S. S. College, Jehanabad

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6. AIR BLADDER (SWIM BLADDER) IN FISHES

6.1 Introduction

The air bladder or the swim bladder is a characteristic structure present in all bony fishes except a few. They are absent in elasmobranchs. The air bladder arises from the dorsal wall of the gut as a median diverticulum. It is present dorsal to the gut and ventral to the vertebral column. In dipnoans and Polypteridae it originates as ventral outgrowths from the floor of the pharynx and later rotates to occupy the dorsal position.

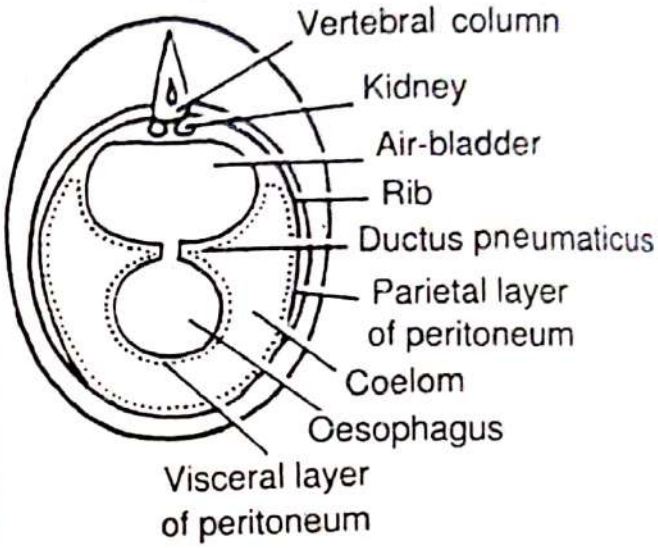

Fig. 6.1 TS of the body of a fish to show relative position of the air bladder

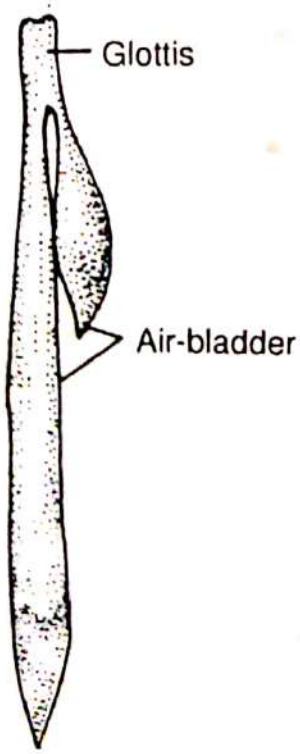

Fig. 6.2 Air bladder of *Polypterus* (a crossopterygii)

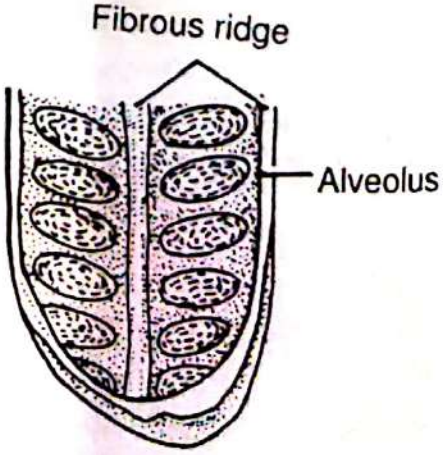

Fig. 6.3 Internal view of a portion of air bladder of *Neoceratodus*

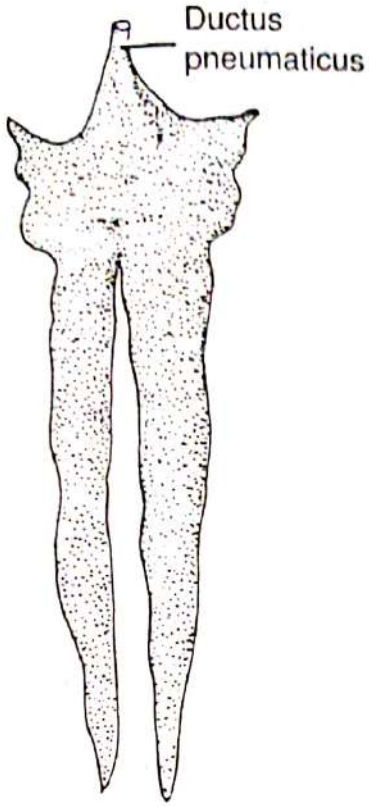

Fig. 6.4 Air bladder of *Protopterus*

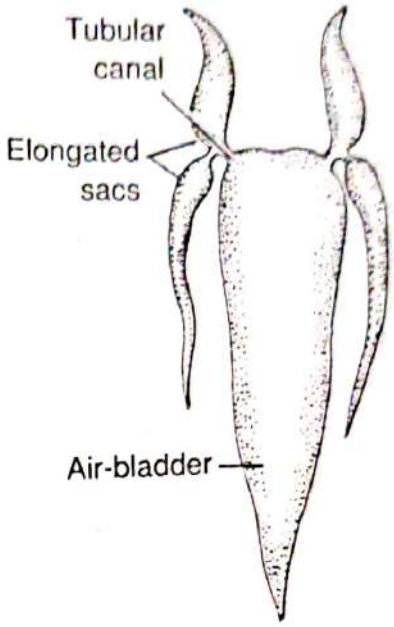

Fig. 6.5 Air bladder of *Otolithus*

6.2 Structure

The air bladder differs greatly in shape, size and structure. Primarily, it is a tough sac-like structure overlain with capillary network. Beneath the capillary network lies the **tunica externa** made of connective tissue and then the **tunica interna** composed of smooth muscle fibres and epithelial gas gland. The air bladder may be composed of one or two or more chambers. Generally the air bladder opens into the oesophagus by duct known as the **ductus pneumaticus**. The pneumatic duct may remain open and the air bladder is then said to be of the **physostomous** type. When the connection is lost and the pneumatic duct is closed, the air bladder is said to be of the **physoclistous** type. As regards shape the air bladder may be tubular, oval, fusiform, etc.

In **physostomous** type a vessel arising from the coeliaco-mesenteric artery supplies the swim bladder. The blood from it is carried to the heart through a vein joining the hepatic portal vein. This condition is found in dipnoans, bony ganoid fishes and soft-rayed teleosts.

Physoclistous type of air bladder is found in spiny-rayed fishes. In this type of air bladder, there lies an antero-ventral secretory **gas gland** and a postero-dorsal gas-absorbing region called the **oval**. The air bladder is supplied by the coeliaco-mesenteric artery and also by arteries from the dorsal aorta. The blood from different parts of the bladder is however returned by two different

routes, (a) the blood from the gas gland is returned by hepatic portal vein and (b) from rest of the bladder by the posterior cardinal veins. Among the chondrosteans the most primitive air bladder is found in *Polypterus*, where it is a bilobed sac with a short left and long right lobe. It opens on the floor of the pharynx just behind the gill-slits. The air bladder lies ventrally to the oesophagus for the most part, and only the elongated right lobe takes up a position dorsal to the gut. It leads to the glottis through a muscular vestible. The air bladder, in *Acipenser* is oval in shape having smooth walls.

Among holosteans, such as *Lepidosteus*, the air bladder is a single elongated sac which opens into the oesophagus by a short and wide *ductus pneumaticus*. The inner wall of the air bladder has many alveoli which are disposed in two rows. Each alveolus is further divided into smaller sacculi. In *Amia* the number of alveoli is more than in *Lepidosteus*.

In dipnoans the air bladder is entirely dorsal in position. It is single in *Neoceratodus* but bilobed in *Protopterus* and *Lepidosiren*. There are two fibrous bands in the form of ridges on the inner wall of the bladder in *Neoceratodus*. The space between the ridges is divided into alveoli by transverse septa and the alveoli are further subdivided into smaller sacculi. The structure of air bladder is more complex in *Lepidosiren* and *Protopterus*. Internally the cavity of each bladder opens into a series of alveoli. Each alveolus opens into smaller cavities, which in turn communicate with still smaller sacculi. Hence they basically resemble the lungs of higher vertebrates. The **red bodies** or **red glands** found in teleosts are however absent in dipnoans.

In **teleosts** the air bladder presents a variety of structure and shape. Usually, it lies below the kidneys, between the gonads and above the gut. Essentially it is a tough sac-like structure with an overlying capillary network. Below it there is a connective-tissue layer called **tunica-externa** and beneath this layer lies the **tunica interna** consisting primarily of smooth muscle fibres and epithelial gas gland. In some fishes it is divided into two inter-communicating chambers (Cyprinidae). It may extend up to the tail in the form of a pair of caeca in some fishes (Scombridae, Notopteridae, etc.)

The air bladder is greatly reduced in hill-stream fishes (*Nemacheilus* and *Psillorhynchus*) and also in some air-breathing fishes (*Clarias, Heteropneustes*). In many fishes finger-like outgrowths may develop from the air bladder. These caecal outgrowths are found mostly in sound-producing fishes.

The bladder tends to become differentiated into an anterior oxygen-producing and a posterior oxygen-absorbing region. A special area in the former becomes differentiated for secreting gas and is known as **red body.** It consists of the internal oxygen-secreting epithelium and a capillary network on the wall of the bladder together forming the **gas gland** proper. This is in close connection with a **rete mirabile** (wonder net) which is a complex structure of venous and arterial capillaries which do not communicate until they reach the gland. In **physostomous** fishes where the gland is covered with simple flat

epithelium, the structure is known as **red body.** In higher **physoclistous** fishes where the gland is covered with thick, folded, glandular epithelium, it is called the **red gland.** In still more specialised forms (*Mugil, Balistes* and *Gadidae*) the posterior region becomes converted into a flattened **oval** which can be closed off by a circular fold provided with sphincter and dilator muscles.

6.3 Blood Supply

As stated earlier the air bladder receives its blood supply either from the branches of the coeliaco-mesenteric artery or directly from the branches of the dorsal aorta. The blood from the air bladder is taken to the heart either through a vein joining the hepatic portal vein or the vein from the bladder may join the posterior cardinal vein. In *Polypterus* and Dipnoi, the blood is supplied by paired afferent pulmonary arteries which arise from the fourth aortic arch.

The degree of vascularity is different in various teleosts. The capillaries may be uniformly distributed over the air bladder (as in clupidae and salmonidae) or the capillaries may become localised at one or more points in a fan-like manner and form the 'red bodies'. In the **physoclistous** fishes the capillaries are covered with a folded glandular epithelium and is known as the red gland or the 'gas gland'. The anterior part of the air bladder is specialized for gas secretion while the posterior region is concerned with absorption of gas. In some physoclistous fishes the postero-dorsal gas-absorbing region forms the **'oval'.**

The air bladder is supplied with branches from the vagus, but the oval is innervated by sympathetic nerves.

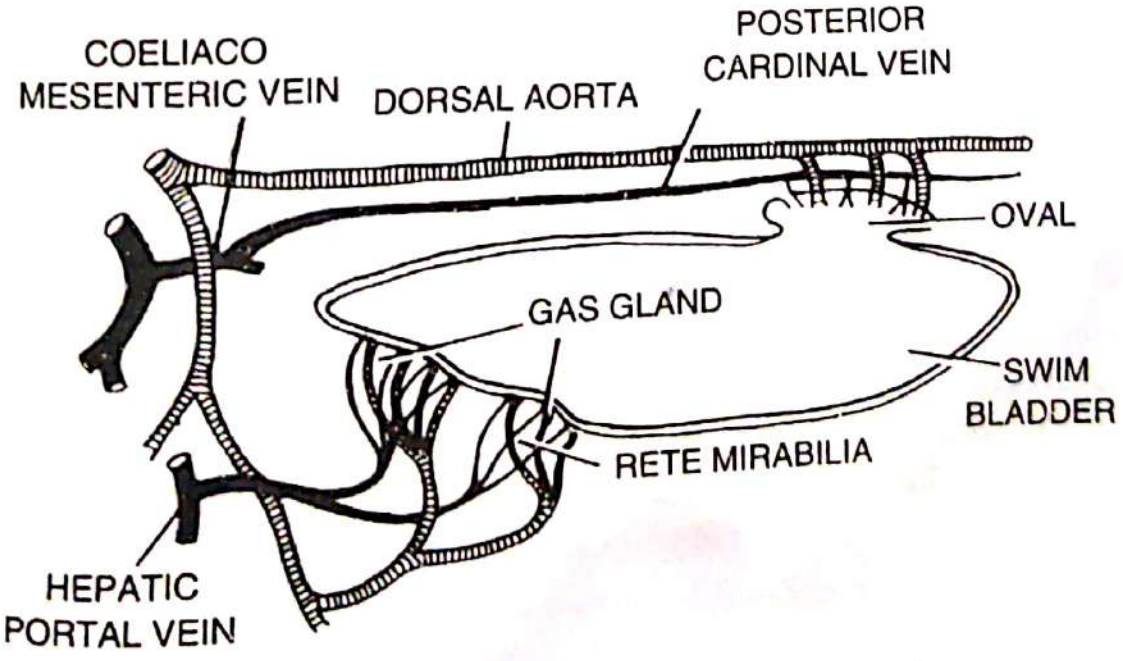

Fig. 6.6 Air bladder showing oval and gas glands

6.4 Functions of Air Bladder

In fishes the air bladder performs a variety of functions as described below.

1. Hydrostatic organ It primarily functions as a hydrostatic organ keeping the weight of the body equal to the volume of the fish displaced. The body is kept at equilibrium by increasing or decreasing the volume of gas content.

2. Adjustable float With the help of air bladder the fish can swim at any depth. When the fish rises up the air bladder is distended decreasing its specific gravity and when the fish sinks to lower depths the specific gravity is increased by expelling air from the air bladder.

3. Respiration In many fishes, like *Polypterus*, *Amia* and *Lepidosteus* the air bladder mainly functions as a respiratory organ. In Dipnoi the air bladder is modified into the 'lung' which is able to take up atmospheric air. In fishes which live in swamps or ponds where oxygen content is low the air bladder functions as lung. Air bladder can also store oxygen for use when required. The oxygen produced in the bladder definitely helps the fish in respiration.

4. Resonator In some fishes the air bladder acts as a resonator intensifying the sound vibrations.

5. Sound production The circulation of the air contained inside the air bladder causes vibration of the incomplete septa producing sound. Contraction of the extrinsic and intrinsic muscles of the air bladder may also produce sound. Sound may be produced when the gas passes through the pneumatic duct (e.g., eel, *Anguilla*).

6. Sensory function The air bladder functions as a pressure receptor and enables the fish to maintain a steady depth.

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