Course: Animal form and function

CHAP : CIRCULATION, IMMUNITY, AND GAS EXCHANGE

- INTERNAL TRANSPORT AND CIRCULATORY SYSTEMS IN INVERTEBRATES
- TRANSPORT SYSTEMS IN VERTEBRATES, BLOOD, BLOOD CELLS AND BLOOD VESSELS.
- BLOOD PRESSURE AND LYMPHATIC SYSTEM
- THE IMMUNE RESPONSE
- GAS EXCHANGE
- RESPIRATORY SURFACES
- INVERTEBRATES AND VERTEBRATES RESPIRATORY SYSTEMS.

❑INTERNAL TRANSPORT AND CIRCULATORY SYSTEMS IN INVERTEBRATES

- **All animals must maintain a homeostatic balance in their bodies. This need requires that nutrients, metabolic wastes, and respiratory gases be circulated through the animal's body.**

- **Any system of moving fluids that reduces the functional diffusion distance that nutrients, wastes, and gases must traverse is an internal transport or circulatory system**

TRANSPORT SYSTEMS IN INVERTEBRATES

Protozoa

- ✓ high surface-area-to-volume ratios
- ✓ plasma membrane and cytoplasm are the media through which materials diffuse.
- ✓ Simple diffusion for gas, nutrient and gas exchange

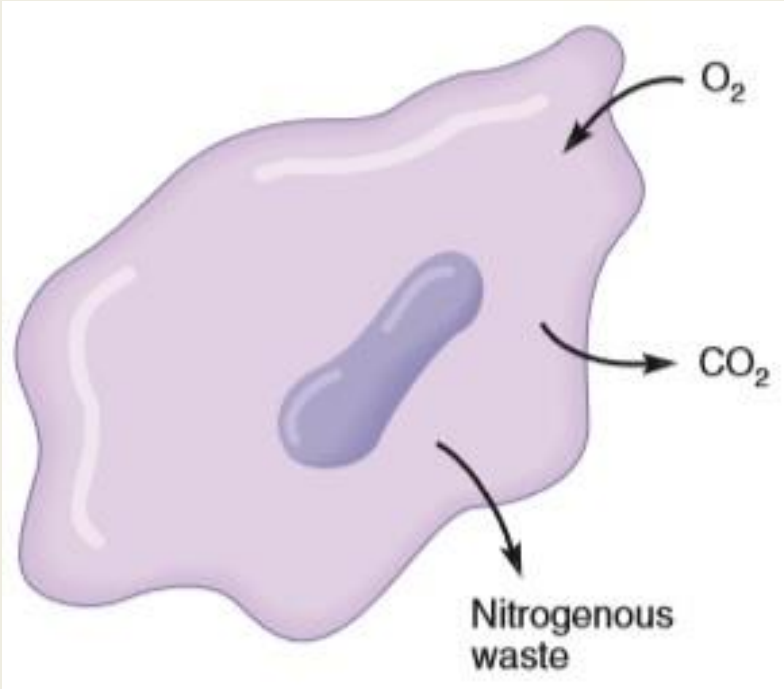


Fig: Invertebrate Respiration: Diffusion through Body Surfaces. The cells of small organisms, such as protozoa

Sponges

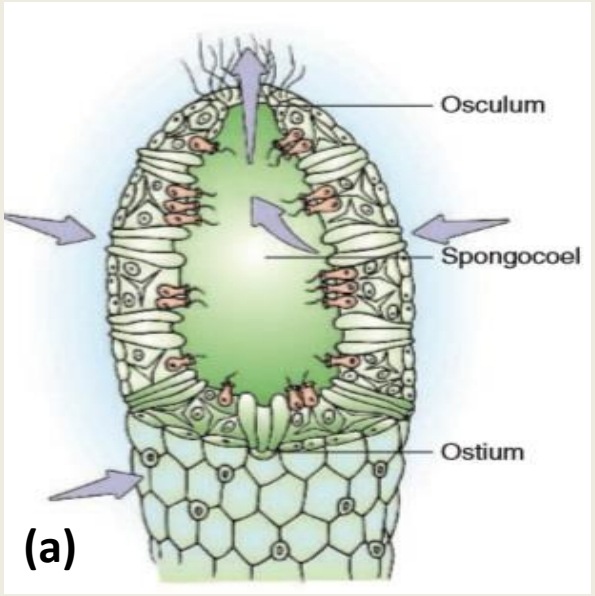
- circulate water from the external environment through their bodies

Cnidarians

- Such as Hydra, have a fluid-filled internal gastrovascular cavity.

Gastrovascular cavity

- This cavity supplies nutrients for all body cells lining the cavity.
- It provides oxygen from the water in the cavity.
- It is a reservoir for carbon dioxide and other wastes.



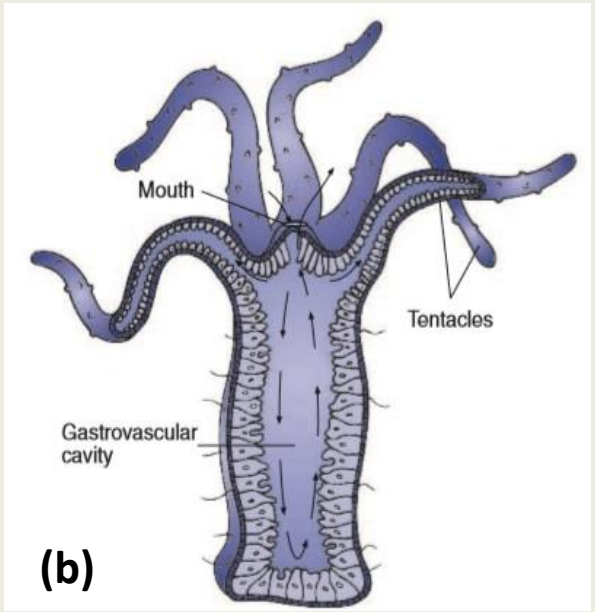


Fig: Transport and Circulatory Systems. (a) Sponges (b) Cnidarians, such as this Hydra

Platyhelminthes

FLATWORMS:

- More complex than hydra.
- Branches penetrates to all parts of body.
- Branched gastro vascular cavity run close to all body cells.
- Diffusion distance for nutrients, gases & wastes is short.
- Body movement help distribute the materials.

Disadvantage

- Disadvantage of this system is that it limits these animal to relatively small sizes or to shapes that maintain small diffusion distances.

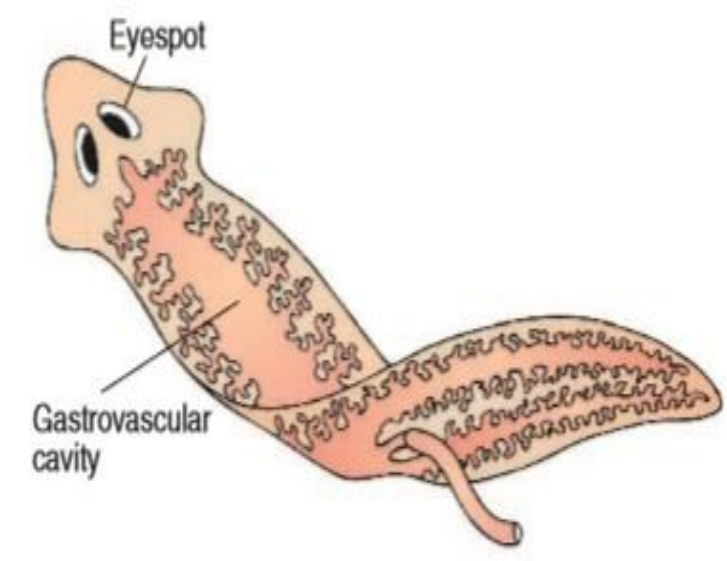


Fig: Transport and Circulatory System. The planarian's gastrovascular cavity is branched, allowing for more effective distribution of materials.

PSEUDOCOELOMATE INVERTEBRATES:

- Rotifers, nematodes etc use the body fluid of their body cavity for transport.
- Small animals & movements of the body against the coelomic fluids, which are in direct contact with internal tissue and organs produce adequate transport.
- Few other invertebrate such as ectoprocts, echinoderms also depend on their body cavity as a coelomic transport chamber.

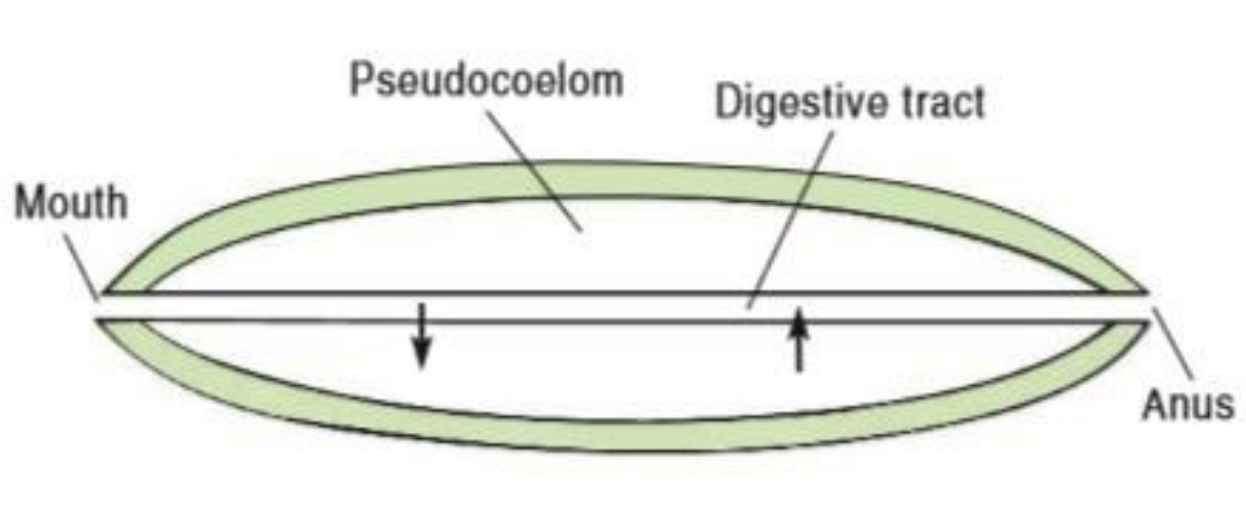


Fig: Transport and Circulatory Systems in Pseudocoelomates

circulatory systems in animal kingdom

open circulatory system

- ✓ Heart pumps hemolymph out into the body cavity or at least through parts of the cavity
- ✓ Hemolymph bathes the cells, tissues, and organs
- ✓ Examples: Most molluscs and arthropods

In a closed circulatory system

- ✓ Blood circulates in the confines of tubular vessels.
- ✓ Coelomic fluid of some invertebrates also has a circulatory role either in concert with, or instead of, the hemolymph or blood.
- ✓ Examples: annelids, such as the earthworm

Open and Closed circulatory systems

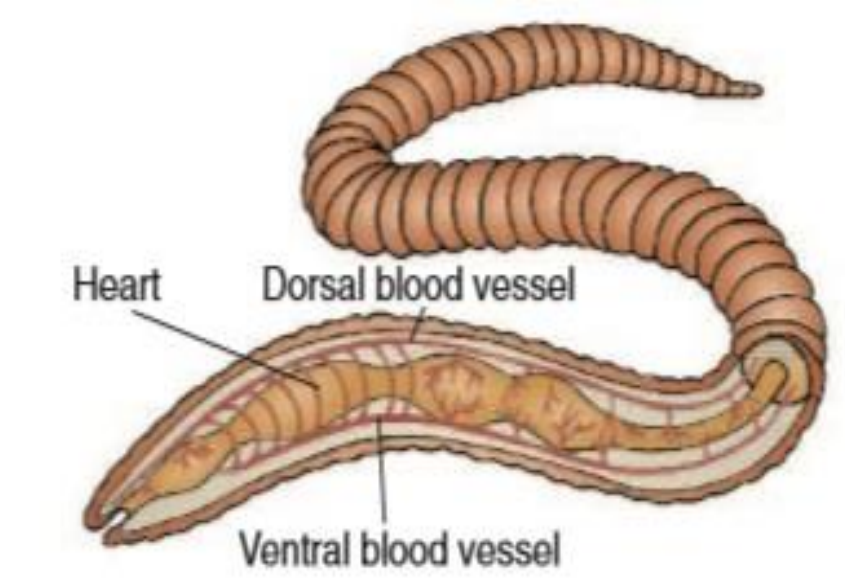


Fig: Circulatory system of an earthworm contains blood that is kept separate from the coelomic fluid. This is an example of a closed circulatory system.

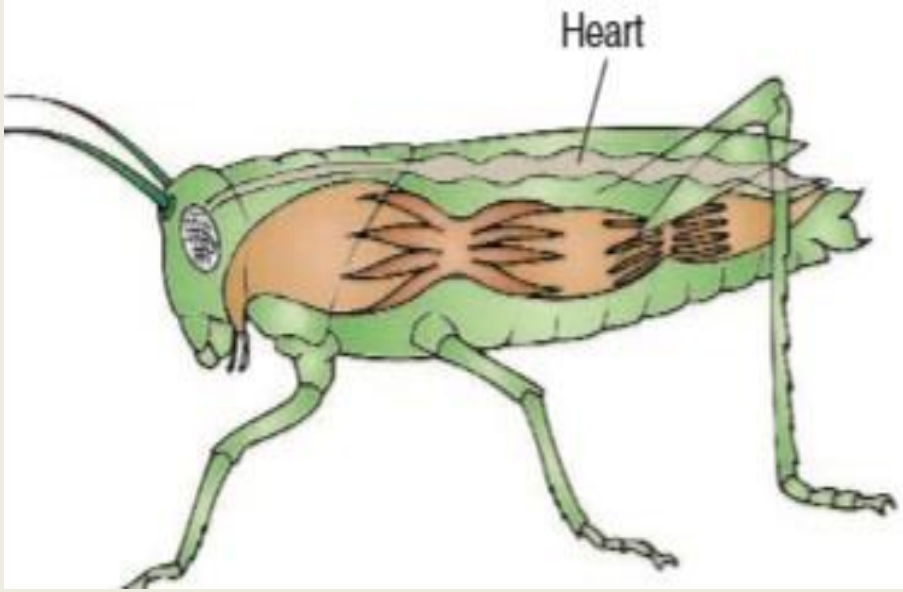


Fig: Dorsal heart of an arthropod, such as this grasshopper, pumps blood through an open circulatory system

CHARACTERSTICS OF INVERTEBRATES COELOMIC FLUID, HEMOLYPH & BLOOD CELLS

COELOMIC FLUID

- ✓ Some animals (e.g., echinoderms, annelids, sipunculans) use coelomic fluid as a supplementary or sole circulatory system.
- ✓ may be identical in composition to interstitial fluids
- ✓ may differ, particularly with respect to specific proteins and cells.
- ✓ Transports gases, nutrients, and waste products.
- ✓ Function in certain invertebrates (annelids) as a hydrostatic skeleton

HEMOLYMPH

- Hemolymph is the circulating fluid of animals with an open circulatory system.
- Most arthropods, ascidians, and many molluscs have hemolymph.

❖ **Circulatory functions of Hemolymph:**

- a heart pumps hemolymph at low pressures through vessels to tissue spaces (hemocoel) and sinuses.
- In the process of movement, essential gases, nutrients, and wastes are transported.

❖ **Non circulatory functions of Hemolymph:**

For example

- in insects, hemolymph pressure assists in molting of the old cuticle
- in inflation of the wings.
- In certain jumping spiders, hydrostatic pressure of the hemolymph provides a hydraulic mechanism for limb extension.

HEMOCYTES

- Circulating cells
- Also called blood cells
- Some contain hemoglobin (respiratory pigment) are called erythrocytes or red blood cells.
- High number to facilitate oxygen transport.
- Cells without respiratory pigment have other functions, such as blood clotting.

NUMBER &TYPE OF BLOOD CELLS

- Amoebocytes
- Eleocytes
- Lampocytes
- Linocytes

Function in phagocytosis, glycogen storage, defense purpose & excretion. Mollusc contain amorbocytes & granulocytes

TRANSPORT SYSTEMS IN VERTEBRATES

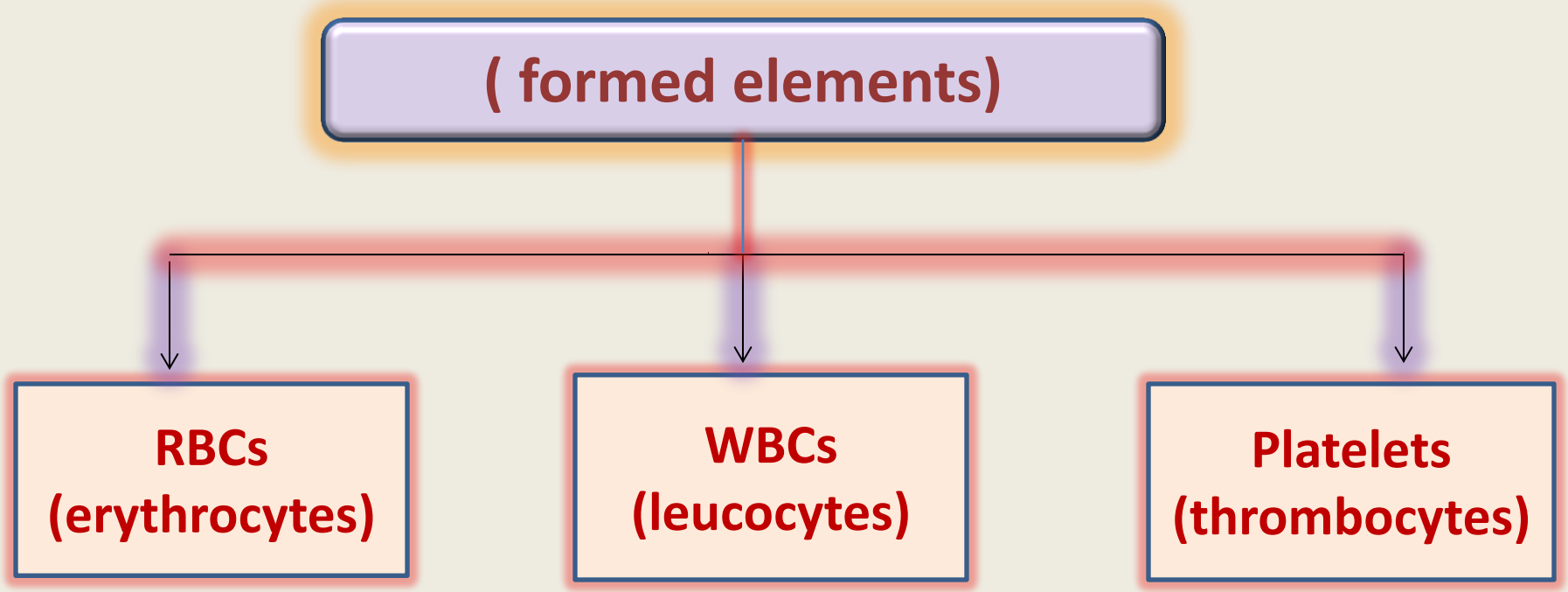
CHARACTERISTICS OF VERTEBRATE BLOOD

- vertebrate blood transports oxygen, carbon dioxide, and nutrients.
- defends against harmful microorganisms, cells, and viruses
- Prevents blood loss through coagulation (clotting).
- Helps regulate body temperature and pH

Plasma

- Straw-colored, liquid part of blood.
- 90% water (provides solvent for transporting and dissolving nutrients/wastes).
- 7% protein (albumin, fibrinogen, globulins)
- 3 % (electrolytes, amino acids, glucose, various enzymes, hormones, metabolic wastes , organic and inorganic molecules).
- Albumin- major portion of plasma protein (60%)
- Plays important role with respect to water movement.

- **Fibrinogen**
  - **Necessary for blood coagulation**
- **Globulin**
  - **Include immunoglobulins and various metal binding proteins**


(formed elements)
RBCs
(erythrocytes)
WBCs
(leucocytes)
Platelets
(thrombocytes)

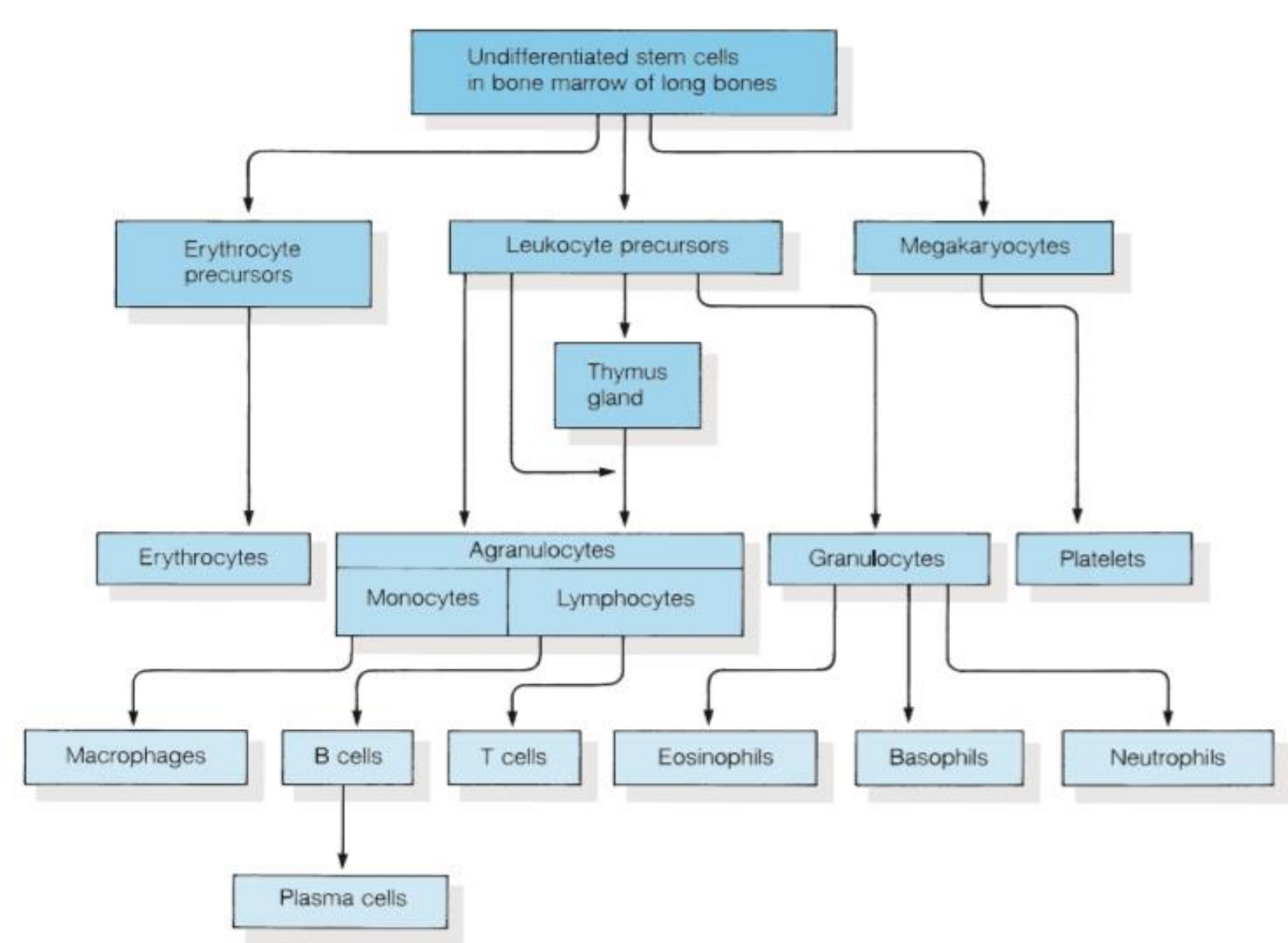


Fig: Cellular Components of Vertebrate Blood. Hematopoiesis is the process of blood cell production. Notice that all blood cells initially begin their lives in the bone marrow of long bones within a vertebrate's body.

RBCs (erythrocytes)

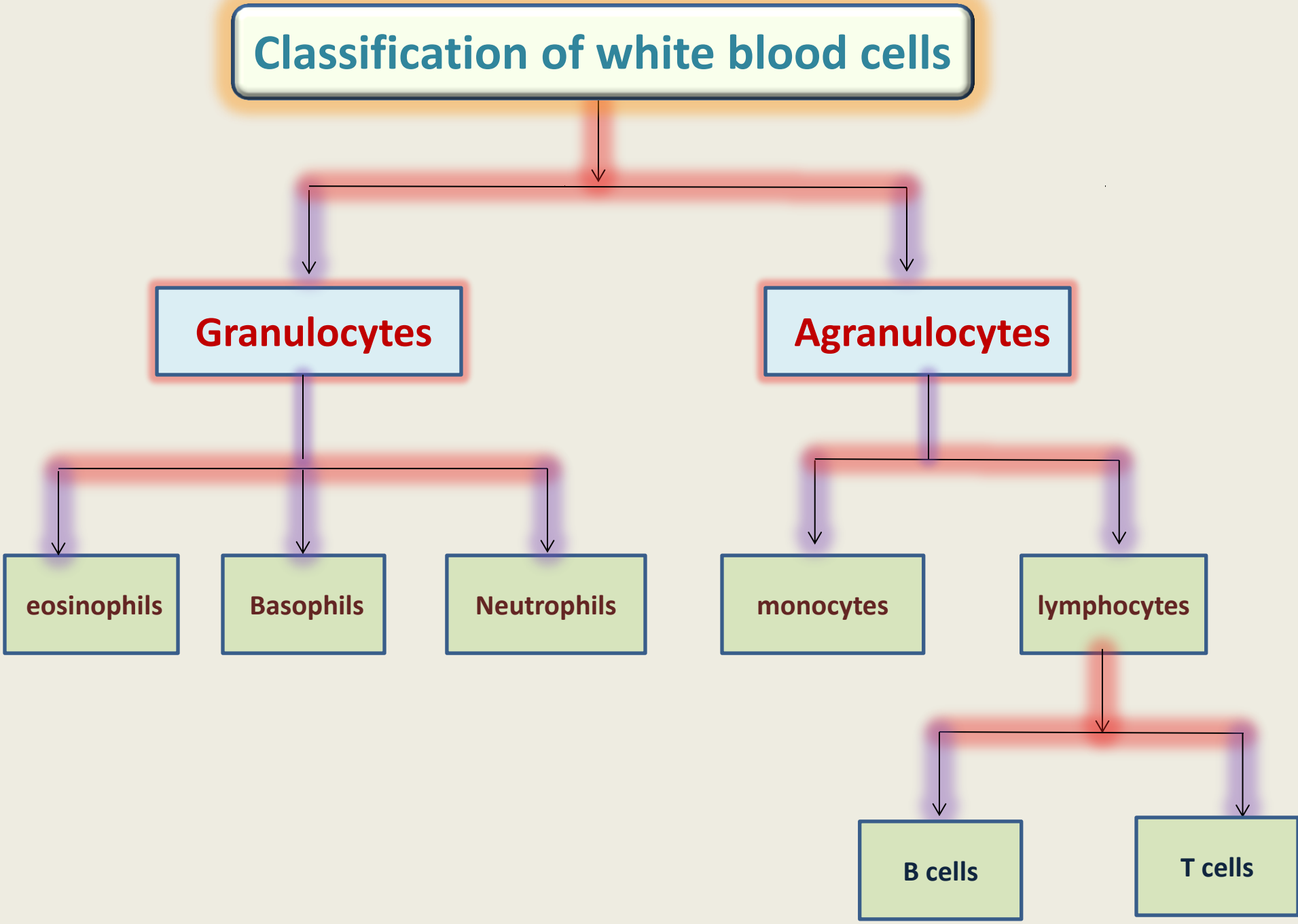
- vary in size, shape, and number in the different vertebrates.
- the entire mass of a RBC consists of hemoglobin an iron-containing protein.

Function

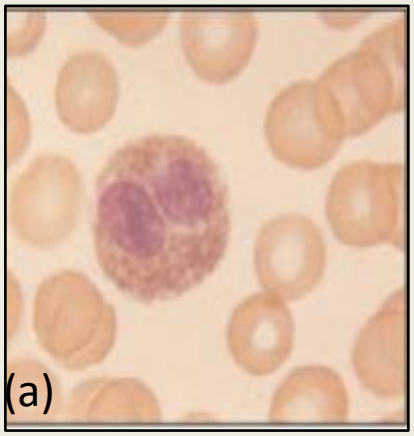
- The major function of an erythrocyte is to pick up oxygen from the environment, bind it to hemoglobin to form oxyhemoglobin, and transport it to body tissues.
- Hemoglobin also carries waste carbon dioxide (in the form of carbaminohemoglobin) from the tissues to the lungs (or gills) for removal from the body.

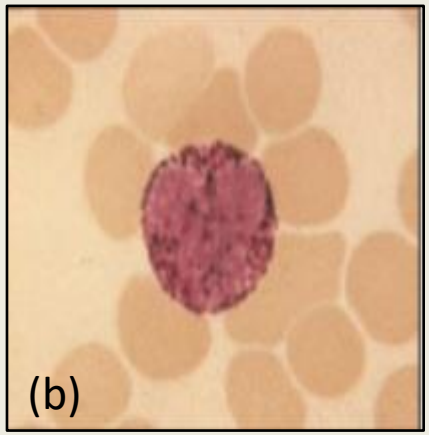
WBCs (leucocytes)

- Scavengers that destroy microorganisms, remove foreign chemicals, remove debris that results from dead/injured cells.
- Derived from stem cells in bone marrow **Hematopoiesis.**


Classification of white blood cells
Granulocytes
Agranulocytes
eosinophils
Basophils
Neutrophils
monocytes
lymphocytes
B cells
T cells

Granulocytes and Agranulocytes





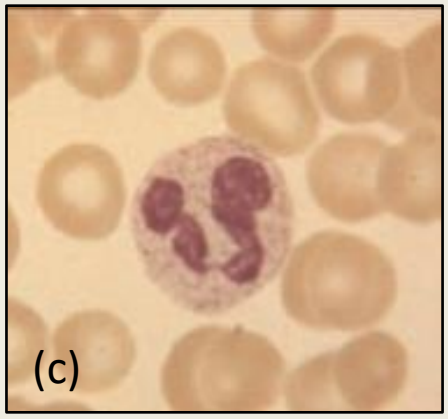
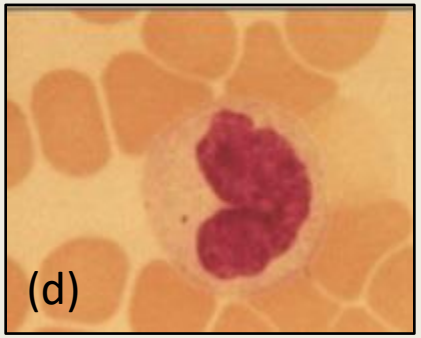


Fig: Granulocytes: (a) Red-staining cytoplasmic granules characterize an eosinophil. (b) Blue-staining granules characterize a basophil. (c) Lightpink granules and a multilobed nucleus characterize a neotrophil.



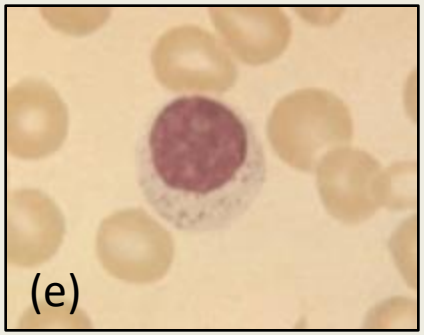


Fig: Agranulocytes consist of large monocytes (d) and lymphocytes (e)

Platelets (Thrombocytes)

- Platelets (so named because of their platelike flatness), or thrombocytes (Gr. thrombus, clot cells), are disk-shaped cell fragments that initiate blood clotting.
- When a blood vessel is injured, platelets immediately move to the site and clump, attaching themselves to the damaged area, and thereby beginning the process of blood coagulation.

VERTEBRATE BLOOD VESSELS

Arteries

- Carry blood away from the heart to the organs and tissues of the body.
- Arteries lead to terminal arterioles (those closest to a capillary).
- The arterioles branch to form capillaries, which connect to venules and then to veins.
- Capillaries are generally composed of a single layer of endothelial cells and are the most numerous blood vessels in an animal's body.
- Capillaries makes an enormous surface area available for the exchange of gases, fluids, nutrients, and wastes between the blood and nearby cells

veins

- Most veins are relatively inelastic, large vessels that carry blood from the body tissues to the heart.
- The wall of a vein contains the same three layers (tunicae) as arterial walls, but the middle layer is much thinner, and one or more valves are present.
- The valves permit blood flow in only one direction, which is important in returning the blood to the heart.

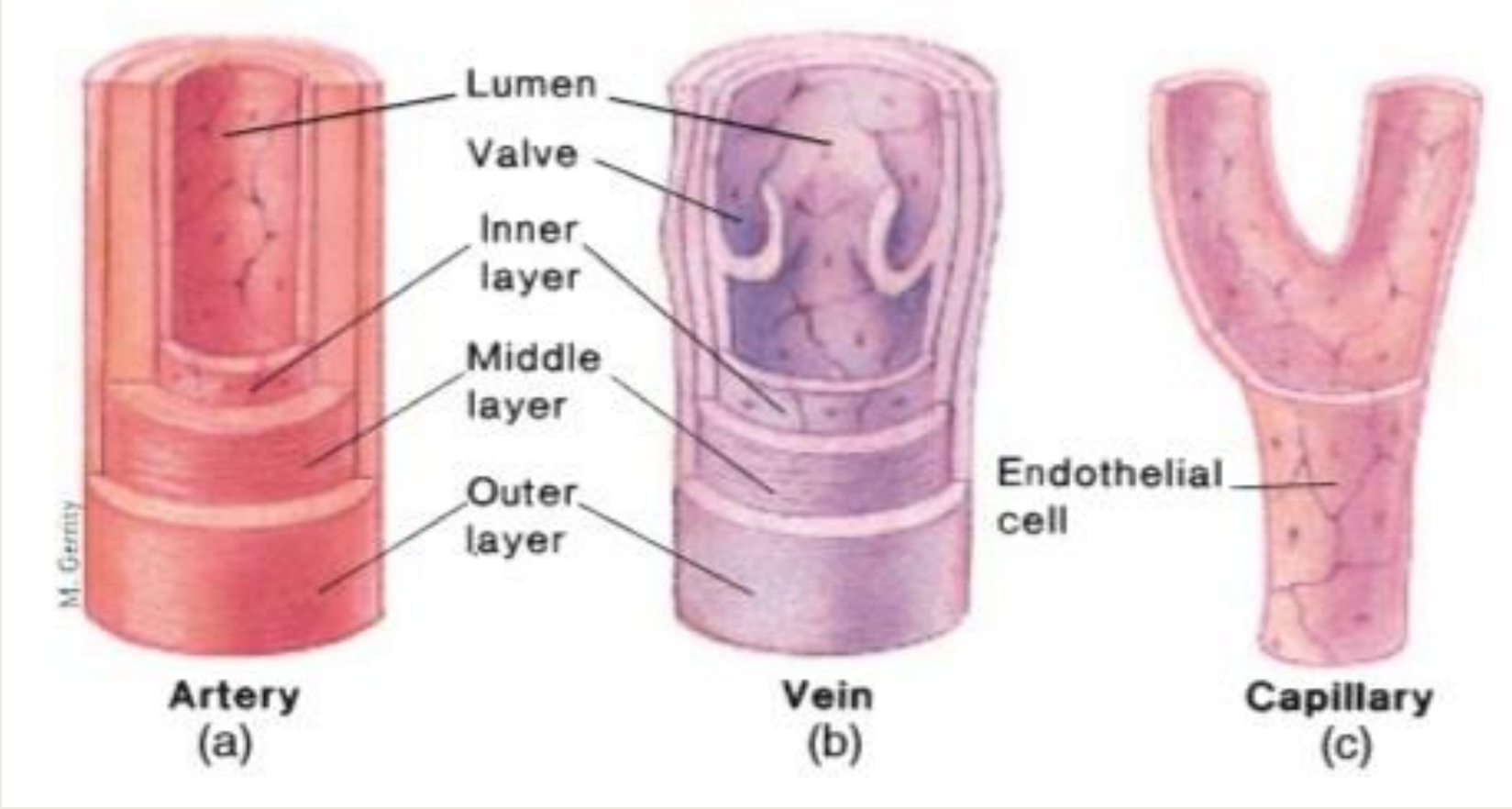


Fig: Structure of Blood Vessels. (a,b) The walls of arteries and veins have three layers (tunicae). The outermost layer consists of connective tissue, the middle layer has elastic and smooth muscle tissue, and the inner layer consists of a single layer of smooth endothelial cells (endothelium). Notice that the wall of an artery is much thicker than the wall of a vein. The middle layer is greatly reduced in a vein. (c) A capillary consists of a single layer of endothelial cells.

THE HEARTS AND CIRCULATORY SYSTEMS OF BONY FISHES, AMPHIBIANS, AND REPTILES

- The heart and blood vessels changed greatly as vertebrates moved from water to land and as endothermy evolved.
- The bony fish heart has two chambers—the atrium and ventricle.
- blood only passes through the heart once, this system is called a single circulation circuit.
- In amphibians and reptiles, the evolution of a double circulatory circuit, in which blood passes through the heart twice during its circuit through the body, has overcome the slow blood-flow problem.