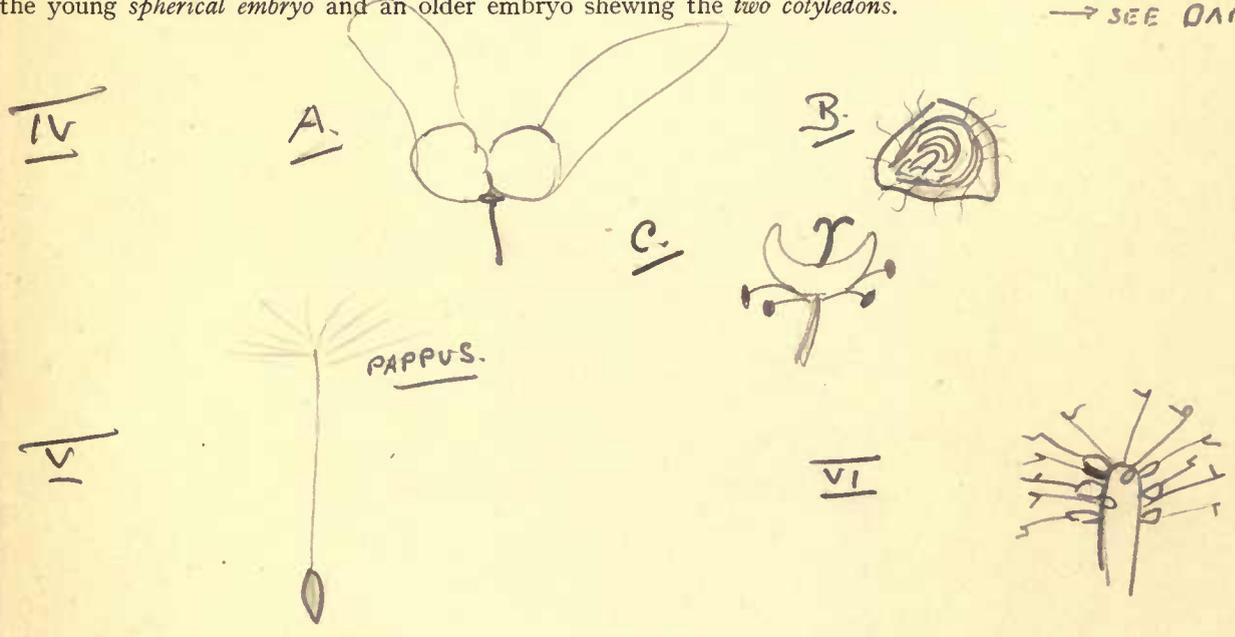
VI. HERB BENET (*Geum urbanum*) (*Rosaceæ*).

- A. Sketch a fruit-head cut in half longitudinally, to shew the numerous *achenes* borne on the *receptacle*.
- B. A single fruit (*achene*) shewing the hooked *style*, and the *stigma* which breaks off.

VII. SHEPHERD'S PURSE (*Capsella*).

Sketch various *embryos* under a high power illustrating different stages in development; note the *suspensor*. The young *spherical embryo* and an older embryo shewing the *two cotyledons*.

→ SEE DARWIN.





### Seeds and Germination.

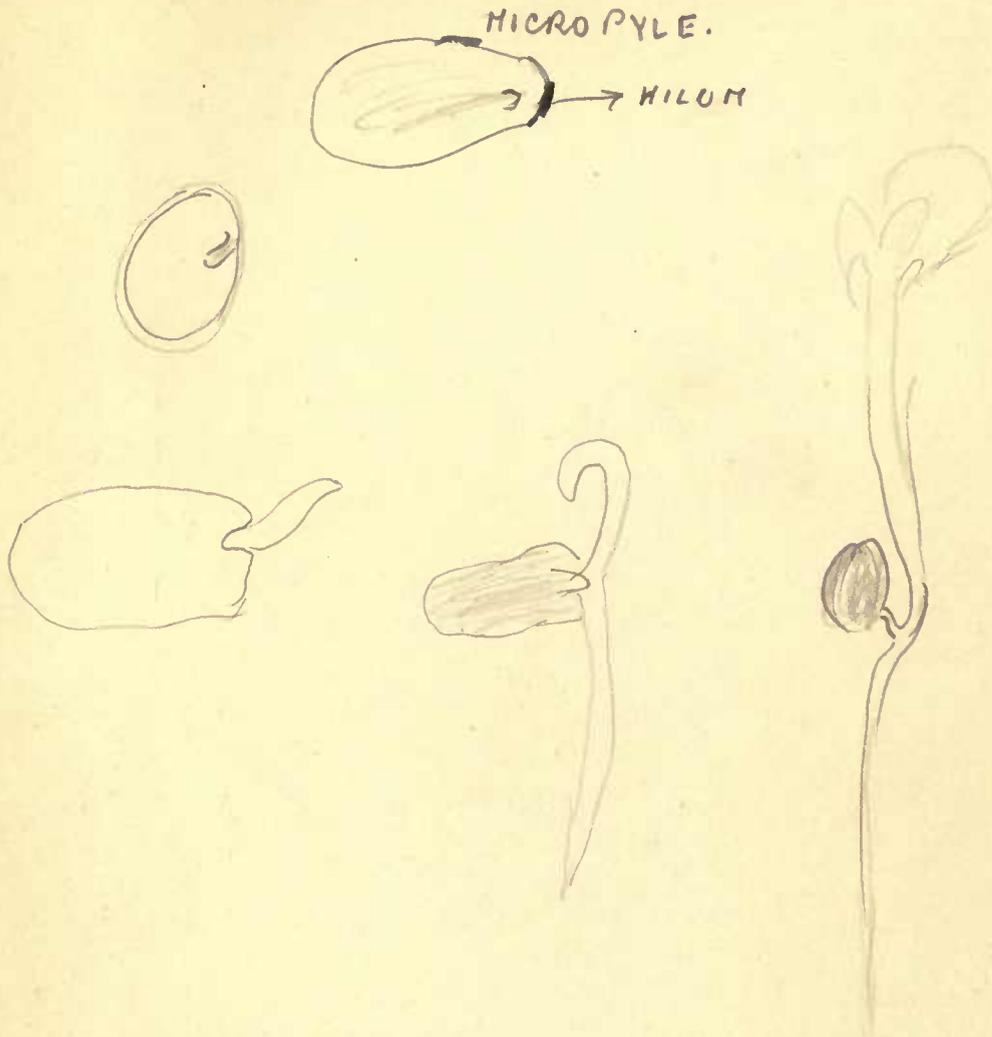
#### I. SEEDS WITH FOOD MATERIAL IN THE COTYLEDONS, WHICH REMAIN BELOW ON GERMINATION.

##### 1. BEAN (*Vicia faba*).

A. Sketch a seed, noting the *testa*, the *hilum*, and the position of the *micropyle*. (By squeezing a soaked seed a drop of water is forced out through the *micropyle*.)

B. Split the seed longitudinally, and sketch a *cotyledon*, the *radicle*, *hypocotyl* and *plumule*.

C. Make a series of sketches of germinating seeds and seedlings in different stages, shewing the *radicle*, *hypocotyl*, *plumule*, *cotyledons*; *primary root* and its *lateral branches*; *stem* and *first foliage leaves*: also the developing *axillary buds* in the axils of the cotyledons.





**Seeds and Germination** (*continued*).

SEEDS WITH FOOD MATERIAL IN THE COTYLEDONS, WHICH ARE RAISED ON GERMINATION.

GOURD (*Cucurbita*).

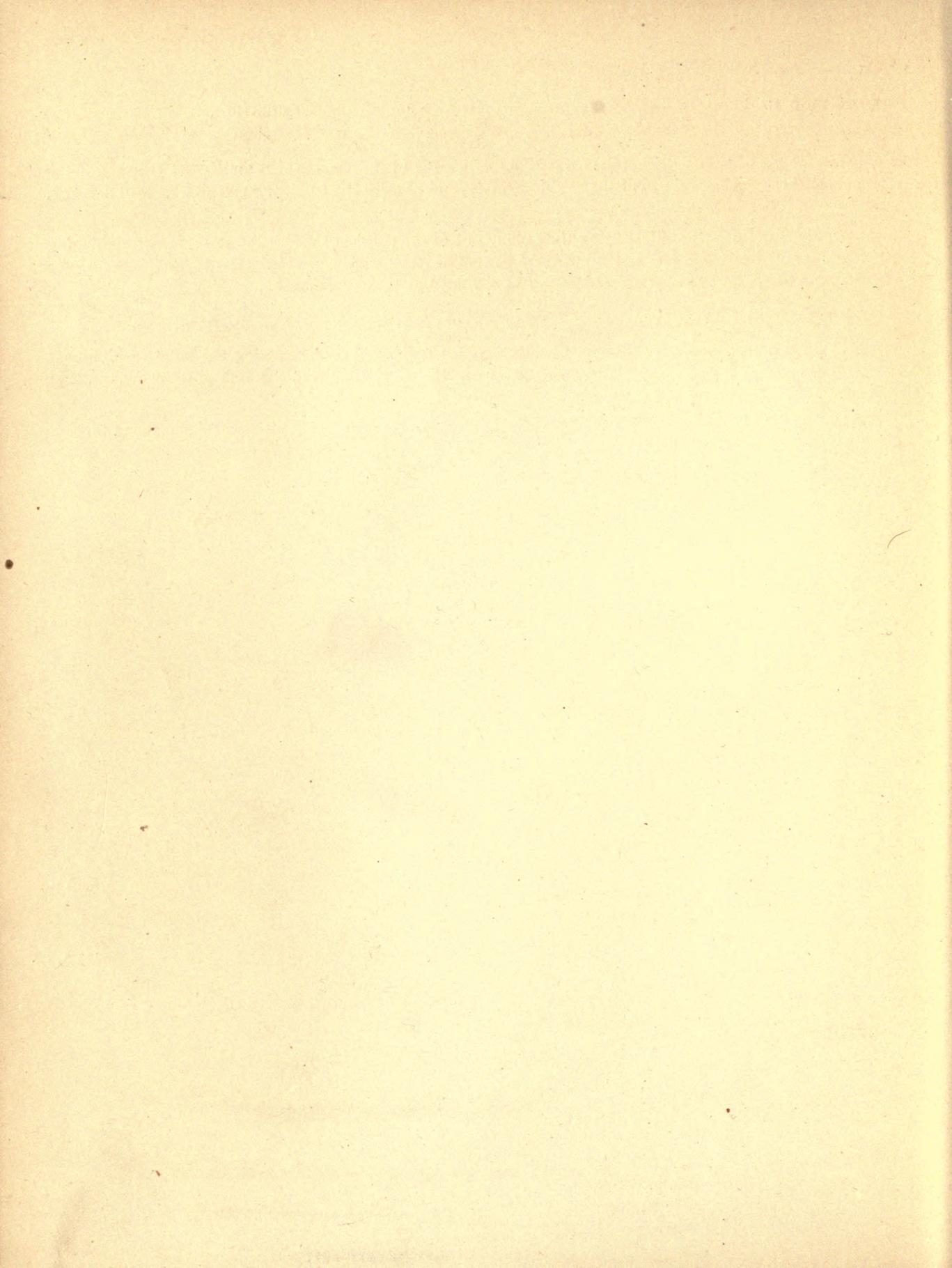
A. Sketch a seed of *Cucurbita*. Notice the *hilum* and a pit in the testa which marks the position of the *vascular bundles* of the seed-stalk. Split the seed lengthwise and observe the testa, the greenish layer of *nucellus*, two *cotyledons*, *radicle* and very minute *plumule*.

B. Make a series of drawings illustrating the pulling out of the cotyledons from the testa, the straightening of the hypocotyl and the expansion and growing of the cotyledons; note the *radicle*, the *hypocotyl*, the *peg* or *heel*, *plumule*, *cotyledons* and *foliage leaves* differing in shape from the cotyledons.

SEEDS WITH FOOD MATERIAL STORED OUTSIDE THE EMBRYO—COTYLEDONS RAISED ON GERMINATION.

CASTOR OIL SEED (*Ricinus*). A. Remove the testa from a *Ricinus* seed, exposing the hollow white mass of oily *endosperm*; split it open and observe the *embryo* in the middle. Draw the embryo shewing the thin *cotyledons*, the *radicle*, *hypocotyl* and *plumule*.

B. Sketch a series of *Ricinus* seedlings, shewing the gradual straightening of the hypocotyl and the expansion and turning green of the cotyledons.



**Reserve food materials in seeds and tubers.**

## I. CASTOR OIL SEED.

Examine sections of the *endosperm* and observe the aleurone grains of reserve *protein* in the cells. Oil is also present in very minute drops.

## II. BEAN.

Examine sections of the cotyledon and observe the reserve *starch-grains* surrounded by fine granules of *protein* in the cells.

III. TUBER OF POTATO (*Solanum tuberosum*).

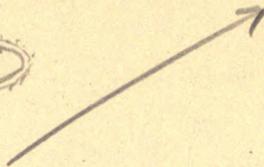
Examine a small section of a Potato including the brown skin and a little of the internal tissue; stain with Schulze's solution and mount. Sketch a portion of the section to show the *cork cells* of the skin, and the darkly stained *starch-grains* in the large parenchymatous cells of the internal tissue.

Spot slides

1. Vorticella



3. Paramecium



4. Scyllium trans. sec.

7. Lumbricus trans. sec.

9. Scyllium spiral valve

10. Hydra trans. sec.



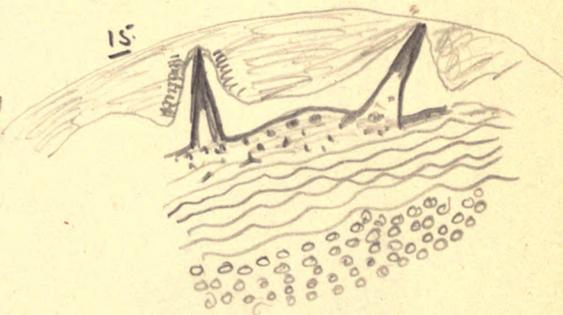
12. Lumbricus setae



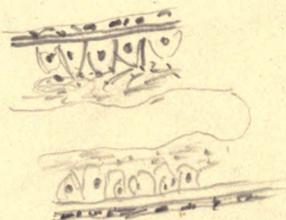
15. Scyllium (skin)

16. Lumbricus. long sec.

17. ~~Hydra~~ Spermatozoa



19. Hydra long sec.



21. Frog intestine fat absof.



23. Bacillus



24. Frog intestine

26.

27. Lumbricus ovary.



28. Scyllium trans. secu. pelvic fin.

29. Lumbricus skin.



31. Frog sciatic nerve



34. Scyllium scales

39. Frog stomach



Botany.

2.



*Junonia stem.*

5.



*Bean root.*

6.

8.



*Capsule Pellia.*

11.



*Helianthus stem (long. secn.)*

13.



*Aspidogonia embryo-sac.*

14.



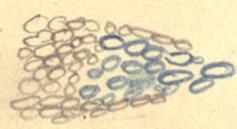
*Caltha old anthers.*

18.



*Jucca ovary.*

20.



*Helianthus <sup>trans.</sup> long. secn.*

22.



*Caltha young anthers.*

25.



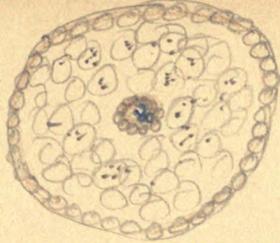
*Fucus female*

30.



*Sea root tip.*

32.



*Ranunculus root.*

33.



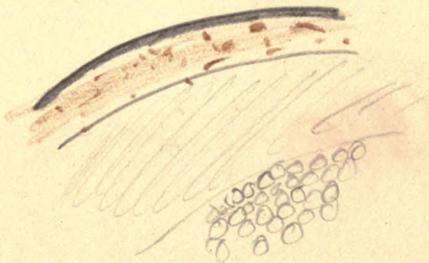
*Caltha young bud*

35.



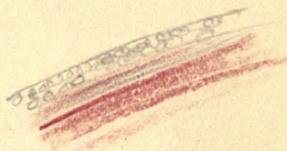
*Juncus male.*

36.



*Acer 3 years  
trans sec.*

37.



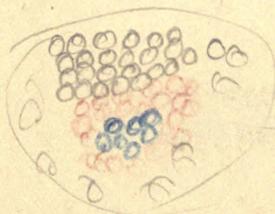
*Onothena stigma.*

38.



*Ailanthus  
stem cork.*

39 40

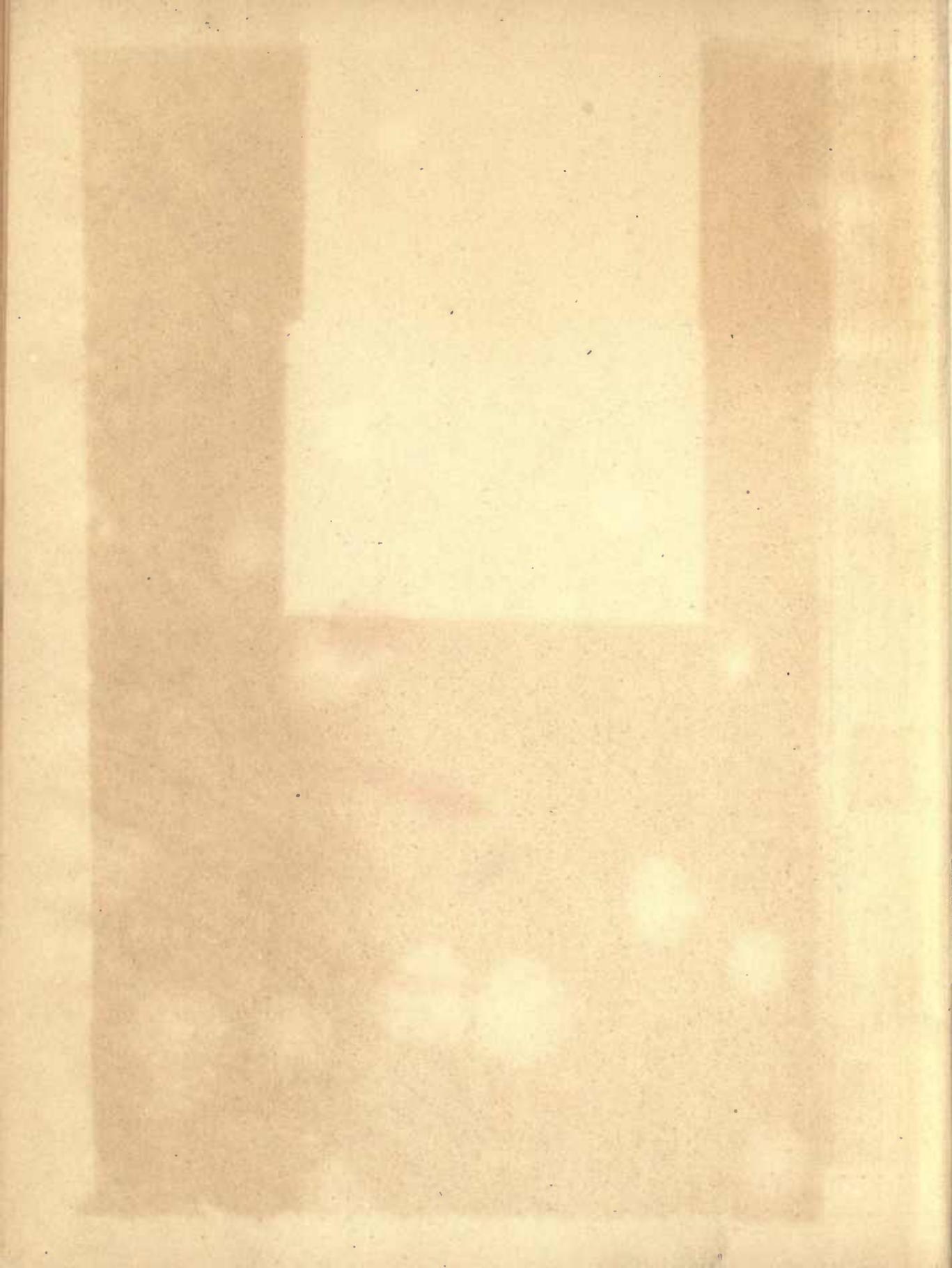


*Vicia young root.*

41.



*Mucor zygospores.*



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