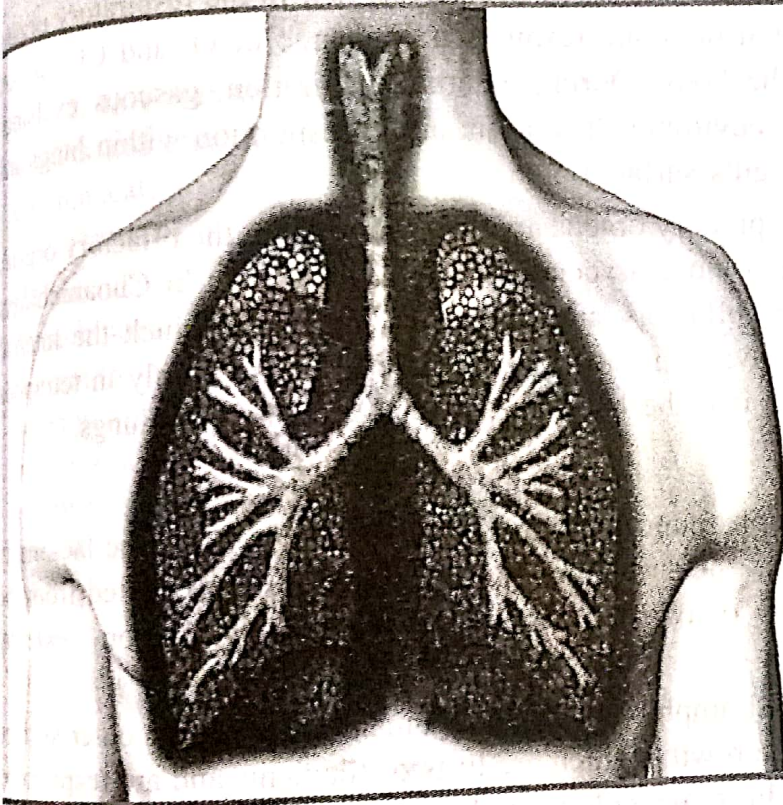


44

Chapter

Respiratory System in Vertebrates



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- Lungs
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- Accessory Respiratory Organs

In vertebrates the blood takes up oxygen from the respiratory organs (e.g., skin, gills, lungs) and transports it to each and every cell of tissues. The red blood corpuscles contain **haemoglobin**, a respiratory pigment. Haemoglobin combines readily with oxygen to form oxyhaemoglobin which is carried by blood from the respiratory organs to the tissue cells where it readily gives up its oxygen in the tissues where it oxidises the food stuffs to form CO_2 , heat and energy. Carbon dioxide formed in the tissues enters the blood and red blood corpuscles and is carried away as carbonic acid and carbonates of the sodium and potassium from the tissues to the respiratory surface where free carbon dioxide is liberated.

blood vessels associated with aortic arches so that carbon dioxide in the blood may be exchanged for dissolved oxygen in the water.

Sharks and rays have generalised structure of gills. In higher bony fishes the interbranchial septum is lacking so that the hemibranchs on the anterior and posterior part of each branchial arch are no longer separated from one another. Furthermore, the gill-apertures also no longer open separately to the outside. Instead, the gills are enclosed in a single chamber and covered externally by a large **bony operculum** which opens and closes posteriorly to permit water to pass to the outside. In most bony fishes there are four pairs of functional gills.

Spiracles. In sharks and rays an anterior pair of non-respiratory openings, one on either side between mandibular and hyoid arches are called **spiracles** or **pseudobranchs**. These are internally closed. These become closed or lost in lung fishes and bony fishes.

B. Lungs

Most adult amphibians and all amniotes breathe by means of **lungs**, though lungs are also present in lung fishes. In an embryo a hollow outpushing, called **lung primordium** arises from the ventral wall of the pharynx. It grows backwards and divides into two, right and left lung buds. The undivided proximal portion develops into **trachea** and **larynx**, and opens into pharynx by **glottis**. Later lung buds grow posteriorly into coelom and branch repeatedly and get covered by mesoderm. Thus, each lung has an endodermal lining and an outer visceral peritoneum and in between the two mesodermal mesenchyme having blood and lymph vessels, nerves, and smooth muscle fibres and connective tissue. Inner endodermal epithelium of lungs is raised into a network of ridges to increase the vascularised surface exposed to the action of air.

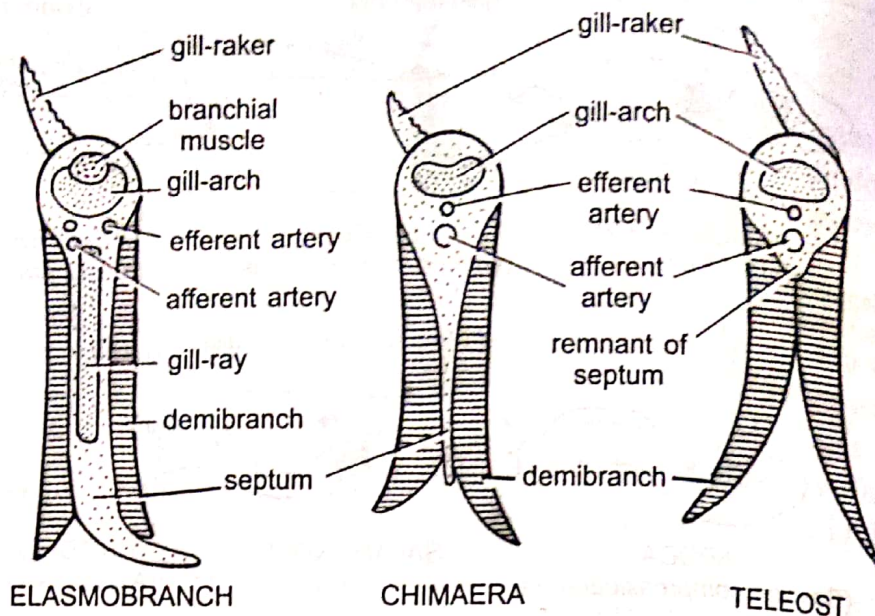


Fig. 44.3. Types of gills in fishes in section.

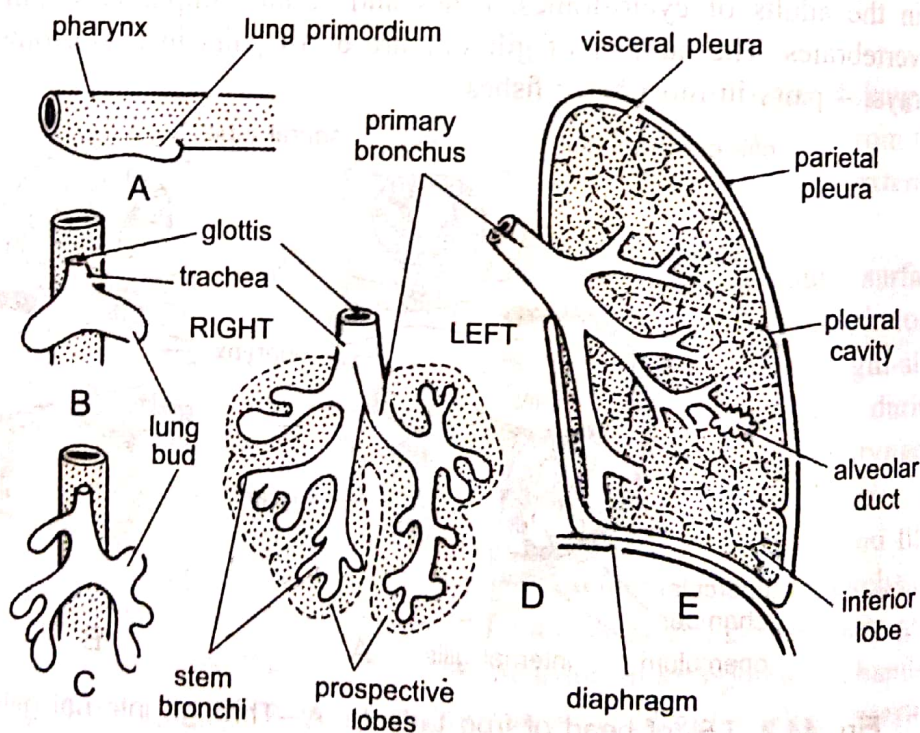


Fig. 44.4. Development of a vertebrate lung in embryo. A - Lung primordium; B & C - Lung buds; D - Embryonic lung; E - Lung at birth.

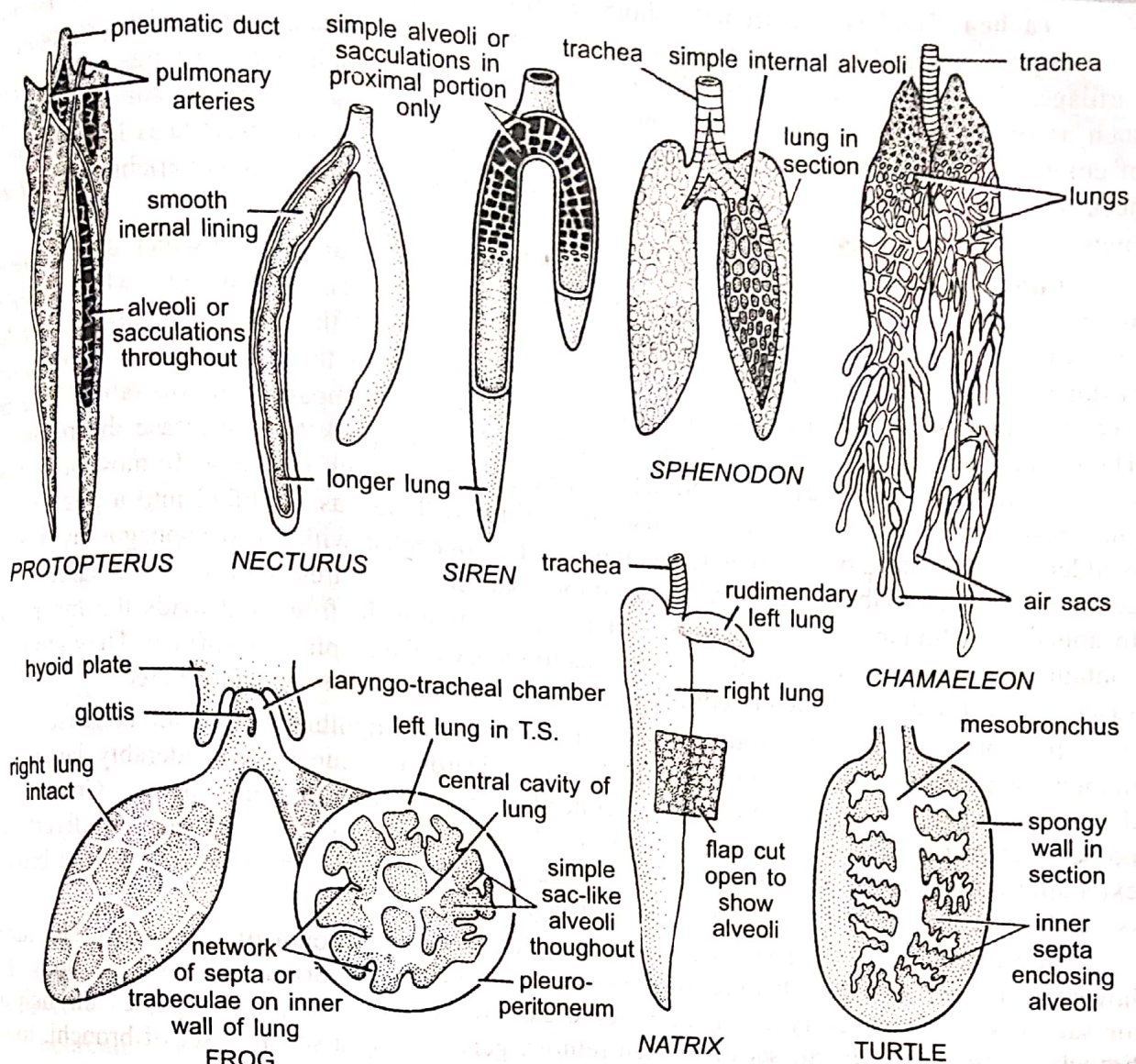


Fig. 44.5. Different types of vertebrate lungs.

In lower forms, the lungs are hollow bags, but in higher forms the ridges increase in number and unite with one another across the lumen of the lung to convert it into a solid but spongy structure with innumerable air spaces. In mammals, the internal surface area of lungs may be thirty times that of the external surface area of the body. The original duct of the lung sac connecting the pharynx to the lungs becomes a **trachea** in most. Trachea is absent in anurans. In many tetrapoda the anterior end of the trachea becomes modified into a **larynx** or sound box which opens into the pharynx by a **glottis**. At its lower end, the trachea divides into two bronchi, each of which enters a lung. The bronchi divide to form an immense system of bronchioles carrying air into minute bags or **alveoli**. The alveoli have very thin walls invested with blood capillaries, an exchange of gases occurs in the alveoli.

Larynx. The upper end of trachea is enlarged, especially in frogs and toads, to form the larynx or sound box in which the vocal cords are located. In *Necturus*, it is supported by a pair of lateral cartilages bounding the glottis. In other amphibians, each lateral cartilage is divided into a dorsal **arytenoid** and a ventral **cricoid** cartilage. In frog, both the cricoids fuse to form a cartilaginous ring. Larynx is not more developed in reptiles. Larynx is not sound producing organ in birds, but serves to modulate tones that originate in the **syrinx**. Syrinx lies at the lower end of trachea where it divides into two bronchi. It is the sound producing organ. Larynx is greatly developed in mammals. Its wall is supported by a pair of **arytenoid**, single **cricoid** and a single **thyroid** cartilage on the ventral surface. Glottis may be closed at the time of swallowing of food by a flap of muscular **epiglottis**.

Trachea. Trachea is extremely short or absent in Anura. It is merged with the larynx to form laryngo-tracheal chamber. Many caudate amphibians possess a short trachea, supported by cartilages. Trachea is simple in reptiles as in amphibians or may be long in long-necked reptiles such as turtles, trachea is long and convoluted. Tracheal cartilages are sometimes in the form of complete rings. In birds, the trachea is long. In swans and cranes, trachea is longer than the neck and tracheal rings are complete and ossified. Trachea in mammals is variable and tracheal rings are usually incomplete on the upper side.

Lungs. In *Polypterus* (African bichir) paired ventral lungs are present which enable these to survive during periods of draught. Dipnoans belonging to subclass Sarcopterygii which branched off from Actinopterygii also have a lung-like structure. In all the living lung fishes, the lung is dorsal to the gut connected by a tube to the ventral side of the oesophagus. In *Protopterus* (African) and South American *Lepidosiren* it is bilobed and unpaired in Australian lung fish. Their lungs unlike *Polypterus* contain internal chambers or pockets to increase the respiratory surface and highly vascularised by branches of pulmonary arteries and veins. In most bony fishes and presumably the crossopterygians also, the primitive lung has modified into a gas or swim bladder or hydrostatic organ. It may or may not be connected with the oesophagus by a dorsal connection. In amphibians the lungs are simple, sac-like structures with a central large cavity. In aquatic amphibians the inner surface of lungs is smooth. In frogs and toads the inner walls contain numerous folds lined with alveoli so as to increase the respiratory surface. They are richly vascular and lined with mucous epithelium whose cells are columnar and ciliated.

In reptiles, lungs are more complex than those of amphibians with an increase in the number of internal chambers and alveoli. In some lizards one lung is considerably larger than the other, and in snakes the left lung is reduced or even absent in some species. Crocodilians possess lungs that are quite similar to those of mammals. A few lizards possess diverticula, extending posteriorly from the lungs, resembling air sacs of birds. In some lizards, the bronchi is subdivided into primary, secondary and tertiary bronchi.

In birds, the lungs are small and incapable of the great amount of expansion. The lungs, however, are connected with nine air sacs that are situated in various parts of the body. The air sacs have no respiratory epithelium, serve essentially as reservoirs. Air passes through the bronchial circuit into the air sacs and then returns, generally by a separate set of bronchi, to the air capillaries in the lungs.

The respiratory system of the mammal is much less complicated than that of the bird. The primary bronchi after entering the lung into secondary bronchi which divide into smaller and smaller bronchioles, finally terminating in tiny alveoli or blind pockets in which there is an exchange of gases. In most mammals, lungs are subdivided externally into lobes, i.e., left lung has two lobes and right lung has three lobes in man and four lobes in rabbit. Lungs are simple and without lobes in whales, sirenians, elephants, hyrax and several perissodactyles. Right lung is lobulated in monotremes and rats. In sirenians, the lungs are elongated.

Mechanism of Respiration

In fishes and amphibians the mechanism of respiration is the same, the floor of the buccal cavity is lowered and water (fishes) or air (amphibians) is taken in, then the mouth is closed and the floor of the buccal cavity is raised which forces the water into gill-clefts in fishes or the air into the lungs in amphibians. In amniotes air is taken in by increasing the volume of the lungs by an expansion of the thorax, this is done by movement of the ribs (and by movements of the diaphragm in mammals). In turtles where ribs are fixed to the carapace, the volume of lungs is increased by movements of the neck and limbs.

C. Accessory Respiratory Organs

Gills are the chief respiratory organs in aquatic vertebrates, like fishes and some aquatic urodeles, etc. The land vertebrates have the lungs for respiration. There are also other accessory structures for respiration, i.e., for taking oxygen directly from water or air.

1. Skin. Some fishes are able to survive outside water. The common eel, *Anguilla* can travel by wriggling on damp grass though it has no special respiratory organs, but it has vascular areas in the skin by which it can breathe both in water and on land. Secondly the opening of the operculum is small and rounded so that the eel can retain water in the branchial chamber and journey on land. In amphibians also, the moist skin is highly vascular. Lungless salamanders (plethodonts) respire only through skin. Their larvae loses gills at metamorphosis and lungs do not develop in adults. African male hairy frog, *Astylosternus* have vascular hairy cutaneous outgrowths which act as respiratory surface. Vascular caudal fin of *Periophthalmus* (mud-skipper) acts as respiratory organ during submergence. In the mud-skipper *Periophthalmus* fish project above water when it perches on a rock, only the caudal fin remains submerged and acts as a respiratory organ.

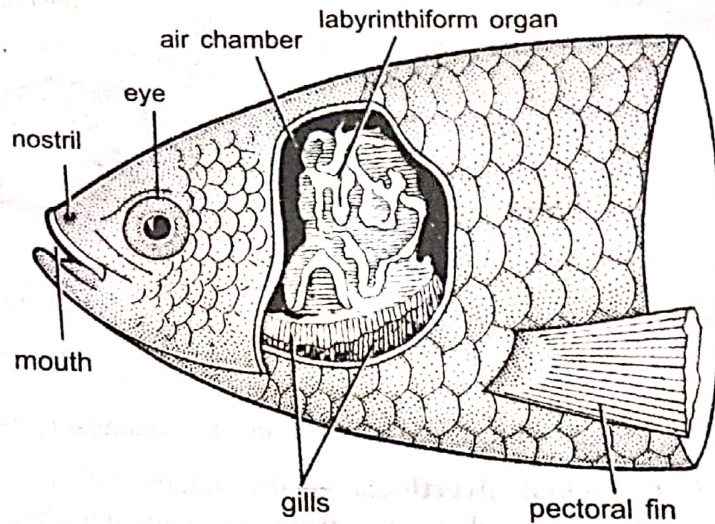


Fig. 44.6. Diagram showing the accessory respiratory organs of *Anabas*.

2. Swim-bladders. (i) The Indian climbing perch *Anabas scandens* (Fig. 44.6) has special air chambers above the gills, where three concentrically folded bony laminae, called **labyrinthiform organs** are developed from the first epibranchial bone on each side. Their covering vascular mucous membrane brings about respiration. *Anbas* is so dependent on air that even in water it comes to the surface to gulp air and it is asphyxiated if prevented from doing so. It can survive for long periods on land and makes excursions by means of its many long spines on the operculum and ventral fins. (ii) In *Ophiocephalus* there is an **accessory branchial cavity** on each side above the gills.

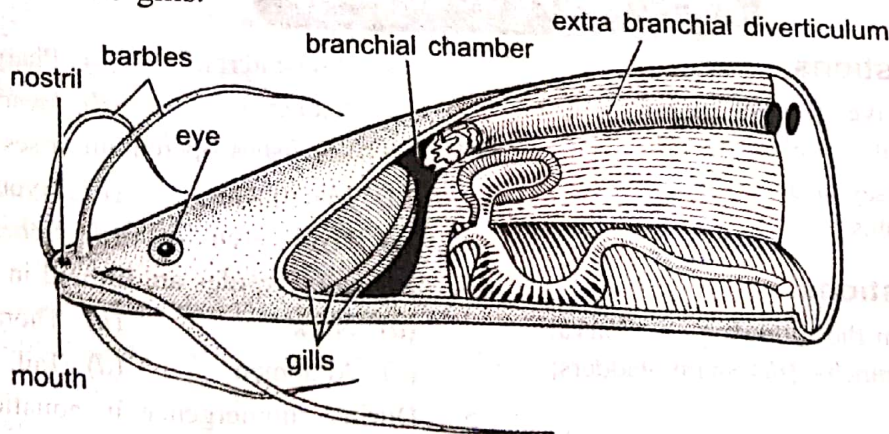


Fig. 44.7. Diagram showing the accessory respiratory organs of *Saccobranchus*.

3. Epithelial lining. The loach *Misgurnus* swallows air which passes through the intestine and is voided by the anus, the highly vascular mucous membrane absorbs oxygen from the air, carbon dioxide is also passed through the anus.

There may be other special organs for gaseous interchange. In *Calichthys* rectal respiration takes place, the rectum is highly vascular into which water is alternately taken in and pumped out.

4. Pharyngeal diverticula. The Indian 'Cuchia eel' *Amphipnous* has poorly developed gills, but on each side of the body there is a **vascular sac** as an outgrowth of the pharynx which opens anteriorly into the first gill-cleft. These sacs are respiratory.

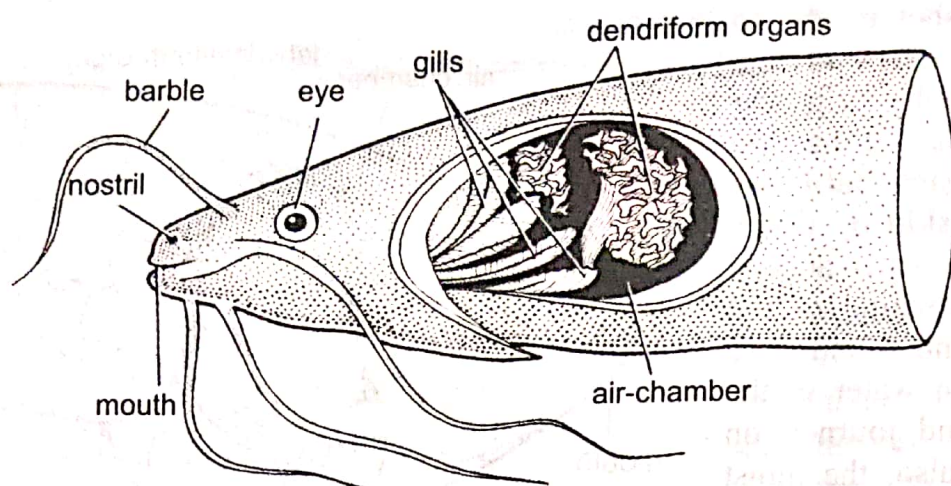


Fig. 44.8. Diagram showing the accessory respiratory organs of *Clarias*.

5. Branchial diverticula. In the Indian catfish *Saccobranchus* (Fig. 44.7) there is a pair of large **air sacs**, each arising from the branchial chamber and extending laterally backwards into the trunk muscles. They can be filled with air for respiration. The catfish *Clarias* (Fig. 44.8), found in Indian and African rivers, has a pair of **supra-branchial organs**, each lying on one side and divided into two parts, a highly branched **arborescent organ** formed from second and fourth branchial arches, and a **vascular sac** of the branchial chamber which encloses the arborescent organ. Several **gill-fans** formed by coalescing of gill-filaments close the entrance of the suprabranchial organ. Air is taken into the organ through the mouth continuously, and *Clarias* cannot only live outside water for several hours but it can move along on damp grass. Accessory respiratory organs are found generally in tropical fishes of amphibious habit, they are devices for sustaining life out of water.

6. Swim or Air-bladders. Swim or air-bladder arises as a diverticulum from the pharynx or oesophagus in bony fishes. It is originally lateral in position but becomes dorsal. It usually lies below or lateral to the vertebral column outside the coelom.

IMPORTANT QUESTIONS

Long Answer Questions

1. Give a comparative account of respiratory organs in vertebrates studied by you.

- | | |
|-----------------|-------------|
| (a) Archenteron | (b) Pharynx |
| (c) Kidney | (d) Heart. |