Medical Academy named after S.I. Georgievsky of Vernadsky CFU

PHYLOGENETIC DISORDER OF CIRCULATORY SYSTEM

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Circulatory Systems Reflect Phylogeny

- In unicellular organisms
  - Exchanges occur directly with the environment
- For most of the cells making up multicellular organisms
  - Direct exchange with the environment is not possible

WILLIAM HARVEY (1628)

- Father of cardiovascular physiology
- Set forth the first proof that HEART PROPELS THE BLOOD THROUGH BLOOD VESSELS IN A CIRCULATORY PATTERNS
- Before HARVEY'S proposal it was believed that blood flows in TIDAL FASHION similar to respiratory system
- However the circularity of the cardiovascular system makes it difficult
- No clear ideas about tissue supply demand & supply of blood to pheriphery

Circulatory & Phylogeny

- Diffusion is inefficient over distances more than a few mm.
- Circulatory system ensures that no substance must diffuse very far and connects the aqueous environment of cells to organs that exchange gases, absorb nutrients, and dispose of wastes
- Those that lack a circulatory system utilize a gastrovascular cavity to digest and distribute substances throughout body

42.1 Circulatory Systems Reflect Phylogeny

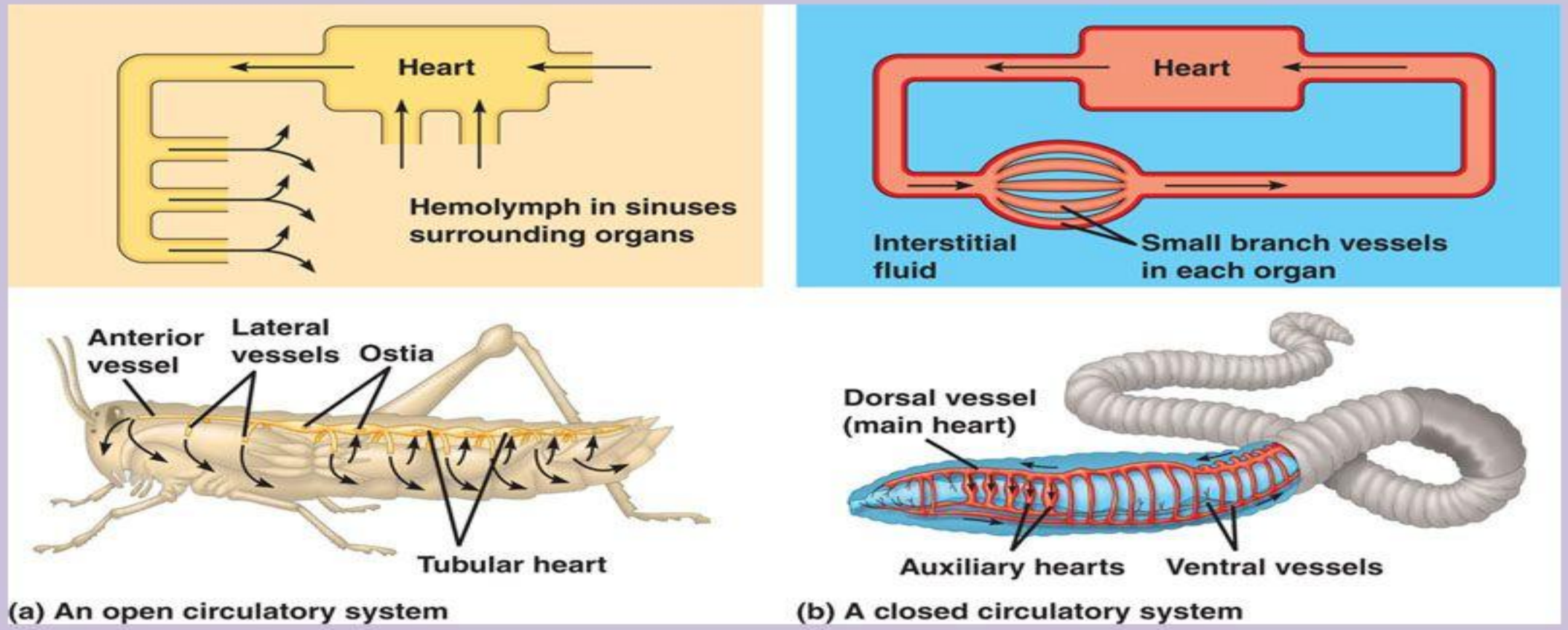
Invertebrate Circulation

- Hydras & other cnidarians
  - Have gastrovascular cavities,
  - Serves both digestion and distribution of substances

Open and Closed Circulatory Systems

- Overcome the limitations of diffusion
- 3 basic components –
  - blood
  - blood vessels
  - heart
- Open system bathes organs directly in blood
- Closed system blood confined to vessels separate from interstitial fluid

Open vs. Closed



(a) An open circulatory system

(b) A closed circulatory system

3. Vertebrate phylogeny is reflected in adaptations of the cardiovascular system

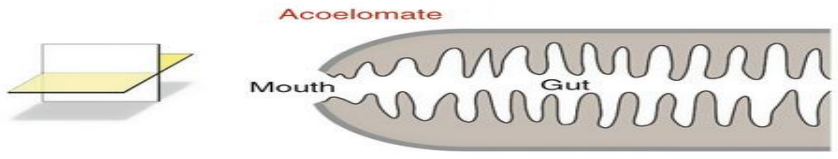
- The closed circulatory system of humans and other vertebrates is often called the **cardiovascular system**.
- The heart consists of one **atrium** or two **atria**, the chambers that receive blood returning to the heart, and one or two **ventricles**, the chambers that pump blood out of the heart.

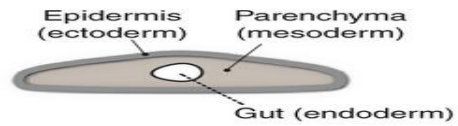
Longitudinal section

Cross-section

Notes

Acoelomate

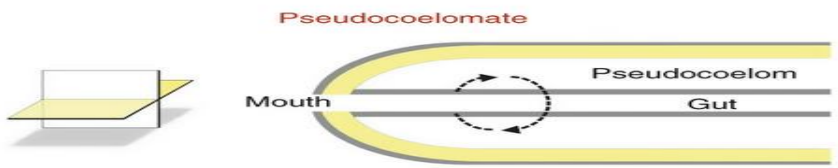


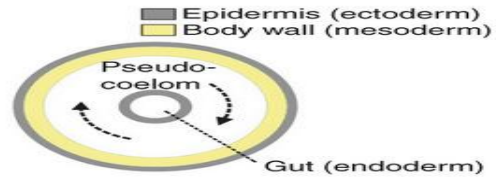


- Mesoderm forms somewhat solid mass of tissue, called *parenchyma*
- No system of internal fluid support
- Oxygen exchange/delivery occurs by diffusion across the skin and gut

e.g., flatworms

Pseudocoelomate

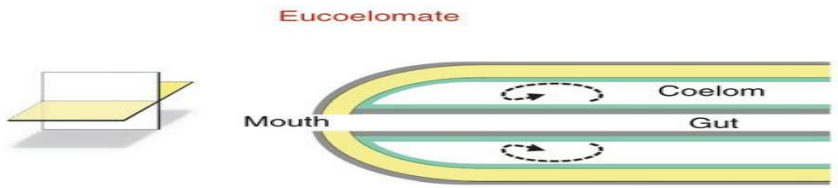


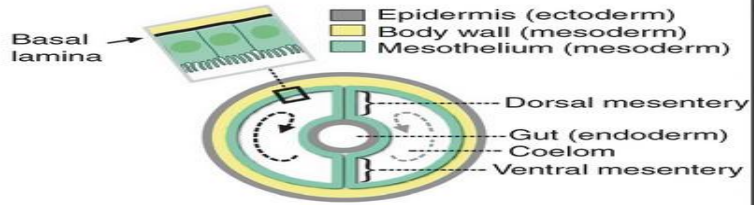


Fluid-filled clefts in mesoderm form a body cavity, termed a *pseudocoelom*

e.g., nematodes

Eucoelomate

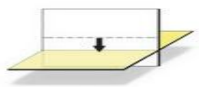


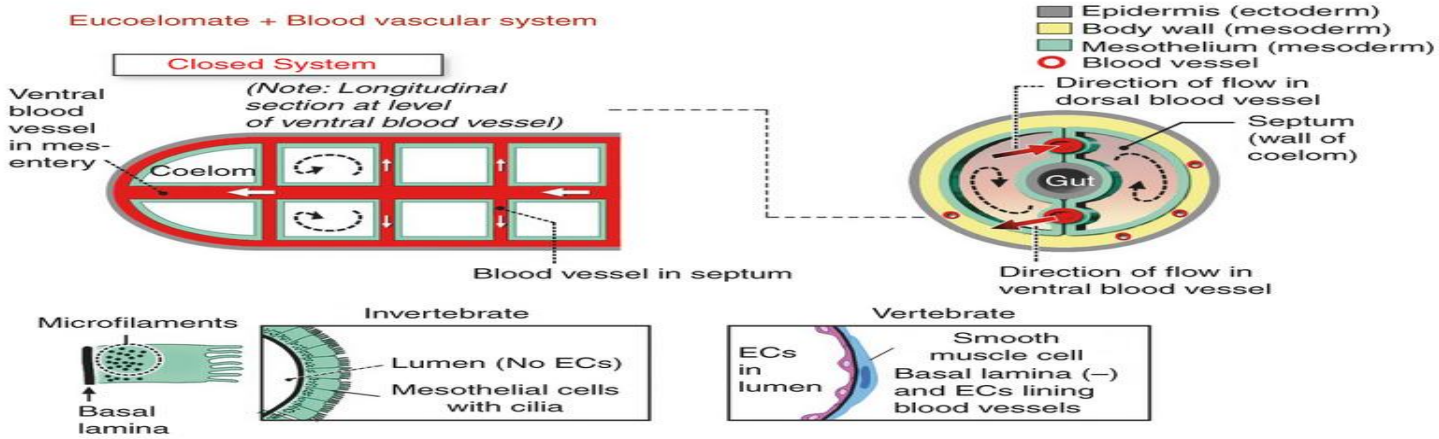


- Fluid-filled body cavity forms within mesoderm, termed the *coelom*
- Coelom is lined by mesoderm-derived epithelium termed *mesothelium*
- The apical surface of the mesothelial cells faces towards the lumen
- The cavity is filled with coelomic fluid and in some cases cells
- No pumping system
- Fluid transport is produced by cilia on the surface of the mesothelial cells, by contraction of mesothelial cells or by contraction of body wall muscle
- Coelom provides convective flow of gases, nutrients and wastes, allows organs to move freely, provides space for organ development, absorbs shock and provides a hydrostatic skeleton essential for certain types of movement

e.g., mollusks, annelids, arthropods, chordates

Eucoelomate + Blood vascular system





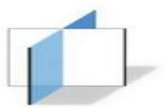
- In most animals, the coelom is subdivided into several compartments by septa and mesenteries
- Owing to compartmentalization, fluid circulation in the coelomic cavities is localised
- Blood vessels form to bypass the septal bulkheads
- Blood transport is produced by contraction of specialized mesothelial cells (termed *myoepithelial cells*) and/or muscular pumps
- The blood vascular systems is used for transport of substances, hydraulic force generation, regulation of heat, ultrafiltration, protection, immune factors/cells and whole-body integration

Closed System

- Blood remains inside distinct channels or chambers, physically separated from the intercellular fluid, body cells and coelom
- In invertebrates, blood vessels consist of a network of spaces in the extracellular matrix, lined by the basal lamina/basement membrane of surrounding epithelial cells
- In vertebrates, blood vessels are lined by endothelium and invested with smooth muscle cells or pericytes
- Blood transport is produced by the pumping action of the blood vessels (most invertebrates) or a chambered heart (cephalopods, vertebrates)

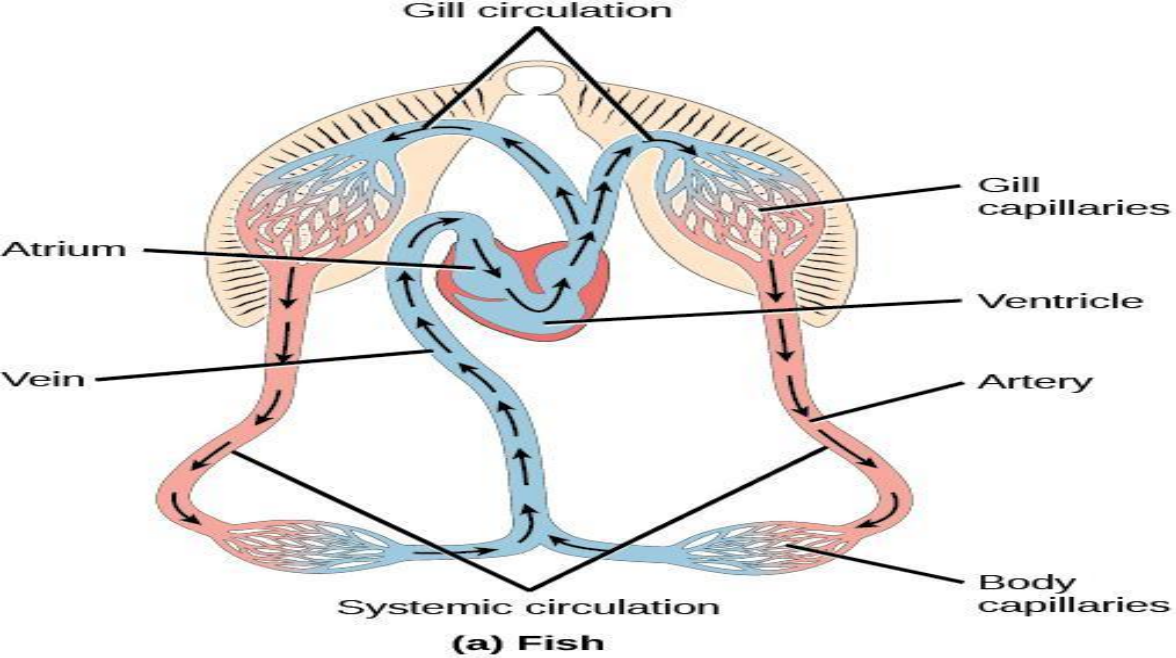
e.g., annelids, cephalopods, chordates

Open System

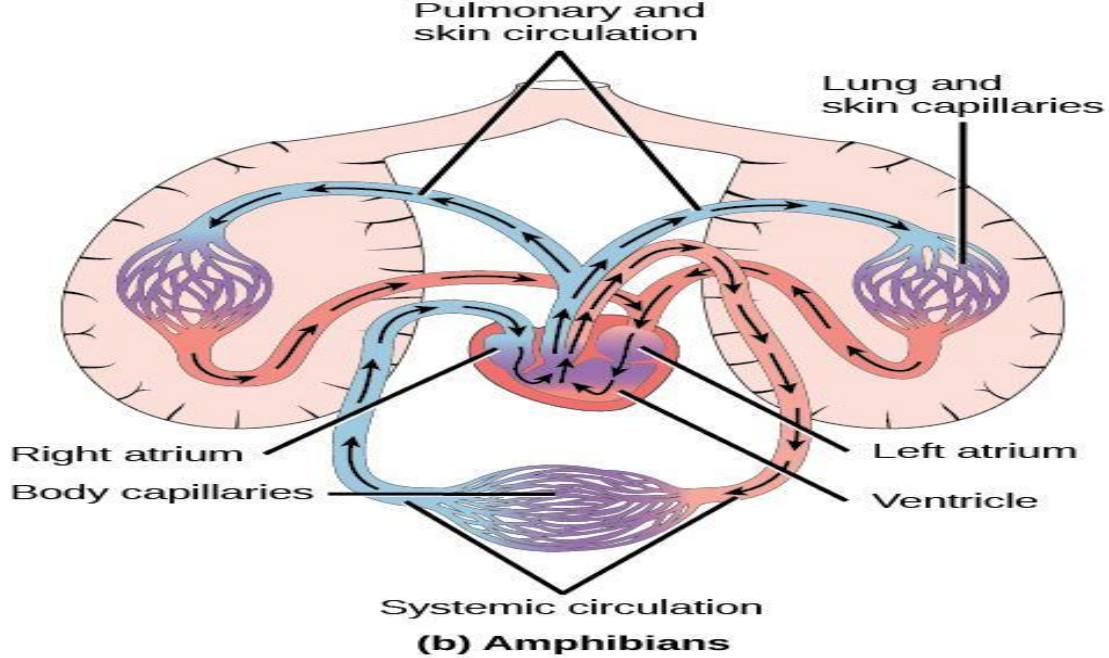


- Coelomic cavities and their cell lining regress in the adult, leaving a body cavity, termed a *hemocoel* (a type of acquired pseudocoelom)
- Hemocoel is bordered not by mesoderm-derived mesothelial cells, but rather by the basal surface of tissue cells
- Blood is propelled from a contractile heart (+/– supply vessels) into the hemocoel, where it directly bathes the organs

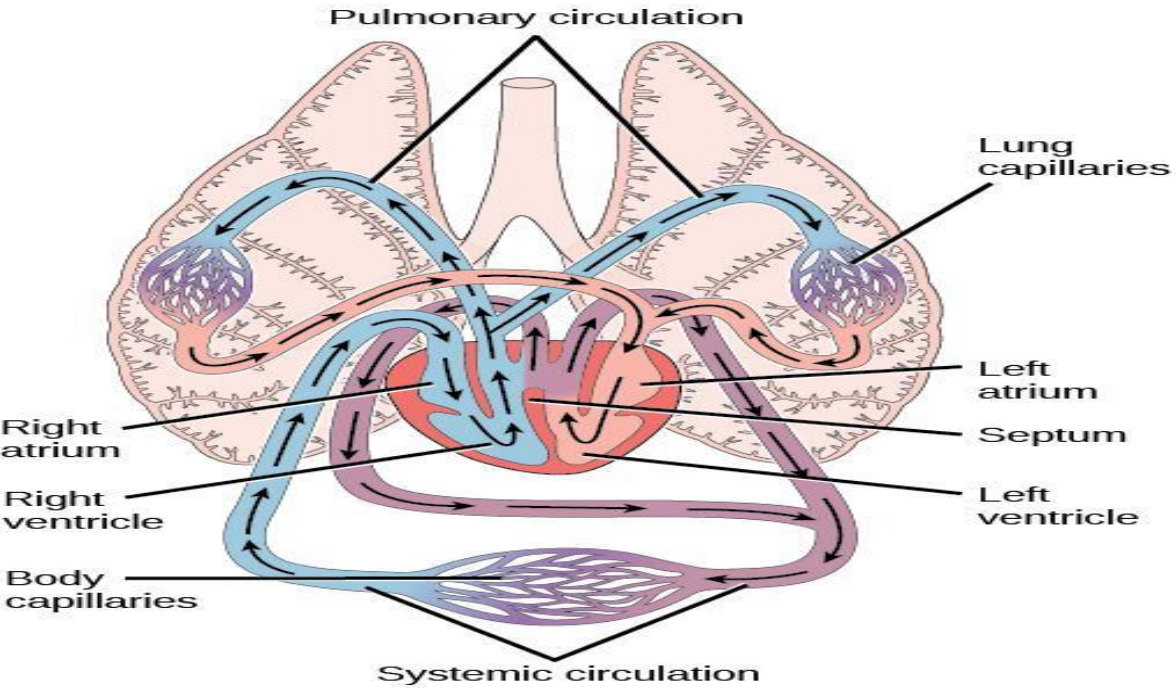
e.g., mollusks (except cephalopods), arthropods



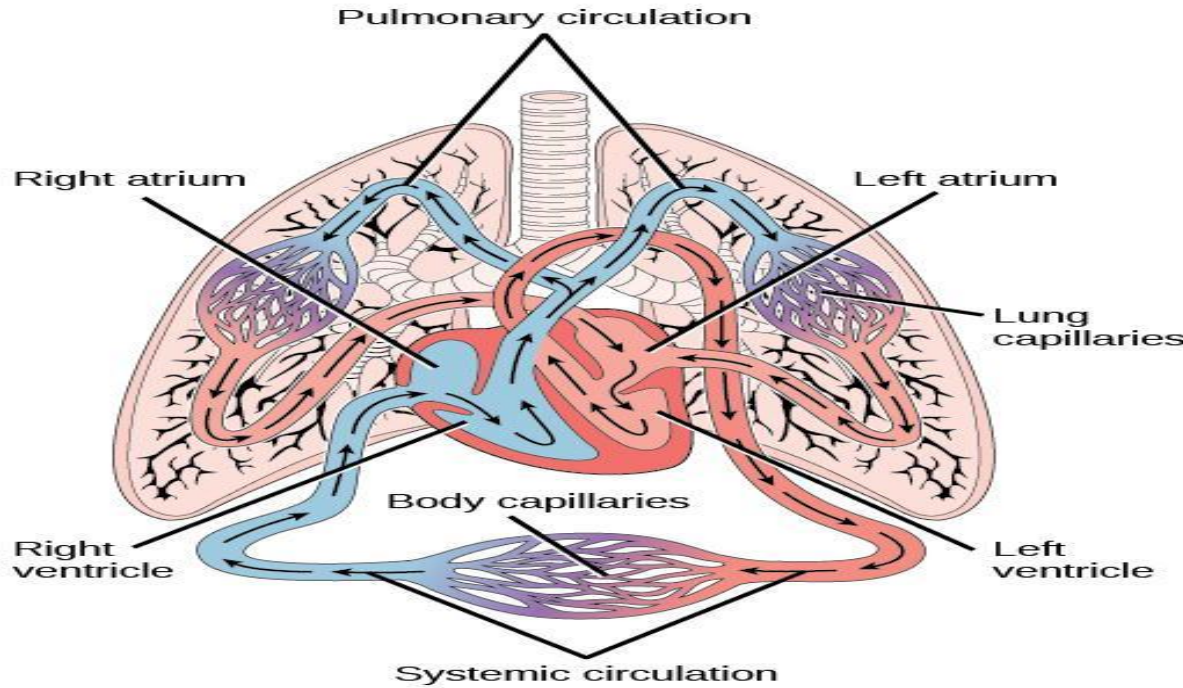
(a) Fish



(b) Amphibians



(c) Reptile

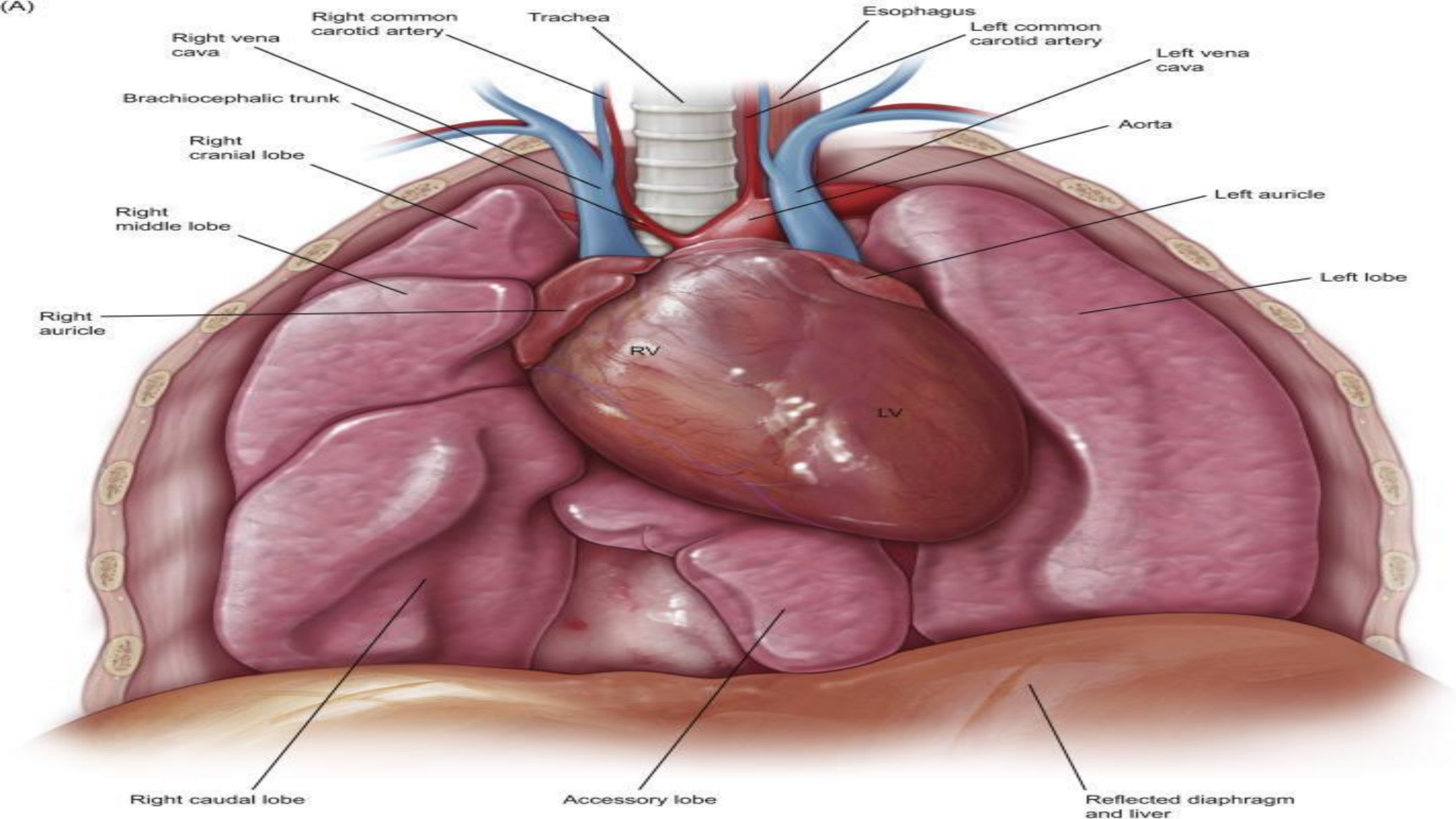


(d) Mammals

Blood vascular system type
None
None
Closed
Open
Closed
Open
Closed circulation
Major propulsive organ
None
None
Multi-chambered heart
Contractile vessels
Single-chambered heart
Contractile vessels
Two-chambered heart
Three-chambered heart
Four-chambered heart
Porifera
Cnidaria
Mollusks (cephalopod)
Mollusks (noncephalopod)
Annelids
Arthropods
Amphioxus
Hagfish
Bony fish
Amphibians
Reptiles
Birds
Mammals
Endothelium
EC HETEROGENEITY
Last common ancestor of vertebrates
First endothelium (540-510 mya)
Protostome deuterostome ancestor
First blood vascular system
(600-700 mya)

Main Components of the Circulatory System

- Heart
- Veins
- Arteries


(A)
Right common carotid artery
Trachea
Esophagus
Right vena cava
Left common carotid artery
Left vena cava
Brachiocephalic trunk
Aorta
Right cranial lobe
Left auricle
Right middle lobe
Left lobe
Right auricle
RV
LV
Right caudal lobe
Accessory lobe
Reflected diaphragm and liver

Parts of the Circulatory System

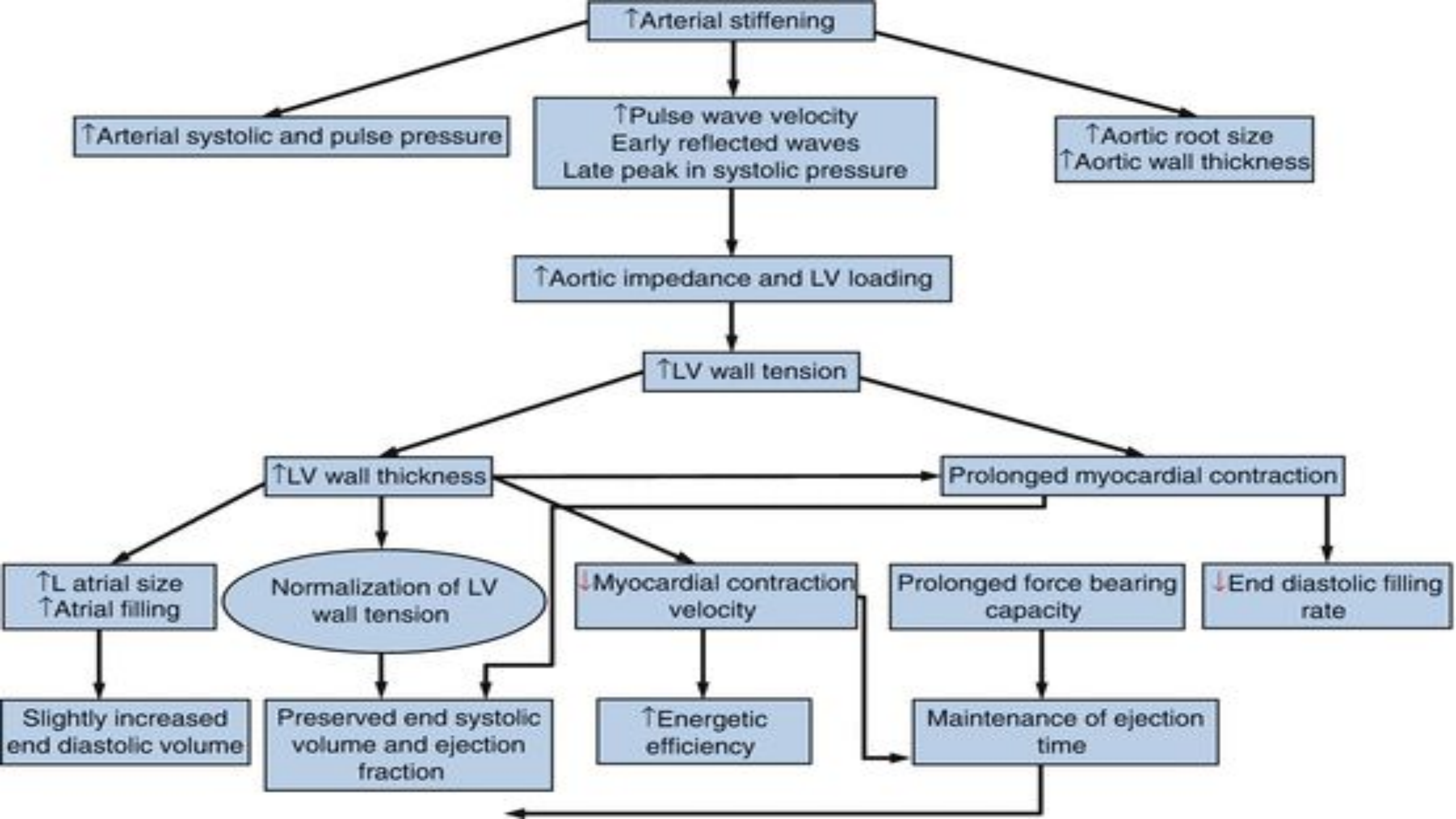
- Veins
  - Carry blood to the heart
- Arteries
  - Carry blood away from the heart

- Pulmonary Veins/Arteries
  - Veins or arteries that connect with the lungs

Heart: Chambers & Valves

- CHAMBERS OF THE HEART
- Right/Left Atrium
  - Upper chambers of the heart where blood is collected
- Right/Left Ventricles
  - Lower chambers of the heart where blood is ejected

- VALVES OF THE HEART
  - Allow blood to flow in one direction. One will not open until the valve before it closes. This is to prevent the blood from flowing backwards.
    - Tricuspid (atrium), Mitral (atrium), Pulmonary(ventricular), Aortic (ventricular)


↑Arterial stiffening
↑Arterial systolic and pulse pressure
↑Pulse wave velocity
Early reflected waves
Late peak in systolic pressure
↑Aortic root size
↑Aortic wall thickness
↑Aortic impedance and LV loading
↑LV wall tension
↑LV wall thickness
Prolonged myocardial contraction
↑L atrial size
↑Atrial filling
Normalization of LV wall tension
↓Myocardial contraction velocity
Prolonged force bearing capacity
↓End diastolic filling rate
Slightly increased end diastolic volume
Preserved end systolic volume and ejection fraction
↑Energetic efficiency
Maintenance of ejection time

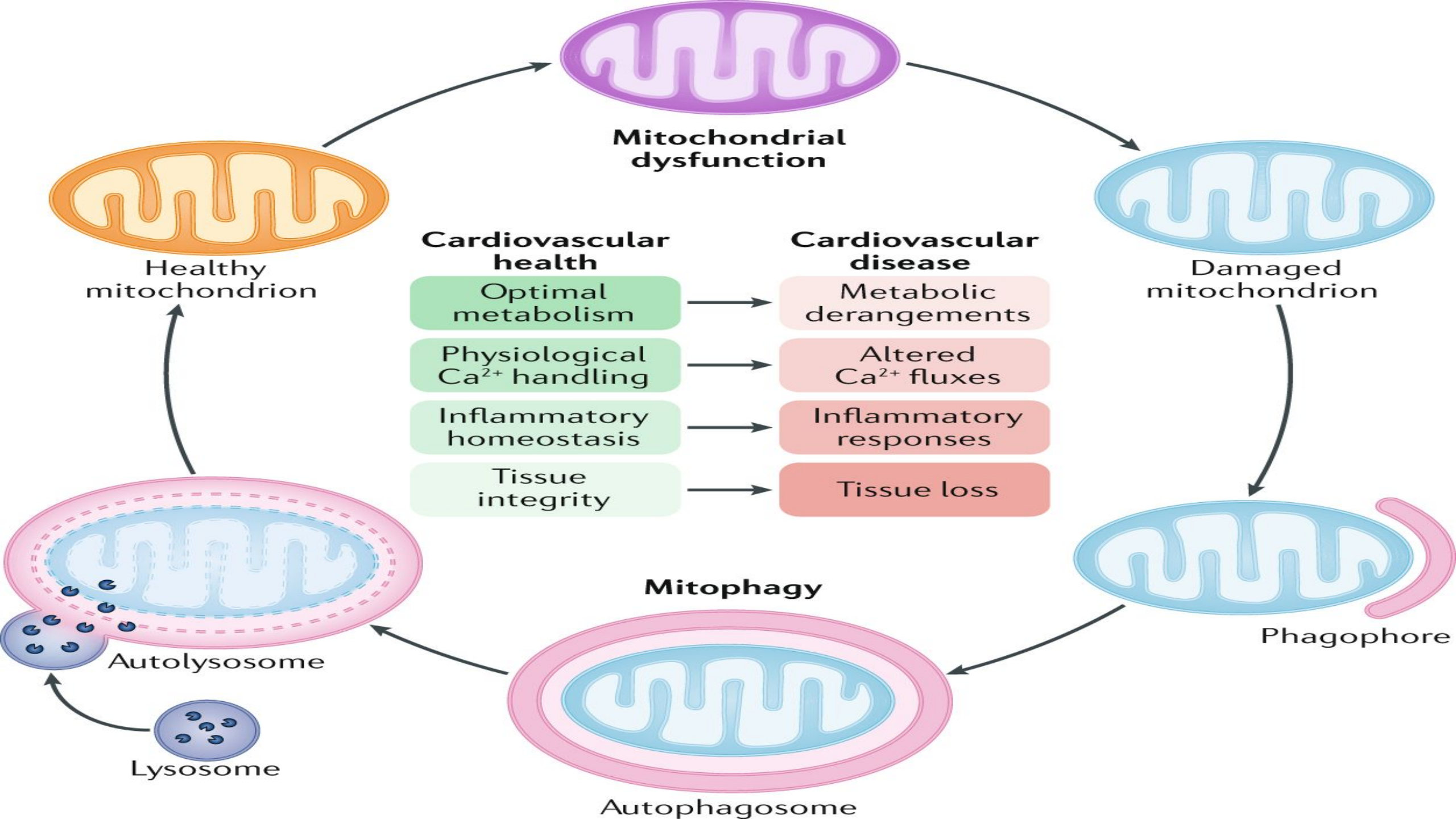
Diseases/Conditions

- Mononucleosis
  - Viral infection resulting in extreme fatigue, swollen glands, and a sore throat
    - Treatment: Adequate bed rest and fluid intake
- Leukemia
  - Extremely high levels of white blood cells, cannot be removed
    - Treatment: Chemotherapy, Radiation Treatment, Bone marrow transplant, Stem cell transplan

Diseases/Conditions (con't)

- Hemophilia
  - Lack of blood-clotting factors in the blood
    - Treatment: No cure(can be tolerated in most cases), Injection, Plasma infusion, infusions of recombinant clotting factors
- Stroke
  - Blood clot in brain leading to blockage of blood vessels
    - Treatment: Removal of obstruction to restore blood flow, injection of clot-breaking drug into vein to release clot and restore blood flow
- Heart Attack
  - Stoppage of blood flow to the heart
    - Treatment: Nitroglycerin if available (dilates veins and arteries to help blood flow), Aspirin (inhibits blood-clotting), CPR if victim is unconscious


Causes of Heart Disease
Ageing
As people age their cardiovascular system becomes weaker
Diet
Food rich in fat, salt and sugar, as well as food containing alcohol, increases the risk of angiosclerosis and can cause high blood pressure
Genetics
People who have direct family members that have had heart disease are at a higher risk of developing it themselves
Diabetes
Hypertension and blood glucose can lead to angiosclerosis and damage to tunica intima
Lifestyle
Aspects of everyday life, from work stress to lack of exercise and tension can increase the risk of heart disease
Smoking
Nicotine and carbon monoxide increase the heart rate, lower the oxygen level in heart muscles and can cause thrombosis
Gender
Men are 3 to 5 times more likely to develop heart diseases than women


Mitochondrial dysfunction
Healthy mitochondrion
Damaged mitochondrion
Cardiovascular health
Cardiovascular disease
Optimal metabolism
Metabolic derangements
Physiological Ca^{2+} handling
Altered Ca^{2+} fluxes
Inflammatory homeostasis
Inflammatory responses
Tissue integrity
Tissue loss
Mitophagy
Phagophore
Autolysosome
Lysosome
Autophagosome

Thank You!