# UNIT : 2

## TYPE: FROG (Rana tigrina)

# Habit and Habitat of Indian Bull Frog

- Rana tigrina, the common Indian bull frog, generally lives in or near water but in rains it may be found far away from its natural habitat, the aquatic home.
- It lives near water probably- (i) to carry out the cutaneous respiration by keeping the skin moist as soon as it gets dry and
- (ii) to escape from the man and a number of other enemies by slipping or jumping into the water.

# Cont.....

- During the breeding season frogs are more closely confined to the water than other times of the year.
- Frogs are harmless, non-poisonous and quick-moving active animals.
- It rests on land by keeping its short angular forelimbs upright and the long hindlimbs folded by the side of the body; when disturbed; it jumps into water by suddenly extending its hind limbs in order to escape.

# Feeding:

- It is carnivorous in its feeding habit and feeds on small insects, spiders and earthworms which are caught by throwing out the extensible sticky mucous-coated tongue from the mouth and swallowed entire organisms.
- The tongue is attached anteriorly, while the forked posterior end lies free.
- It always rejects motionless animals and undesirable food.

# Locomotion:

- Frogs move by leaping and swimming, and in both of these operations the long hind legs play the chief part.
- **(i) Leaping:**
- In the ordinary resting position the body is inclined upward in front, being supported on the forelegs and its thumb points nearly backward.
- The posterior part of the body rests upon the ground and the hind limbs are folded up ready for a spring.

# Cont.....

- By sudden extension of the hind legs the body is propelled through the air.
- In leaping, the forelimbs are used more to hold up the anterior part of the body and to point the animal in the desired direction of movement than as actual organs for propulsion.
- It may leap from 2 to 3 feet.

# (ii) Swimming:

- In both operations the hindlegs are alternately drawn up in the form of a “Z” and quickly extended.
- As the hindlegs are pushed back during swimming, the toes are spread apart, the webs between them affords resistance to passing through the water.
- This motion gives the body a forward impulse.
- The forelimbs are also used in swimming, taking strokes sometimes together and sometimes alternately.

# Cont….

- When the animal swims downward, the forelegs beat backward and upward.
- When it swims upward, forelegs beat downward elevating the anterior part of the body, which is then pushed upward by the strokes of the hind legs.
- When frog comes to surface to breathe or simply to float, only the tip of the nose remains exposed.
- The hindlegs hang obliquely in a state of moderate extension and the forelegs are held out from the body.

# Croaking Sound:

- The sound produced by the frog is called the croaking. It is more often heard during the breeding season (rainy season), when they are supposed to serve the purpose of a sex call.
- The sound of male is louder and deeper than that of the female.
- In large frogs the voice are deeper than in small ones. Frogs croak under water as well as on land.
- It is produced by forcing the air from the lungs over vocal cords into the mouth, the external nares remain closed to prevent its escape.
- Then the buccal cavity contracts, forcing the air back into the lungs again. The same process is repeated again and again.

# Seasonal Changes:

- It is cold-blooded or poikilothermal or ectothermal animal as its body temperature does not remain constant but fluctuates with that of environment.
- In winter the temperature of the body becomes so much low that its all body activities get ceased down and it becomes sluggish.
- In this condition it cannot live more on the land, so it digs down into damp earth at the bottom of ponds to pass the adverse conditions of winter and rest.

# Cont….

- This going of underground is known as winter sleep or hibernation.
- During winter sleep or hibernation lung breathing is stopped, while skin breathing continues which suffice the need of the oxygen.
- Moreover it does not feed but to keep up its vital activities it consumes the reserve food stored in the form of glycogen and fat.

# Cont....

- It remains underground till the rain falls.
- Similarly during the summer it once again goes underground to sleep as its all body activities are slowed down due to high temperature.
- This going of underground is known as summer sleep or aestivation.
- The spring and rainy seasons are the periods of great activity for the frogs.

# Colour Changes:

- Frogs have the power of changing their colour in harmony with their surroundings to protect from enemies.
- The power of the skin to change its colour in relation to surrounding conditions depends upon changes in chromatophores (pigment cells).
- The colour change of the skin depends upon the difference in the distribution of pigments (black and yellow).
- When the pigment of black chromatophores is expanded, the skin becomes dark in colour and when it becomes contracted, the skin becomes light coloured.

# Breeding:

- In mating or copulation the male clasps the female by its forelegs from its back just behind her forelegs.
- The nuptial pads on the bases of inner fingers of male also help in firmly clasping the female.
- This sexual embrace is called **amplexus** which continues for several days until the female deposits the eggs through cloaca in water.

# Amplexus

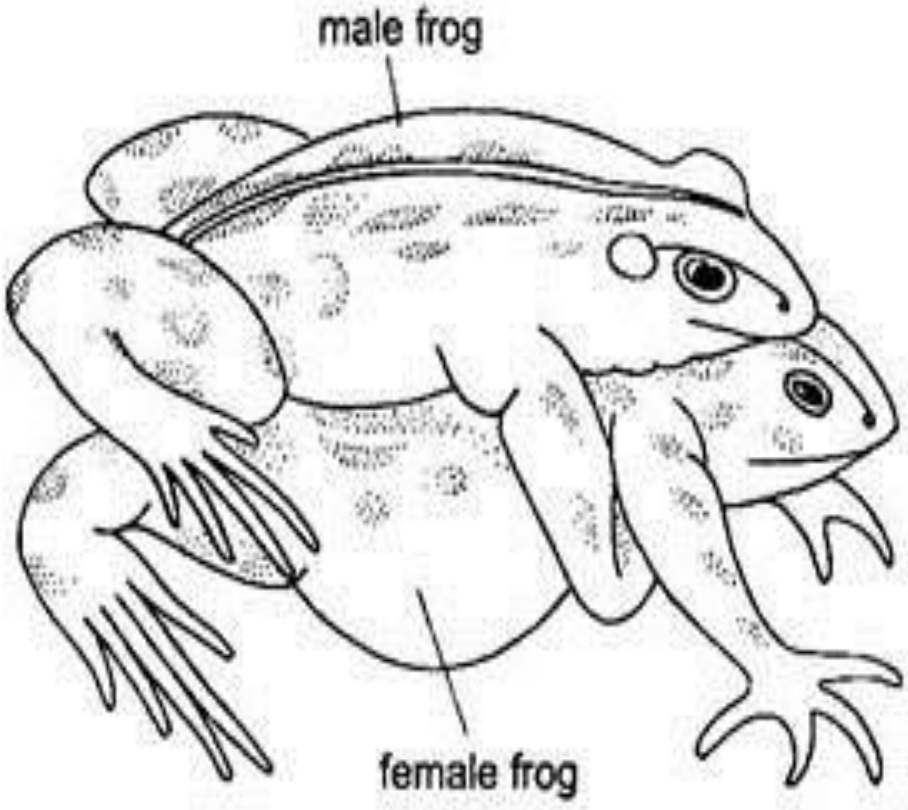



**Fig. 18.2.** Frogs in amplexus.

# Cont…..

- The male also discharges his spermatic fluid over them to fertilize.
- The male then loses his clasping instinct and is totally indifferent to the other sex.
- Egg's mass called frogs spawn is formed by adhering the jelly surrounding the eggs.
- The jelly of the eggs absorbs water and swells and adheres with each other.
- The fertilized eggs (zygotes) develop into free-swimming tadpole within a fortnight and then undergo metamorphosis to become miniature adult.

# Leaping

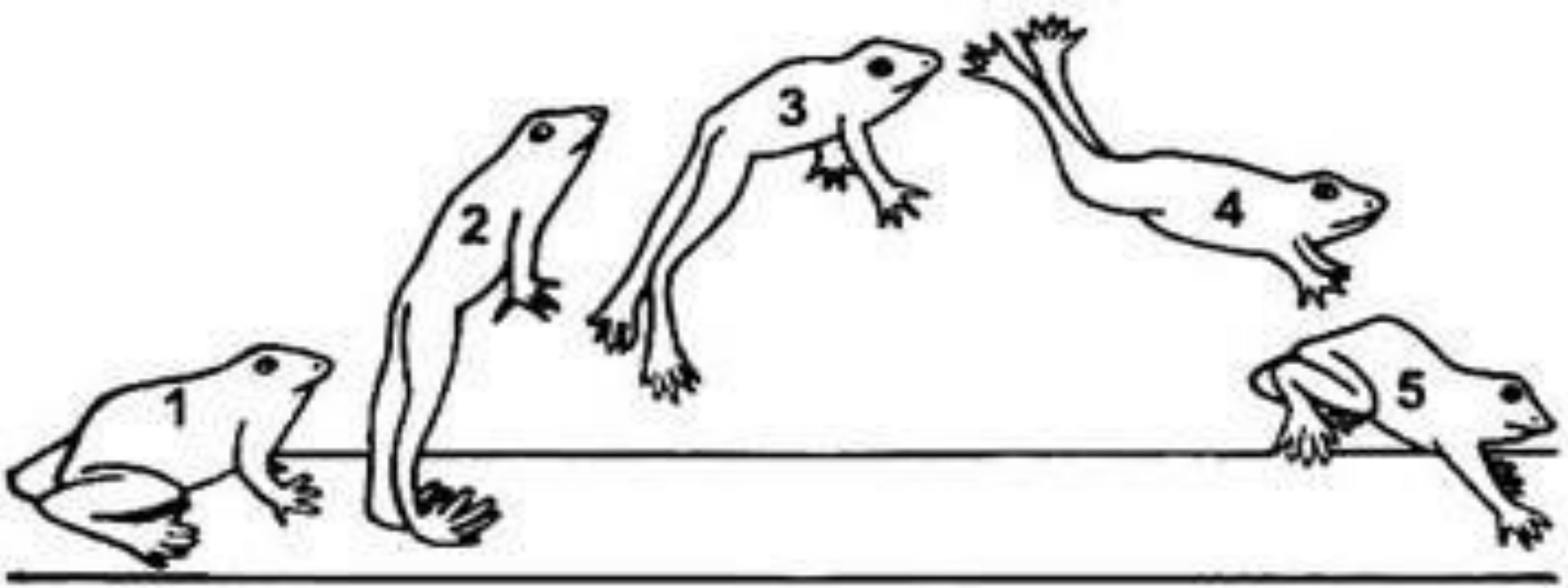



**Fig. 18.1.** Frog. Stages of leaping on land.

# Enemies:

- Frogs are the most defence less animals and fall easy prey to a variety of carnivorous animals, who devour them in great numbers.
- These animals are snakes, turtles, mongooses, racoons, cranes, herons, hawks and crows. Man is also their enemy who is very fond of their legs.
- The frog is also afflicted by a large number of parasitic forms, such as leeches remain attached to frog for a long period, larvae of blowflies infest the intestine of frogs, but usually in great numbers in toads.
- Nematodes such as round worms are found in the intestine of frogs.

# Cont…..

- Trematodes or flukes are also found in the intestine and bladder, and sometimes in lungs are also found.
- Among protozoans are Opalina, Balantidium, Copromonas found in rectum; Entamoeba found in the intestine; Eimeria infest intestinal epithelum; Isospora spp. in the cells of kidneys.

# Economic Importance:

- Frog has remained a favourite object for the study of animal structure and function since a long time.
- It is very commonly used in the physiological researches. It is due to its easy availability.
- It is also widely used in instruction, since its structure is more or less similar to that of the human body. It is a good friend of farmers because it feeds on insects harmful to crops.
- Its muscular hind legs are eaten in China and so they are reared in ponds, etc.

# Cont….

- The frogs, generally, breed in the rainy season, appearing with the first shower. As soon as the rains fall the frogs come out from their hidden places (hibernation and aestivation) and start croaking.
- Male frogs, by croaking, attract the female frogs for breeding or copulation.
- Frogs, generally, seek shallow quiet water as a breeding place where they lay down their eggs for fertilization.

# Cont….

- The parents never pay any attention to them but lead a carefree life of excessive feeding. The eggs develop into embryos that hatch out as tadpoles or larvae in about two weeks.
- There are so many natural enemies of frog such as snakes, turtles, herons, raccoons and man.
- To escape from these enemies frog tries to jump into water or conceal itself in the bottom of debris or green vegetation as its body colour coincides with that of environment.

# External Features of Indian Frog

- **Shape and Size:**
- Besides aerial mode of life, frog also leads aquatic mode of life. Therefore, it has streamlined body which is the characteristic of the aquatic animals and assist in swimming in water.
- The two ends, the anterior and the posterior, of the body are pointed and the triangular flattened head, with its blunt apex directed forward, is broadly united to the trunk.
- Thus, there is no neck to connect the head and trunk together and no tail.

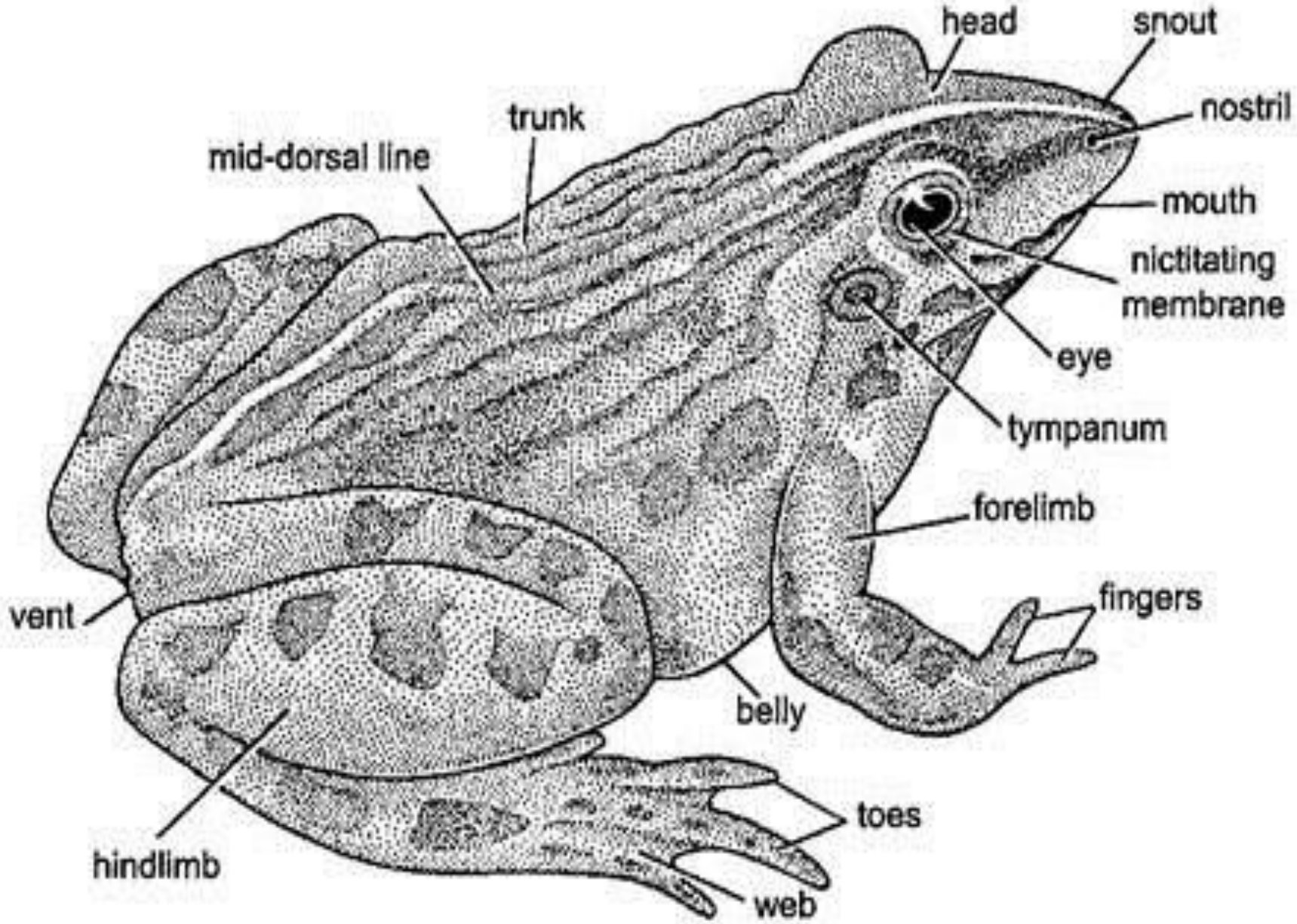



**Fig. 18.3.** An Indian frog, *Rana tigrina*, in sitting posture.

# Cont.....

- The size of the frog varies from species to species or even in the same species depending upon the age of the individual.
- The size may range from few centimetres to many centimetres.

# Colour:

- The head dorsolateral bears two large prominent bulging eyes. This position enables the frog to see in all the directions and, thus, compensate the disadvantage on land due to the absence of the neck.
- The colour of the body at the dorsal side is green with black spots and streaks but ventrally it is paler.
- This type of colouration harmonises with that of surrounding environment.
- Skin is smooth, thin, moist and slimy, and fits loosely on the body. Skin of back is folded or thickened longitudinally called dermal plicae.

# Division of Body:

- The body of the frog is divided into two parts, the head and trunk, the true neck and tail of tadpole being absent. The head and trunk are broadly joined.
- **Head:**
- The head is almost triangular and somewhat flattened. Its anteriority directed blunt apex is known as snout which terminates into a large, transverse mouth.
- At the tip of the snout are two laterally placed nostrils or external nares communicating with the buccal cavity through internal nares, serving in respiration.

# Cont.....

- The eyes are protected by two eyelids, the upper eyelid is thick, fleshy, opaque and almost immovable but the lower one is thin, transparent and movable, capable to cover the eye.
- Beneath it there is a transparent third eyelid or nictitating membrane which is merely an outgrowth of the lower eyelid that can cover the eyeball in water and also keep it moist in the air.

# Cont…..

- The frog can see through it. In the middle of the head, just in front of the eyes, there is a light coloured patch - the brow spot which represents the vestigial pineal eye.
- There are no external ears but behind and below each eye there is a nearly circular obliquely placed a tough transparent membrane-the **tympanic membrane or ear drum.**
- In the male frog under the head on either side are placed two bluish wrinkled patches of skin-the vocal sacs which are used to produce croaking sound to attract the females for copulation.

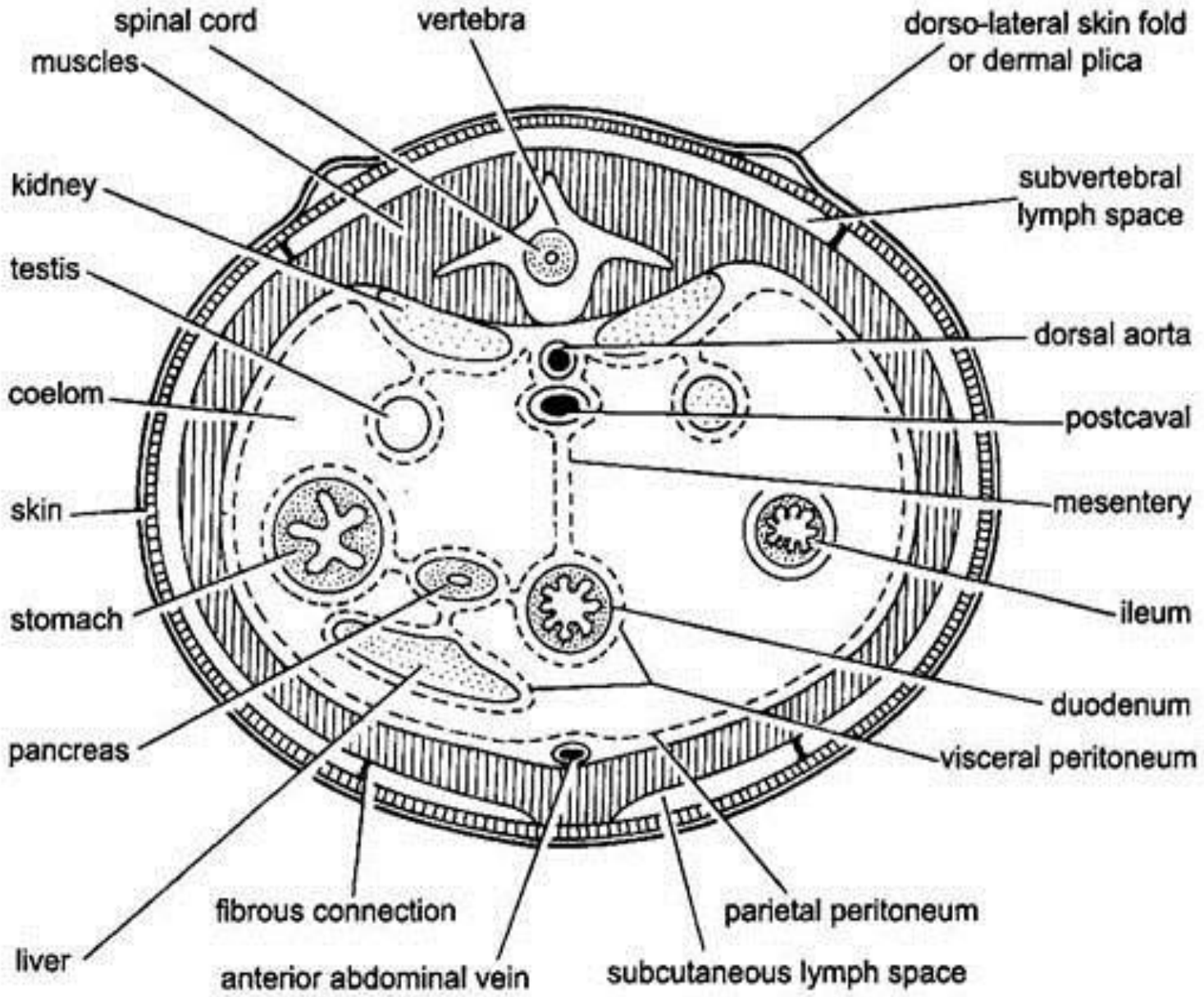



**Fig. 18.4.** Frog. Diagrammatic T.S. of trunk showing coelom, peritoneum (broken lines) and viscera.

# Trunk:

- The head is broadly joined with short somewhat flattened ovoid trunk.
- At its dorsal side in the middle region in the resting stage there is a characteristic sacral hump which is due to the linking of the hip girdle to the vertebral column.
- At the posterior end of trunk, in between the hind limbs is present the cloacal opening or vent through which faecal matter, urine and reproductive bodies (sperms and ova) are discharged.

# Cont…..

- Attached to the trunk are two pairs of limbs. The forelimbs are shorter, while the hind limbs are larger.
- The forelimbs are meant to hold and support the front part of the body at the time of jumping but the hind limbs assist in jumping and swimming as the webs are present in between the toes.
- Each forelimb comprises an upper arm (brachium), forearm (ante brachium), wrist and hand (manus) with four fingers (digits) and a vestigial “thumb” or pollex.

# Cont……

- In male the base of the first (inner) finger is thickened especially in the breeding season, forming the nuptial pad for clasping the female at the time of **amplexus.**
- Each hind limb comprises an upper thigh, shank or lower leg, ankle (tarsus) and long foot.
- The latter has a narrow sole and five slender toes connected by broad thin webs of skin which help in swimming.

**TABLE 18.1. SEXUAL DIMORPHISM.**

| Male | Female |
|---|---|
| 1. Smaller in size and darker in colour. | 1. Larger in size and less dark in colour. |
| 2. Slim. | 2. Stout in breeding period. |
| 3. Possess vocal sacs. | 3. Vocal sacs absent. |
| 4. Possess nuptial or copulatory pads on inner fingers. | 4. Nuptial or copulatory pads absent. |

# Cont....

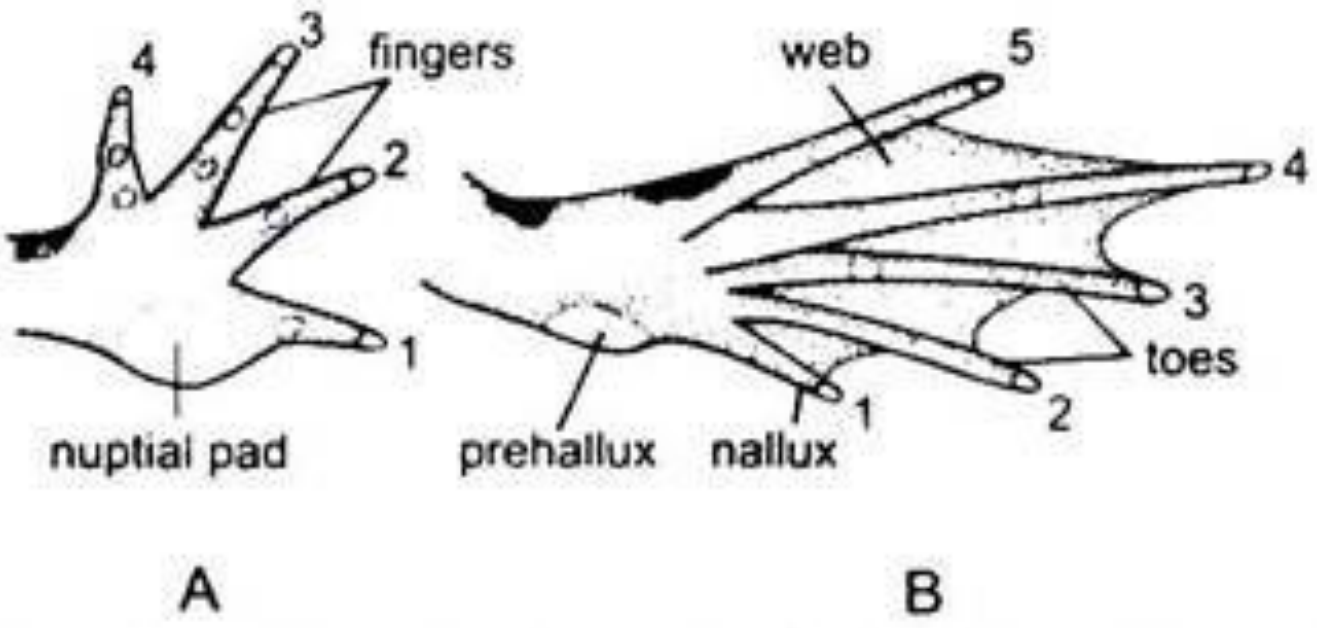



**Fig. 18.5.** Frog. A–Underside of right hand of male in breeding season showing nuptial pad; B–Root showing web.

# Coelom and Viscera:

- The coelom or body cavity is large and spacious in which are present viscera or internal organs.
- It lies ventral to the vertebral column or backbone. The walls of the body cavity and the visceral organs are covered by a thin, moist peritoneum.
- This membrane is perfectly continuous throughout and is simply reflected over the various organs.

# Cont……

- The portion of the peritoneum surrounding the alimentary canal and its appendages is called the **visceral layer** and the part applied to the body wall is the **parietal layer.**
- The parietal layer on the dorsal side of the body is separated from the wall forming a large lymph space, the subvertebral lymph space.
- The kidneys lie in this space, hence, they are covered with peritoneum on the neutral side.

# Cont....

- The alimentary canal and gonads are suspended from dorsal body wall by thin sheet of membrane called the mesentery.
- The coelom is filled with a transparent coelomic fluid which is like lymph.
- Near the anterior end of the body cavity lies the heart enclosed in a transparent sac, the pericardium.

# Skin:

- The skin is smooth, moist, slippery and lacking in the external protective scales or hairs.
- It is loosely attached by thin bands of connective tissue to the underlying musculature due to subcutaneous lymph spaces and, thus, these animals are easily skinned.
- It is considerably thicker on the dorsal side of the body than it is below.

# Cont…..

- At the dorsal side of the body it is thrown into a number of folds which extend from behind the eyes.
- The ridges, thus, formed by the thickening of the skin are known as dorsolateral dermal plicae.
- Its colour on the back and the limbs is dark green with dark coloured streaks and patches, while on the ventral side it is pale yellow.

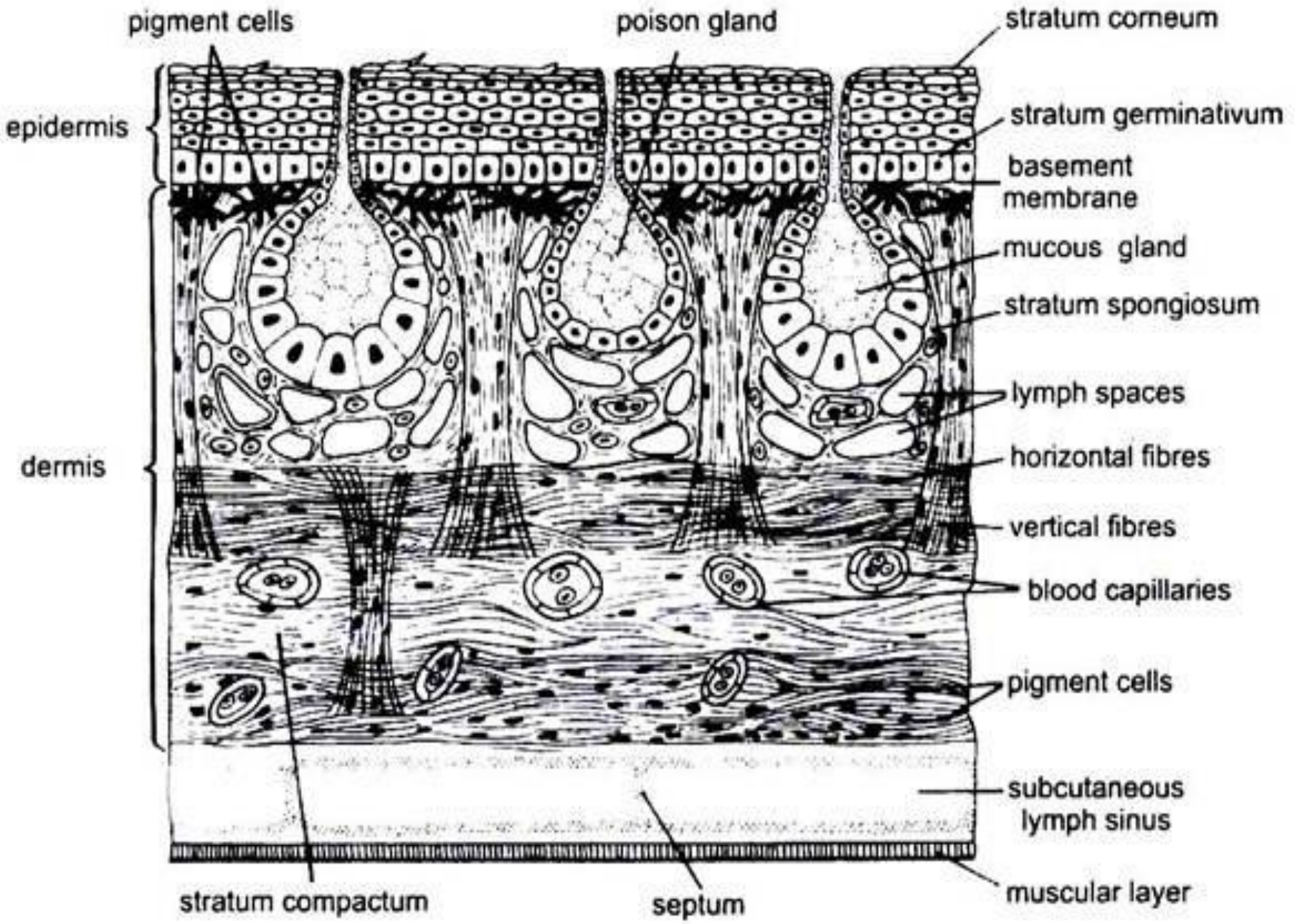



**Fig. 18.6.** Frog. V.S. of skin.

# Structure:

- Structurally, like other vertebrates, the skin is composed of two layers, the epidermis and the dermis.
- **Epidermis:**
- The epidermis is an outer layer which is non-vascular, stratified and further composed of several layers of epithelial cells.
- It is usually shed and renewed at regular intervals by a process of moulting.
- The outermost layer is keratinized and made up of flattened, squamous epithelial cells. It is known as stratum corneum.

# Cont.....

- The innermost layer called stratum germinativum or stratum Malpighii is made up of active columnar epithelial cells which are capable in producing the new cells that pass towards the outer surface and become more and more flattened and ultimately lose their columnar shape as they reach the surface.
- It is due to the gradual change of protoplasm of these cells into a horny substance called keratin.

# Cont……

- As the old cells are worn out due to friction, they are replaced by new ones formed by the cells of the layer stratum germinativum or stratum Malpighii.
- The stratum corneum is shed off from time to time and eaten by frog. The shedding of stratum corneum is due to the secretions of **thyroid and pituitary glands**.
- This activity is known as moulting.

# Dermis:

- The dermis forms a tough, flexible and somewhat elastic layer just underneath the epidermis.
- The dermis is separable into two layers, an outer comparatively loose layer (stratum spongiosum), which contains most of the glands, and an inner layer (stratum compactum) formed of dense connective tissue.

# Cont….

- The stratum spongiosum consists of a loose network of fibrous connective tissue, richly supplied with lymph spaces and blood vessels.
- Just beneath the epidermis it forms a thin layer which contains numerous pigment cells. Each cell is irregular in shape with branched processes.
- They have black and yellow pigments and impart colouration to the skin.
- In the deeper portion are embedded the glands.

# Cont….

- The stratum compactum is composed of a dense layer of connective tissue whose fibres run in a wavy course parallel to the surface of the skin.
- At intervals this layer is crossed by vertical strands, which often extend through the stratum spongiosum into the epidermis.
- In addition to fibrous connective tissue, these strands contain smooth muscle fibres, elastic fibres, nerves and bloodvessels.

# Cont.....

- The subcutaneous connective tissue forms a loose layer beneath the stratum compactum and a second very thin layer next to the muscles.
- The two layers are separated by large lymph spaces except in the septa, where they become continuous.

# Glands:

- In the skin of frog two types of glands are found—**the mucous glands and the poison glands.**
- Actually these glands are the derivatives of the epidermis but they lie in the stratum spongiosum of the dermis.

# Cont….

- The **mucous glands** are somewhat smaller, flask-shaped found in abundance practically over the entire surface of the body.
- Their ducts are narrow and lined with a layer of small flattened epithelial cells.
- The body of the gland is also lined by a single layer of epithelial cells except near the opening of the neck, where there are two layers.

# Cont……

- It is this epithelium which forms the mucus which is discharged into the lumen of the gland, and poured out through the neck over the surface of skin.
- The mucus is a colourless watery fluid which keeps the skin moist, glistening and sticky.
- Outside of the epithelium of glands is a muscular coat of smooth muscle cells.
- The function of the muscle cells is the expulsion of the mucus of the glands.

# Cont….

- They are more numerous on the dorsal side of the body and hind legs, and they are especially abundant, and large in the dermal plicae.
- These glands are lined with a single layer of epithelial cells and communicate with the exterior through their respective fine ducts which are narrow and lined with a layer of small flattened epithelial cells.
- Their epithelial cells are cylindrical nearly filled with granules.

# Cont....

- Outside the epithelium like mucous glands, is a muscular coat and a connective tissue coat.
- The secretion of the **poison glands** is a whitish fluid with a burning taste.
- It protects the animal in some degree from the enemies.

# Functions of the Skin:

- 1. It gives definite shape and texture to the body and also acts as a protective covering over the body.
- 2. It protects the body against the invasion of foreign bodies and fungal spores.
- 3. The mucous glands keep the skin moist, glistening and sticky.
- The mucus also prevents the invasion of the water and other harmful materials dissolved in water.

# Cont…..

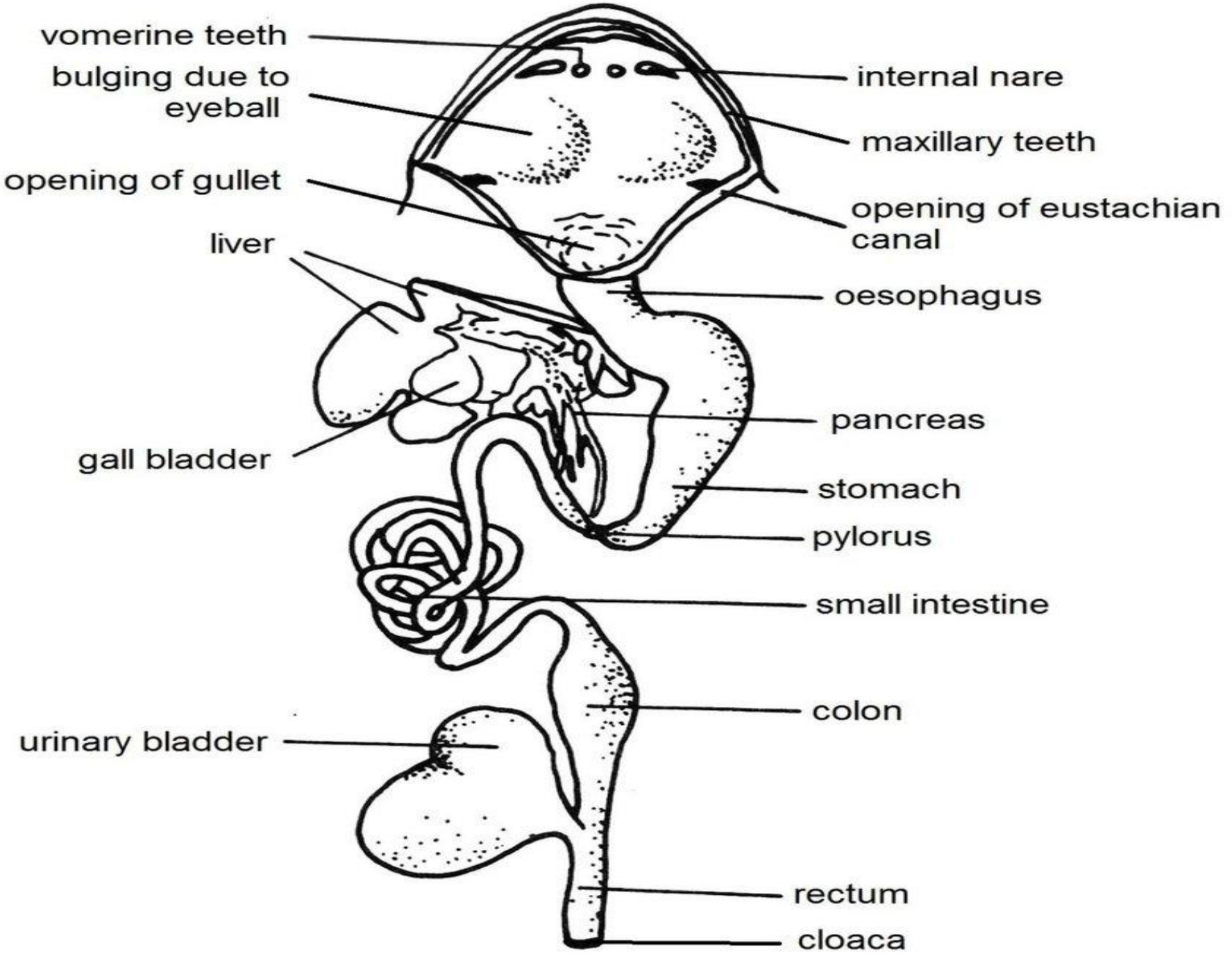
- 4. It forms a chief respiratory organ as its moist surface brings about an exchange of respiratory gases ($O_2$ and $CO_2$) in between the body of the animal and the environment.
- 5. Being devoid of sweat glands it acts as an excretory organ as the shedding of stratum corneum from time to time helps in removing the excretory wastes which are no longer needed for the body.

# Cont.....

- 6. Due to presence of nerve endings it acts as an important sensory organ.
- 7. The frog never drinks the water through buccal cavity but absorbs through skin and, thus, compensates the loss of water from body. The skin is loosely attached to the body, and a considerable quantity of water may collect in the large subcutaneous lymph spaces.
- 8. The skin of frog larva produces hatching enzymes which dissolve the egg membrane so that hatching may occur.

# Alimentary canal:

- Alimentary canal of frog is complete.
- It is long and coiled tube. The tubes have varying diameter.
- It extends from mouth to cloaca.
- It consists of:
  - Buccal cavity
  - Pharynx
  - Oesophagus
  - Stomach
  - Small intestine
  - Large intestine
  - Cloaca


vomerine teeth
bulging due to eyeball
opening of gullet
liver
gall bladder
urinary bladder
internal nare
maxillary teeth
opening of eustachian canal
oesophagus
pancreas
stomach
pylorus
small intestine
colon
rectum
cloaca

# 1. Mouth:

- It is the beginning to the alimentary canal.
- Mouth is a very wide gap. It extends from one side of the snout to the other.
- Two bony jaws bound the mouth, and the jaws are covered by immovable lips.
- The upper jaw is fixed.
- The lower jaw is flexible i.e. it can move up and down to close or open the mouth.

# 2. Buccal cavity of frog:

- Mouth opens into buccal cavity.
- Buccal cavity is large, wide and shallow.
- It has ciliated columnar epithelial lining that contains mucous glands.
- These mucous glands secrete mucus that helps in lubricating the food.
- Frog lacks salivary glands.

# Teeth:

- The lower jaw lacks teeth.
- However, teeth occur in a row of either side on the premaxillae and maxillae bones of the **upper jaw**. The teeth are backwardly pointed.
- Vomers (two small bones in the roof of the mouth) also consists of two groups of **vomerine teeth**.
- **The function of teeth is to simply hold the prey and prevent it from slipping out.**
- Teeth are not meant for chewing.

# Cont….

- The nature of teeth is **homodont (similar), acrodont (not set in a socket**).
- But teeth are attached to the jaw bone by a broad base made of a bone-like substance.
- The crown is the free part of tooth.
- It is made up of dentine (a hard ivory-like substance), which is traversed by numerous fine canals or canaliculi.
- Enamel covers the tip of the crown.

# Cont.....

  - Enamel is a very hard, resistant and glistening substance.
  - Tooth contains a central pulp cavity open at the side.
  - It is filled with a soft nourishing pulp, containing connective tissues, blood vessels, nerve and odontoblast cells that produces new material for the growth of tooth.
- Frog are **polyphyodont** in nature, i.e. teeth is replaced several times in life.

# Tongue:

- In frogs, tongue is large, muscular, sticky and protrusible.
- It lies on the floor of mouth cavity.
- The anterior end of tongue is attached to the inner border of lower jaw.
- The posterior end is free and bifid.
- This free end can be flicked out and retracted immediately after catching the prey.
- The slimy surface of tongue facilitates in capturing the prey.
- The change of pressure in large sublingual lymph sac causes the protrusion of tongue.

# Cont....

- **Internal nostrils:**
  - Just in front of vomerine teeth, the roof of buccal cavity contains anteriorly, a pair of small openings of internal nares.
  - By these internal nares, the nasal cavities open into buccal cavity.
- These serves in respiration.

# Cont….

- **Bulging of orbits:**
  - The roof of buccal cavity shows two large oval and somewhat pale areas, behind the vomerine teeth. These areas are the bulging of eye balls.
  - In course of swallowing the food, frog depresses the eyes.
  - This causes the orbits to bulge inwards which in response pushes the food towards the pharynx.

# 3. Pharynx

- Posteriorly, the buccal cavity reaches short pharynx without any clear demarcation.
- So, sometimes these are termed as single bucco-pharyngeal cavity.
- Several apertures open into pharynx.
- A median elevation on the floor carries the glottis.
- Glottis is a longitudinal slit like aperture.
- The glottis leads to the laryngo-tracheal chamber.

# Cont….

- A wide eustachian aperture is present on either lateral side in the roof.
- This aperture opens into the middle ear.
- In male frogs, on the floor of pharynx, the small opening of a vocal sac is present on either side near the angle of two jaws.
- Now, the pharynx tapers behind to lead to esophagus through the gullet.
- Gullet is the wide opening that leads to Oesophagus.

# 4. Oesophagus:

- Oesophagus is a short, wide, muscular and highly distensible tube.
- Its mucous epithelial lining is folded longitudinally and contains some mucous glands.
- During the passage of food, its expansion is allowed by longitudinal foldings.
- An alkaline digestive juice is secreted by the glandular lining of oesophagus.
- Oesophagus enlarges to join with stomach in the peritoneal cavity.

# Stomach:

- Stomach is present on the left side in the body cavity.
- It is attached to the dorsal body wall by a mesentery termed as mesogaster.
- It is around 4 cm long, broad and slightly curved bag or tube with thick muscular walls.
- The anterior part is large, and broad. It is called as cardiac stomach.
- The posterior part is short and narrow. It is called the pyloric stomach.

# Cont….

- Several prominent longitudinal folds are present in the inner surface of the stomach.
- It allows the distension of stomach when food is received.
- Its mucous epithelium has multicellular gastric glands.
- These glands secrete the enzyme pepsinogen and unicellular oxyntic glands, secreting hydrochloric acids.

# Cont.....

- The pyloric end of stomach is slightly constricted.
- Pyloric valve guards its opening into small intestine.
- Pyloric valve is a circular ring like sphincter muscle.
- Stomach serves for storage as well as digestion of food.

# Small intestine:

- Small intestine is a long, coiled and narrow tube.
- It is about 30cm long, and is attached mid-dorsally to body wall by mesenteries.
- It comprises of two parts:
  - A small anterior duodenum
  - A much longer posterior ileum
- Besides, intestinal glands, the mucosal lining of the small intestine consists of two types of cells.

# Cont....

- They are:
  - **Goblet cells:**
  - Large cells containing oval vacuoles and granular substances which produces mucus.
  - Near the base of the cell, nucleus is present.
    - Absorbing cells:
    - Small cells with nuclei near the base.

# Cont.....

- **Duodenum:**
  - Duodenum runs ahead being parallel to stomach and forms a shape like U.
  - It receives a common hepatopancreatic duct.
  - Liver and pancreas bring bile and pancreatic juice respectively.
  - Low transverse folds are formed by the internal mucous lining.

# Cont....

- **Ileum:**
  - Ileum is the longest part of alimentary canal.
  - Before enlarging posteriorly to join rectum, it makes several loops.
  - The internal mucus lining forms many longitudinal folds.
  - However, as in case of higher vertebrates, there are no true villi and definite glands and crypts.
  - In the small intestine, digestion of food and absorption of digested food takes place.

# Cont….

- Large intestine or rectum:
- Large intestine is short, wide tube about 4cm long.
- It runs straight behind to open into cloaca by anus.
- The opening is guarded by an anal sphincter.
- The inner lining of large intestine forms numerous low longitudinal folds.
- It serves for the re-absorption of water and the preparation and storage of faeces.
- **Cloaca:**
- It is the small terminal sac-like part.
- The anus and the urinogenital apertures open into cloaca.
- Cloaca opens to outside by the vent or cloacal aperture, lying at the hind end of body.

# Digestive glands of frog

- Keeping aside gastric glands and intestinal glands, two large glands that are linked with the alimentary canal of frog are the liver and the pancreas.
- **Liver:**
  - The largest gland in the body of vertebrate is the liver.
  - It is reddish-brown in colour.
  - It is multilobed gland and lies close to the heart and lungs.
  - 3 lobes are present in the liver of frog i.e. right, left and median.
  - Liver consists of innumerable polygonal cells that secretes bile.
  - Bile is a greenish alkaline fluid.

# Cont…

- Bile is stored in the thin-walled sac called as gall bladder.
- Gall bladder is large, spherical, and greenish in color.
- A common bile duct is formed when cystic ducts from gall bladder and hepatic ducts from liver lobes combines.
- It runs through pancreas and joins the pancreatic duct to form a hepatopancreatic duct.
- Now, it ultimately opens into duodenum.
- Bile lacks any digestive ferments and only emulsifies fats.
- Thus, liver is not a true digestive gland.

# Pancreas

- Pancreas of frog is much branched, irregular flattened and is yellow in color.
- It lies in the mesentery between stomach and duodenum.
- It carries out both exocrine and endocrine function.
- The endocrine part is formed by scattered islets of Langerhans. It produces insulin hormone which is related to sugar metabolism.
- The exocrine part secretes pancreatic juice. This juice contains of several digestive enzymes.
- Since pancreas lacks independent duct, the pancreatic juice reaches the duodenum through the hepatopancreatic duct.

# Physiology of digestion in frog:

- Being strictly carnivorous, frog feeds on insects, worms, crustaceans, molluscs, small fish and even small frogs and tadpoles.
- The prey is caught by rapid flicking of tongue and is swallowed as a whole.
- The food is now passed to stomach.
- As salivary glands are absent in case of frogs, the food is lubricated by the mucus secreted from the lining of bucco-pharyngeal cavity and oesophagus.
- The wave of contraction of the muscular wall of oesophagus pushes food down, it is called as peristalsis.

# Gastric digestion:

- Food remains in the stomach for up to 2-3hrs, which is sufficient time.
- Gastric juice is secreted by the gastric glands of stomach wall.
- The gastric juice consists of hydrochloric acid and an inactive pre-enzyme pepsinogen.
- Pepsinogen is converted to active pepsin in presence of hydrochloric acid.
- Now, the pepsin catalyzes the hydrolysis of proteins, breaking them into peptones and proteases.

- Acid makes the food soft and also provides acidic medium. It kills bacteria and fungi present in the food

# Cont....

- The disintegration and mixing of digestive enzymes with food is aided by the muscular contractions of stomach wall.
- In presence of food, stomach secretes gastrin hormone.
- Gastrin activates cells that secrete HCl.
- Now, the liquified semidigested acidic food is termed as chyme.
- When the chyme reaches a proper state, the pyloric sphincter relaxes, hence chyme enters the duodenum.

# Intestinal digestion:

- As the acidic chyme enters the duodenum, several intestinal hormones are produced which have their own respective functions.
- Enterogastrone reaches the stomach trough blood and stops the production of gastric juice with HCl.
- Cholecystokinin causes gall bladder to contract hence releasing bile into duodenum through hepatopancreatic duct.
- Secretin and Pancreozymin work together to stimulate pancreas to secrete pancreatic juices into duodenum.
- Enterocrinin activates secretion of intestinal juice, the succus entericus.
- Thus, three important substances mix with the food in intestine for the completion of digestion.
- They are derived from three different sources: bile, pancreatic juice and intestinal juice.

# Cont,….

- **Bile:**
  - Bile is a greenish alkaline fluid secreted by liver.
  - It lacks digestive enzymes.
  - It contains bile salts such as sodium bicarbonate, sodium glycocholate, sodium perocholate, etc.
  - Bile being alkaline in nature neutralizes the acidity of chyme, emulsifies fats, stimulates peristaltic action of intestine and activates pancreatic lipase.

# Pancreatic juice

- The watery alkaline pancreatic juice contains several enzymes that acts on all 3 classes of foods.
- Intestinal enterokinase converts inactive trypsinogen to active proteolytic enzyme trypsin. Trypsin converts proteoses, peptones and polypeptides to simple amino acids.
- Amylase or amylopsin reduces starch (polysaccharides) to maltose (disaccharides).
- Lipase formerly called steapsin, converts emulsified fats into fatty acids and glycerol.

# Succus entericus:

- Succus entericus or intestinal juice contains several enzymes, besides enterokinase.
- These enzymes act on all classes of food stuffs.
- Erepsin is the collective name for all proteolytic enzymes or peptidases.
- It converts polypeptides to amino acids.
- Maltase converts maltose to glucose.
- Sucrase or invertase converts sucrose to glucose and fructose
- Lactase converts lactose to glucose and galactose.
- Lipase splits fats into fatty acids and glycerol.

# Egestion, absorption, and assimilation:

**Egestion:**

- Digestion is accomplished in the small intestine.
- By peristalsis, the undigested part of food is slowly moved into rectum for storage and preparation of faeces.
- At intervals, the faecal matter passes into cloaca.
- And now it is egested through cloacal aperture.

# Absorption:

- The final products of digestion are absorbed through the walls of small intestine.
- The internal absorptive surface is increased by folds with villi like processes.
- The actual mechanism of absorption is only little known.
- Osmotic forces and other factors are seemed to play a part.
- The epithelial lining absorbs water, mineral salts and other nutrients in the solution directly.

# Cont…

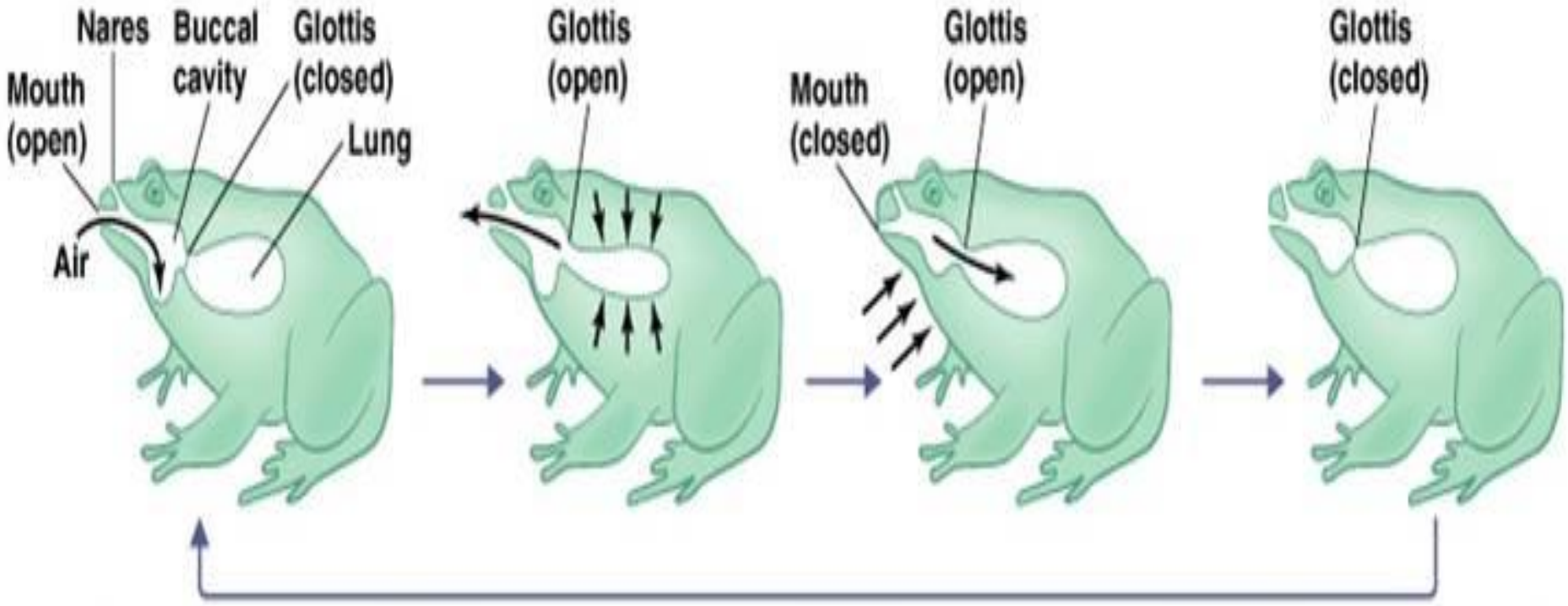
- Carbohydrates are absorbed as glucose and fructose, and proteins as amino acids.
- These pass into blood capillaries in the folds.
- Then it is passed into hepatic portal system and so into liver.
- Fatty acids and glycerol pass into lymphatic capillaries or lacteals in the folds and so into the veins.

# Assimilation:

- The absorbed food can be used for two basic purposes of nutrition:
- Liberation of energy during respiration.
- Assimilation as part of intimate structure of the animal.
- Excess of glucose may be stored as glycogen in liver and skeletal muscles or converted into fats. These are deposited in adipose tissue.
- Amino acids may for proteins for growth and repair.
- Or, it undergoes deamination resulting in the formation of urea to be excreted by kidneys with urine.

# Respiratory system of Frog

- **How Frog breathe?**
- Respiratory system is comprised of the organs that help in the intake and supply of oxygen to the tissues as well as to get rid of excess carbon dioxide.
- Branchial respiration occurs in case of tadpoles or larval stage.
- Branchial respiration takes place by means of external gills.
- Respiration in adult frog occurs through 3 different ways:
  - **Cutaneous respiration:** It takes place through moist surface of outer skin.
  - **Buccal respiration**: It takes place through lining of bucco-pharyngeal cavity.
  - **Pulmonary respiration**: It takes place through lungs.
- In each of the above cases, there are numerous blood capillaries lying close to the epithelium.
- Through these capillaries, the incoming $O_2$ and outgoing $CO_2$ diffuse readily.




1. Air enters pocket of buccal cavity

2. Glottis opens
   - Elastic recoil of lungs and compression of chest wall reduces lung volume
   - Air forced out of the lungs and out the mouth and nares

3. Mouth and nares close
   - Floor of buccal cavity rises
   - Air is pushed into lungs

4. Glottis closes
   - Gas exchange occurs in lungs

# i. Cutaneous respiration in frog:

- Cutaneous respiration takes place all the time, whether frog is in or out of water.
- When the frog is under water or hibernating, it is the only mode of respiration.
- There is rich supply of blood in the skin and it is permeable to gases.
- Oxygen must first dissolve in a moist surface before it diffuses into blood.
- This is also one of the reasons for frogs to stay near water and keep their skin moist.
- The mucus glands also secrete mucus so that the skin doesn’t dry out of water.
- Movement is not required in cutaneous respiration as skin remains exposed to air or water.

# ii. Buccal respiration in frog:

- In buccal respiration on land, the mouth stays permanently closed while the nostrils remain open.
- The floor of the buccal cavity is alternately raised and lowered.
- It allows the air to be drawn into and expelled out of the buccal cavity repeatedly through the open nostrils.
- The glottis remains closed during buccal respiration. It is done so that no air enters or leaves the lungs into buccal cavity.
- The mucus epithelial lining of buccal cavity is rich in blood capillaries which absorbs $O_2$ in the air and gives out $CO_2$.

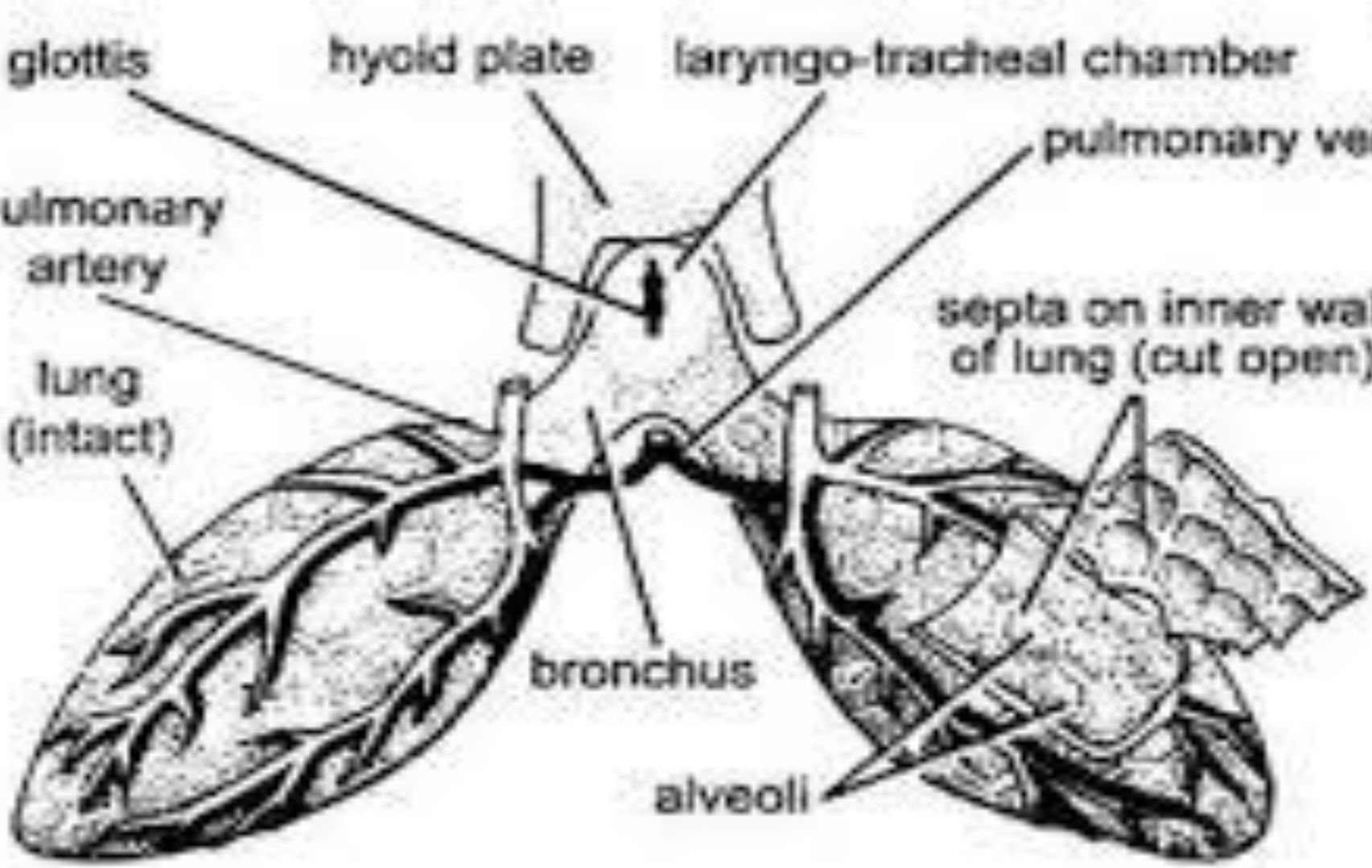
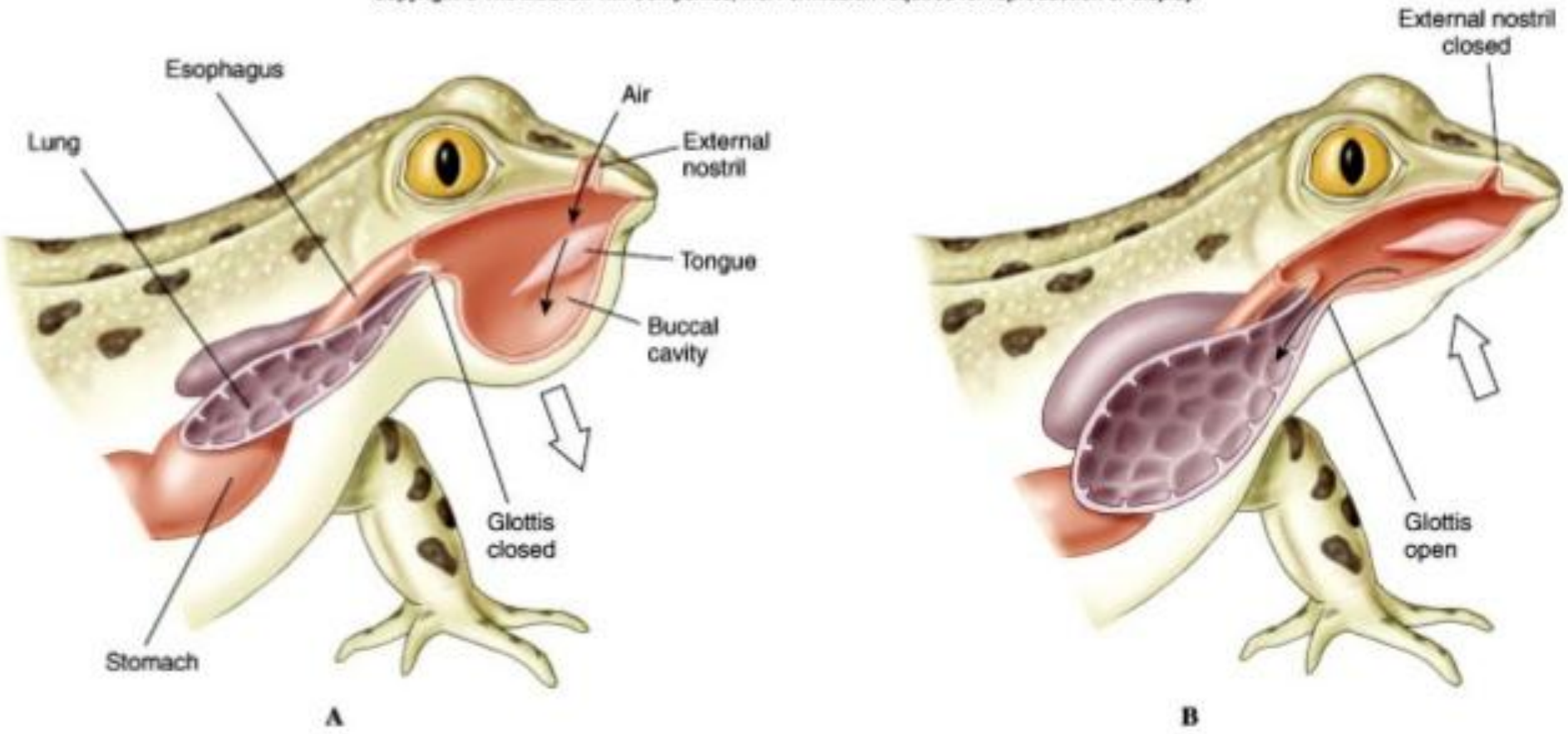



**Fig. 18.35.** Frog. Respiratory organs in dorsal view. Right lung partly cut open to show inner partitions and alveoli.

- **Lungs of frogs**






A frog ventilates its lungs by **positive pressure breathing**.

# iii. Pulmonary respiration and sound production in frog:

- The breathing that takes place on land in the atmospheric air by the help of lungs is termed as pulmonary respiration.
- In case of frogs, the lungs are poorly developed.
- Thus, the insufficient supply of $O_2$ obtained through lungs is supplemented by the moist skin and buccal cavity.

# Respiratory Organs of frog:

- The main organs for aerial respiration are the two lungs.
- The passage through which the air enters and leaves the lungs is termed as respiratory tract.
- **Respiratory tract;** It consists of:
  - External nostrils
  - Internal nostrils
  - Nasal chambers
  - Bucco-pharyngeal cavity
  - Glottis
  - Laryngo-tracheal chamber
  - Two bronchi
  - On the floor of pharynx, the median slit-like glottis is present.

# Cont…

- Glottis opens into larynx. Larynx or laryngo-tracheal chamber is a thin walled chamber.
- Cartilages (2 arytenoid + 1 cricoid) support the walls of larynx.
- Its internal lining forms a pair of elastic horizontal bands, the vocal cords.
- Vocal cords are for sound production thus larynx is also called as voice box.
- The characteristic croaking is produced because of the vibrations formed when the air from lungs is forced outside.
- The tension of the cords can be changed by special muscles, hence, changing the pitch of the sound.
- Only male frogs have vocal sacs so as to amplify the croaking sound.
- From larynx, bronchus leads to each lung.
- Bronchus is a very small tube.

# Lungs:

- Lungs are ovoid in structure.
- They are thin-walled and highly elastic sacs.
- They are suspended freely inside the peritoneal body cavity, one on either side of the heart.
- Peritoneum covers the lung externally.
- The inner surface of each lung is divided by septa (a network of folds) into many small air sacs or alveoli, leaving a clear large central cavity.
- The alveoli are lined by thin epithelium.
- This epithelium is richly supplied with blood capillaries that contains de-oxygenated blood for gaseous exchange.
- $O_2$ in the inhaled air diffused to blood whereas $CO_2$ is released into alveoli.

# Mechanism of Respiration in frog:

- Pulmonary respiration occurs in between buccal respiration.
- Here, buccal cavity acts as a force pump.
- The action of two special sets of muscles brings the rhythmic up and down movements of the floor of buccal cavity.
- **Sternohyal muscles:**
  - These muscles are attached at the lower end to the sternum and at the upper end to the undersurface of cartilaginous hyoid apparatus embedded in the floor of buccal cavity.
- **Pterohyal muscles:**
  - These muscles are attached below to the upper surface of hyoid apparatus and above to the squamosal bone of skull.
- The whole respiratory mechanism involves two phases:

# Inspiration:

- The frog closes its glottis and mouth while drawing air into the lungs.
- In this phase, nostrils remain open.
- Now, the sternohyal muscles contract.
- This contraction allows the hyoid apparatus and the floor of buccal cavity to be lowered.
- The buccal cavity is enlarged and the air is drawn into the buccal cavity through the nostrils.
- Now, the glottis opens and the mentomeckalian bones of lower jaw push upwards the premaxillae bones of upper jaw. This closes the nostrils.
- Then, the pterohyal muscles contracts which raises the hyoid apparatus and the floor of buccal cavity.
- The reduction in volume of buccal cavity forces the compressed air through the opened glottis into the two lungs.
- This process by which lungs are filled with air is called inspiration.

# Expiration:

- The glottis closes when lungs are filled with air.
- For some time, air is held in the lungs during which buccal floor is repeatedly raised and lowered to carry on buccal respiration.
- Soon, the glottis opens.
- The air in the lungs are driven out into the buccal cavity by lowering its floor.
- It is aided by the elasticity of lungs and contraction of the body muscles.
- The glottis closes when the buccal floor is raised again.
- Now, the air is expelled through the opened nostrils to outside.
- This process by which the lungs are emptied is called expiration.

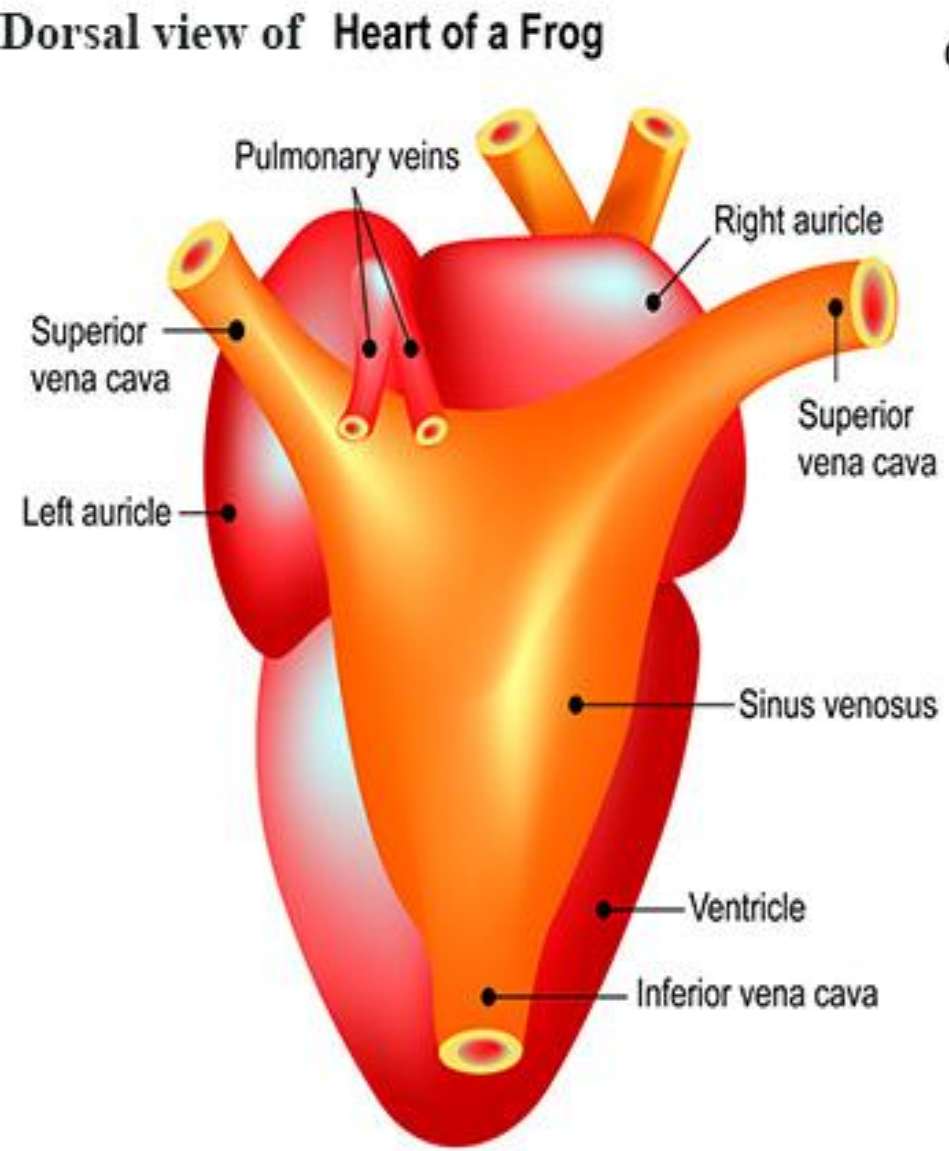
# Frog's Heart; Structure and physiology

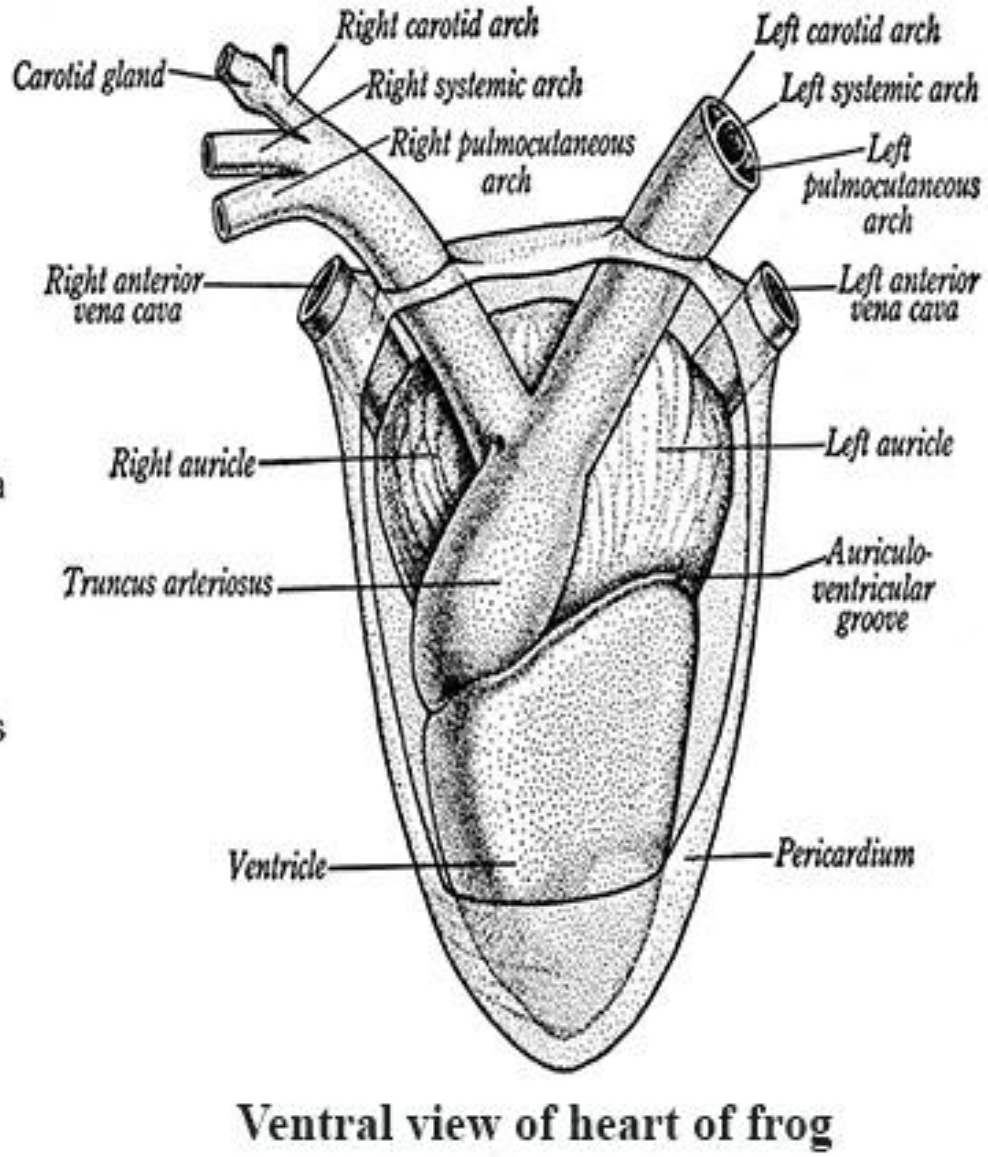
- The heart is muscular central pumping station.
- It drives blood through the closed circulatory system.
- **External features:**
  - Heart lies mid-ventrally inside the anterior trunk region.
  - It is protected by the pectoral girdle.
  - It is reddish in color.
  - It is somewhat conical or triangular in shape.
  - It has the broad base which is directed anteriorly and the narrow apex posteriorly.

# Pericardium

- Pericardium encloses the heart.
- It is thin, transparent, two-layered sac.
- The outer wall of pericardium is termed as parietal pericardium.
- The inner wall of pericardium is termed as visceral pericardium.
- Visceral pericardium closely invests the heart.

# EXTERNAL VIEW



# Chambers of heart:

- There are 3 chambers in a heart of frog. It is made up of:

  Two atria or auricles (right and left): It is dark colored and lies anteriorly.
- One ventricle: It is pink colored, conical and lies posteriorly.
- A very faint longitudinal inter-auricular groove demarcates the two auricles externally.
- However, a narrow transverse auriculo-ventricular groove or coronary sulcus clearly marks off the two auricles from ventricle.

# Cont…..

- Two additional chambers are present in the heart of the frog i.e. sinus venosus and truncus arteriosus.
- **Sinus venosus:** It is dark colored, thin-walled and triangular chamber. It is attached dorsally to heart.
- **Truncus arteriosus:** It is a tubular chamber that arises anteriorly from the right ventral side of ventricle.

- It immediately bifurcates anteriorly into two branches, each again breaks into three arches i.e. carotid, systemic and pulmocutaneous.

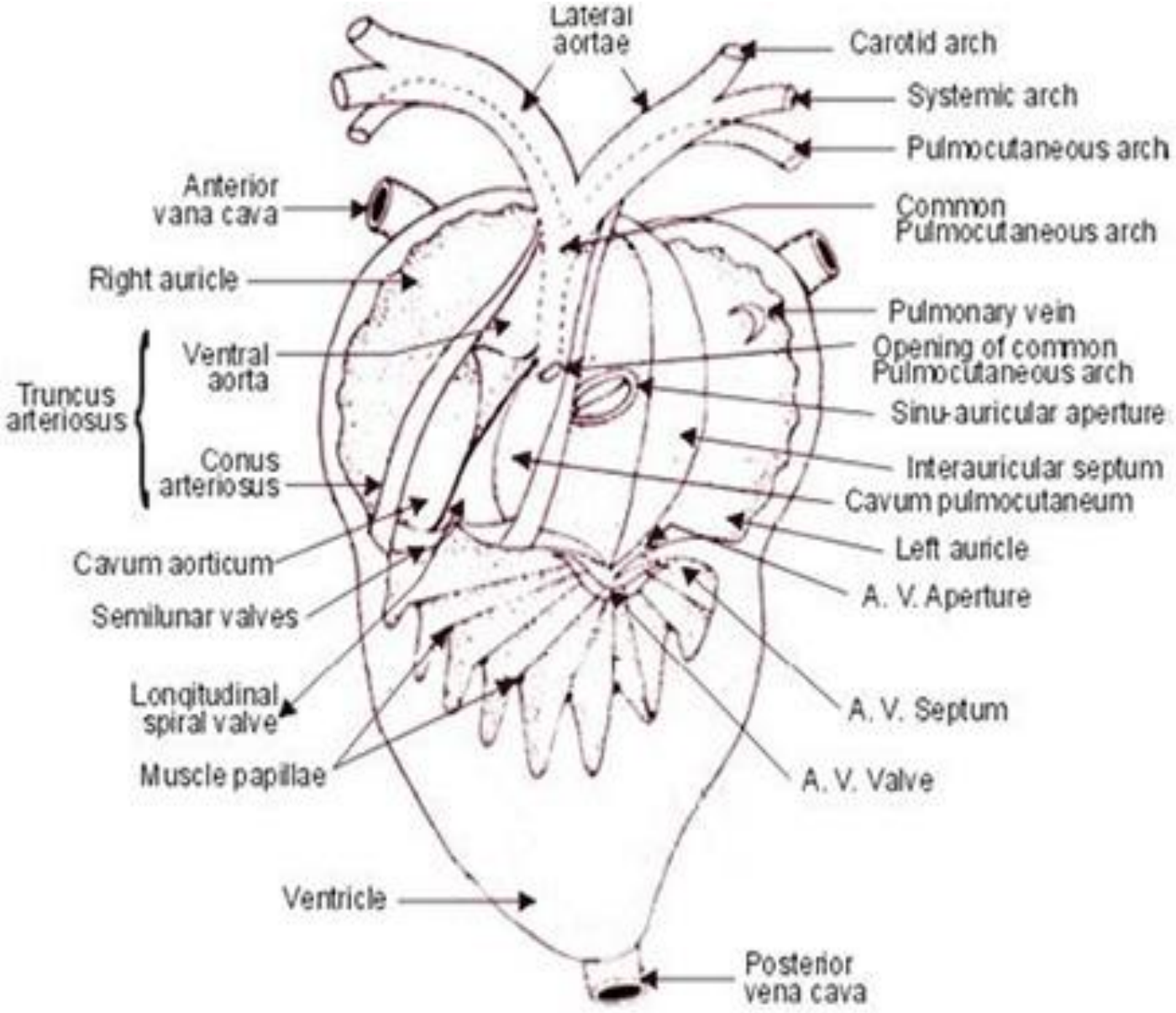



*Figure: Internal Structure of Frog's Heart*

# *Internal structure of frog's heart*

- When the frog is sectioned, its internal structure is visible.
- It is hollow and muscular.
- In order to keep the unidirectional flow of blood, the various chambers are separated by valves.
- **Auricles:**
  - There are two auricles, left and right.
  - They are thin walled and are completely separated from each other by a thin vertical inter-auricular septum.
  - The left auricle is smaller than the right.

# Cont....

- Sinus venosus opens into dorsal wall of the right auricle through the sinu-auricular aperture.
- The sinu-auricular aperture is a large transverse oval aperture.
- Sinus venosus lies close to the inter-auricular septum. It is guarded by a pair of flap-like valves.
- Likewise, the common pulmonary vein opens into left auricle, near septum, by a small opening without valves.
- Both auricles open into ventricles by a common large auriculo-ventricular aperture.
- This aperture is guarded by two pairs of flap-like auriculo-ventricular valves.

# Ventricle:

- The ventricle has thick muscular and spongy wall.
- Its inner surface consists of:
- Columnae carnae or trabeculae (irregular strands or ridges)
- Fissures(depressions)
- These highly reduce the cavity of ventricle.
- Chordae tendineae are thread like structure that connects the flaps of auriculo-ventricular valves to the wall of ventricle.

# Cont…

- Truncus arteriosus:
- 3 semilunar valves guard the opening of ventricle into truncus arteriosus.
- These valves prevent the backflow of blood from truncus into ventricle.
- The spirally twisted cavity of truncus arteriosus is divided unequally by another set of 3 semilunar valves into:
- Conus arteriosus or pylangium: long basal thick-walled
- Bulbus aorta or synangium:  short distal thin-walled
- The cavity of conus or pylangium is divided incompletely into a left dorsal cavum pulmocutaneum and a right ventral cavum aorticum by a large twisted longitudinal spiral valve.

# Cont….

- The spiral valve is attached dorsally while its ventral edge is free.
- The common opening of two pulmocutaneous arches is situated in cavum pulmocutaneum.
- However, separate openings of carotid and systemic arches lie in synangium.
- All these openings are guarded by valves.
- The distal right and left branches or trunks appear externally to be single vessels.
- However, internally, each is made of 3 channels which ultimately form three distinct arches on either side.

# *Working of heart:*

- Heart is a muscular organ that continuously beats throughout the lifetime.
- Heart works under the control of nervous system to pump blood into the circulatory system.
- The contraction of the heart is termed as systole whereas the relaxation of the heart is termed as diastole.
- The different chambers of heart contract in a regular sequence and the valves present.
- On the contraction of sinus venosus, the non-oxygenated venous blood is forced into the right auricle through sinu-auricular aperture.
- For the moment, the oxygenated blood from lungs is poured into left auricle through common pulmonary vein.
- Now, the two auricles contract almost simultaneously forcing their blood into ventricle through the single auriculo-ventricular aperture.

# According to the **older view:**

- The ventricle possesses only deoxygenated blood in its right side received from right auricle.
- Only oxygenated blood is contained in the left side of ventricle received from left auricle, with some mixed blood in the middle region.
- The mixing of two types of blood was prevented because of their viscous nature and also because of the spongy nature of ventricle.
- The ventricle is spongy because of the presence of network of columnae carneae.
- As the contraction of ventricle initiates, firstly, the deoxygenated blood from the right side being nearer, flows into the truncus arteriosus.
- Then it is directed by the spiral valve into the common opening of pulmocutaneous arches and is carried to lungs and skin for oxygenation.
- The opening of pulmocutaneous arches is now closed by the spiral valve.

# Modern view:

- Recent studies show that it is actually completely mixed blood in ventricle and truncus which flows simultaneously through the three pairs of arches to all parts of the body.
- The blood received from skin and buccal cavity into sinus venosus and right auricle in more oxygenated in comparison to the blood received from the lungs into the left auricle.
- As per this view, the inter-auricular septum and spiral valve in truncus is functionless in frogs.

# The nervous system includes:

- (i) A central nervous system comprising the brain and spinal cord,
- (ii) A peripheral nervous system consisting of cranial and spinal nerves arising from the brain and spinal cord respectively and
- (iii) An autonomic nervous system made of two ganglionated sympathetic nerves.
- The autonomic nervous system is often regarded as a part of the peripheral nervous system because the two are connected.

# Central Nervous System: *Brain*

- The brain of frog is elongated, bilaterally symmetrical, white coloured structure safely situated in the cranial cavity of the skull. It is surrounded by a thin, pigmented and vascular connective tissue membrane, the piamater, which is closely applied with the brain. Outside this membrane is a tough, fibrous membrane lining the interior of the cranial cavity called duramater. These two membranes are called meninges (singular, menix).
- The space between the piameter and duramater is known as subdural which is filled with a kind of shock absorbing watery, clear lymphatic cerebro-spinal fluid. It is also found in the cavities of brain and central canal of spinal cord.

# The brain of frog is divisible into three main parts:

- (i) Forebrain or Prosencephalon;
- (ii) Midbrain or Mesencephalon;
- (iii) Hindbrain or Rhombencephalon.
- **(i) Forebrain:**
- It is the largest part of the brain consisting of a pair of anteriorly directed olfactory lobes, a pair of cerebral hemispheres, and a diencephalon.
- **(a) Olfactory Lobes:**
- The olfactory lobes are anterior small, spherical structures which are fused together in the median plane. Each lobe gives off an olfactory nerve and possesses a small cavity rhinocoel or olfactory autricle.

# Cont….

- **(b) Cerebral Hemispheres:**
- The two cerebral hemispheres are long, oval structures separated from olfactory lobes by a slight constriction. They are wider behind and narrower in front. They are separated from each other by a deep median longitudinal fissure.
- Each cerebral hemisphere has a large lateral ventricle or paracoel which is continuous anteriorly with the rhinocoel. Posteriorly the lateral ventricles communicate with each other and with the ventricle of diencephalon called diocoel by an opening, the interventricular foramen or foramen of Monro.

# Cont…

- The nerve cell bodies form masses around the lateral ventricles and lie in layers. Fibres of the olfactory, tactile and optic impulse reach the cerebral hemisphere which may act as correlating centres but the hemispheres are largely olfactory in function.

# Cont…

- On ventro-lateral side of each of the cerebral hemispheres there is a thick fibrous tract called the corpus striatum containing a network of white medullated nerve fibres and nerve cells.
- The corpora striata of two hemispheres are joined by a transversely running tract of fibres called anterior commissure and above which is another commissure (upper line) partly representing the hippocampal commissure of the brain of reptiles and mammals. They have a thick roof called the pallium in which more nerve cells have moved to the periphery.

# Cont....

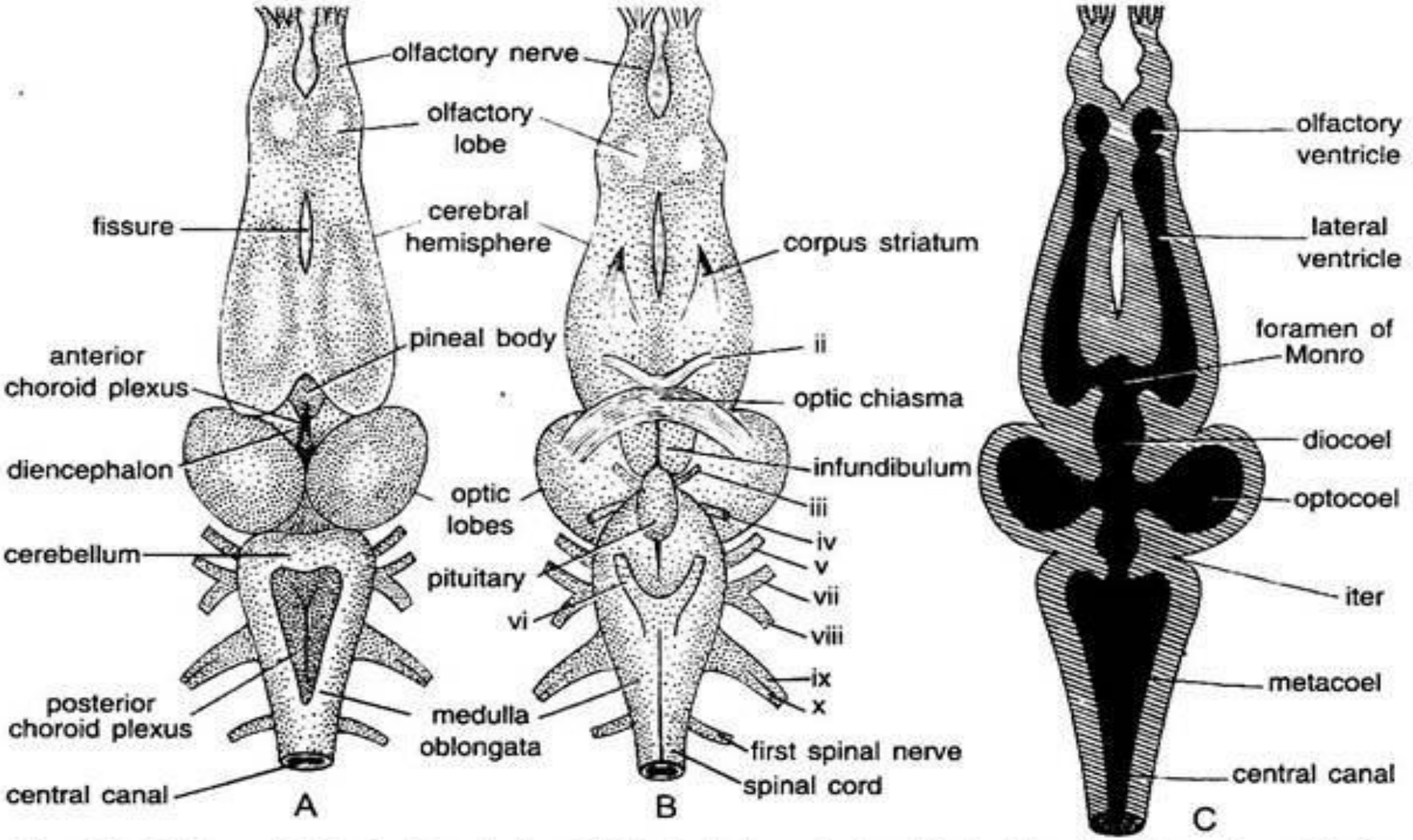



**Fig. 18.49.** Frog. Brain. A–Dorsal view; B–Ventral view; C–Longitudinal horizontal section of brain showing ventricles.

# Cont…

- **(c) Diencephalon or thalamencephalon** is a short unpaired structure of the forebrain situated behind the cerebral hemispheres.
- Its lateral walls are thick called optic thalami (singular thalamus) and its thick floor is called the hypothalamus. Its roof is thin and lined with a vascular membrane, the anterior choroid plexus.
- Behind it arises a hollow, thin-walled stalk, called the pineal stalk which terminates dorsally at the brow spot.

# Cont…

- The pineal stalk or epiphysis, which originally was continuous with the brow spot, becomes constricted off from it in early larval life. On the ventral side of diencephalon is the optic chiasma or crossing of the optic nerves which go the eyes.
- Just behind the optic chiasma is a flattened bilobed infundibular lobe or infundibulum extending posteriorly and divided by a median longitudinal groove.

# Cont…

- It is formed of nervous tissue and contains a cavity which is continuous with the III ventricle or diocoel of diencephalon. The hypothalamus cerebri or pituitary body lies behind and partly covered by infundibulum.
- The hypothalamus is an important centre regulating the whole endocrine system as well as other parts of the brain. It is composed of anterior and posterior parts. The anterior part of the hypophysis has no connection with the brain.

# (ii) Midbrain:

- It is well developed consisting of two dorso-lateral large rounded optic lobes. The optic lobes are centres for impulses coming from the eyes.
- Their cavities are called optocoel or optic ventricles communicating with each other and the fourth ventricle behind through a narrow cavity, the iter or aqueduct of Sylvius.

# Cont…

- Below the optic lobes are present two thick longitudinal bands of nerve fibres, called the crura cerebri.
- These connect diencephalon and medulla. These form the floor of midbrain.
- Lying transversely between the diencephalon and optic lobes is a band of nerve fibres called posterior commissure.

# (iii) Hindbrain:

- **It consists of the cerebellum and the medulla oblongata:**
- (a) The cerebellum is a rudimentary narrow transverse solid band lying dorsally immediately behind the optic lobes. Its function is probably to regulate the vestibulo-oculomotor system controlling movements of the eyes,
- (b) Medulla oblongata is short and somewhat triangular structure which is simply a widening of the spinal cord.

# Cont…

- Its cavity is also triangular called fourth ventricle or metacoel which is joined in front to the iter but posteriorly it is continuous with the central cavity of the spinal cord. Its roof is thin, vascular and thrown into folds called the posterior choroid plexus.
- From the sides of medulla arises several pairs of cranial nerves. Its lower surface is divided by a median fissure which is continuous with the ventral fissure of the spinal cord.
- On the dorsal surface of the medulla oblongata there is a triangular area of reddish brown colour which is called posterior choroid plexus.

# Cont….

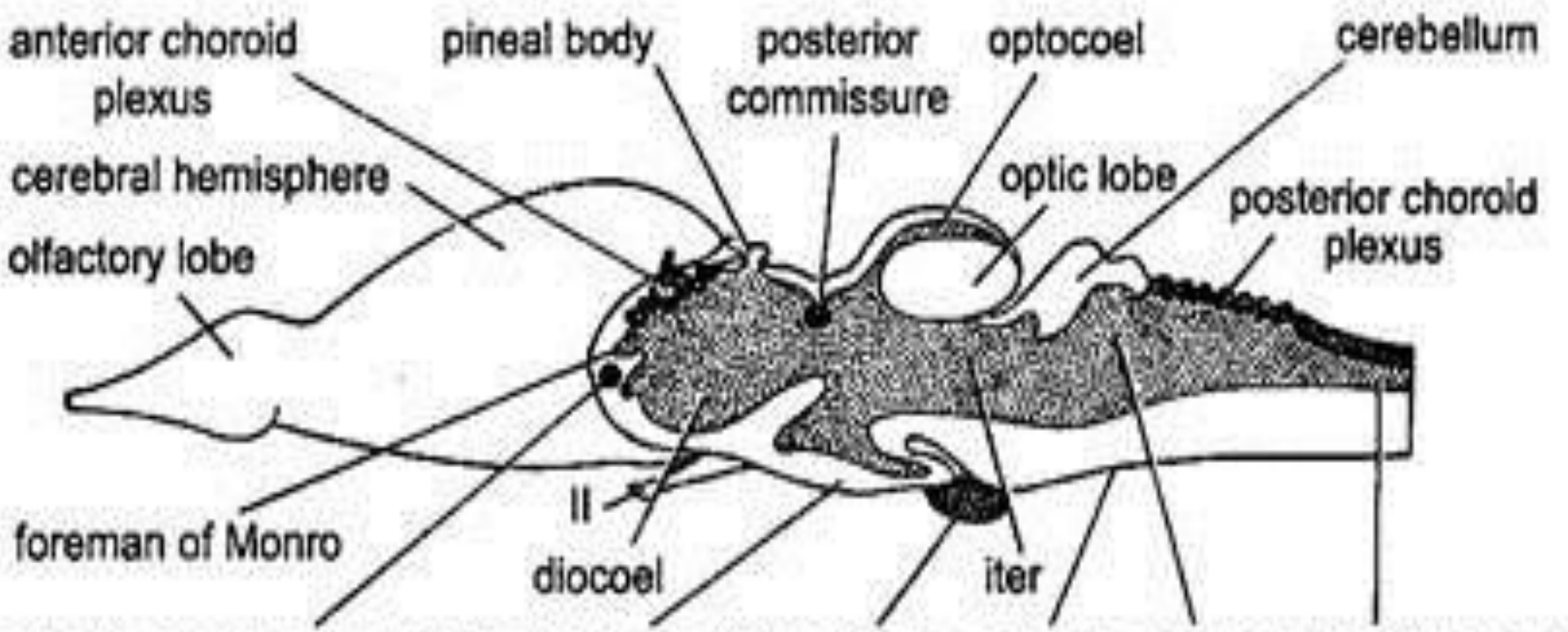



**Fig. 18.50.** Frog. Brain. Longitudinal vertical section of brain.

# *B. Spinal Cord:*

- The medulla oblongata continues behind as spinal cord, lying in the neural canal of the vertebral column. It is short, somewhat flattened dorsoventrally and terminates behind the lumbar swelling in a tapering narrow thread called filum terminale lying in the urostyle.
- The filum terminale with the nerve roots on either side is sometimes called cauda equina as it looks like a horse tail. It presents two enlargements during its course, one at the level of the forelimbs where nerves for arms arise and one far behind at the level of hindlimbs where nerves for hindlimbs arise.

# Spinal Cord

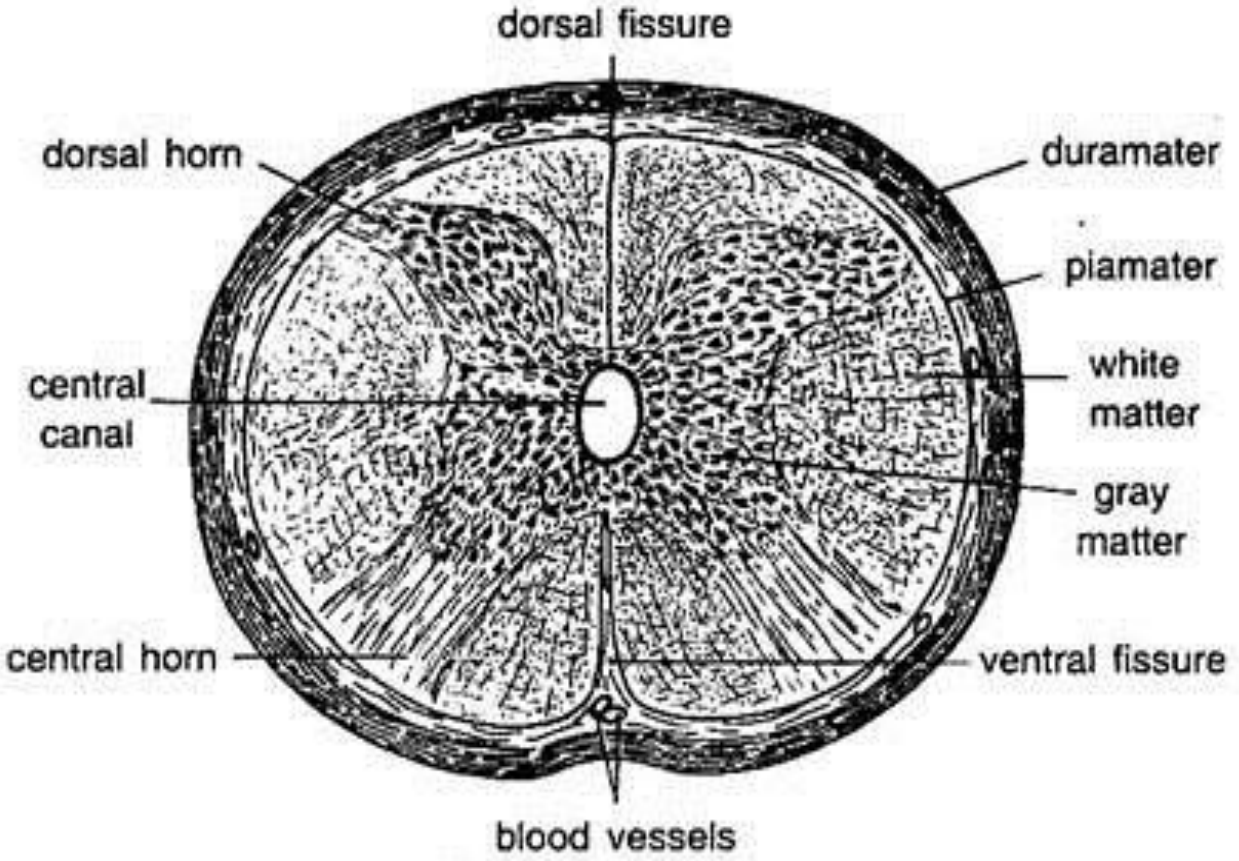



**Fig. 18.51.** Frog. T.S. of spinal cord.

# Cont….

- The anterior enlargement of the spinal cord is known as brachial or cervical swelling, while the posterior as lumbar or sciatic swelling.
- It is traversed throughout its length by two longitudinal grooves, one on the dorsal side and the other on the ventral side, known as dorsal and ventral fissure respectively.
- These two fissures almost completely divide the spinal cord into two symmetrical halves.

# Cont…

- Like the brain the spinal cord is also formed of gray matter with ganglion cells and non-medullated nerve cells surrounding the central canal, and white matter with ganglion cells and medullated nerve fibres surrounding the grey matter.

# Cont…

- Grey matter is produced at the comers into dorsal and ventral columns or horns, while the white matter is divided by grey matter into four zones or funicules, the dorsal, the ventral and two lateral funicules.
- It is covered by two protective membranes; the duramater lines the neural canal and the vascular, thin and pigmented piamater closely covers the cord.

# *Functions of Different Parts of the Brain:*

- Brain is the only centre for the immediate control of all vital activities as it receives impulses from different parts of the body through sensory nerves and issues orders through motor fibres to different parts of the body for appropriate action.

# Cont….

- **i. Cerebrum:**
- The pallium of cerebral hemispheres controls the activities of the olfactory, tactile and optic organs, whereas the cerebral hemispheres coordinate the activities of the neuro-muscular mechanism of the body, but these are supposed to be the seat of intelligence and voluntary control in higher animals.
- **ii.** Diencephalon region of the brain controls the metabolism of the fats and carbohydrates and also regulates the genital functions.

# Cont….

- **iii.** Optic lobes and optic thalami are supposed to be concerned with the sensation of sight and the control of the movement of the eye muscles.
- **iv.** Cerebellum controls the mechanism of the automatic movements and also brings about coordination in movements of locomotion.
- It is in correlation with the medulla oblongata and regulates complex muscular movements of the body.

# Cont....

- **v.** Medulla oblongata is an important nerve centre. It has nerve centres of all reflex functions and, thus, regulates particularly those functions of the body which are not directly under the control of the will like heart beating, respiration, swallowing, taste, hearing, sound production and secretions of various digestive juices.

# Peripheral Nervous System:

- The peripheral nervous system includes the nerves arising from the brain and spinal cord. Those nerves which arise directly from the brain are called cranial nerves, while those arising from the spinal cord are called spinal nerves.
- ***Structure of Nerve:***
- The nerves are solid structures looking like white threads. Each nerve is composed of several bundles of nerve fibres called the funiculi (singular funiculus) and is covered externally by a sheath of loose connective tissue called the epineurium.

# Cont…..

- Each funiculus is also being enclosed by a thick covering of dense tissue called the perineurium.
- In each bundle or funiculus the individual nerve fibre is also covered by a connective tissue sheath called endoneurium which is continuous with the neurilemma of nerve fibres.

# *Types of Nerves:*

- A nerve may be afferent or sensory with sensory nerve fibres or efferent or motor with motor nerve fibres or mixed with both sensory as well as motor nerve fibres.
- Sensory nerves or nerve fibres are those which carry the impulses from the receptors to the central nervous system, whereas the motor nerves or fibres carry the impulses of appropriate order from the central nervous system to the effector organs.

# Cont.....

- **In the body the following four types of fibres are recognised:**
- (a) Somatic sensory;
- (b) Somatic motor;
- (c) Visceral sensory; and
- (d) Visceral motor.

# Cont…..

- **(a) Somatic Sensory:**
- These are the fibres or nerves which carry the impulses from receptors such as skin, eyes, nose, body wall, muscles and joints to the central nervous system.
- The dendrons of these nerve fibres are very long, starting from the receptors pass to dorsal root ganglion in which their cell body lies.

# Cont.....

- **(b) Somatic Motor:**
- Such fibres or nerves carry impulses from the central nervous system to the effector organs which include mainly the muscles.
- Their dendrites and cell bodies are always found in grey matter but their long axons pass through the ventral roots to the muscles (effector organ).

# Cont…..

- **(c) Visceral Sensory:**
- Such fibres or nerves carry sensations from the receptors situated in the wall of alimentary canal to the central nervous system.
- Their dendrites start from the receptors located in the wall of alimentary canal and pass to the cell bodies situated in the dorsal root ganglia from where the axons pass into the grey matter.

# Cont....

- **(d) Visceral Motor:**
- These fibres are able to convey impulses from the central nervous system to the involuntary muscles of the alimentary canal, glands and other visceral organs.
- Their dendrites and cell bodies are found in the grey matter, while the axons pass out through the ventral root and end in the autonomic ganglia (preganglionic) from where the second neuron starts whose axon extends to the involuntary muscles or glands (post-ganglionic).

# Cont….

- ***Cranial Nerves:***
- In an adult frog ten brain pairs of cranial nerves are found which emerge from the brain through various foramina of the cranium to supply the different organs of the body.
- Each cranial nerve originates from the brain by two roots, a dorsal and a ventral root, but these two roots do not unite with each other and, thus, look like separate nerves.
- These are numbered I to X, some of which are purely motor, some are sensory, while others are mixed.

# Cont....

- **The cranial nerves with their names are as follows:**
- **I. Olfactory Nerve:**
- It arises from the anterior end of olfactory lobe and innervates the cells of olfactory sac. It is sensory in nature.
- **II. Optic Nerve:**
- Nerve fibres arise from the retina of the eye. The fibres of the two sides generally cross or decussate out the optic chiasma and then enter the optic thalamus of the opposite side, finally terminating in the thalamencephalon. It is also purely sensory.

# Cont….

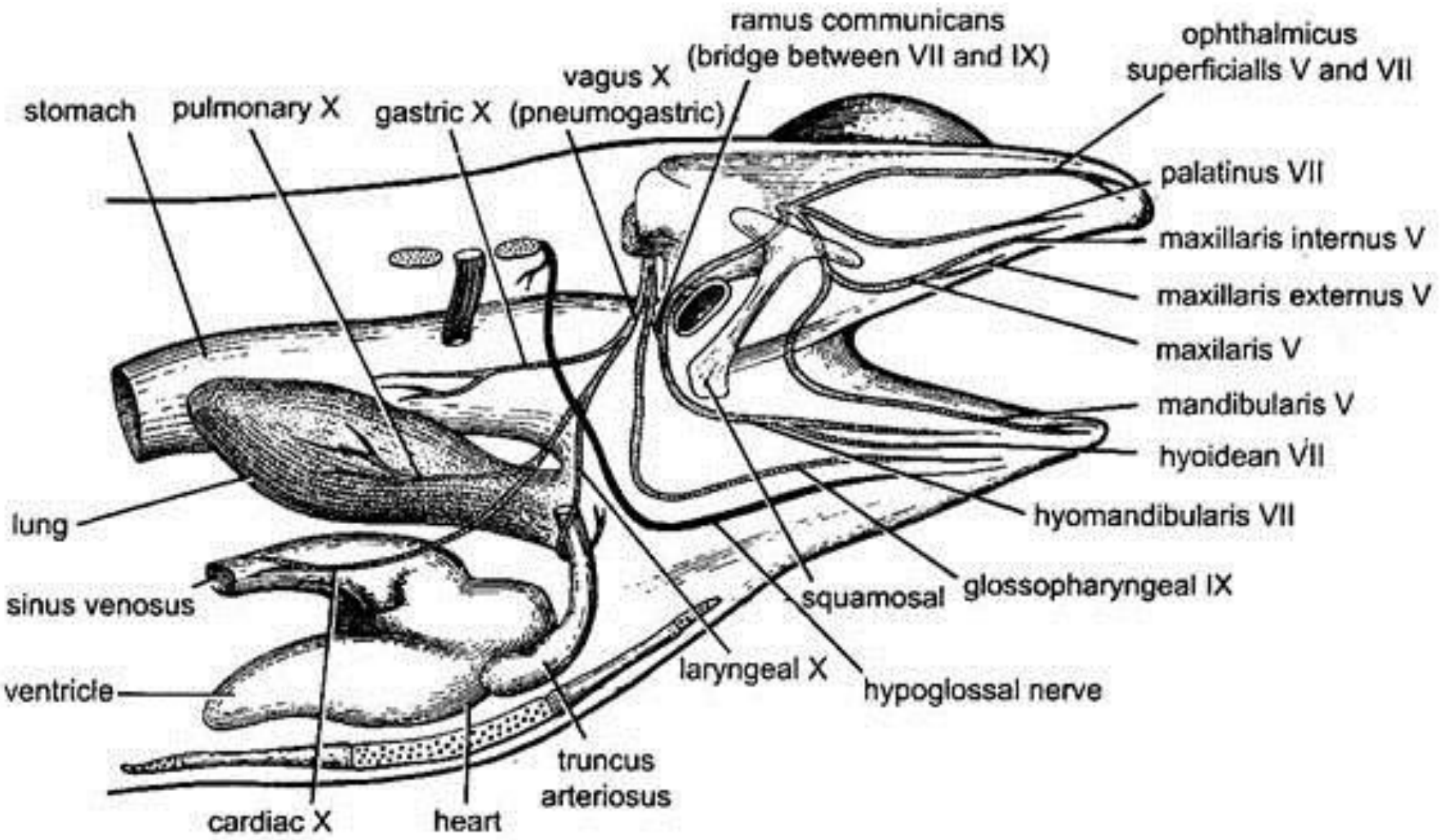



**Fig. 18.52.** Frog. Cranial nerves.

# Cont….

- **III. Oculomotor Nerve:**
- It is small nerve arising from the ventral side of the midbrain (crura-cerebri). It divides into branches which supply the anterior, superior and inferior recti muscles and the inferior oblique muscle of the eye ball. It is exclusively motor.
- **IV. Trochlear or Pathetic Nerve:**
- It is also a small nerve arising from the dorsal side of the brain between the optic lobes and cerebellum and going to the superior oblique muscle of the eye ball, it is exclusively motor.

# Cont…..

- **V. Trigeminal Nerve:**
- It is the largest of the cranial nerves arising from the sides of the anterior end of the medulla oblongata. Before it emerges from the skull it bears Gasserian ganglion.
- **It divides into three branches:**
- (a) Ophthalmic superficialis passes along the dorsal border of the orbit and goes to the skin of the snout. It is somatic sensory,
- (b) Mandibular and
- (c) Maxillary arise from a common stem and then separate.

# Cont…..

- The mandibular goes to the muscles of lower jaw and the maxillary forms the two branches going to the skin of the upper jaw and upper lip. Maxillary is a somatic sensory, whereas the mandibular is visceral motor nerve. Thus, trigeminal is a mixed nerve.
- **VI. Abducens Nerve:**
- It arises from the ventral side of the medulla oblongata and enters the orbit and goes to the posterior rectus muscle of the eye ball. It is a motor nerve.

# Cont…..

- **VII. Facial Nerve:**
- It arises from the antero-lateral side of medulla oblongata close behind the fifth. It is mixed nerve as having both visceral sensory and visceral motor fibres.
- **It is divided into two branches:**
- (a) Palatine going to the roof of the buccal cavity,
- (b) Hyomandibular going to the tongue and muscles of the lower jaw.

# Cont…

- **VIII. Auditory Nerve:**
- It is somatic sensory arising from the medulla oblongata behind the seventh and goes to internal ear.
- **IX. Glossopharyngeal:**
- It is mixed nerve arising from the lateral side of medulla and goes to the tongue, hyoid and pharynx. It does not bear pre-frematic and post-trematic branches to the first gill.
- **X. Vagus or Pneumogastric:**
- It is mixed nerve arising from the lateral side of medulla and goes as visceral branch to the larynx (laryngeal), oesophagus and stomach as gastric, heart (cardiac) and lungs (pulmonary).

# *Spinal Nerves*

- In Indian frog, Rana tigrina usually 9 pairs of spinal nerves are found which arise from the spinal cord by two roots, a dorsal or sensory root and a ventral or motor root.
- Both the dorsal and ventral roots unite immediately after coming out of the neural canal through intervertebral foramen.
- Dorsal root has a ganglion of nerve cells.

# Cont.....

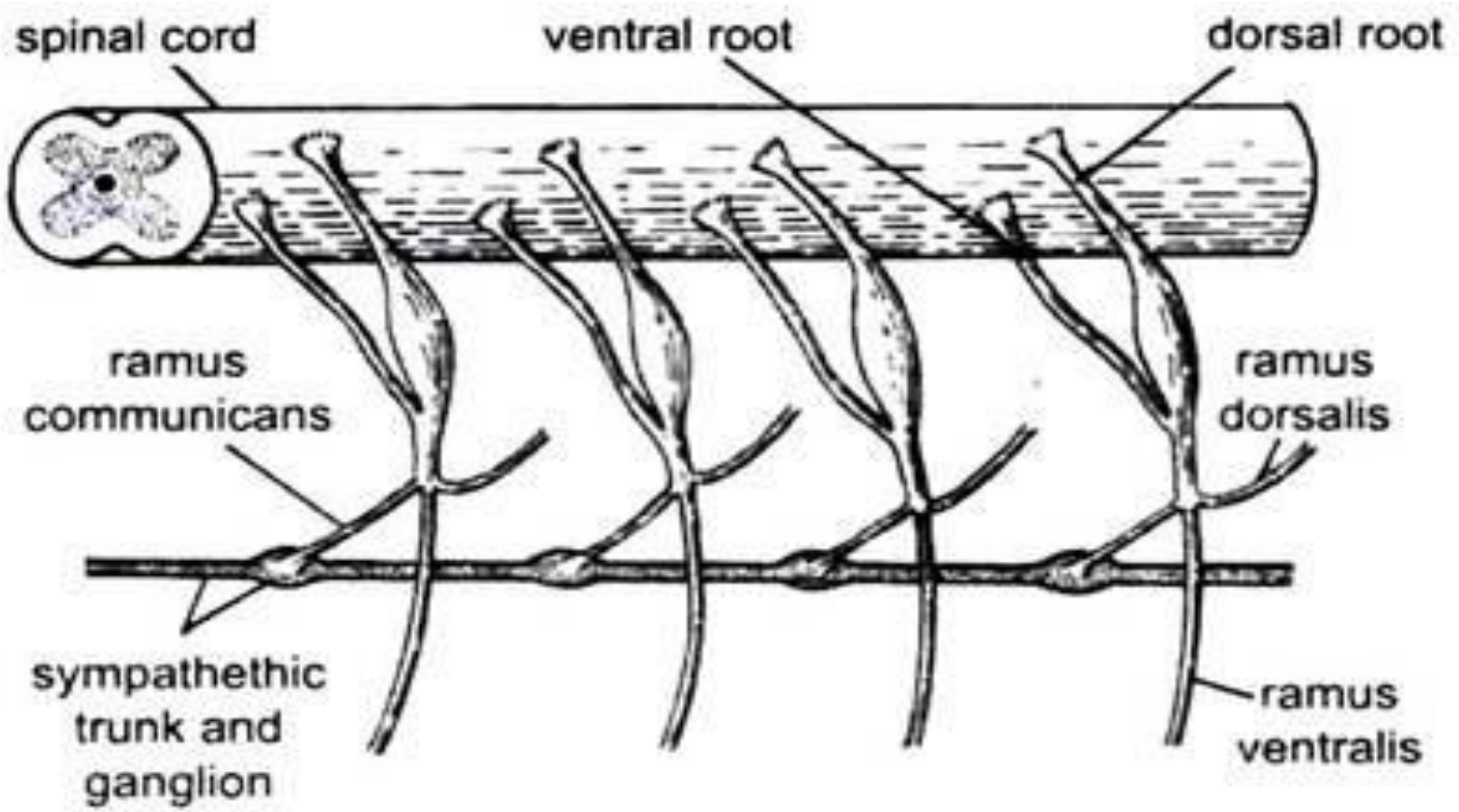



**Fig. 18.53.** Frog. Four spinal nerves and their branches.

# Cont…..

- The dorsal root entirely of afferent fibres which may be somatic sensory or visceral sensory which carry impulses from different body parts towards the spinal cord.
- The ventral root consists of somatic motor or visceral motor fibres of which the cell bodies together with dendrons are situated in the ventral part of the grey matter of spinal cord.
- These carry responses from the spinal cord to the body tissues. Thus, in the spinal nerves these different kinds of fibres are mixed but as the roots are approached, they are segregated.

# Cont…..

- The dorsal root ganglia are covered by white soft chalky masses, calcareous bodies or glands of Swammerdam or periganglionic glands.
- It is probably the reserve supply of calcium to the body. Each nerve immediately after its origin gives off a short dorsal branch, ramus dorsalis to the dorsal skin and muscles of the back, a large ventral branch, ramus ventralis to the ventral skin and muscles of the body and a very short ramus communicans which unite to the nearest sympathetic ganglion.
- Ramus dorsalis contains only somatic sensory fibres, whereas the ramus ventralis contains somatic motor fibres, while ramus communicans contains both visceral sensory and visceral motor fibres.

# Cont……

- The first spinal nerve (hypoglossal) comes out between the first and second vertebrae and innervates the tongue and several muscles attached to the hyoid.
- The second spinal nerve is quite large and emerges between the second and third vertebrae. It receives the branches of the first and third spinal nerves to form a brachial plexus, then it proceeds as the brachial nerve to the skin and muscles of the forelimbs.
- The fourth, fifth and sixth nerves are small going obliquely to the skin and muscles of the abdomen.

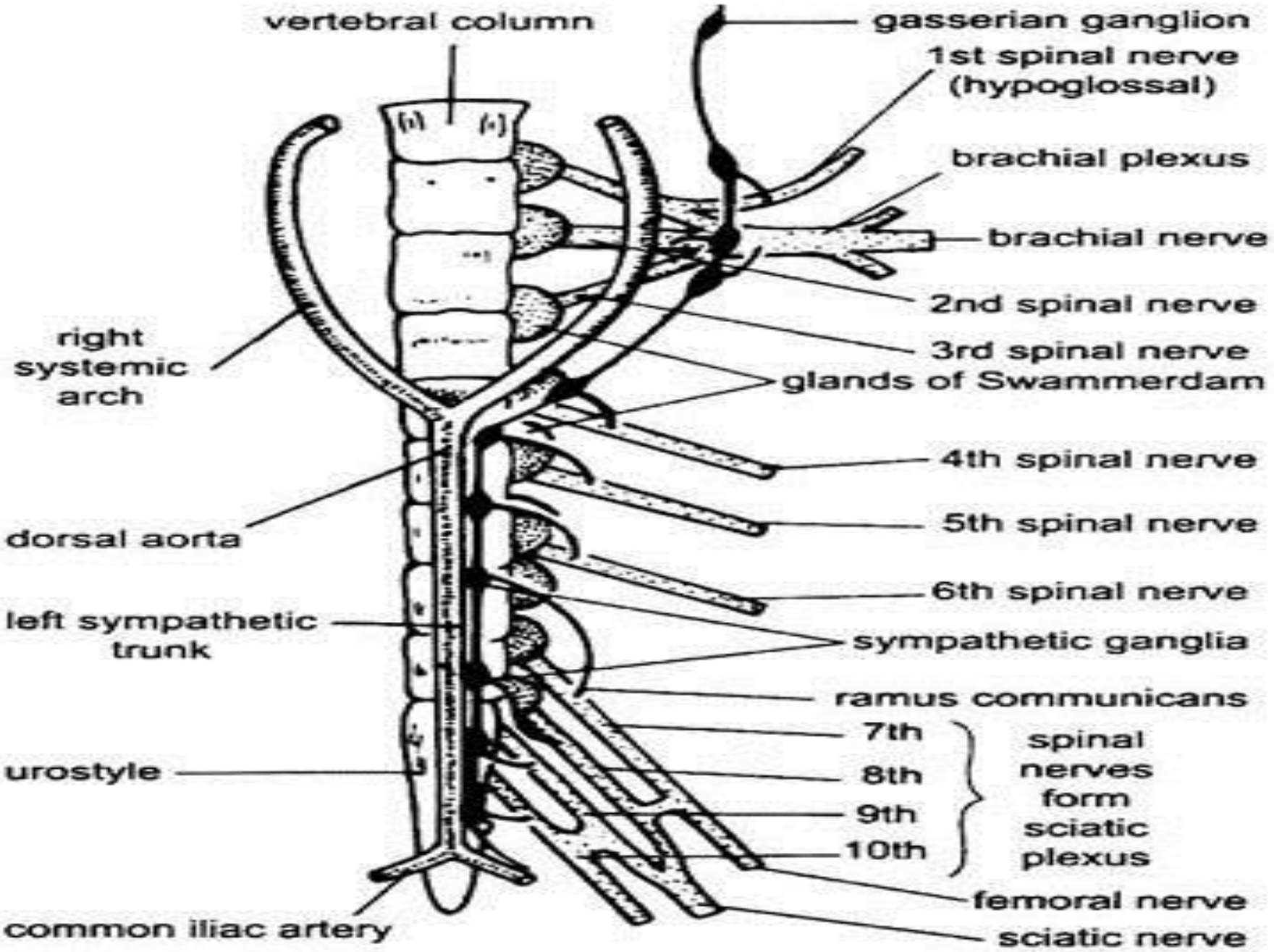



**Fig. 18.54.** Frog. Dissection showing spinal nerves 1–10 and sympathetic trunk on the left side only.

# Cont…

- The seventh, eighth and ninth spinal nerves pass almost directly backward and anastomose to form the sciatic or lumbo-sacral plexus from which a large sciatic nerve and several small nerves enter the hindlimb. The most important one is sciatic nerve which divides into tibialis and peroneus.
- The tibialis gives branches to the gastrocnemius, tibialis posticus and numerous muscles of the plantar surface of the foot. The peroneus supplies the peroneus muscle tibialis.

# Cont…

- The tenth spinal nerve is not found in Rana tigrina but in other frogs it is present. When it is present it emerges from a foramen in the anterior part of the urostyle and goes to the cloaca and urinary bladder.
- The roots of the last four pairs of spinal nerves are elongated forming a bundle of nerves called Cauda equina which lies inside the vertebral column along the filum terminale.

# Autonomic Nervous System:

- The autonomic nervous system is partly independent and not under voluntary control. Though it is involuntarily controlled by the nerve centres located in the central nervous system, it is also connected to spinal nerves and some cranial nerves.
- It is simply concerned with the intestinal regulation of the body with the central nervous system together with its spinal and cranial nerves and is concerned with the external regulations.

# Cont….

- The autonomic nervous system consists of two delicate longitudinal chains of ganglia, lying one on either side of the backbone and the dorsal aorta from the brain to the end of the urostyle.
- Each chain at regular intervals has ten small metamerically arranged sympathetic ganglia. Each ganglion is connected with the corresponding spinal nerve by a small branch called ramus communicans.

# Cont….

- Corresponding ganglia of both the cords are also connected together by small transverse commissure. Between the first and second ganglia the sympathetic chain of each side divides to form a loop around the subclavian artery which is known as annulus of Vieussens.
- Each sympathetic chain enters the skull along with the Xth cranial nerve through the vagus foramen and joins the vagus ganglion and then proceeds forward to join the Gasserian ganglion of the fifth cranial nerve.

# Cont....

- Posteriorly each sympathetic chain ends by joining with one or more branches of the 9th spinal nerve.
- Sympathetic ganglia give nerves to the viscera, where they form plexuses, such as a solar plexus near the coeliaco-mesenteric artery and a cardiac plexus on the heart.

# *Kinds of Automatic Nervous System:*

- **The autonomic nervous system is simply formed of visceral motor and visceral sensory fibres, which can be classified as follows:**
- 1. The sympathetic;
- 2. The parasympathetic.

# Cont…..

- The visceral sensory fibres have their cell bodies in the dorsal root ganglia and their dendrites lie in the organs which are not under voluntary control like the heart, blood vessels, different parts of the alimentary canal.
- Their axons are extended from the dorsal root ganglia to the grey matter of the central nervous system.
- The visceral motor fibres have their cell bodies in the spinal cord forming synapses with neurons whose cell bodies are situated in the sympathetic ganglia.

# Cont....

- **Because of these synapses the visceral motor fibres are classified under two heads:**
- 1. Preganglionic fibres which arise from the grey matter of the spinal cord and pass through spinal nerves and rami communicants and go to the corresponding sympathetic ganglia are medullated.
- 2. Postganglionic fibres are those whose cell bodies are in sympathetic ganglia and going in organs they supply are non-medullated.

# Cont…..

- Thus, sympathetic nerves are made of both visceral sensory and visceral motor fibres which on stimulation secrete a chemical substance called sympathy which generally stimulate the organs.
- Parasympathetic system includes parasympathetic nerves and ganglia. The fibres of parasym-pathetic nerves come from cranial and spinal nerves, while parasympathetic ganglia are situated in the organs innervated by parasympathetic nerves.

# Cont…..

- Their preganglionic fibres are very long and extend from the central nervous system to a ganglion in or near the organ which they innerverate. Here they are connected to the short postganglionic fibres.
- These fibres on stimulation secrete a chemical substance called acetylcholine which has an inhibitory effect on the organs.
- The parasympathetic nerve fibres are included in oculomotor, trigeminal, facial and vagus cranial nerves.

# Cont.....

- The visceral and some other organs receive fibres both from sympathetic and parasympathetic nerves. These are antagonistic in effect as sympathin of sympathetic fibres brings an action, whereas acetylcholine of parasympathetic fibres retards it.
- The autonomic nervous system simply regulates the functions of certain organs which are involuntary.
- It is not independent because it is intimately bound structurally and functionally with central and peripheral nervous system. Its nerve centres are located in the central nervous system, while its most fibres are parts of the peripheral nervous system.

# Urinogenital System of Frog

- Since the excretory and reproductive systems are closely associated, hence, it is customary to call the two systems together as a urogenital or urinogenital system, though both are unrelated functionally. In frog the sexes are separate.
- **The urinogenital organs can be studied under the following heads:**
- ***1. Excretory System:***
- The excretory system in both male and female frog is similar. The excretion is mainly carried out with the help of a pair of kidneys, a pair of ureter, a urinary bladder and cloaca.

# (i) Kidneys:

- Both the kidneys are elongated, compact, flattened and dark red in colour.
- These are found in the lymph spaces (subvertebral lymph sinus) above the coelom attached on either side of vertebral column.
- In tadpole the kidneys are pronephros, whereas in adult these are mesonephros. These are covered ventrally by peritoneum.

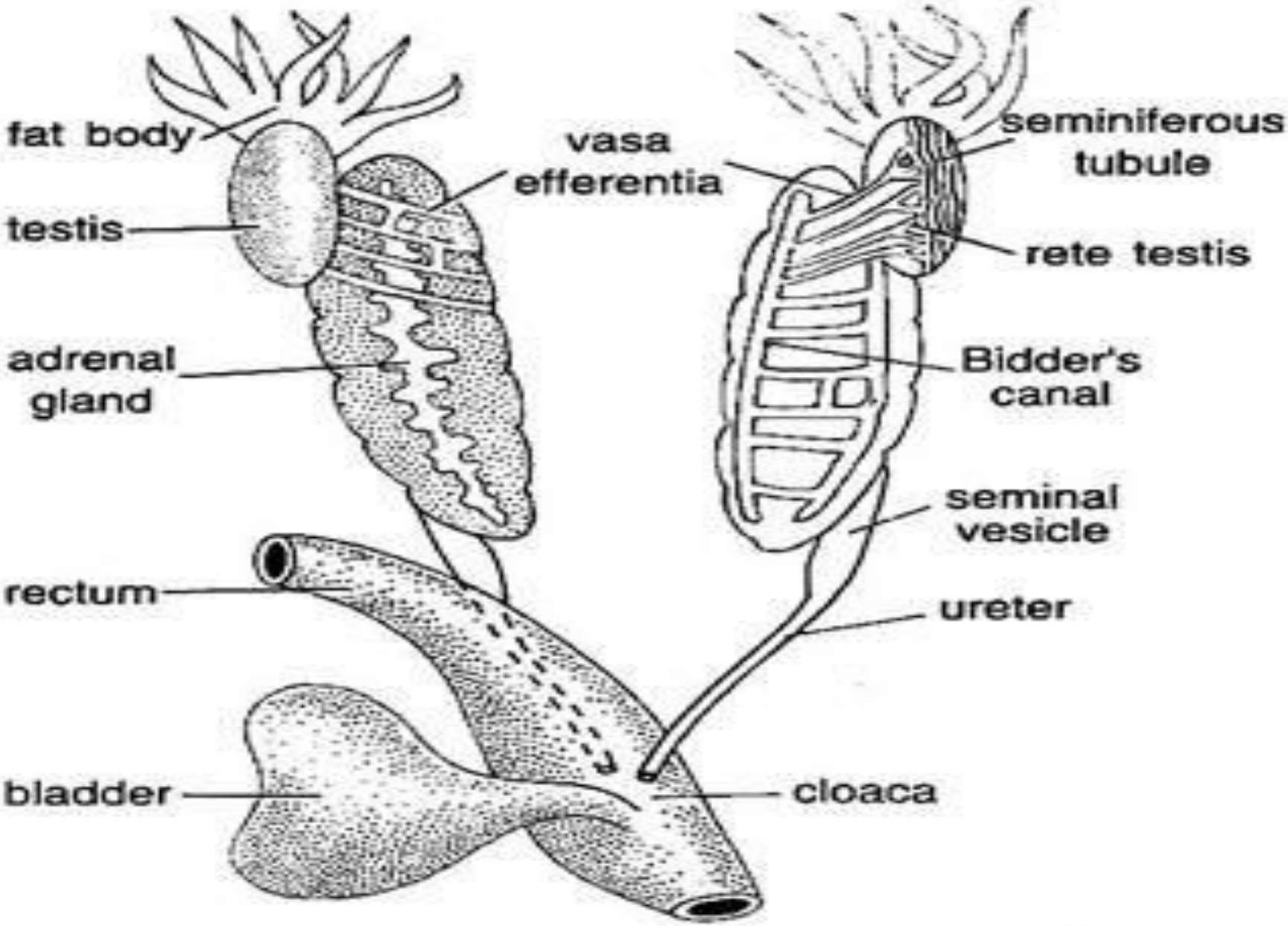



**Fig. 18.61.** Frog. Male urinogenital organs.

# (ii) Ureters:

- From the outer smooth convex posterior side of each kidney arises a mesonephric or Wolffian duct or ureter which passes backwards to open into dorsal side of the cloaca.
- The openings of the ureters are placed over a separate papilla on the dorsal side of cloaca. In male frog the ureters dilate just posterior to the kidney to form a vesicula seminalis in which sperms are stored.

# Cont….

- In male frog the ureters convey the sperms and urine, and, hence, are called urinogenital ducts.
- The ventral surface of each kidney has a yellow coloured adrenal or supra renal gland of endocrine function.
- To the anterior of each kidney are attached numerous finger-like fat bodies, a testis in male and ovary in female. Fat bodies are reserves for nourishment.

# (iii) Urinary Bladder:

- It is large, thin-walled bilobed distensible structure. It also opens into the ventral wall of cloaca by a sphinctered aperture. Its aperture lies below and opposite to the openings of ureters.
- The inner surface of bladder is lined with a layer of epithelium about three cells thick. The middle layer of the bladder consists of a network of smooth muscle fibres and outside this layer is a thin sheet of connective tissue covered externally by the peritoneum.

# (iv) Cloaca:

- It is a small, medium sac receiving the anus, urinogenital apertures and the opening of urinary bladder.
- Cloaca opens outside by a cloacal aperture placed at the posterior end of the body between the two hindlimbs.

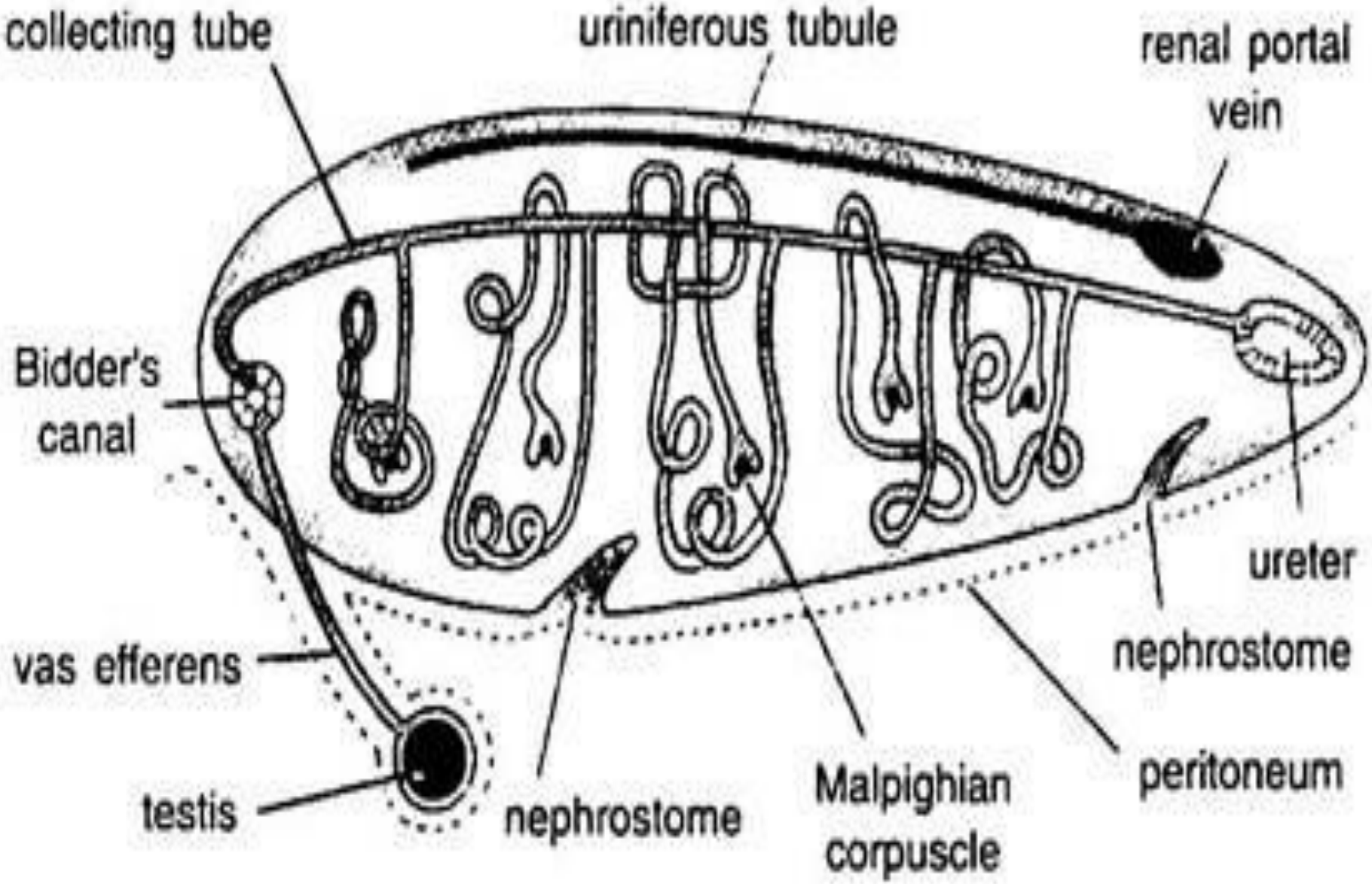



**Fig. 18.62.** Frog. Diagrammatic representation of kidney.

# Histology of Kidney:

- The kidneys are most of the red blood corpuscles. Each kidney is composed of a number of (about 2000) twisted renal or uriniferous tubules held together by connective tissue and richly supplied with blood vessels and their capillaries.
- Each renal or uriniferous tubule starts as a thin, double-walled ciliated cup, the Bowman's capsule enclosing a bunch of blood capillaries, the glomerulus which receives blood from an afferent arteriole of the renal artery.

# Cont....

- Uriniferous tubules are the functional units of kidney. These are lined with a glandular and at places with ciliated epithelium.
- From the glomerulus blood is collected by efferent arteriole which joins with a renal vein. The tubule gets the blood supply from the capillaries of efferent arteriole and renal portal vein.
- The Bowman’s capsule along with its glomerulus is called Malpighian body or corpuscle tubules.

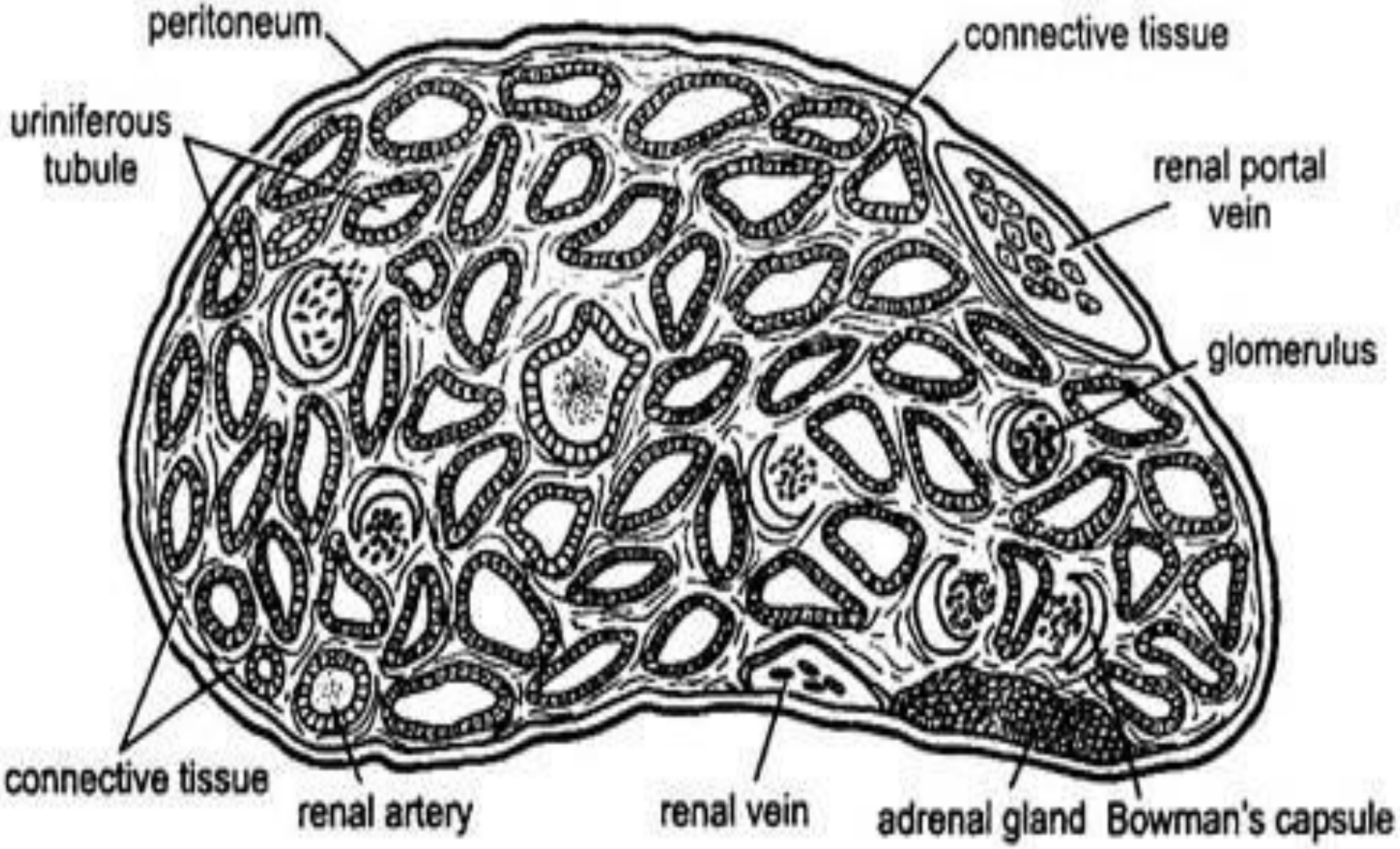



**Fig. 18.63.** Frog. T.S. of kidney.

# Cont…..

- Each tubule opens into the collecting tubule which runs transversely across the kidney towards the dorsal surface.
- In turn all the transverse collecting tubules open into a longitudinal Bidder’s canal lying towards the inner margin of kidney and towards outer margin into the ureter.
- Ventral ciliated funnel-shaped nephrostomes. They carry wastes from the coelom into renal veins in frog or in uriniferous tubules in tadpoles.

# Physiology of Excretion:

- Due to continuous catabolic activities certain substances are formed which are harmful to body, hence, their elimination is very essential which is done by the kidneys.
- The blood brings these substances into the kidneys through the renal portal veins.
- Blood comes to glomeruli from afferent arterioles which have a wider lumen then the capillaries so that the blood in glomeruli is under high pressure which causes filtration of blood.

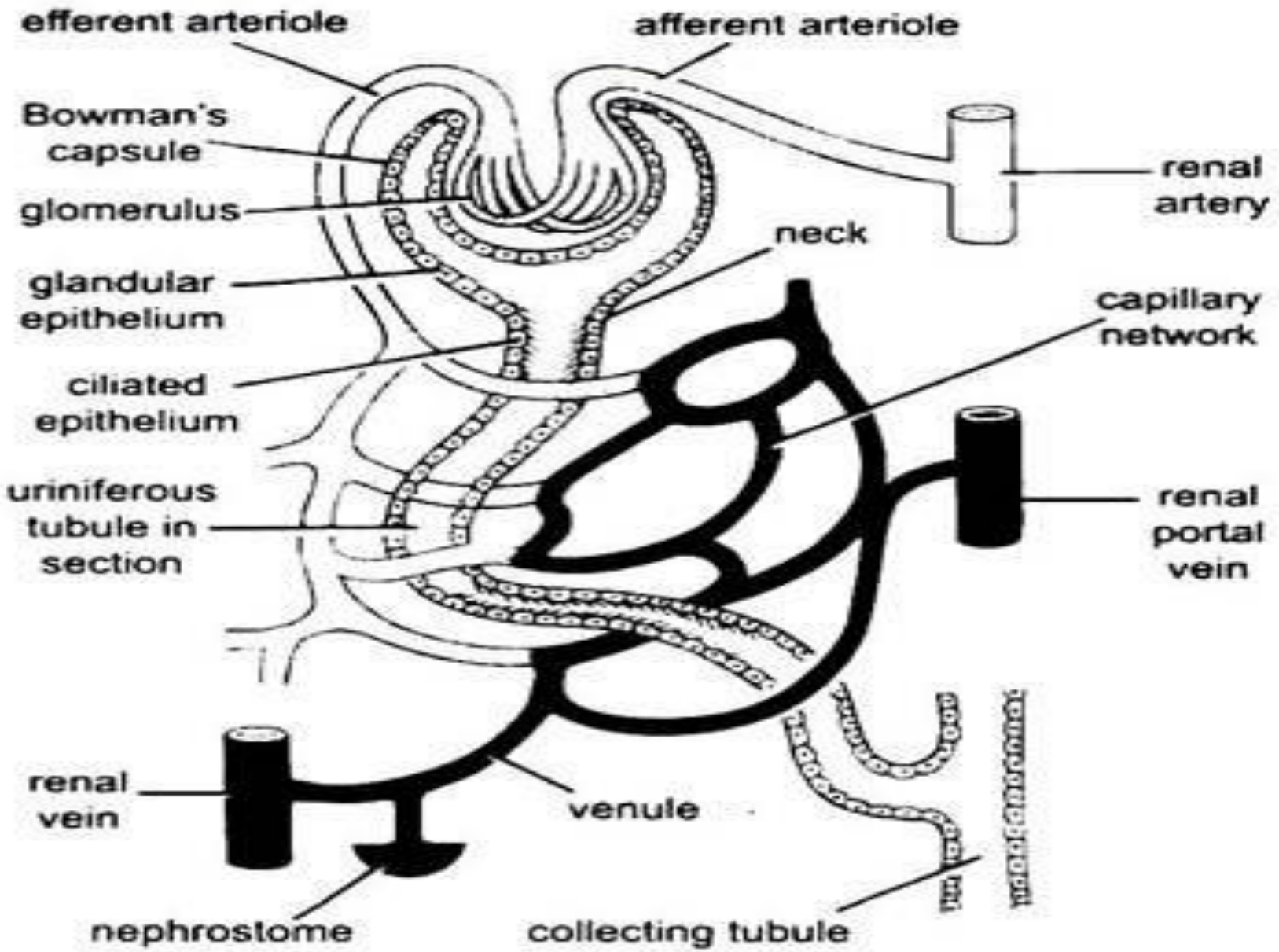



**Fig. 18.64.** Frog. A uriniferous tubule in section with its blood capillaries.

# Cont….

- The glomerular filtrate does not contain corpuscles nor plasma proteins, it has plasma, wastes and crystalloids consisting of urea, inorganic salts, glucose and large quantities of water.
- The glomerular filtrate passes through the thin wall of the Bowman’s capsules into the lumen of uriniferous tubules and the filtered blood goes into renal vein through the efferent arteriole.

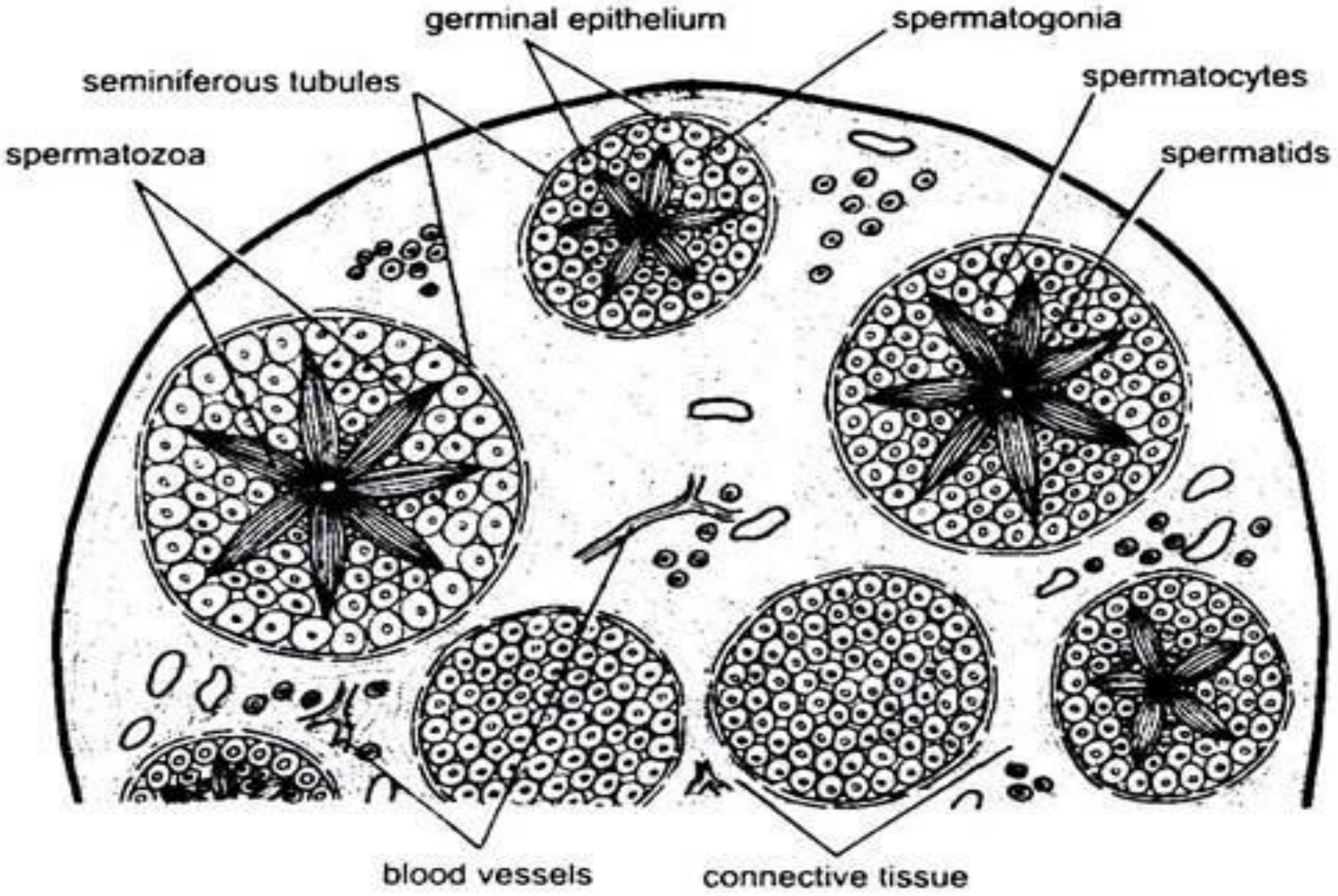



**Fig. 18.65.** Frog. T.S. of a part of testis.

# Cont….

- In the convoluted tubules selective reabsorbtion of useful substances takes place. The substances that are useful, such as glucose, amino acids, inorganic chlorides and some water are reabsorbed from the filtrate and put back into the blood of the capillaries of renal veins, while harmful substances such as urea and other salts along with water form urine which passes through the collecting tubes into ureters and goes to the cloaca.
- It is stored in the urinary bladder for a time. When bladder is full, its involuntary muscles contract, the urine is forced into the cloaca which is voided at intervals through the cloacal aperture.

# *2. Male Reproductive System:*

- Male reproductive system (Fig. 18.61) includes a pair of testes attached to kidneys, vasa efferentia and a pair of urinogenital ducts. Copulatory organs are absent.
- **i. Testis:**
- The testis are rounded or ovoid, light yellow bodies attached to the antero-ventral surfaces of the kidneys by a double fold of peritoneum, the mesorchium.

# Cont…..

- Actually each testis is surrounded by peritoneum, which is extended dorsally as a double membrane, the mesorchium, to the dorsal side of the body cavity, where its becomes continuous with the general coelomic lining.
- Just in front of each testis are found attached yellowish finger-like processes. They serve as a sort of storehouse of nutrients which are provided to the developing spermatozoa and during hibernation.

# ii. Vasa Efferentia:

- The vasa efferentia consist of a variable number of slender tubes arising from the inner margin of testis and extend within the mesorchium and then enter the inner margin of the kidney to open into the Bidders, canal.
- The Bidders' canal communicates with the ureter through collecting tubules of kidney. In this way sperms enter the ureter of kidney through vasa efferentia. Bidders canal and collecting tubules.
- The vasa efferentia are originally outgrowths of the walls of the Malpighian corpuscles which become connected with the testis.

# iii. Urinogenital Duct:

- Ureter in male frog is a urinary duct as well as a vas deferens to convey the urine and spermetozoa.
- Hence, it is called a urinogenital duct. Both the ureters open into the dorsal wall of cloaca separately on urinogenital papillae.

# Histology of Testis:

- Histological, each testis (Fig. 18.65) is composed of a large number of seminiferous tubules held together by connective tissue.
- In the connective tissue are found blood capillaries and lymph vessels, nerves, muscle fibres and groups of interstitial cells in between the lubules.
- These cells secrete a hormone testosterone which brings the secondary sexual characters of the individual.

# Cont……

- The wall of tubule is lined by germinal cells which produce sperms by spermatogenesis. The mature sperms are found in bundles in the lumen of tubules floating in the spermatic fluid.
- The sperms when mature dropped into the lumen to pass into the ureter through vasa efferentia and Bidder’s canal. From the ureter they pass into the vesicula seminalis where they are stored.

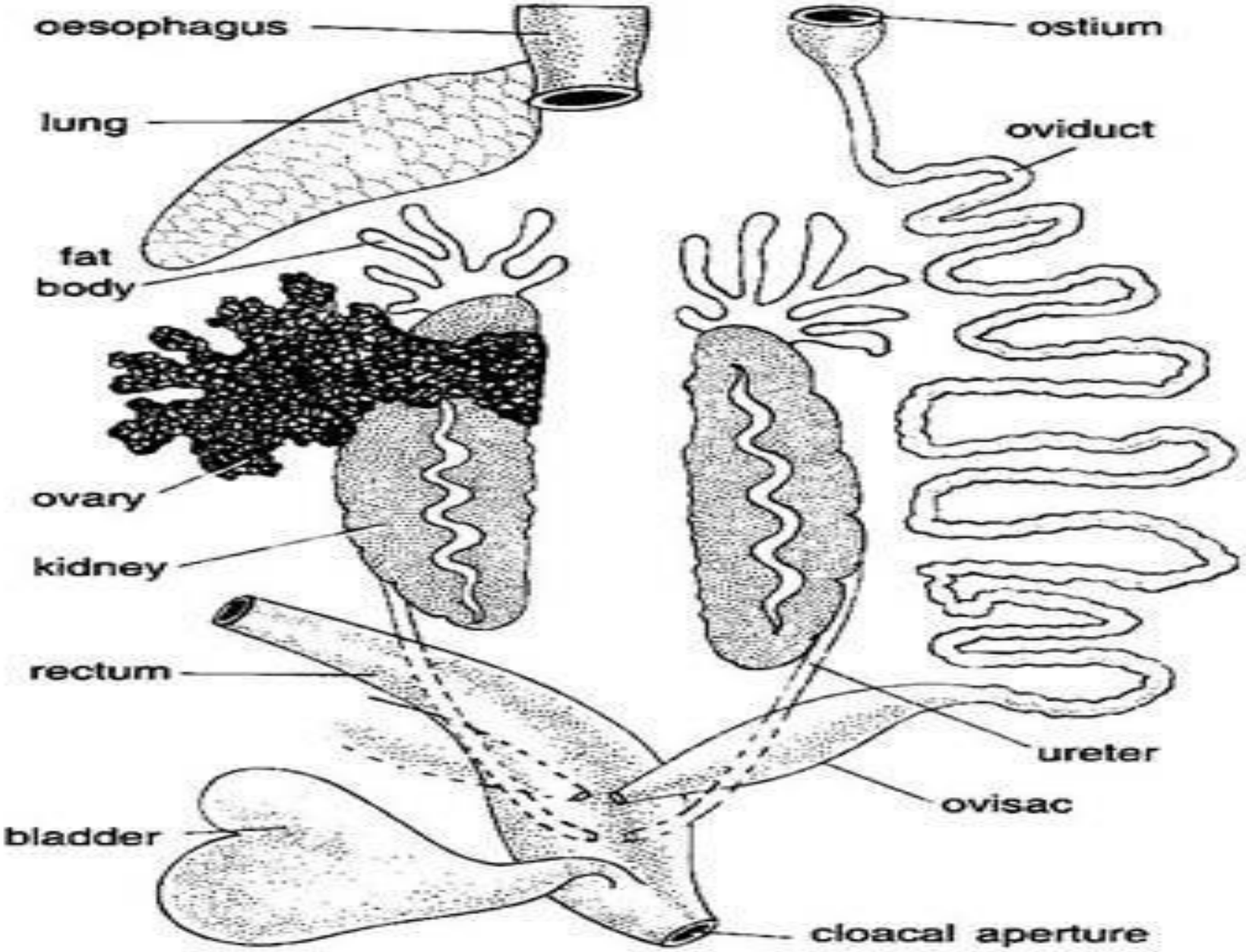



**Fig. 18.66.** Frog. Female urinogenital organs.

# *3. Female Urinogenital System:*

- The excretory organs are the same in female frog as found in male frog, but they do not have any connection with the reproductive organs.
- The ureter does not dilate as vesicula seminalis and no ducts from ovaries open into the kidneys.
- The cloaca serves as a common passage for urinary and genital systems as in the male frog.

# *4. Female Reproductive System:*

- Female reproductive system (Fig.) includes a pair of ovaries and a pair of oviducts.
- **i. Ovaries:**
- Both the ovaries are attached to the dorsal abdominal wall, close to the kidneys, by a fold of peritoneum called mesovarium.
- The ovaries are large, lobulated hollow sac-like structures. In breeding season the ovaries become greatly enlarged.
- Histologically, the wall of each ovary (Fig.) is composed of visceral peritoneum which forms germinal epithelium and internal to it is the fibrous connective tissue having blood vessels, muscle fibres and nerves.

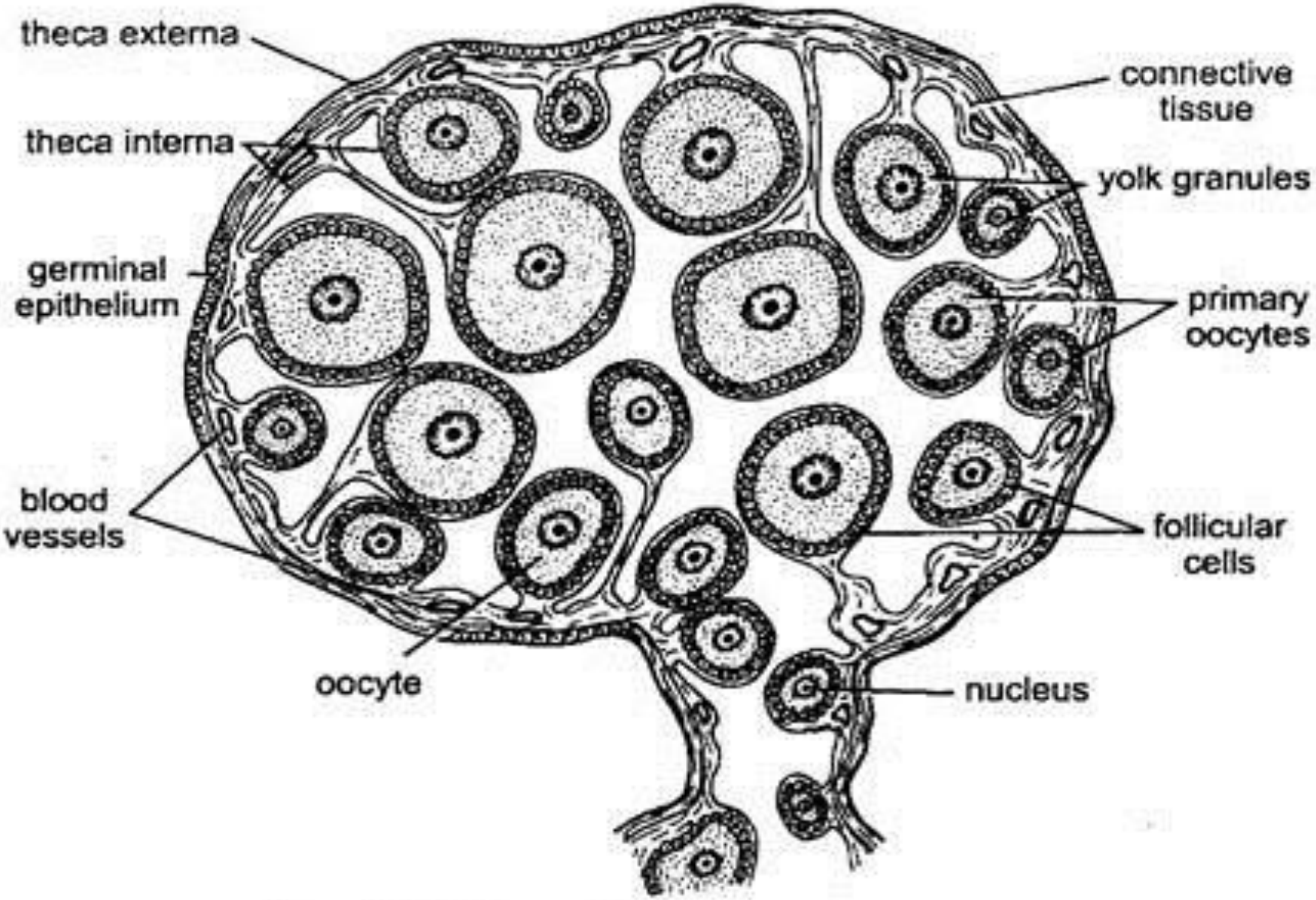



**Fig. 18.67.** Frog. T.S. of a part of ovary.

# Cont…..

- The germinal epithelium gives off several small groups of cells or oogonia which form ovarian follicles. Within each follicle a central cell enlarges forming ovum. It contain a nucleus and granular yolky cytoplasm.
- The remaining follicle cells form the follicular epithelium around the ovum. Later with the maturation of ovum, follicular epithelium is replaced by vitelline membrane secreted by the ovum. In front of each ovary are attached fat bodies.

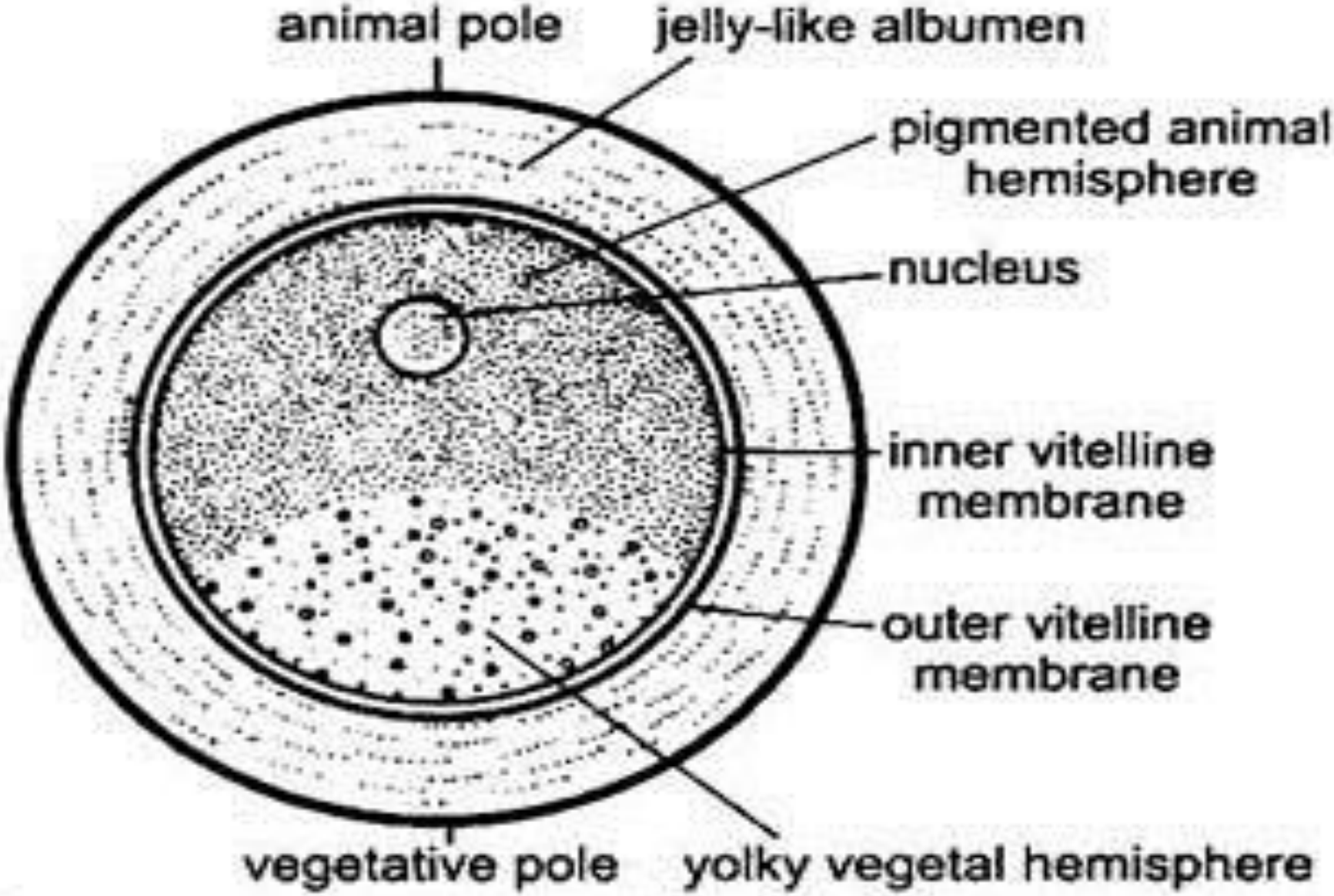



**Fig. 18.68.** An unfertilised ripe egg.

# ii. Oviducts:

- On each side is a long and much coiled glandular and ciliated oviduct or Mullerian duct. It starts near the base of the lung by a thin-walled ciliated coelomic or oviducal funnel.
- At the posterior end near cloaca, each oviduct dilates to form a thin-walled ovisac called uterus which opens by a narrow aperture on a papilla in the cloaca.

# Cont……

- The cilia of the oviduct direct the eggs posteriorly and the glands secrete albuminous coat around each egg during their descent.
- Oviducts become much enlarged and coiled just before the breeding season.
- The eggs escape from the surface of the ovary into the coelom and are directed by cilia into the oviduct and are temporarily stored in the ovisacs.

# Cont....

- Each egg is spherical and about 1.75 mm in diameter. Its upper black pigmented half is the animal hemisphere containing nucleus and the lower half containing white yolk is the vegetal hemisphere.
- Egg is enveloped into a thin vitelline membrane and outer to it is the thick albuminous coat.

# METAMORPHOSIS

- The term metamorphosis is derived from a Greek work *metamorphoun, which mean "to transform".*
- *In embryology it is* defined as transformation of the larva into adult during which many structural as well as physiological changes take place.
- Larval forms and accompanying metamorphosis are found in most groups of animal kingdom. .
- When about 8 weeks old, the tadpole larva undergoes a series of rapid changes, which. transform it into a young frog. This is called **metamorphosis**.
- The metamorphic changes in frog tadpoles may be grouped into three categories: (A) changes in habits and habitat,

  (B) changes in morphology, and

  (C) changes in physiology.

# A. CHANGES IN HABITS AND HABITAT

- (1) In frog, metamorphosis is associated with a transition from an aquatic to a terrestrial mode of life.
- The metamorphosing larva comes frequently to the surface of water to breath air.
- Later, it begins to take short trips to land, *i.e., it becomes amphibious.*

# Cont…..

- (2) The changes of environment during metamorphosis is associated with a change in feeding.
- The tadpoles are herbivorous feeding upon algae and other vegetable matter which they scrape off with the help of the horny teeth surrounding their mouths.
- Adult frogs, on the other hand, are carnivorous living on insects, worms etc.
- Sometimes, they also devour larger prey, such as smaller frogs and even little birds and rodents which they overpower

  and swallow.

# B. CHANGES IN MORPHOLOGY

- **I. Regressive or destructive changes**.
- These include the reduction or complete disappearance of those organs or structures which are necessary during larval life, but not essential in the adults. The important changes of this nature are as follows:
- (1) The long tail of the tadpole along with the fin fold is absorbed again during metamorphosis and disappears altogether at the end of the metamorphosis.

# Cont…

- The reduction of the tail is affected by autolysis of the component tissues with active participation of amoebpid *macrophages.*
- These are rich in lysosomes that contain a proteolytic enzyme *catepsin.*
- *The macrophages phagocytose the debris of the* disintegrating cells.
- During metamorphosis, however, the tadpole is nourished by the substance of its tail.
- (2) The gills are resorbed, the gill clefts are closed and the branchial cavities disappear.
- The resorption of gills also takes place by autolysis.

# Cont…

- (3) The horny teeth of the perioral disc as well as the horny lining of the jaws are shed.
- (4) The lateral line sense organs  present in the skin of tadpoles , disappear during metamorphosis.
- (5) The cloacal tube becomes shortened and reduced.
- (6) Some blood vessels, including parts of the aortic arches, are reduced.

# Resorption of tail

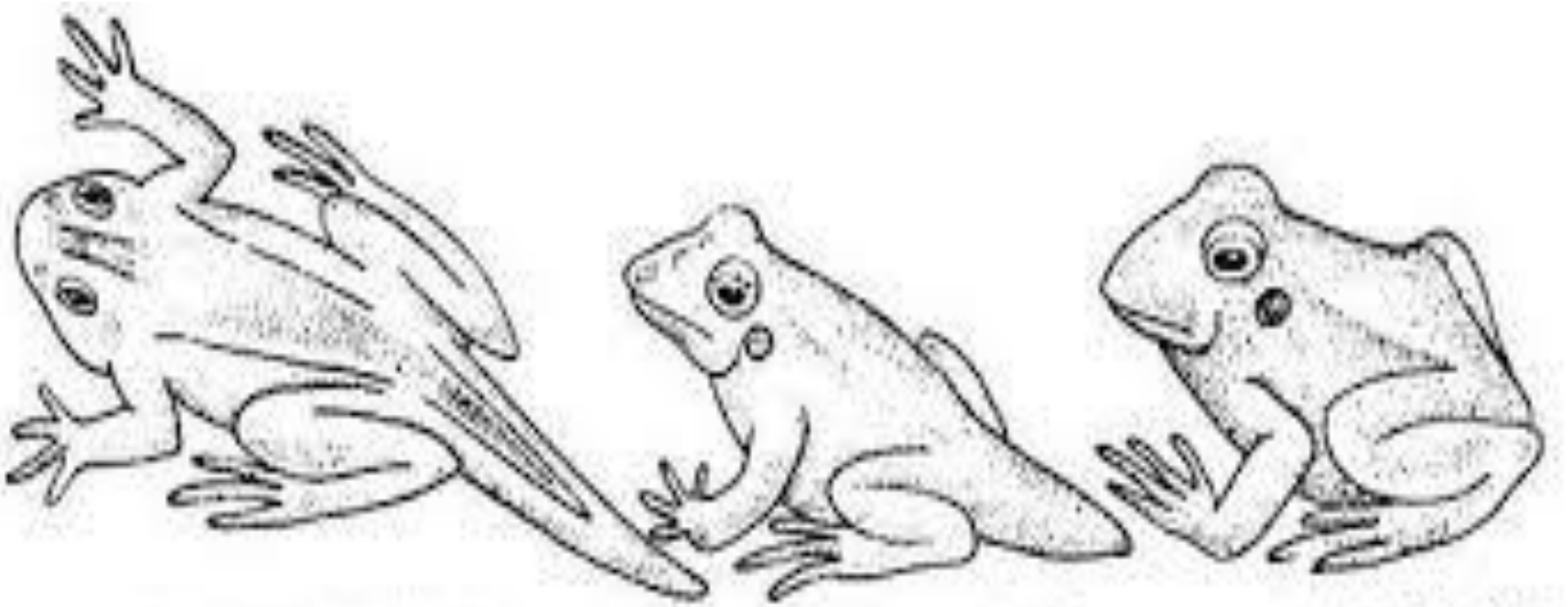



**Fig. 37.13.** Frog. Stages in metamorphosis.

# II. Progressive or constructive changes

- These include the development of some organs which become functional only during .and after metamorphosis.
- (1) There is a progressive development of the limbs which increase in size and differentiation.
- The fore limbs, which in the tadpole develop under cover of opercular membrane, break

  through to the exterior.
- At the same time there is a great increase in the length and strength of the hind limbs.
- Joints develop in them and the toes appear.

# Cont.....

- (2) The middle ear develops in connection with the first pharyngeal pouch.
- The tympanic membrane develops.
- It is supported by the circular tympanic cartilage an enables the frog to receive air-borne vibrations.
- (3) The eyes bulge up on the dorsal surface of the head and develop nictitating membrane.
- (4) There is development Of the tongue and the vomerine teeth.

# III. Remodelling of some structures

- Some organs which function both in the larva and the adult, change their differentiation during metamorphosis so as to meet the requirements of the adult mode of life.
- (1) The skin of the tadpole is covered with a double layered epidermis.

  The number of layers of cells in the *epidermis increases* during metamorphosis.

  Surface layers become cornified.

  Multicellular *mucous and serous glands develop in the skin. The pigmentation to* the skin is changed, new patterns and colours appear .

# Cont..

- (2) There is a widening of the mouth gap due to rotation of the quadrate cartilage backwards and the true jaws become functional.
- (3) The tongue grows much larger and more muscular.
- (4) The stomach and the liver enlarge.
- (5) The eyes grow more prominent.

# Cont…..

- (6) In tadpoles, the intestine is very long and wound up into a spiral like a watch spring.
- The intestine becomes greatly elongated due to a herbivorous habit because the vegetable diet contains less nourishment than the animal diet.
- Hence, a longer gut is required to extract most of the nourishment.
- During metamorphosis, the intestine is greatly shortened and most of the coils which it forms in the tadpole become straightened out.
- This change is apparently correlated with the carnivorous habits assumed by the adult.

# Cont….

- (7) Two chambered heart of frog is transformed into a three chambered one.
- (8) Lungs do not undergo major changes.
- They develop very gradually and become fully functional.
- (9) The cartilaginous skeleton of tadpole undergoes ossification.
- (10) The larval pronephric kidney is transformed into a mesonephros.
- (11) The blood vascular system is modified with the disappearance of some aortic arches and increase of blood supply to the lungs and the skin.

# C. CHANGES IN PHYSIOLOGY

- (1) The endocrine function of the pancreas starts at metamorphosis as it begins to secrete *insulin and glucagon hormones.* This is related to the increased role of the liver in the turnover of glycogen.
- (2) A marked change takes place in the excretory function.
- In the tadpole, the end product of nitrogen metabolism is ammonia which is easily disposed off by diffusion in water.

# Cont.....

- After metamorphosis, however, the frogs excrete most of their nitrogen in the form of urea and only small amounts as ammonia.
- The latter is highly toxic and if accumulated in a terrestrial animal, it could become dangerous. This change over, occurring in the late stages of metamorphosis is due to a changed function of the liver, which begins to synthesize

  urea.