

Evolution of Heart

I Introduction

1. In the embryonic stage two longitudinal endothelial tubes (formed by mesenchyme) in the ventral mesentery below the archenteron fuse together to ultimately form the heart.
2. It is muscular, pulsatile sac-like organ which consists of a series of chambers.
3. The heart receives the blood from the body via the veins and then pumps it to all organs of the body via the arteries.
4. The progressive transition or modification of heart from lower to higher chordates occurs on the following lines.
 - (a) Constriction occurs in the cardiac tube forming chambers
 - (b) Partitions further occur to separate the chambers.
 - (c) The position of heart gradually shifts from behind head in fishes and amphibians near the gills whereas in amniotes it is placed in the thoracic cavity with development of lungs.

II Cephalochordates

In branchiostome a true heart is lacking rather a portion of the ventral aorta below the pharynx becomes pulsatile and muscular, and contracts to function as heart.

III Cyclostomes

Vertebrate heart in its most simplest form is present in cyclostomes. The heart shows a series of chambers

- (a) Sinus Venosus
- (b) Atrium
- (c) Ventricle
- (d) Conus arteriosus

IV Gill Breathing Fishes

(a) Elaemobranchs. such as Shark

It consists of the following chambers in linear sequence

- (i) Sinus Venosus (SV) → Accessory chamber.
- (ii) Atrium/Auricle (A) → True chamber.
- (iii) Ventricle (V) → True chamber.
- (iv) Conus arteriosus (con) → Accessory chamber.

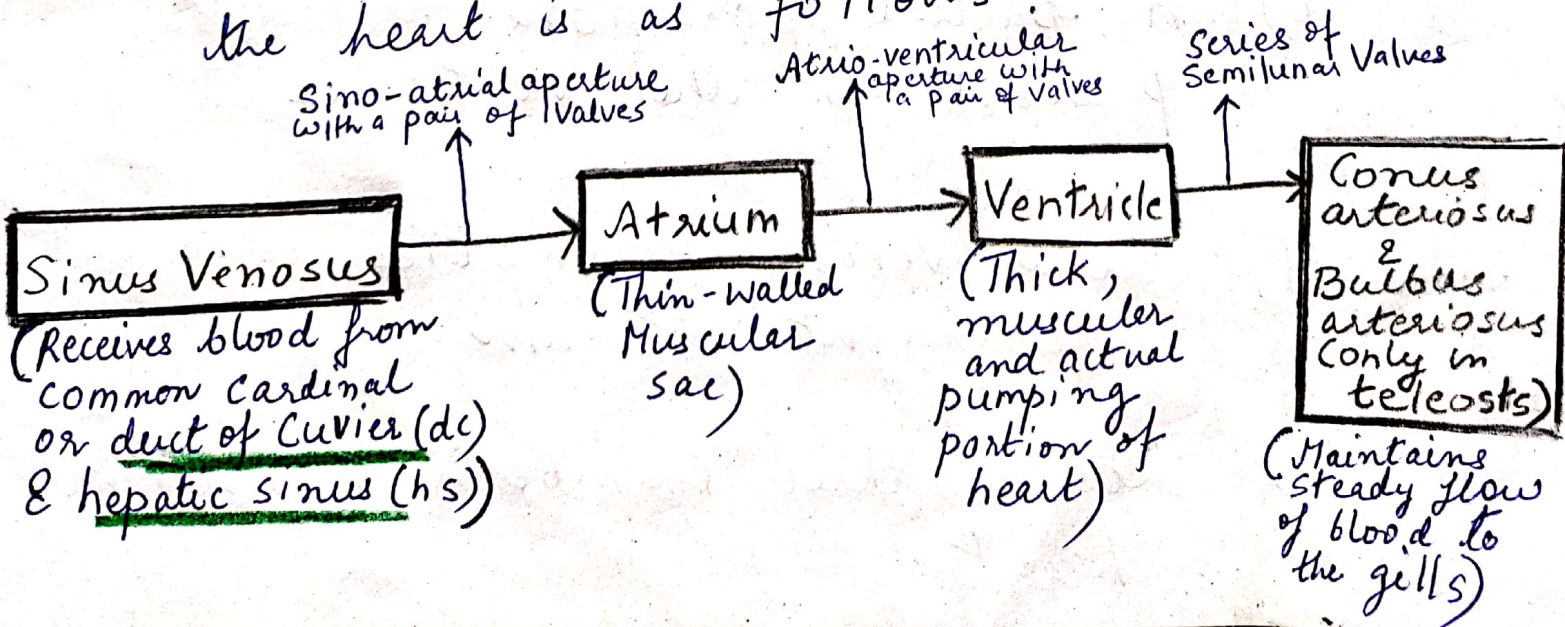
The heart is considered to be two chambered as only auricle and ventricle are true chambers (Not-definitive)

(b) Teleosts

Similar to cartilaginous fishes, however the conus arteriosus is shorter than that of Shark and instead there is a small muscular swelling called the bulbus arteriosus which performs the same role.

Thus in both elasmobranch and teleosts the blood passes from heart to the gills and from there to the body, and ~~then~~ then returns back to the heart forming a single circuit. In this type of single circulation the blood in the heart is deoxygenated and thus such a heart is called a Venous or Branchial heart.

In fishes the pathway of blood through the heart is as follows:



✓ Dipnoans

The heart is modified due to a shift from aquatic life (gills) to aerial respiration (lungs). The modifications are as follows.

(a) A new pulmonary circulation develops along with systemic circulation. Now aerated blood from lungs (or swim bladder) directly returns to the heart via the Pulmonary vein (PV)

(b) Mixing of blood occurs as atrium is divided by an incomplete interauricular septum perforated by the foramen ovale into right & left atrium.

(c) A partial partition is also present in the ventricle

(d) Sinus Venosus ~~of~~ empties into the right atrium

(e) It's a three chambered transitional heart.

VI Amphibians . (Is also 3-chambered transitional heart)

(a) Urodeles

- (i) Similar to dipnoans, however ventricle is undivided with thick muscular walls.
- (ii) Reduced conus arteriosus which is replaced by bulbus arteriosus.

(b) Anurans

- (i) Interauricular septum is complete, without the foramen ovale. This keeps oxygenated and deoxygenated blood separate.
- (ii) Ventricle has thick muscular walls that are raised into trabeculae (ridge) which allow very little mixing of blood. Ventricle is undivided.
- (iii) The conus (or truncus) arteriosus is divided internally by a spiral valve called Septum bulbi. The spiral valve directs deoxygenated blood into pulmonary vessels & oxygenated blood into systemic vessels.
- (iv) Ventral aorta shortens & slowly becomes non-existent.

VII Amniotes

(a) Reptiles

- (i) Heart shows further development
- (ii) Ventricle becomes strongly muscular
- (iii) An incomplete inter-ventricular septum is present in most of the reptiles. This septum divides the ventricle partially and thus reduces the mixing of oxygenated and deoxygenated blood.

[Note:- In crocodile this septum is complete thus making it a very effective four-chambered heart]

- (iv) Conus arteriosus does not exist. Its distal part & the ventral aorta split into 3 main trunks

- (1) Pulmonary trunk
 - (2) Left aorta
 - (3) Right aorta
- } Systemic trunks

The left aorta leads from the right side of ventricle and crosses to the left side whereas the right aorta leads from the left side of the ventricle and crosses over to the right side.

(v) The point at which the right and left aortae cross each other there is a small aperture called the Foramen of Panizza. Because of this aperture there is some mixing of blood.

(vi) Reptilian heart with partially four chambers (2 auricles and 2 incomplete ventricles) represent transitional Hearts.

(vii) Partial mixing of arterial and venous blood occurs before distribution

(b) Birds and Mammals.

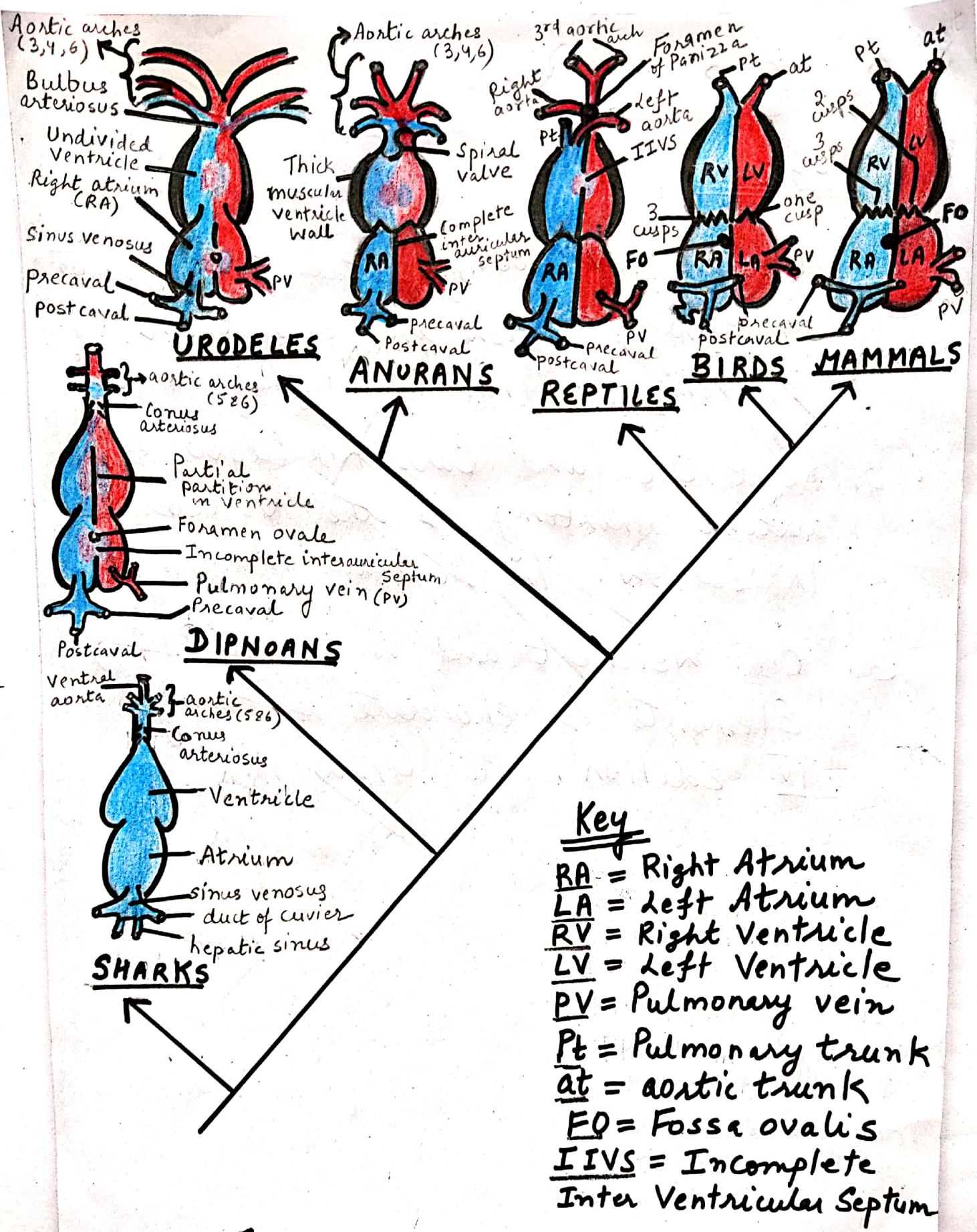
- (i) The ventricle is completely divided thus the heart is four chambered
- (ii) The atria are completely divided and the site of foramen ovale is now marked by a depression called "Fossa ovalis" in the wall of the right atrium
- (iii) Sinus venosus is absent and incorporated into the right atrium. The right atrium receives blood through two precavals and one postcaval.
- (iv) The left atrium receives blood via the pulmonary veins.
- (v) The inner surface of right auricular valve is marked by a small depression of Thebesian foramina
- (vi) Primitive conus arteriosus is replaced by
 - (1) Pulmonary aorta leaving the right ventricle for lungs
 - (2) single systemic aorta leaving the left ventricle for body.

(VII) Valves are present in the passageways from atria into ventricles and from the ventricles into the pulmonary and aortic trunks. Each valve is made up of one or more cusps and is connected by tendinous cords called chordae tendineae to papillary muscles of the ventricle wall.

- (1) Left Valve between the left atrium and left ventricle has two cusps and is called the bicuspid or mitral valve.
- (2) Right valve between the right atrium and right ventricle has three cusps and is called the tricuspid valve. [Note - Birds have only one cusp in the right valve]
- (3) Semilunar valve is present at the exit of Ventricle into pulmonary trunk.
- (4) Semilunar valve is also present at the exit of ventricle into aortic trunk.

Note :- The heart of Birds and Mammals are structurally similar except for one main difference i.e. in birds there is only one cusp in the right valve whereas in mammals there are three cusps in the right valve.

Thus, the amniote heart is a double circuit heart with a (i) pulmonary circuit that carries deoxygenated blood from heart to the lungs and brings back oxygenated blood to the heart. (ii) systemic circuit that carries the oxygenated blood to the body and then returns deoxygenated blood to the ~~to~~ heart. This type of double circulation in which there is no mixing of oxygenated and oxygenated blood is highly efficient and such a heart is called a Pulmonary heart.



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References

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