Circulatory System of Scoliodon

Kingdom: Animalia  
Phylum: Chordata  
Class: Chondrichthyes  
Order: Carcharhiniformes  
Family: Carcharhinidae  
Genus: Scoliodon

Majority of multicellular animal possess a well developed circulatory system or cardiovascular system. “Cardiovascular” comes from the Greek, Kardia (heart) and Latin, vasculum (vessel). Though the circulatory system varies in different animal groups, it serves the following principal functions:

- Nutrients and waste products transport  
- Oxygen and carbon dioxide transport  
- Carries metabolic intermediates  
- Hormone transport to target tissue  
- Uniform distribution of water, H+, chemical substances and body heat.

The circulatory system of Scoliodon is well developed and comprises of 4 parts – Heart and Pericardium, Arteries, Veins and blood.

1. Heart and Pericardium:

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Similar to cyclostomes and other fishes, the heart of Scoliodon receives venous blood only which it pumps into gills for aeration. Such a heart is called venous or branchial heart.

It is situated mid-ventrally in head beneath the pharynx supported below by the coracoid cartilages of the pectoral girdle.

It lies within the pericardial cavity of two layered membranous sacs the pericardium. Heart is a reddish-brown, muscular and dorso-ventrally bent, S-shaped tube differentiated into a series of 4 chambers; sinus venosus, auricle, ventricle and conus arteriosus.

But only two auricles and ventricle are considered true chambers, so that heart is only two chambers.

**Fig: Scoliodon, Percardium and heart in ventral side.**
(a) Sinus venosus:
It is triangular elastic, thin walled chamber, extending transversely across the posterior wall of pericardium.

It receives venous blood through two large veins, called ducti cuvieri laterally one on each side and through a pair of hepatic sinuses posteriorly.

Anterioley sinus venosum opens into auricle by a sinuatrial or sinu-auricular aperture, guarded by a pair of membranous valves.

(b) Auricle:
It lies in front of sinus venosus dorsally upon the ventricle. It is large triangular sac moderately muscular and with walls thicker than those of sinus venosus. Its two lateral sides projecting beyond the ventricle look like ears. It opens into ventricle through an auriculo-ventricular aperture which is also guarded by two pocket-like valves to prevent backward flow of blood.

(c) Ventricle:
It is the most prominent and pear-shaped chamber of heart. Relatively small in size, it has very thick muscular walls to pump the blood into all parts of the body.

Chordae tendinae are present to be attached to opposite walls to prevent ventricle from expanding beyond its capacity.

(d) Conus arteriosus:
Ventricle tapers anteriorly into a stout and muscular tube, the conus arteriosus. Its cavity contains two transverse rows of semilunar valves to block the regurgitation or backward flow of blood.
Each row has three valves, one dorsal and two ventro-laterals in position. Anterior valves are larger than the posterior ones.

Anteriorly conus arteriosus leave the pericardium and extends further in the form of ventral aorta.

**Fig: Heart dissected from ventral side to show internal structure**

**Working of the heart:**

The heart of Scoliodon is a venous heart containing only deoxygenated or venous blood. In a complete circuit of body, the blood passes through heart only once (single circulation). Heart pumps its venous blood into the gills for aeration.
To achieve this different parts of the heart rhythmically contract at regular intervals and in a definite succession, first sinus venosus, then auricle, then ventricle and finally the conus.

Each contraction called systole is followed by a relaxation called diastole. Different valves of the heart serve to prevent the backward flow of blood into preceding chambers. The walls of heart are supplied with oxygenated blood through special coronary arteries.

2. Arterial System:
Arteries are muscular and receive the blood from heart through ventral aorta. There are five main arteries:

(i) Ventral aorta and afferent branchial arteries:
It is a single stout artery running straight mid-ventrally below the floor of pharynx. Reaching upto the hyoid arch, it bifurcates into two short right and left innominate arteries.

Each innominate immediately divides into first and second branchial arteries. Third, fourth and fifth branchial arteries also arise from ventral aorta almost at regular intervals.

The anterior most or the first afferent branchial artery runs along the posterior border of hyoid arch supplying branches to gill lamellae of its demibranch.

Remaining four branchials enter the four inter-branchial septas separately to supply branches to its holobranchs. The afferent vessels break up into capillaries in the gill lamellae for aeration of blood.

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(ii) **Efferent branchial and epibranchial arteries:**

Aerated blood from capillaries of gills is collected by a series of nine efferent branchial arteries.

Those running along the anterior (pretrematic) and posterior (post-trematic) sides of a gill pouch join together forming a complete loop encircling the gill pouch.

Thus, the first eight efferent vessels form four complete loops around the first four gill pouches. Adjacent loops are inter-connected by short longitudinal connectives.

From the upper end of each efferent branchial loop arises an epibranchial artery. The four epibranchials thus formed run backward and inward to join a large median dorsal aorta.

(iii) **Hypobranchial blood plexus:**

The ventral walls of ventral aorta carry a pair of narrow longitudinal median hypobranchial arteries inter-connected by transverse vessels.

Four commissural vessels connect each hypobranchial with a network of lateral hypobranchial chain which further connects the ventral ends of the efferent branchial loops.

Posteriorly the two median hypobranchials unite to form a median coracoid artery which branches into a coronary artery to heart and a pericardial artery sending further branches to pericardium and coracoid region of pectoral girdle.
(iv) Arteries of Head:

The head region is supplied blood mostly by three branches originating from the hyoidean or first efferent.

(a) The external carotid:
It arises ventrolaterally. It branches into a ventral mandibular to coraco-mandibular muscles and a superficial hyoid to skin muscles and sub cutaneous tissue of hyoid arch.

(b) The afferent spiracular:
It is a stout artery, continues forward as the spiracular epibranchial which enters the cranial cavity after giving a great opthalmic branch to the eye ball.

Inside cranium it unites with a branch from internal carotid forming carotid artery which divides into anterior and posterior cerebral arteries supplying blood to brain.

(c) The hyoidean epibranchial:
It arises from the dorsal end of hyoidean efferent. It runs forward and inward to join one lateral branch (or radix) of dorsal aorta and then divides into two – an internal carotid and a stapedial.

The stapedial artery sends a buccal artery to lower jaw muscles and further continues as maxillo-nasal which divides into a nasal to olfactory sac, maxillaries to upper jaw muscles and a rostral to the rostrum.

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(v) Dorsal aorta and its branches:
The median dorsal aorta is a large vessel running along the whole length of trunk and tail beneath the vertebral column.

It collects oxygenated blood from gills through four pairs of epibranchial arteries. It distributes oxygenated blood to the various parts of body through numerous following branches:

(a) Lateral aortae or radices:
These paired branches arise from dorsal aorta and join with the hyoidean epibranchial of its side.

(b) Vertebral:
It is paired and supplies blood to the vertebral column.

(c) Buccal:
It is paired and goes to roof of buccal cavity.

(d) Epibranchials:
Four pairs come from gills.

(e) Subclavian:
One pair goes to pectoral fins.

(f) Caeliaco-mesentric:
They are large, unpaired, supply to stomach, liver, pancreas and intestine.

(f) Lieno-gastric:
Unpaired supply to gonads spleen and stomach.

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(g) Posterior mesentric:
Unpaired and supply to rectal glands.

(h) Iliac:
These are paired and supply blood to pelvic fins.

(j) Parietals:
These are several small pairs of segmental arteries supply blood to myotomes spinal cord, lateral line canal, kidneys and gonads.

(k) Caudal: Posteriorly, the dorsal aorta continues into tail as caudal artery lying in the haemal canal of caudal vertebrae.
Fig: Scoliodon. Arterial system, Afferent arterial (stippled) in dorsal view and efferent arteries (black) in ventral view.
3. Venous system:
Heart receives deoxygenated blood from the body through veins, which have thinner walls than arteries and frequently contain valves to prevent a backward flow of blood. Venous System of scoliodon contains wide irregular spaces called sinuses.

(i) Anterior cardinal System:
Blood from head region is returned on either side by two sinuses.

(a) Inferior jugular sinus:
It is the smaller median ventral sinus. It collects blood from the floor of buccopharyngeal region, gill pouches and pericardial region before opening into the ductus cuvierius.

(b) Internal jugular vein or sinus:
It is the larger aorso-lateral sinus. It collects blood from the dorsal region of head and gill pouches through different sinuses.

(ii) Posterior cardinal or renal portal system:
The renal portal system is encountered for the first time in the chondrichtheys. The caudal vein collects blood from tail and dorsally to cloaca it bifurcates into right and left renal portal veins.

Each of them runs dorsally to the kidney of its side and giving off numerous afferent renal veins and capillaries into the kidney.
Small portal veins from body wall also join each renal portal vein. Several efferent renal veins collect blood from both kidneys and pour into a single vessel which further divides into two posterior cardinal sinuses.

They get enlarged in front of kidneys and receive oesophageal vein, genital veins and finally open into ductus cavierius, which, in turn, empties into the sinus venosus.

(ii) Hepatic portal system:
Blood from different parts of alimentary canal and associated glands is drained by several branches which unite to form a single large hepatic portal vein.

It breaks up into capillaries in the liver lobes. From each liver lobe blood is collected by a large hepatic sinus which opens into sinus venosus.

(iv) Lateral abdominal system:
Blood from inner lateral part of body wall, cloacal region and paired fins on either side is collected by a large lateral abdominal vein.
Posteriorly, it receives blood from pelvic fin, anteriorly, it collects blood from pectoral fins and forms a subclavian vein which enters the ductus cuvierius laterally.

(iv) Cutaneous system:
It includes a mid-dorsal, a mid-ventral and two lateral cutaneous veins collecting blood from their respective parts of skin and finally pouring it into the sinus venosus via ductus Cuvieri.
**Blood:**

The blood of Scoliodon, consists of a colourless plasma and corpuscles. Corpuscles are of two types- RBCs (erythrocytes) are oval and nucleated bodies and contain respiratory pigment, haemoglobin and WBCs (leucocytes) and amoeboid cells resembling with lymphocytes of other vertebrates.