SWIM BLADDER

Swim bladder is an endodermal outgrowth from the oesophagus, shortly behind the pharynx. It resembles a lung in structure and function in some primitive fishes. However, it is not called a lung because in most of the cases, its primary roll is not respiratory. A swim bladder may be single or double. It may open into the oesophagus, dorsally or ventrally or not at all. It may be very small or quite large, extending through the entire length of the coelom. It often lies above the gut, directly beneath the vertebral column. It is retroperitoneal, i.e., the peritoneum is present only on the ventral side. The swim bladder generally opens by a pneumatic duct into the oesophagus through an aperture called glottis. The fishes with such an open swim bladder are described as physostomous. In fishes where the swim bladder is closed, they are described as physoclistous.

Comparative Anatomy of Swim Bladder

1. Placoderms (now extinct): In placoderms, e.g., in *Bothriolepis,* the posterior pair of pharyngeal pouches extended ventrally and probably functioned as pneumatic organs. These pouches thus represent the swim bladders or primitive lungs.
2. Chondrichthyes (cartilaginous fishes): Swim bladder is lacking in all chondrichthyes. It probably disappeared early during evolution. A temporary rudiment is however formed during development in many species.
3. *Latimeria* (living fossil with bony Skelton) : In *Latimeria*, the swim bladder is a small tube, just 5-7.5 cm long. It extends as a filament upto the end of the coelom. It is connected to the underside of the oesophagus. It is a vestigial organ.
4. *Polypterus* (Ganoid): In *Polypterus*, the swim bladder arises from the ventral side of the oesophagus and consists of two unequal lobes, the right being much larger than the left. The two lobes extend backward along the sides of the gut and have thin walls with smooth inner surface and are without alveoli as in lung fishes. They are highly vascularized to facilitate gas exchange. They are facultative air breathers and breathe through lungs or swim bladders when the water they inhabit is poorly oxygenated. The lungs of these fishes get ventilated by recoil aspiration, which means that the muscles in the lung wall relax, generating negative pressure within the lung resulting in a rapid intake of air through two spiracles found on the dorsal surface of the skull. The inhaled air passes to the lungs where exchange of gases takes place, which is followed by the exhalation.
5. *Protopterus and Lepidosiren* (Dipnoi): In both these lung fishes, the air bladder originates from the ventral side of the oesophagus and consists of two equal sized lobes. These lobes lie beneath the gut and have thick highly vascular wall with alveoli and septa on the inner side. They are used as lungs for respiration. These fishes come to the surface of water and gulp air by the process of buccal pumping, which begins with the relaxation of the muscles in the floor of the buccal cavity, causing the cavity to expand so that the air flows into it through the open nostrils. The nares are then closed and the muscles of the buccal cavity floor contract forcing the air into the lungs, where the exchange of gases takes place. It is followed by expiration which is probably by hydrostatic pressure, i.e., the pressure of the surrounding water on the chest of the fish causing the lung muscles to contract and exhaling the foul air. The swim bladder is used for respiration generally during aestivation (summer sleep) in burrows in the mud.
6. *Neocerotodus* (Dipnoi) : In another lung fish, *Neocerotodus,* the swim bladder arises from the ventral side of the oesophagus but lies dorsal to the gut. It is unpaired and opens into the ventral side of the oesophagus by a pneumatic duct. The monopneumonous condition in this fish is due to the suppression of the left lobe. Although the left lobe is represented in the embryo by a small diverticulum, the lung is highly vascularised

and has the alveoli and septa on the inner surface, just like the other two lung fishes. The lungs are ventilated by the process of buccal pumping followed by the exchange of gases which is then followed by the exhalation probably by hydrostatic pressure. It is also a facultative air breather and breathes through lungs only during unfavourable conditions.

7. *Lepidosteus* (Holostei): In *Lepidosteus*, the swim bladder arises from the dorsal side of the oesophagus. It is large, unpaired, highly vascular with a thick wall having folds/ septa on the inner surface. It arises from the dorsal side of the oesophagus and opens on the same side of the oesophagus by a short pneumatic duct. *Lepidosteus* also comes to the surface of water and gulps air by the process of buccal pumping, forcing the air into the lungs, where the exchange of gases takes place followed by exhalation by hydrostatic pressure.
8. Teleostei : A typical teleostean swim bladder originates from the dorsal side of the oesophagus. It extends throughout the entire length of the coelom and is found over the gut. It is an unpaired gas filled sac with a thin wall having smooth inner surface. It plays an important role in hydrostatics and equilibrium and very little or no role in respiration. Teleosts may have open swim bladder which is connected to the oesophagus via pneumatic duct and swim bladders are called physostomous. In higher teleosts, the pneumatic duct becomes atrophied or lost. Such closed swim bladders are called physoclistous.

The swim bladder in teleosts is divided into two chambers- the anterior chamber and the posterior chamber, demarcated by a constriction with a sphincter. The blood capillaries may uniformly vascularise the entire swim bladder or they may form tightly packed localized mass called retia mirabillus. In some teleosts having physostomous swim bladder, the retia mirabillus are further specialized to form red bodies near the anterior end of the swim bladder. In the teleosts with physoclistous swim bladder, the epithelial lining of the swim bladder, covering the red bodies is glandular and folded. Red bodies so modified are called red gas glands. Swim bladder receives blood from the coeliaco mesenteric artery and returns blood to the hepatic portal vein. The red bodies or red glands can transfer oxygen, carbon dioxide and nitrogen from the blood to the swim bladder. Any excess gas secreted into the swim bladder by the red bodies or the red glands is passed out through the pneumatic duct in the physostomous fishes but is absorbed by the capillaries forming the retia mirabillus at the anterior end in physoclistous fishes.

<u>Functions of Air Bladder</u>

1. Respiration: In lower or intermediate fishes such as ganoids and lung fishes, the air bladder serves as a lung. These fishes come to water surface regularly to gulp air. In teleosts, the swim bladder plays some role in respiration. If the carbon dioxide content of water rises, the swim bladder supplies stored oxygen during this time of deficiency.
2. Hydrostasis: Swim bladder in teleosts functions chiefly as a hydrostatic organ and helps to keep the weight of fish body equal to the volume of water displaced by fish. Secretion of more gases means lower specific gravity so that the fish rises in water. Reabsorption of gases means increased specific gravity and the fish sinks. Thus, the fish is able to rise or sink and maintain its equilibrium in water without any muscular effort.
3. Sound Production : In some fishes, sound is produced by expelling the air from the swim bladder through the pneumatic duct and mouth. Sound may be produced by the compression of the muscles of the swim bladder. *Polypterus*, *Protopterus* and *Lepidosiren* produce sound during the forceful expulsion of gas from the swim bladder.

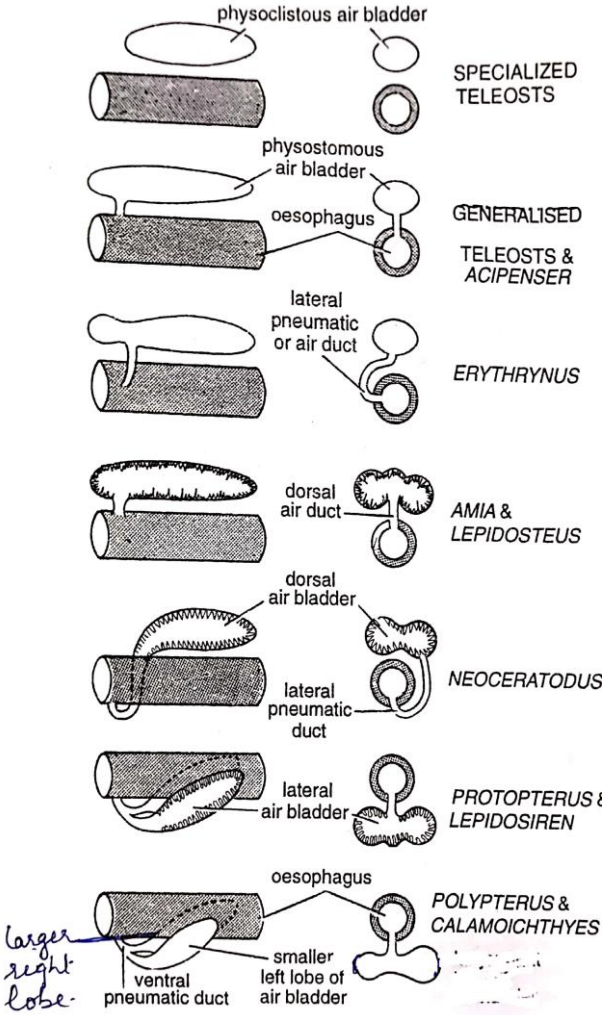

Fig. 7. Various types of swim bladders and lungs in fishes shown in L.S. (left side) and T.S. (right side).

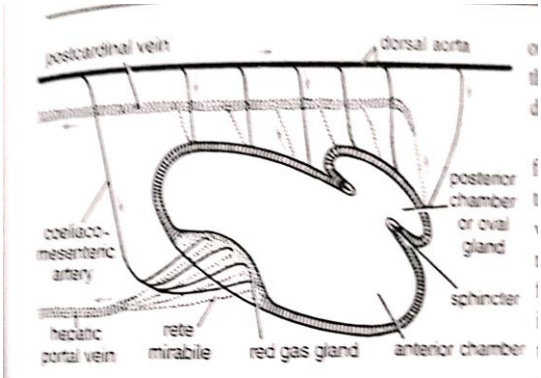

Fig. 8. Structure and blood supply of a ductless teleostean swim bladder in section.