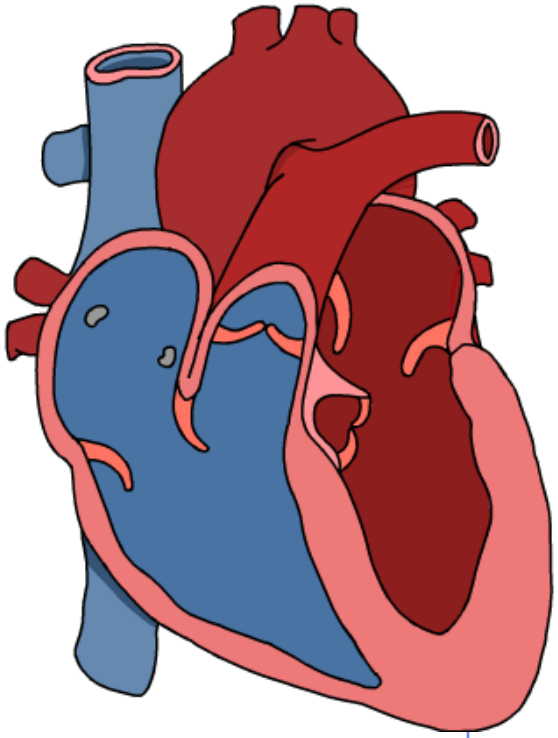
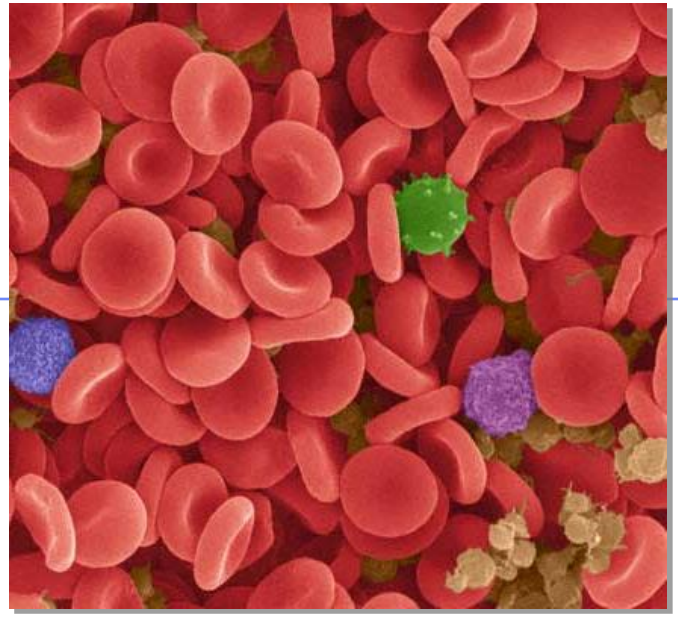
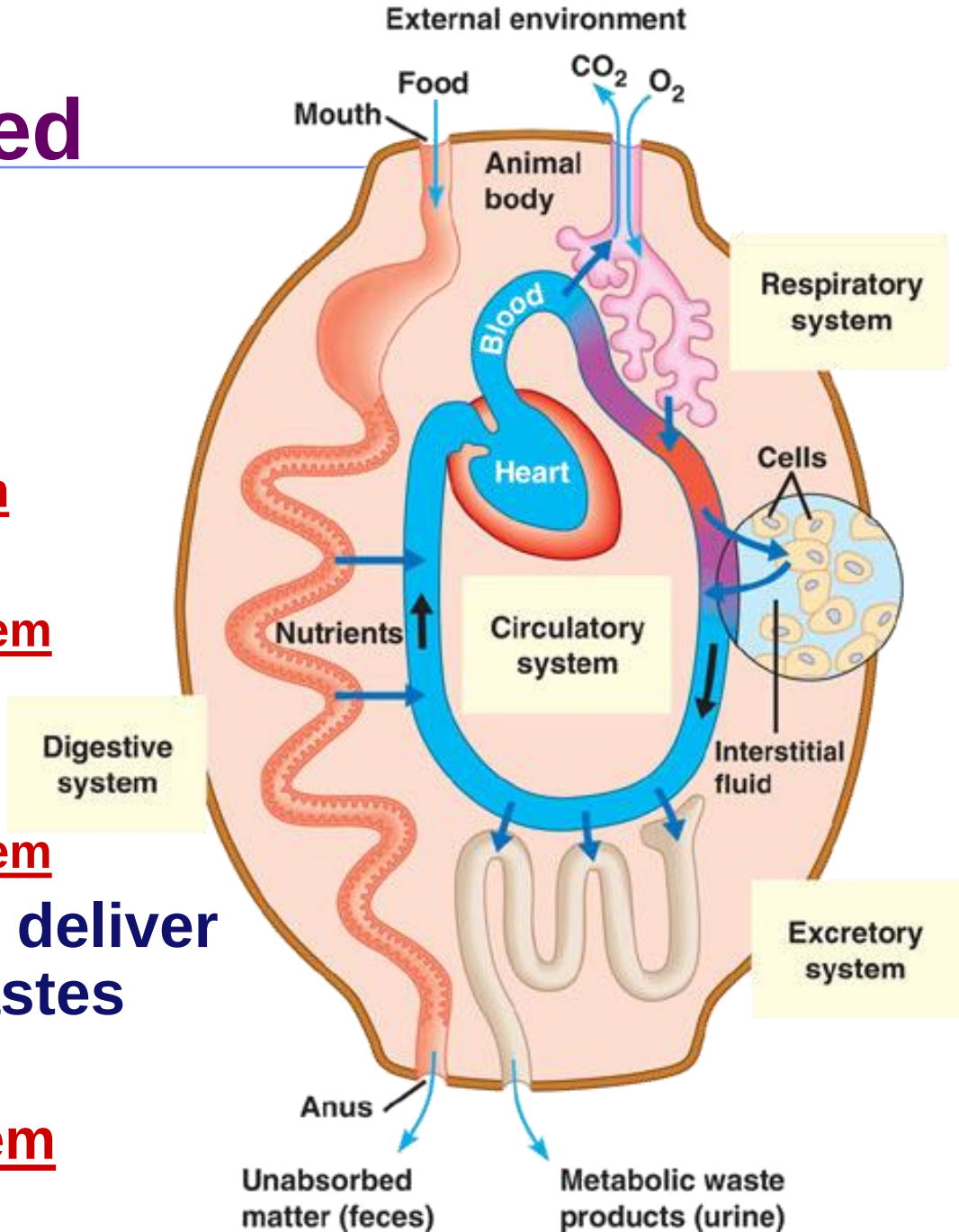


Circulatory System in Animals



Feeding the Need for Energy

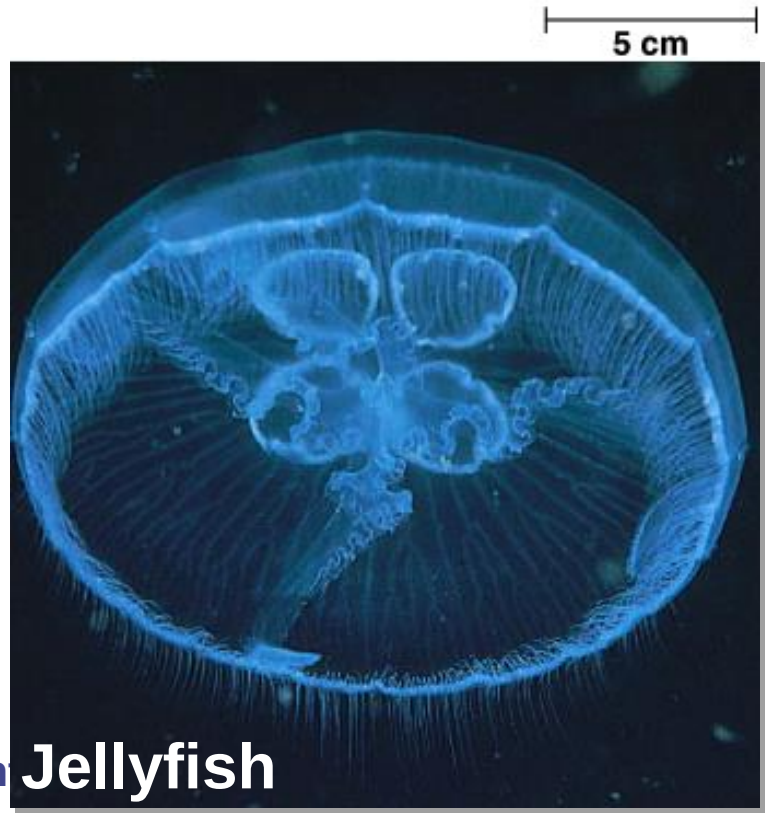
- Supplies in
  - fuel (sugars)
    - digestive system
  - oxygen
    - respiratory system
- Waste out
  - CO_2
    - respiratory system
- Need to pick up & deliver the supplies & wastes around the body
  - circulatory system

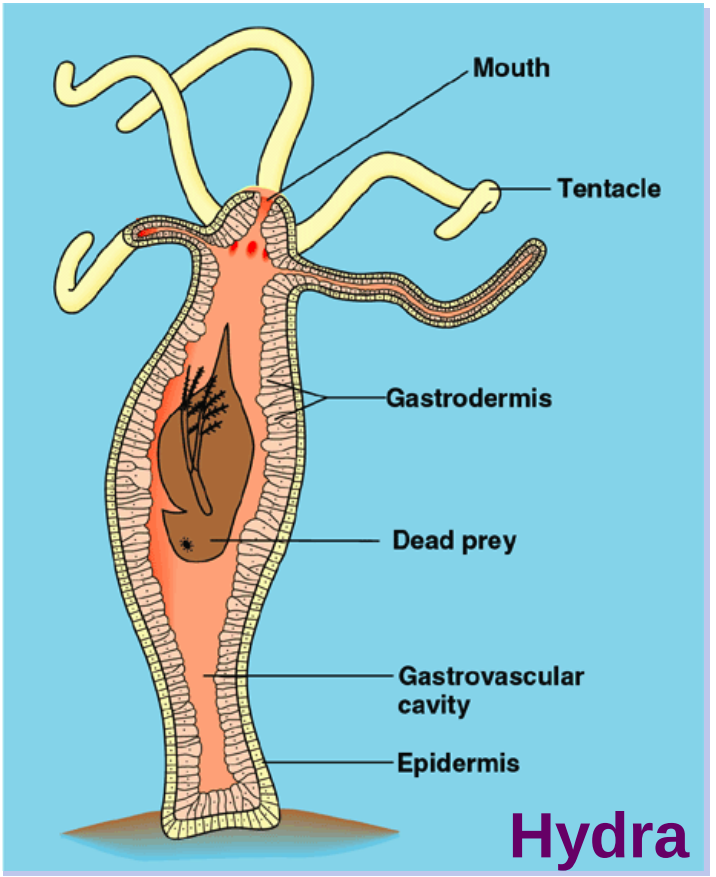


Simpler organisms

When your body is only 2-cell layers thick, you can get supplies in and waste out just through diffusion

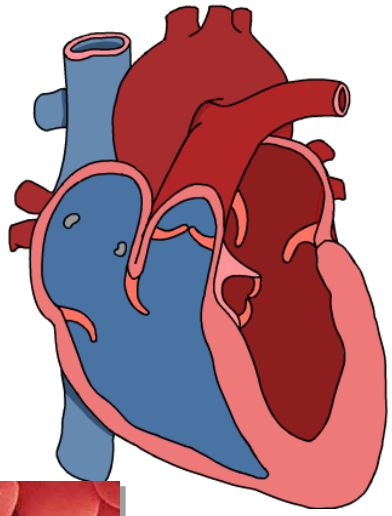
- all cells within easy reach of fluid

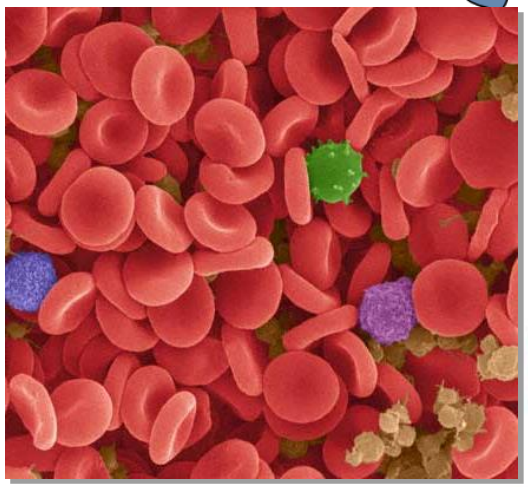


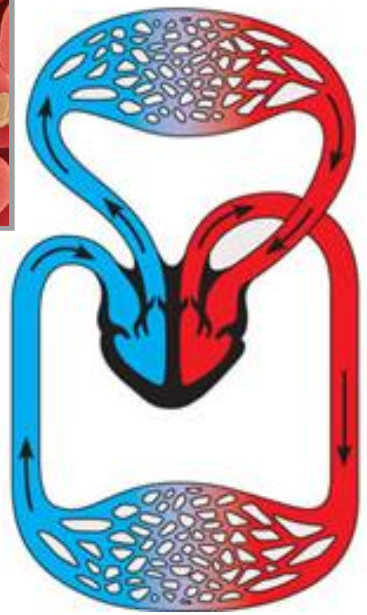


Circulatory system

- Made up of 3 parts
  - organ
    - heart
  - tissues & cells
    - blood
      - red blood cells
    - blood vessels (vascular system)
      - arteries
      - veins
      - capillaries



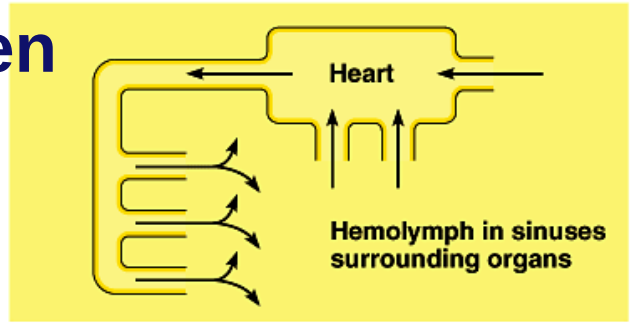




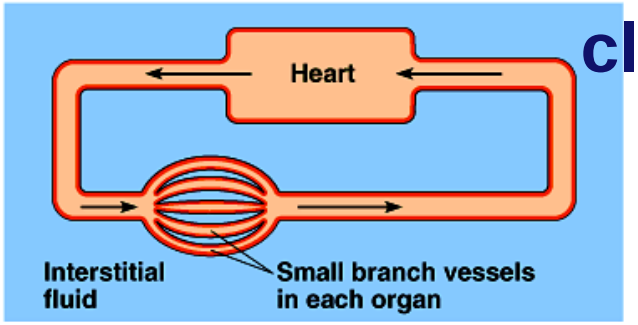
Circulatory systems

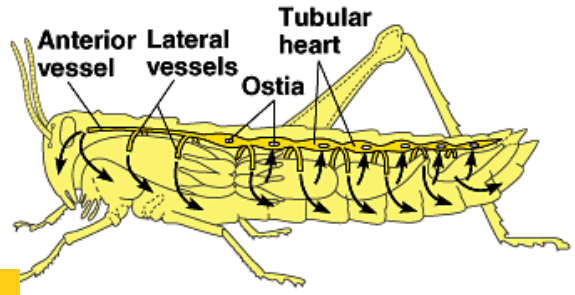
- All animals have:
  - muscular pump = heart
  - tubes = blood vessels
  - circulatory fluid = "blood"

open

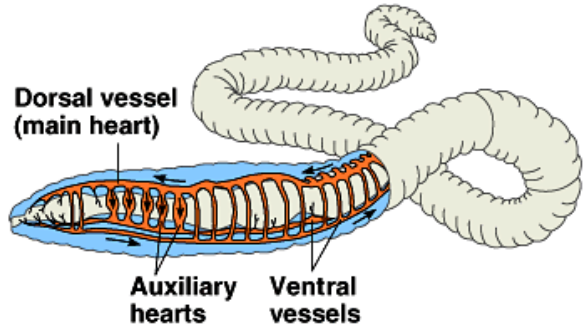


closed





(a) Open circulatory system



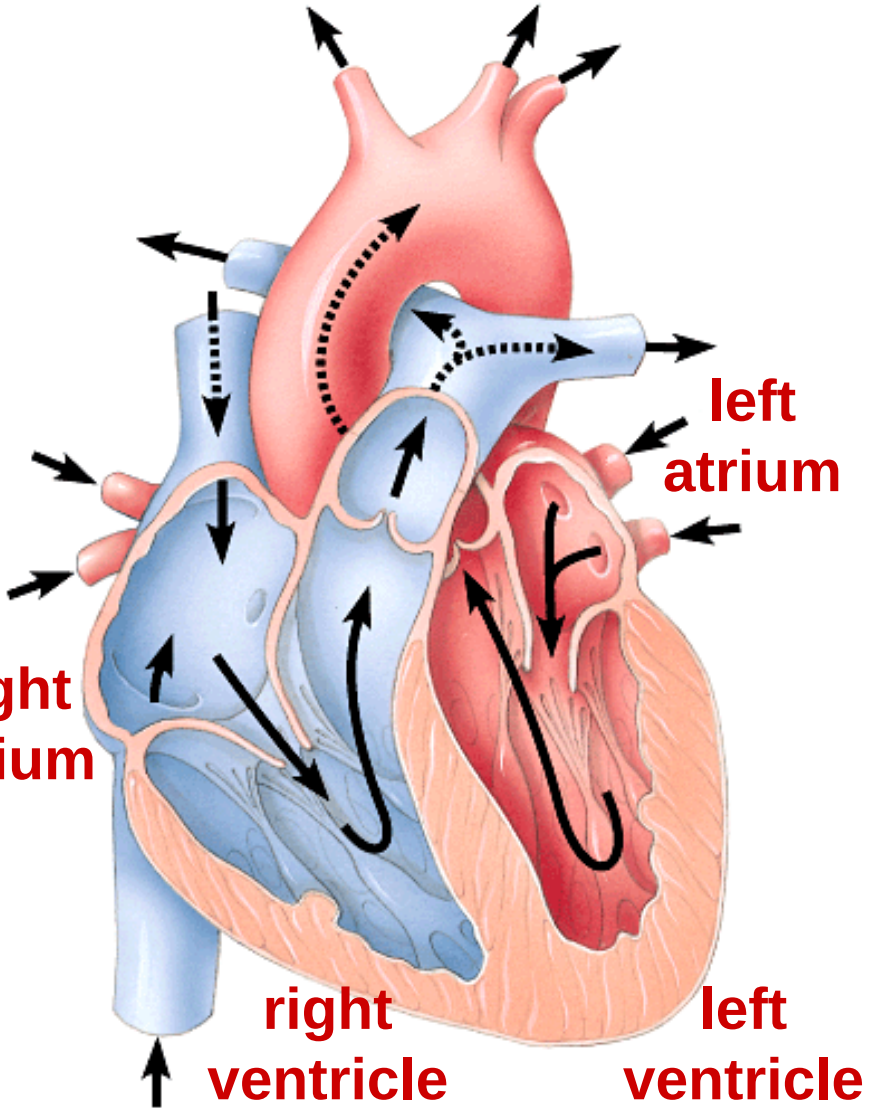
(b) Closed circulatory system

hemolymph

blood

Vertebrate Heart

- 4-Chambered heart
  - atria (atrium)
    - thin wall
    - collection chamber
    - receive blood
  - ventricles
    - thick wall pump
    - pump blood out



Evolution of circulatory system

Not everyone has a 4-chambered heart

fish

2 chamber

amphibian

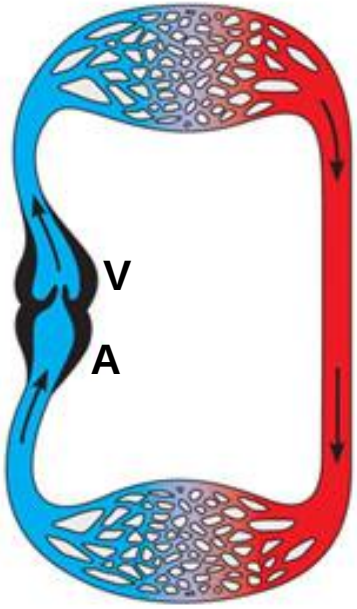
3 chamber

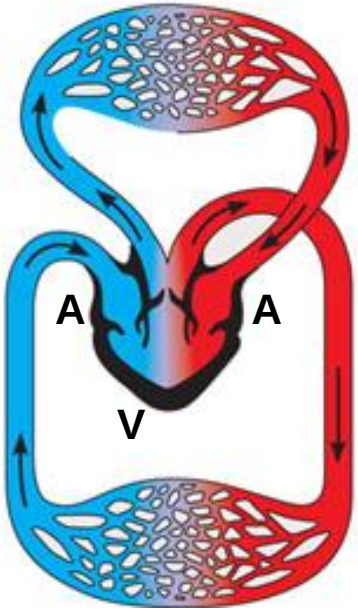
reptiles

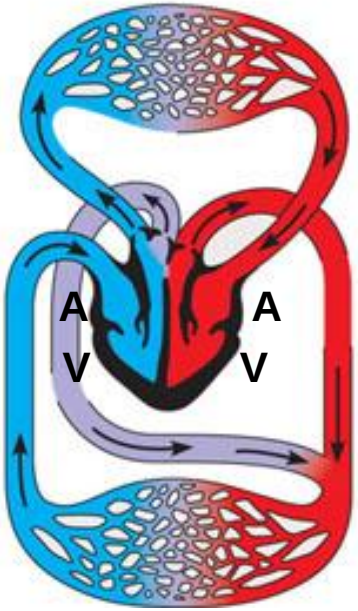
3 chamber

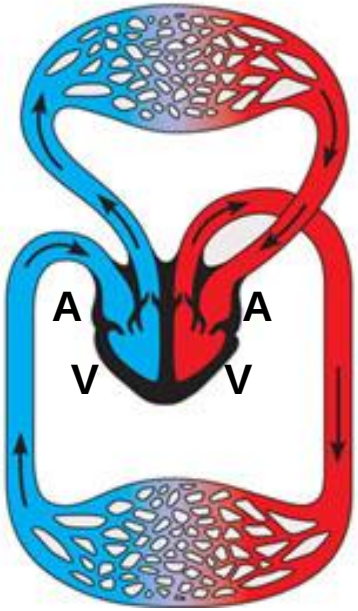
birds & mammals

4 chamber



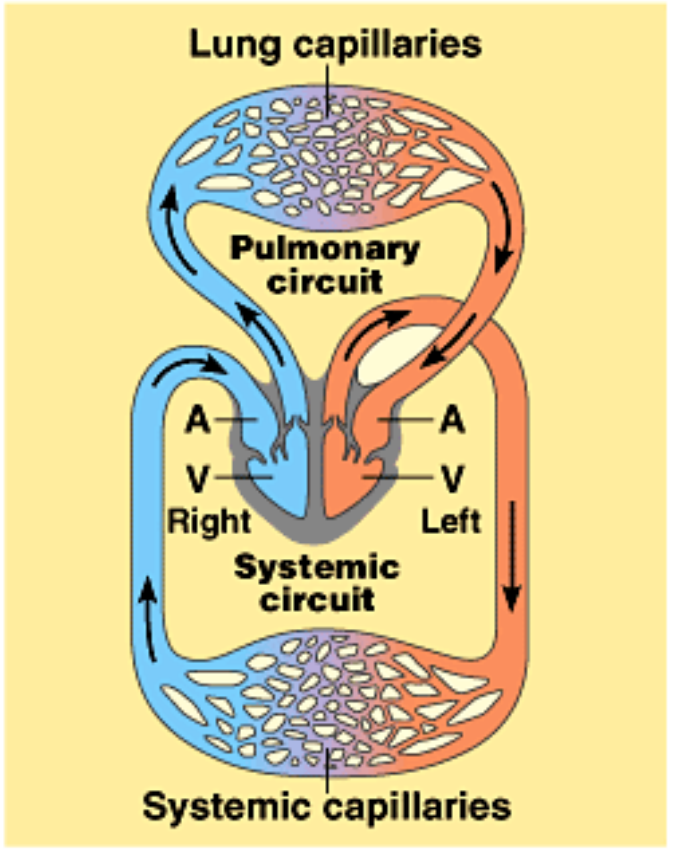




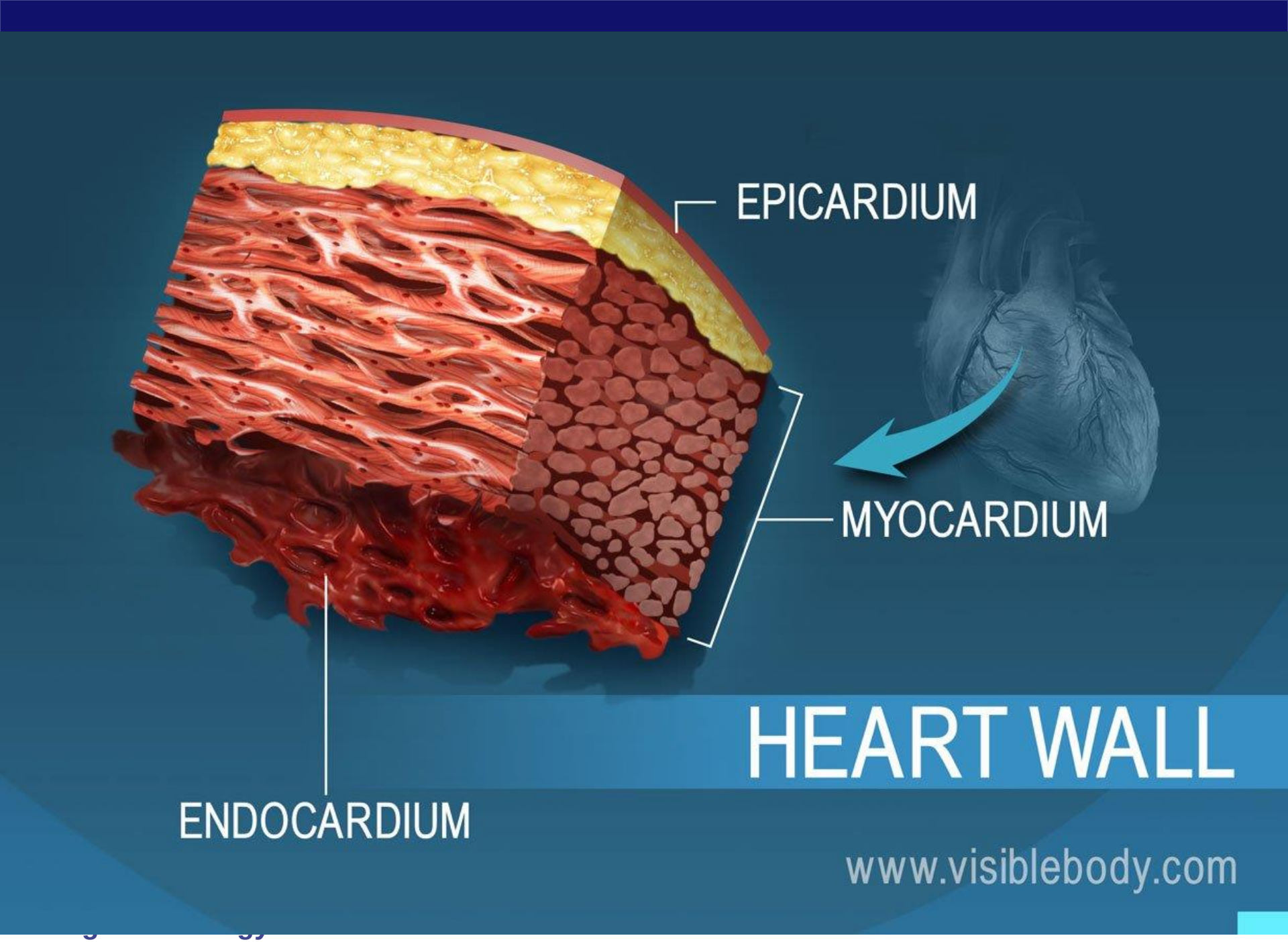


Evolution of circulatory systems

- What advantage was a 4-chambered heart
  - increase body size
  - fuel warm-blooded
  - enable flight
- Higher energy needs
  - greater need for energy, fuel, O_2, waste removal
    - warm-blooded animals & flying need 10x energy
    - need to deliver 10x fuel & O_2

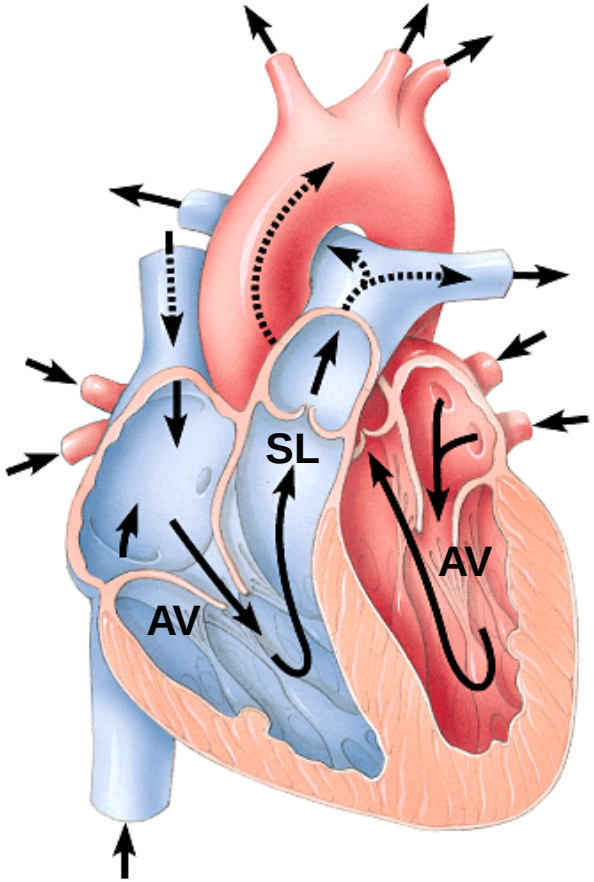


convergent evolution


EPICARDIUM
MYOCARDIUM
ENDOCARDIUM
HEART WALL
www.visiblebody.com

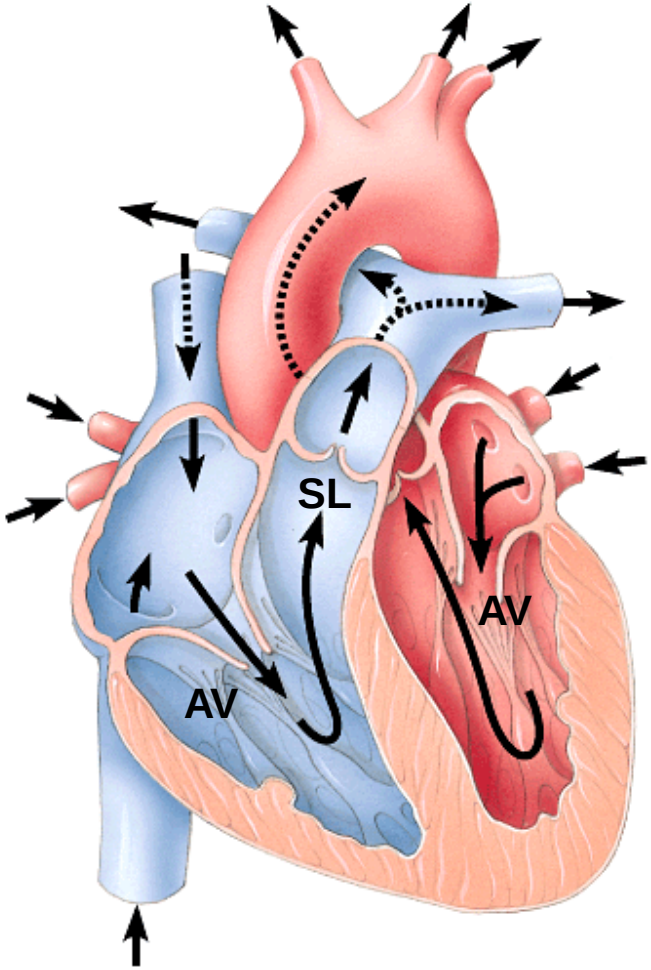
Heart valves

- 4 valves in the heart
  - flaps of connective tissue
  - prevent backflow
- Atrioventricular (AV) valve
  - between atrium & ventricle
  - keeps blood from flowing back into atria when ventricles pump
  - “lub”
- Semilunar valves
  - between ventricle & arteries
  - prevent backflow from arteries into ventricles
  - “dub”



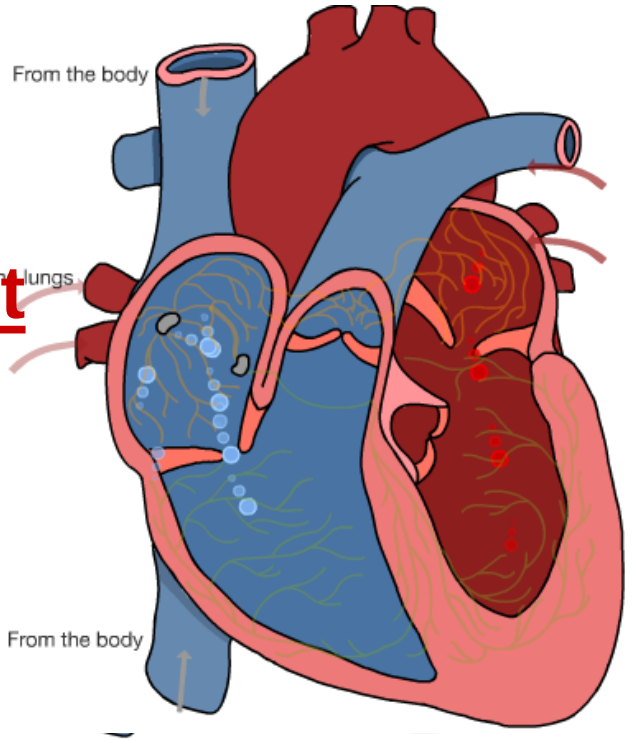
Lub-dub, lub-dub

- Heart sounds
  - closing of valves
  - "Lub"
    - force blood against closed AV valves
  - "Dub"
    - force of blood against semilunar valves
- Heart murmur
  - leaking valve causes hissing sound
  - blood squirts backward through valve

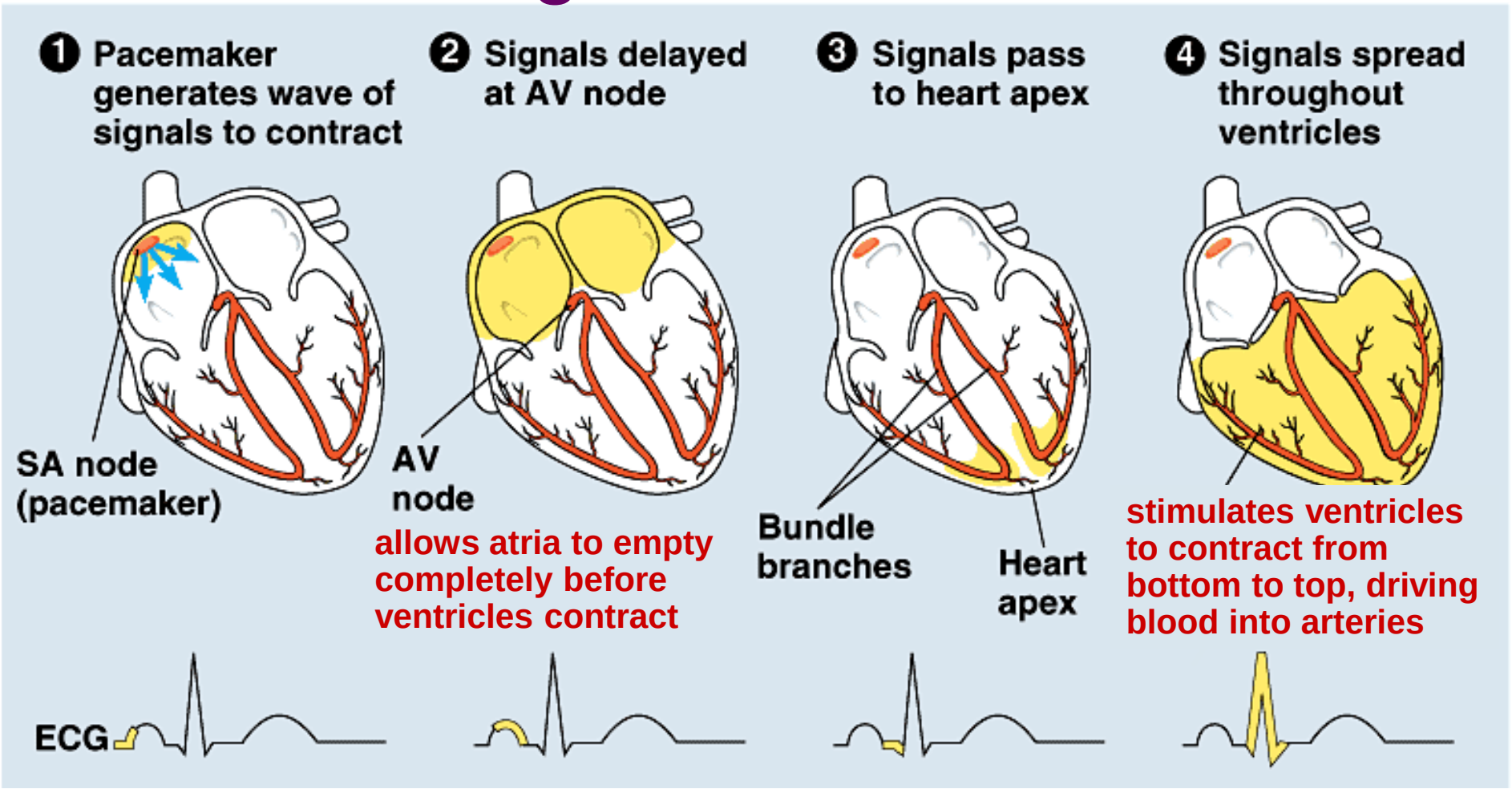


Cardiac cycle

- 1 complete sequence of pumping
  - heart contracts & pumps
  - heart relaxes & chambers fill
  - contraction phase
    - systole
    - ventricles pumps blood out
  - relaxation phase
    - diastole
    - atria refill with blood



Electrical signals



- heart pumping controlled by electrical impulses
- signal also transmitted to skin = EKG

Cardiac Cycle

How is this reflected in blood pressure measurements?

systolic

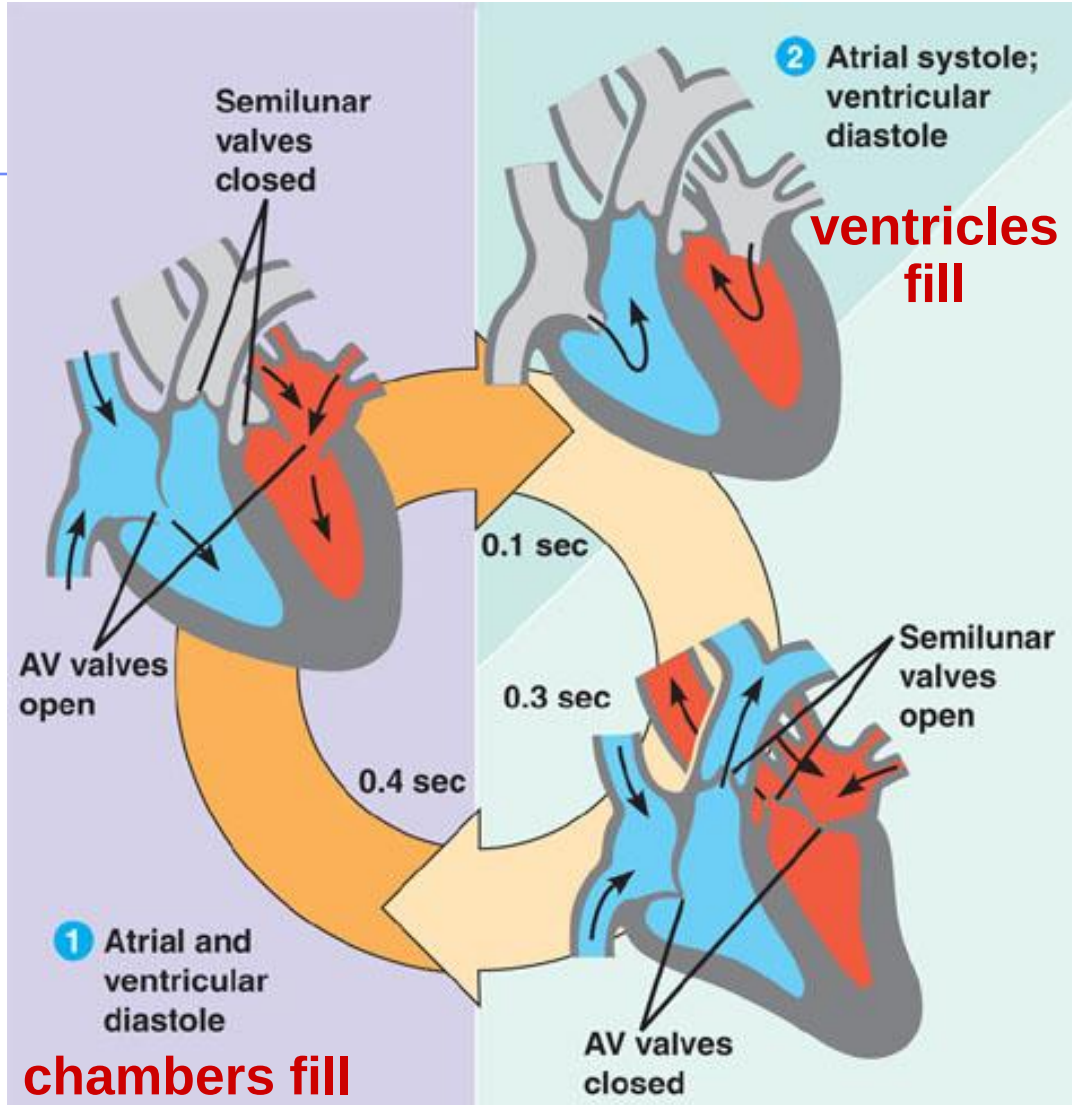
---

diastolic

pump (peak pressure)

---

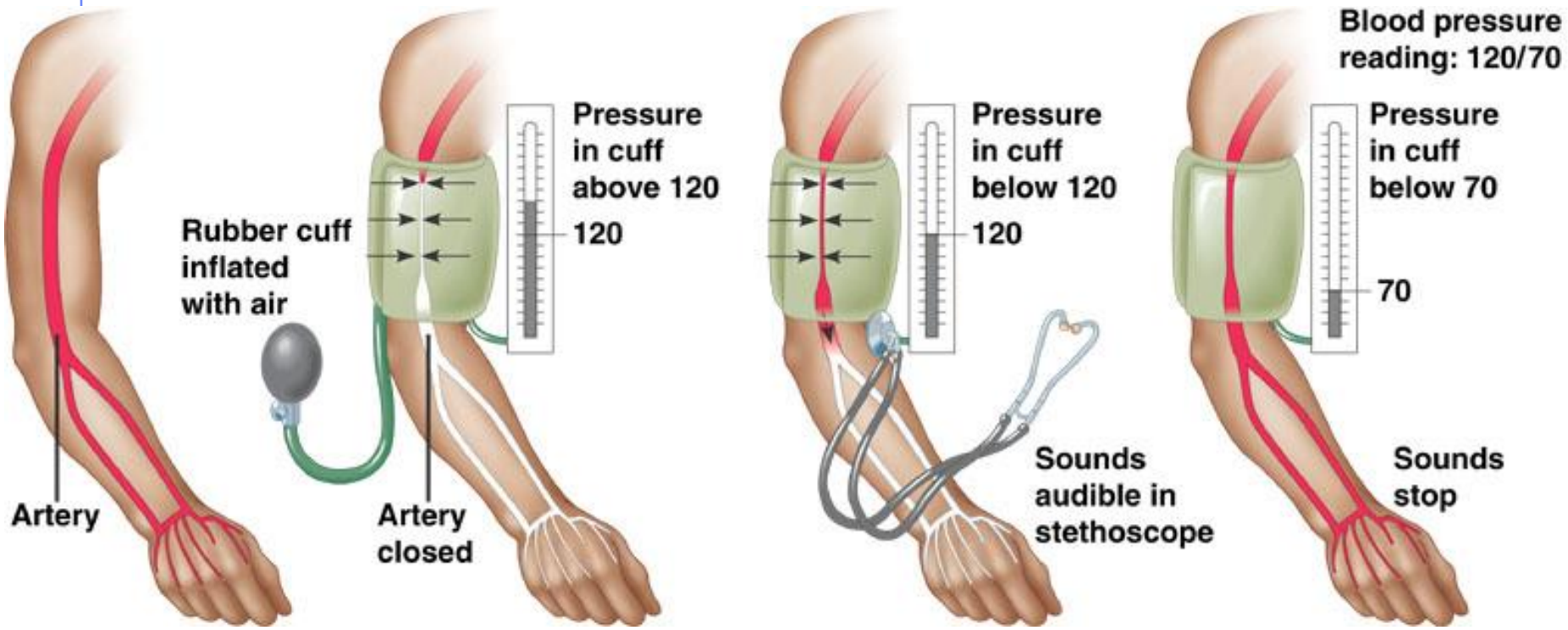
fill (minimum pressure)



110

80

Measurement of blood pressure

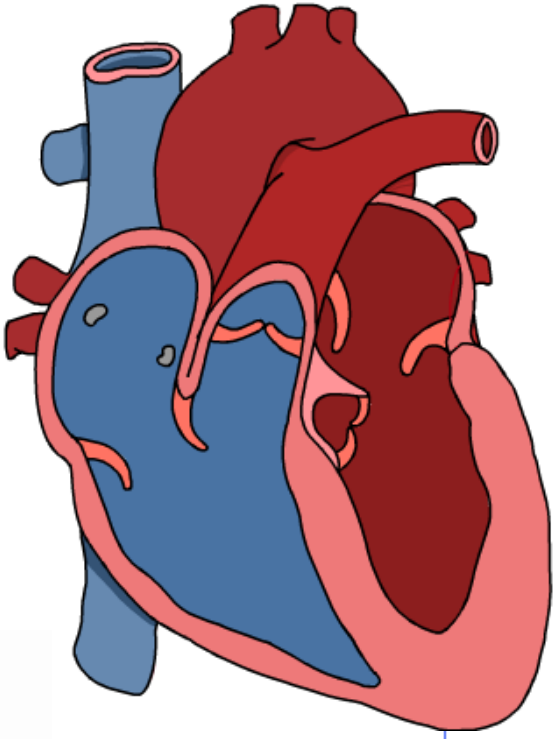


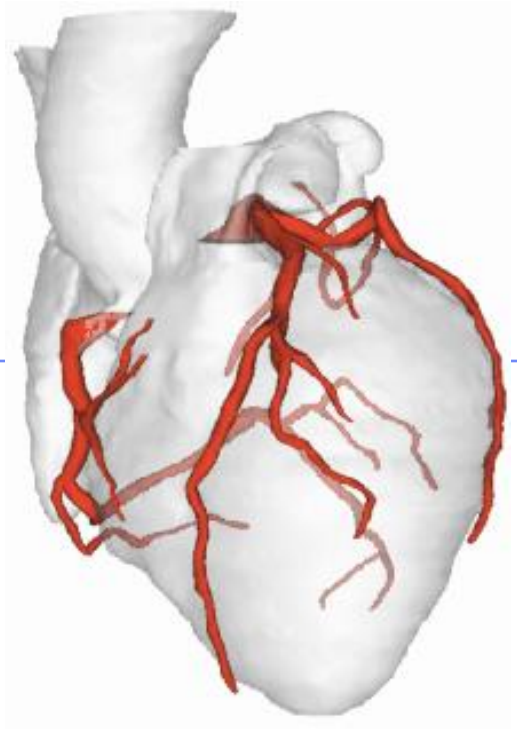
hypertension =
(high blood pressure)

if systolic > 150
or
if diastolic > 90

Any Questions??

Circulatory System
Blood Vessels





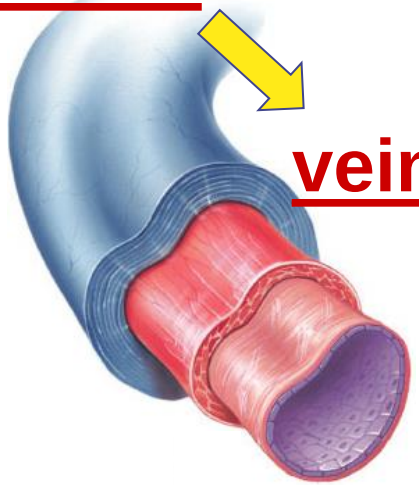
Blood vessels

arteries

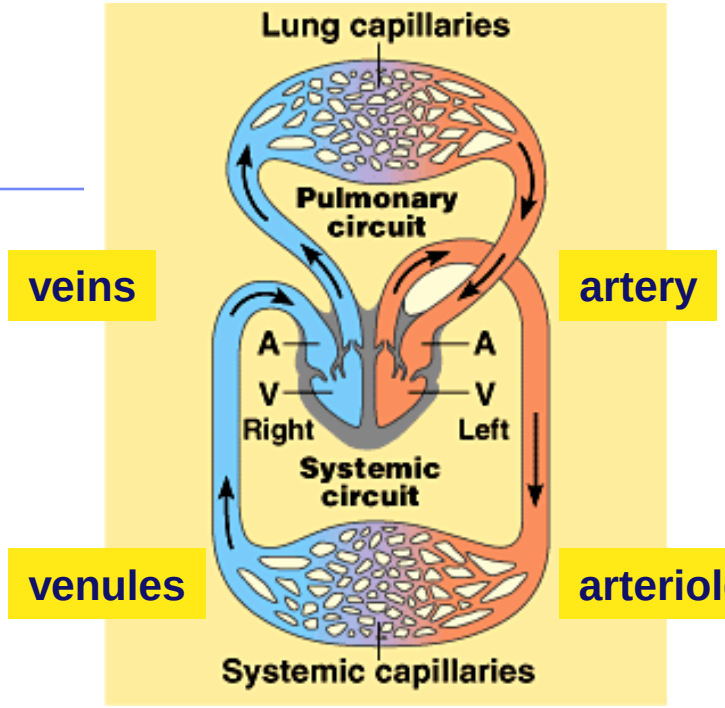
arterioles

capillaries

venules

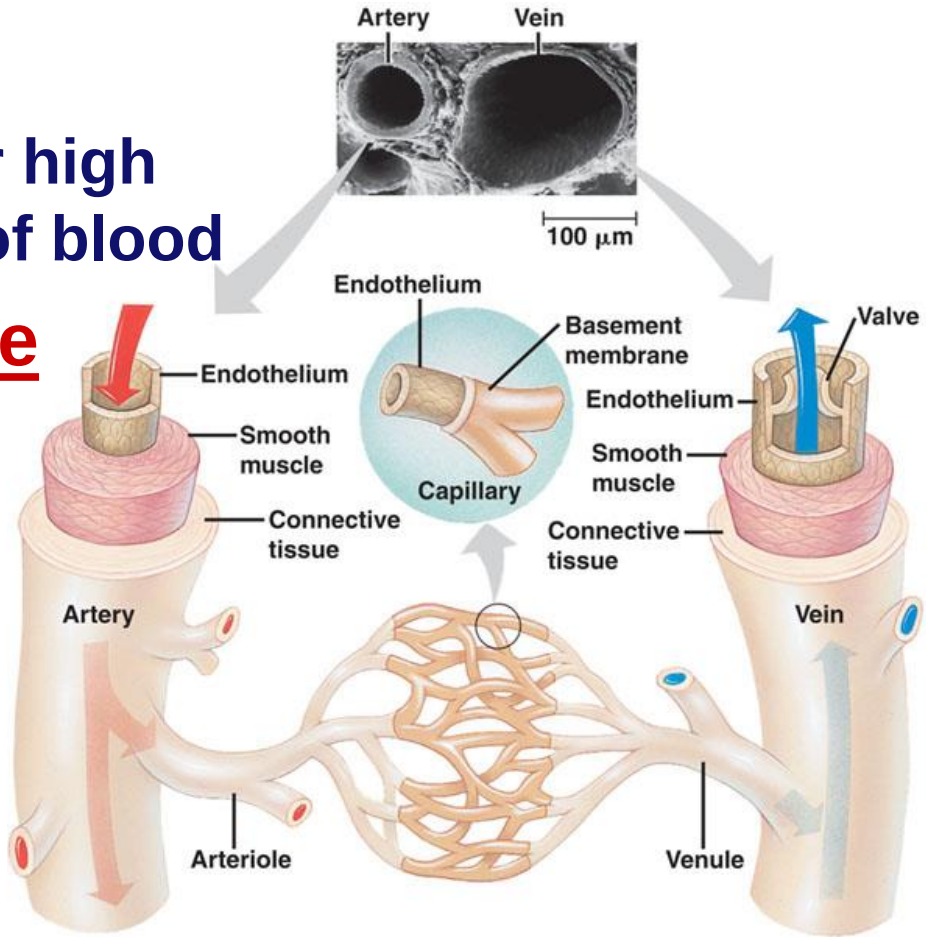


veins



Arteries: Built for their job

- **Arteries**
  - **blood flows away from heart**
  - **thicker walls**
    - provide strength for high pressure pumping of blood
  - **elastic & stretchable**
    - maintains blood pressure even when heart relaxes



Major arteries

aorta

carotid = to head

to brain & left arm

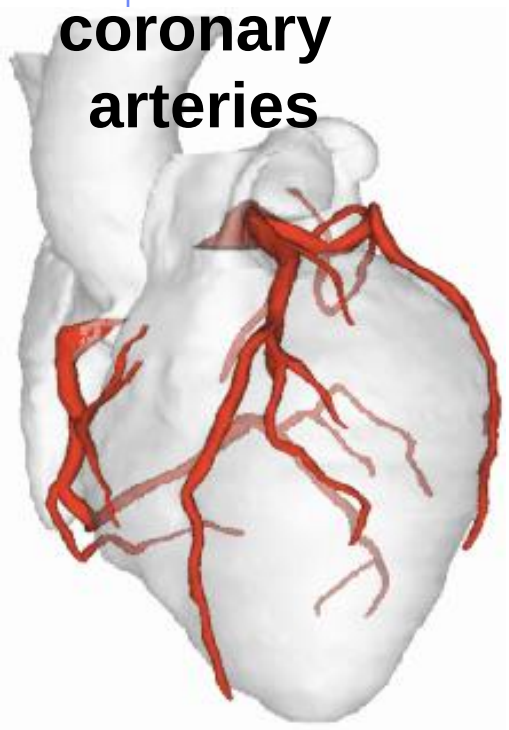
to right arm

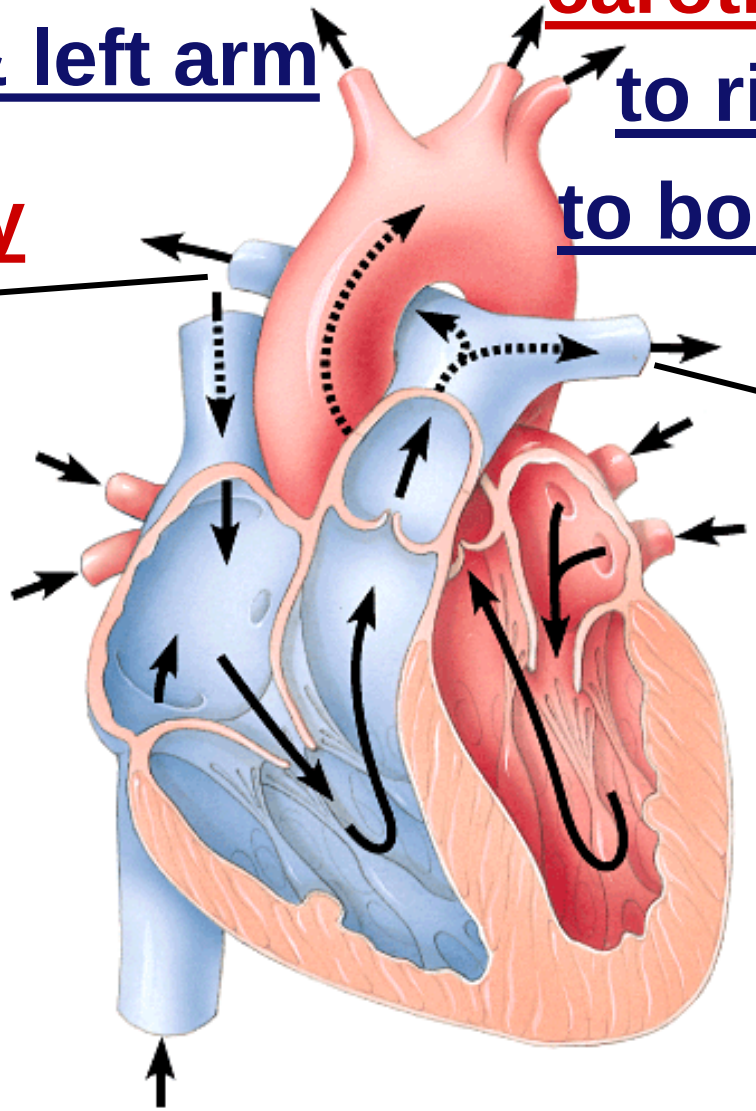
pulmonary artery

to body

pulmonary artery = to lungs

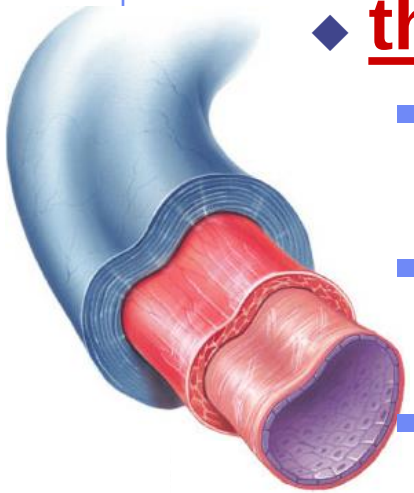
coronary arteries

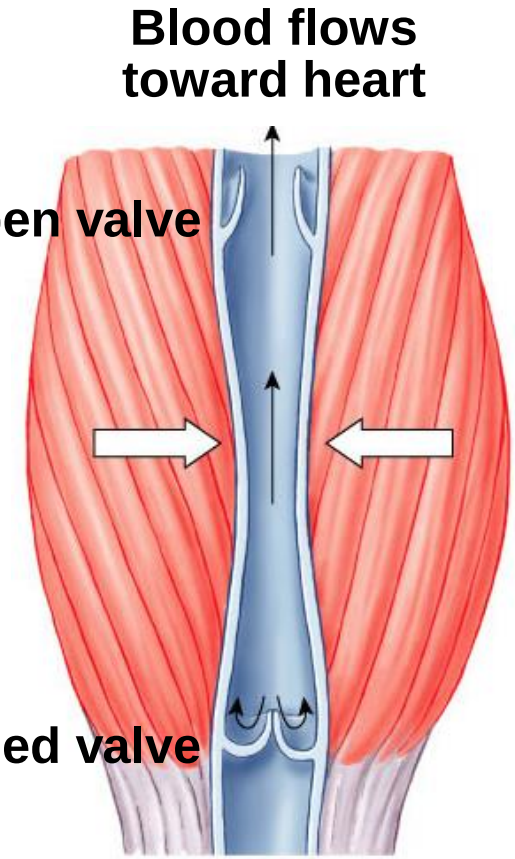




Veins: Built for their job

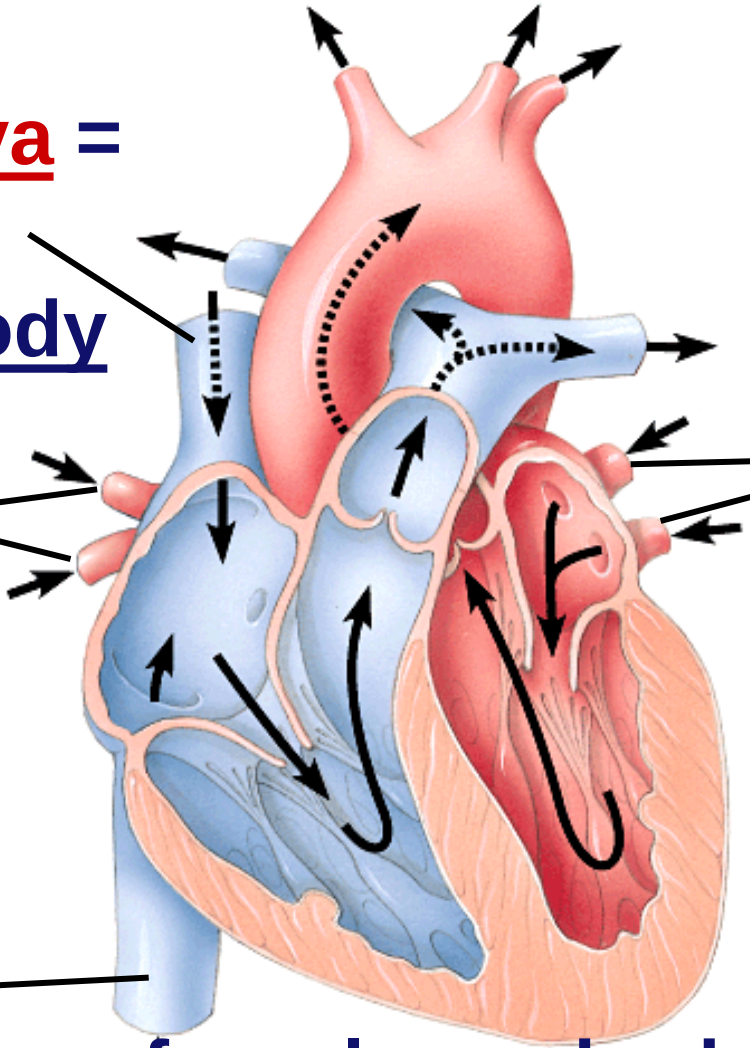
- **Veins**
  - **blood returns back to heart**
  - **thinner-walled**
    - blood travels back to heart at low speed & pressure
    - why low pressure?
      - far from heart
    - **blood flows because muscles contract when we move**
      - **squeeze blood through veins**
  - **valves in large veins**
    - in larger veins **one-way valves** allow blood to flow only toward heart





Major Veins

superior vena cava = from upper body



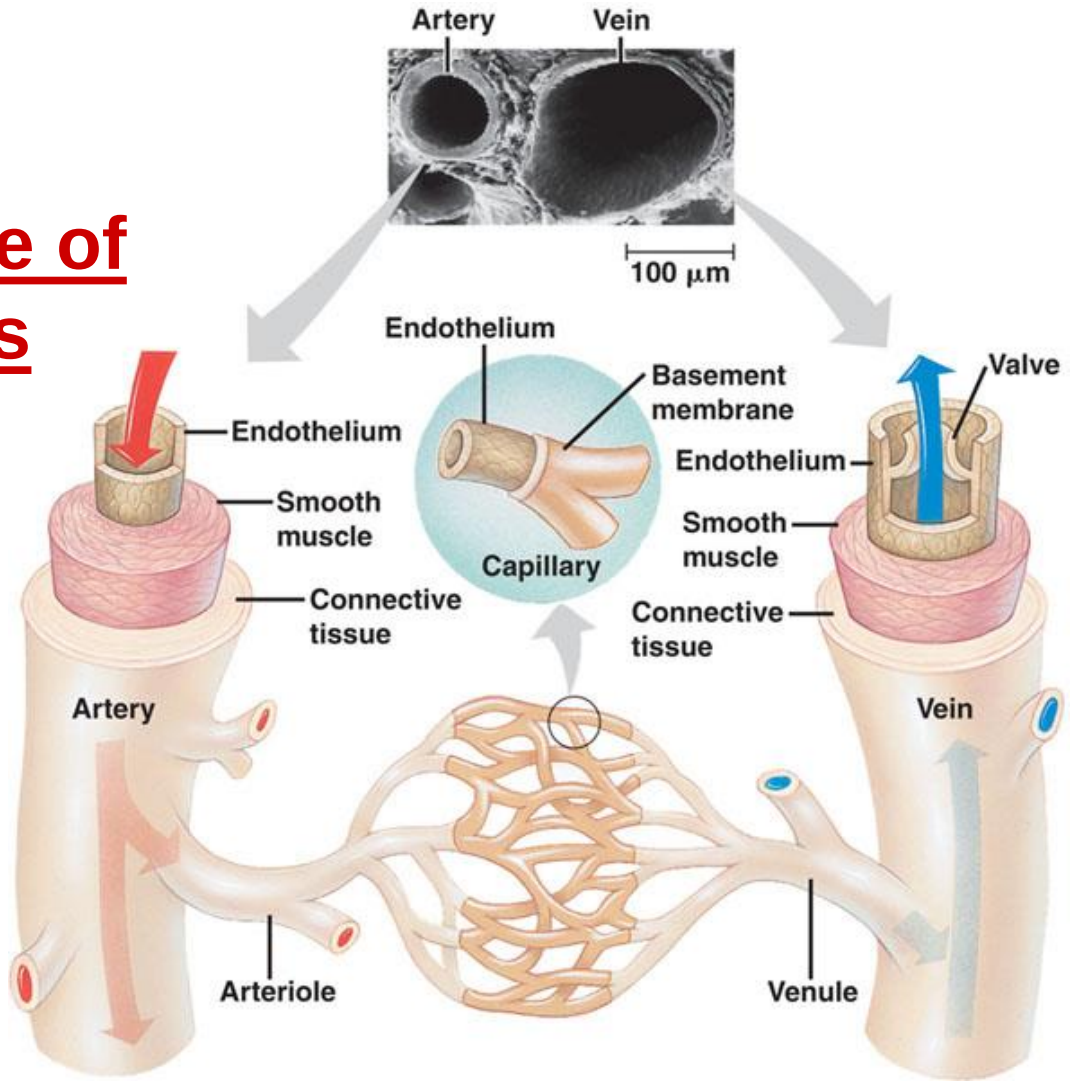
pulmonary vein = from lung

pulmonary vein = from lung

inferior vena cava = from lower body

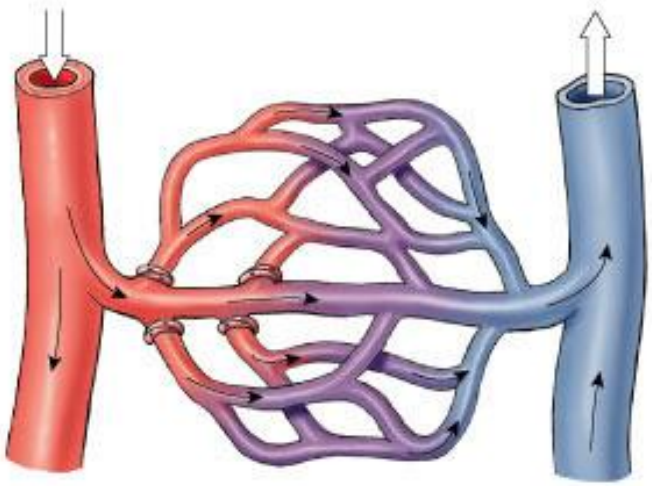
Structure-function relationship

- **Capillaries**
  - **very thin walls**
  - **allows exchange of materials across capillary**

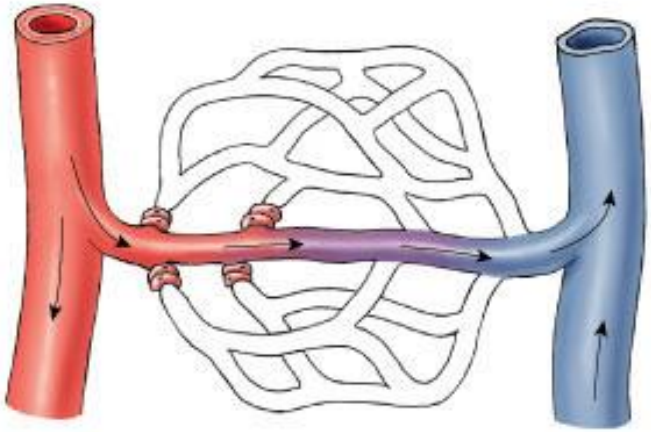


Controlling blood flow to tissues

- **Capillary function**
  - **exchange between blood & tissues**
    - **O_2, CO_2, H_2O, food, waste**
  - **blood flow in capillaries controlled by pre-capillary sphincter valves**



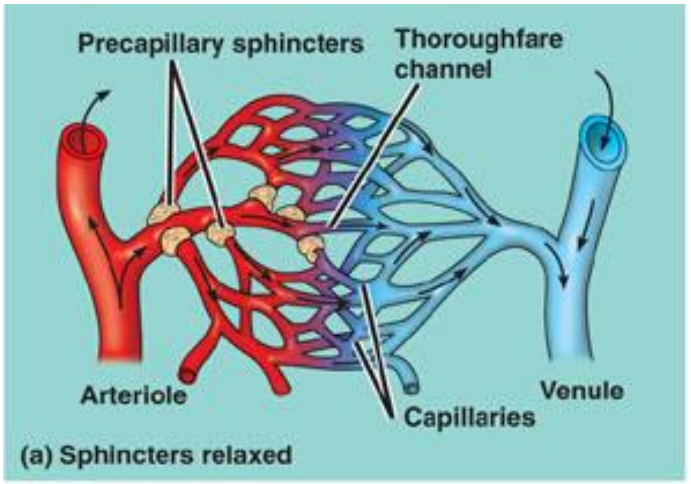
pre-capillary sphincters open

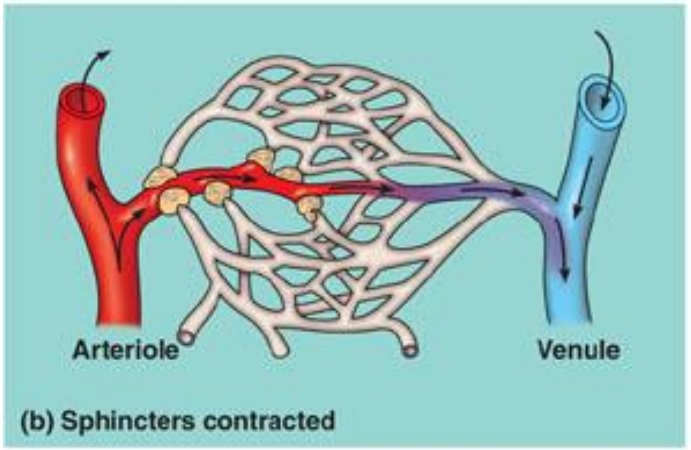


pre-capillary sphincters closed

Capillary Beds

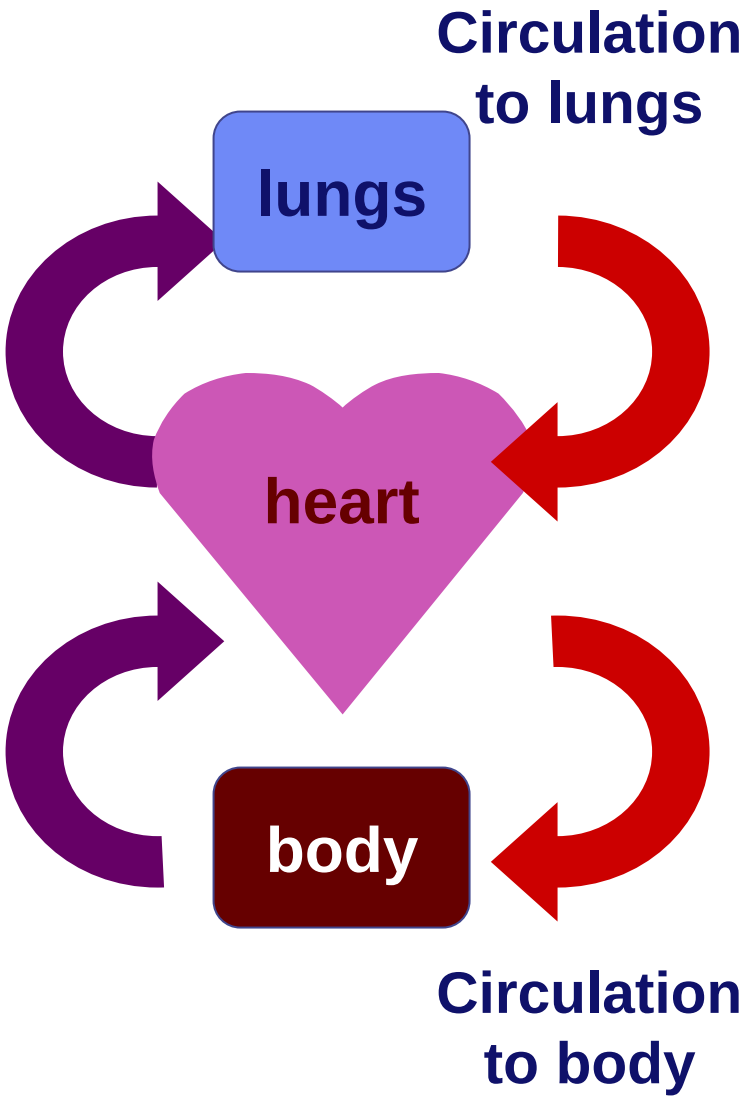
- **Blood flow**
  - at any given time, only **5-10%** of body's capillaries have blood flowing through them
    - supply varies as blood is needed
    - **after a meal**, blood supply to digestive tract increases
    - **during strenuous exercise**, blood is diverted from digestive tract to skeletal muscles
  - capillaries in **brain**, **heart**, **kidneys** & **liver** usually filled to capacity





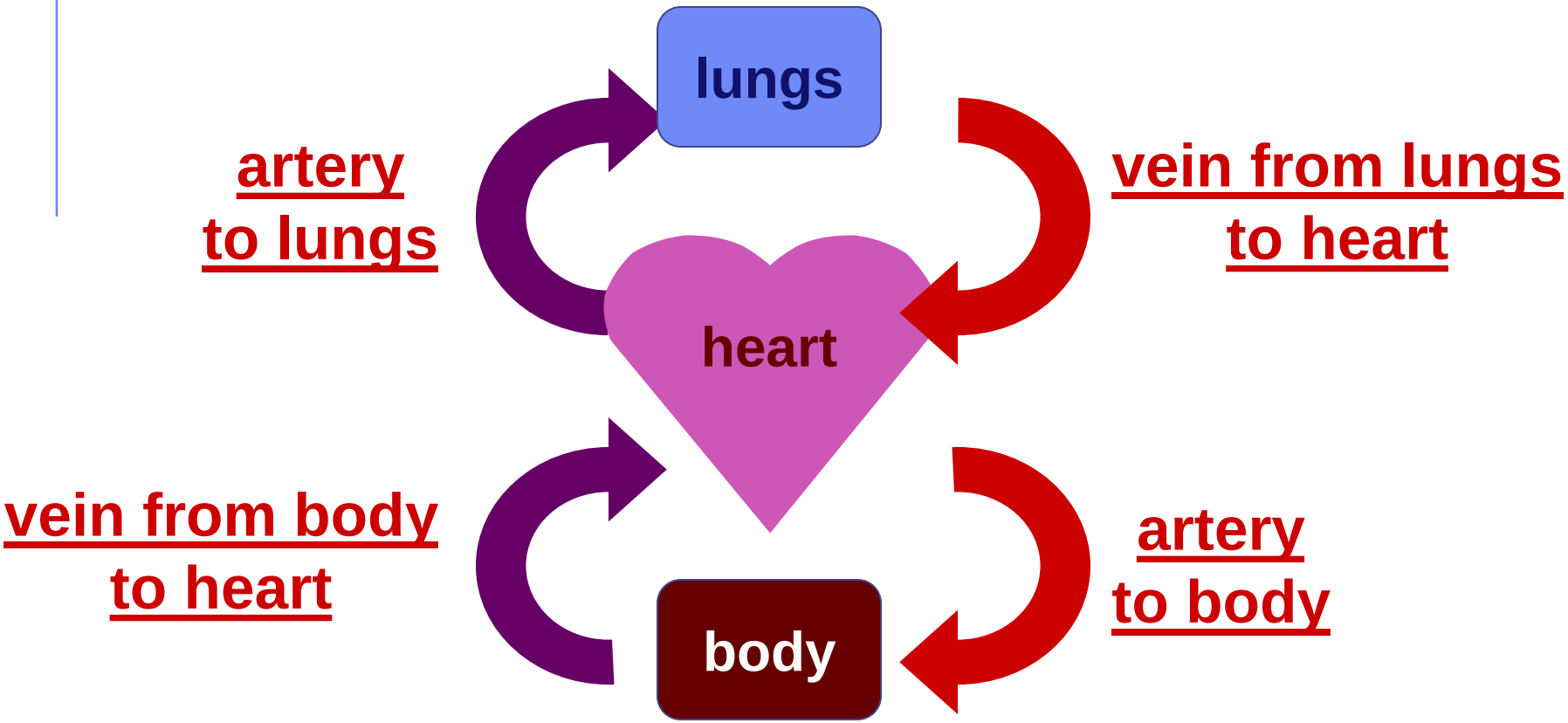
Circulation of Blood

- 2 part system
  - Circulation to lungs
    - blood gets O_2 from lungs
    - brings O_2-rich blood back to heart
  - Circulation to body
    - pumps O_2-rich blood to body
    - picks up nutrients from digestive system
    - brings CO_2 & cell wastes from body to heart



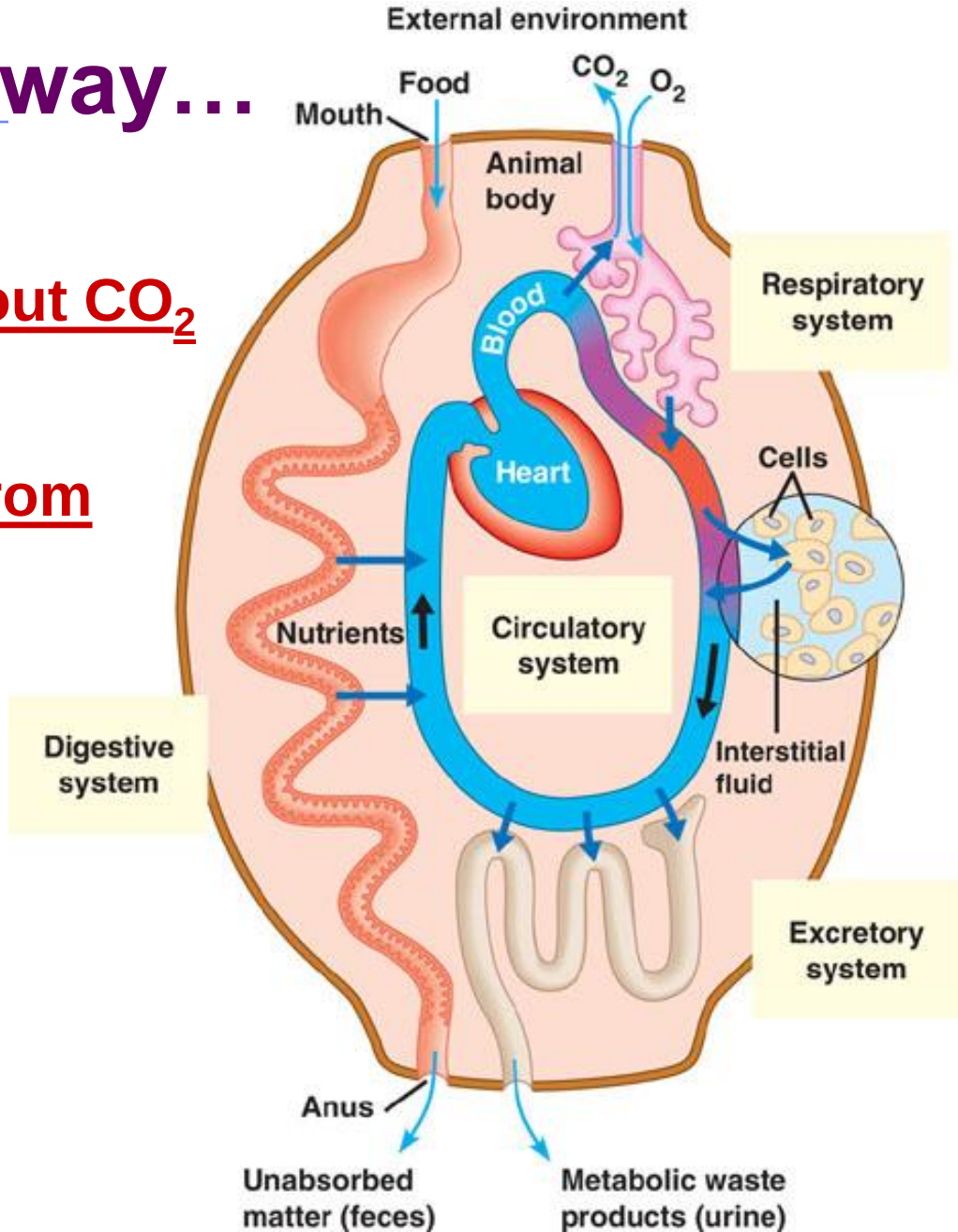
Vertebrate circulatory system

- 2 part system



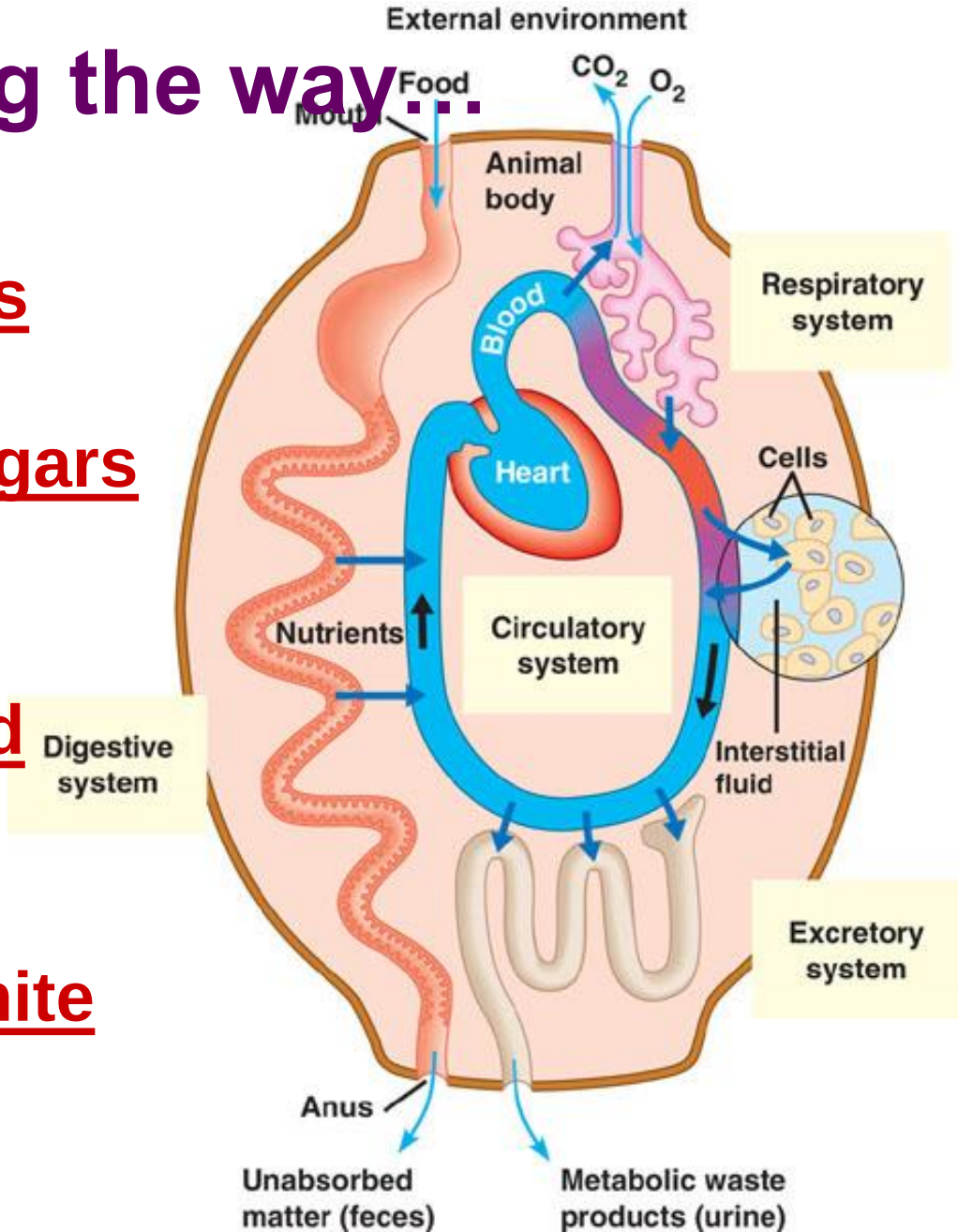
Stops along the way…

- Lungs
  - pick up O_2 / clean out CO_2
- Small Intestines
  - pick up nutrients from digested food
- Large Intestines
  - pick up water from digested food
- Liver
  - clean out worn out blood cells



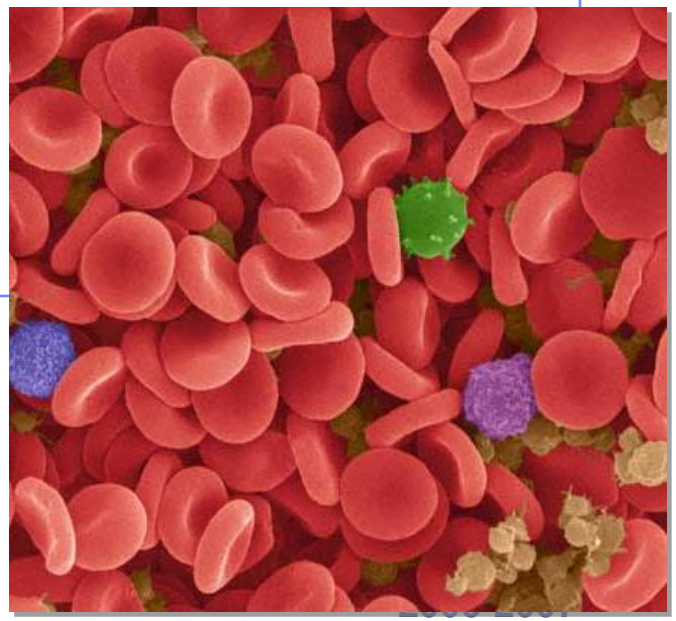
More stops along the way…

- Kidneys
  - filters out wastes (urea)
  - excess salts, sugars & water
- Bone
  - picks up new red blood cells
- Spleen
  - picks up new white blood cells



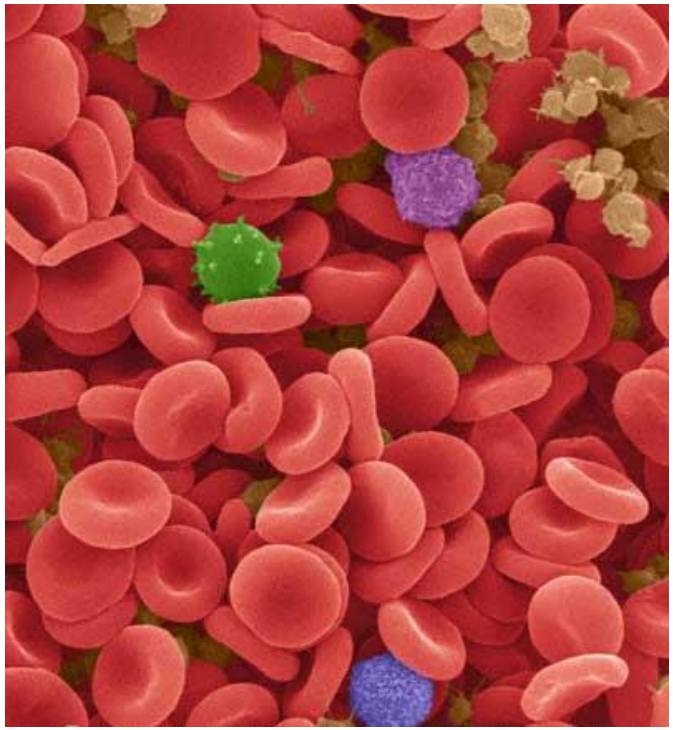
Any Questions??

Circulatory System
Blood



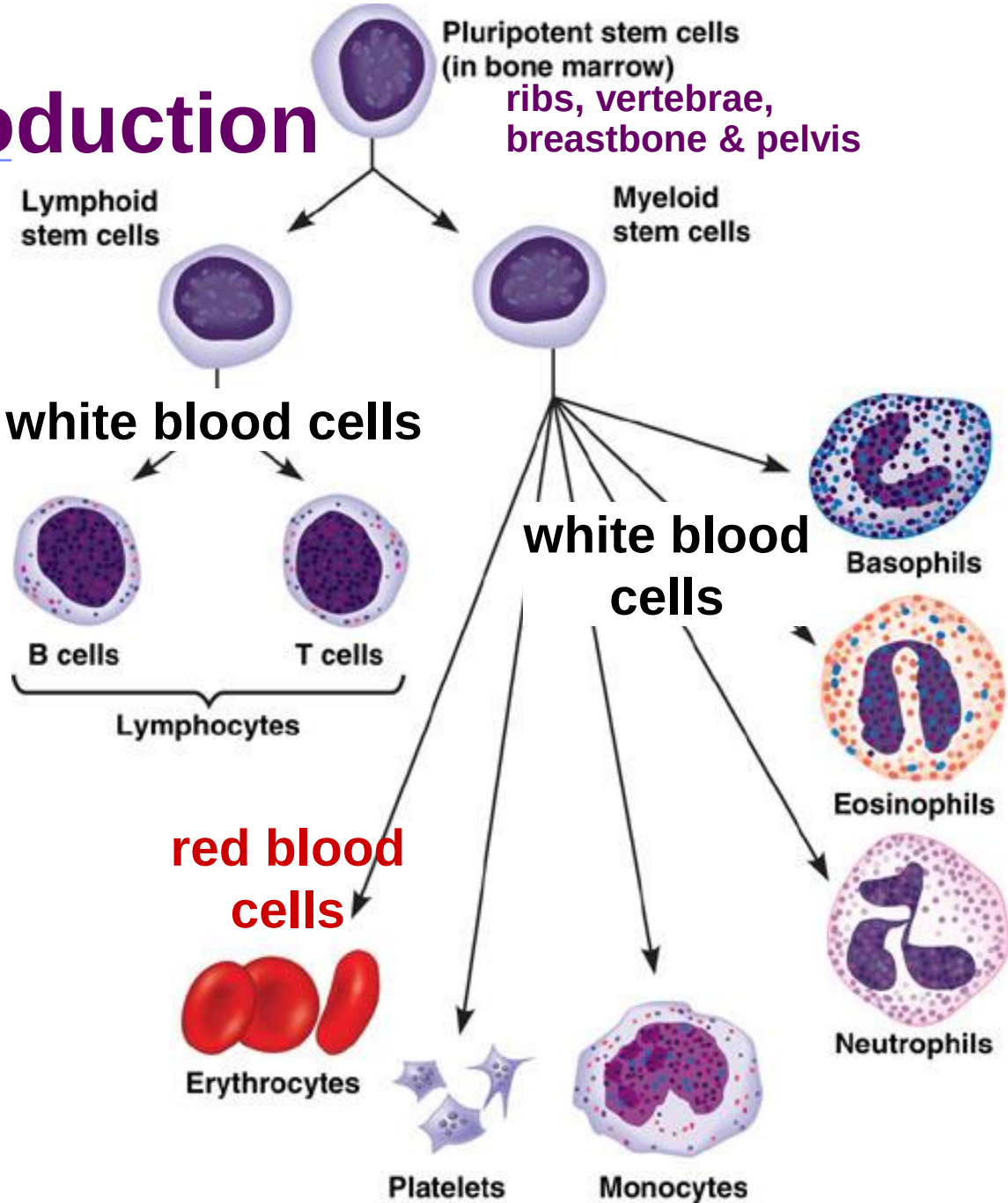
Blood & blood cells

- Blood is a tissue of fluid & cells
  - plasma (55% of volume)
    - fluid
    - dissolved salts, sugars, proteins, and more
  - cells (45% of volume)
    - red blood cells (RBC)
      - transport O_2 in hemoglobin
    - white blood cells (WBC)
      - defense & immunity
    - platelets
      - blood clotting



Blood Cell production

- **Stem cells**
  - **"parent" cells in bone marrow**
  - **differentiate into many different types of cells**

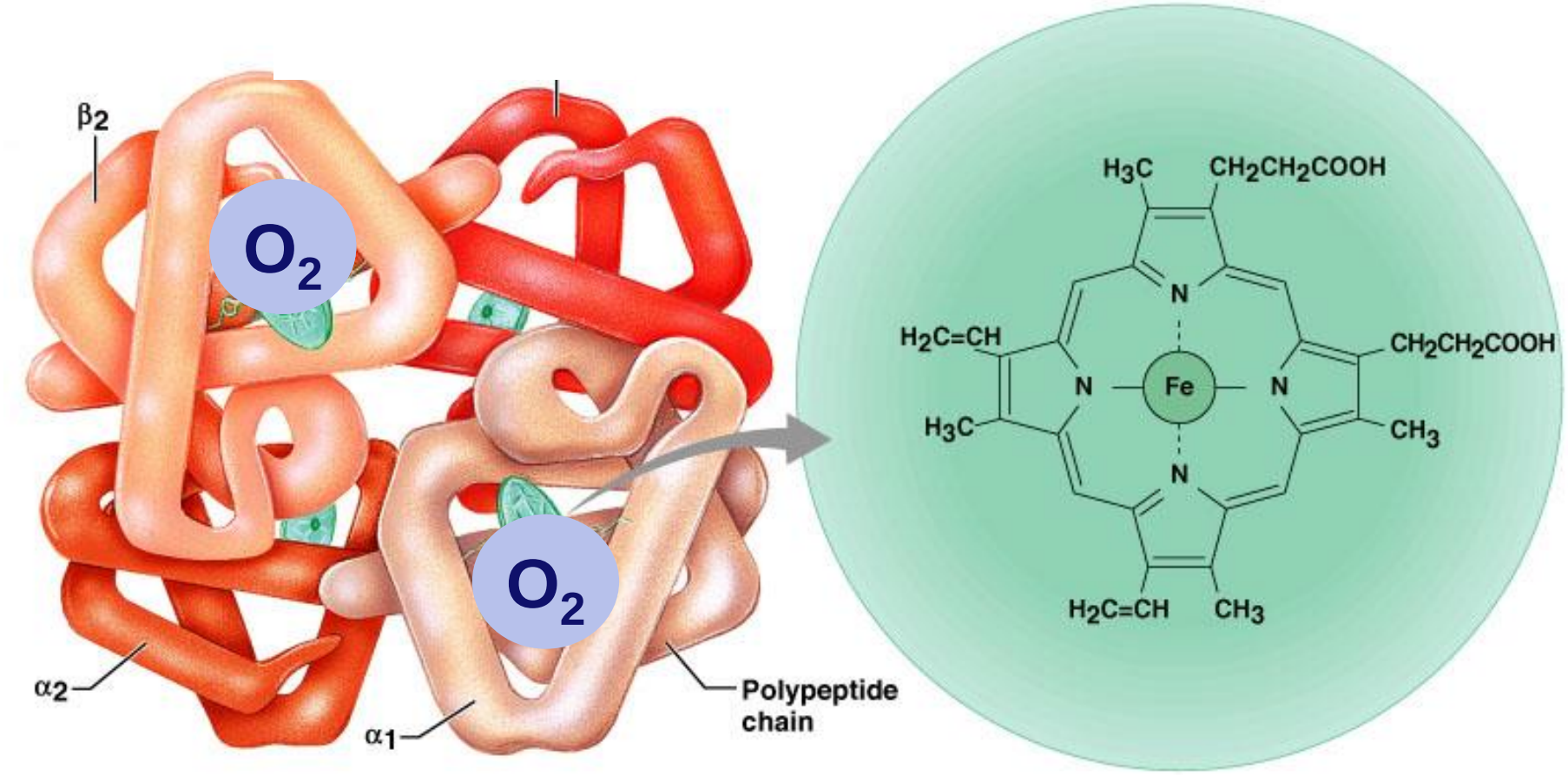


Red blood cells

- Small round cells
  - produced in bone marrow
  - lose nuclei & mitochondria
    - more space for hemoglobin
      - iron-containing protein that transports O_2
  - last 3-4 months (120 days)
    - filtered out by liver
    - ~3 million RBC destroyed each second

Hemoglobin

- **Protein which carries O_2**



(a) Hemoglobin

(b) Iron-containing heme group

Red blood cell production

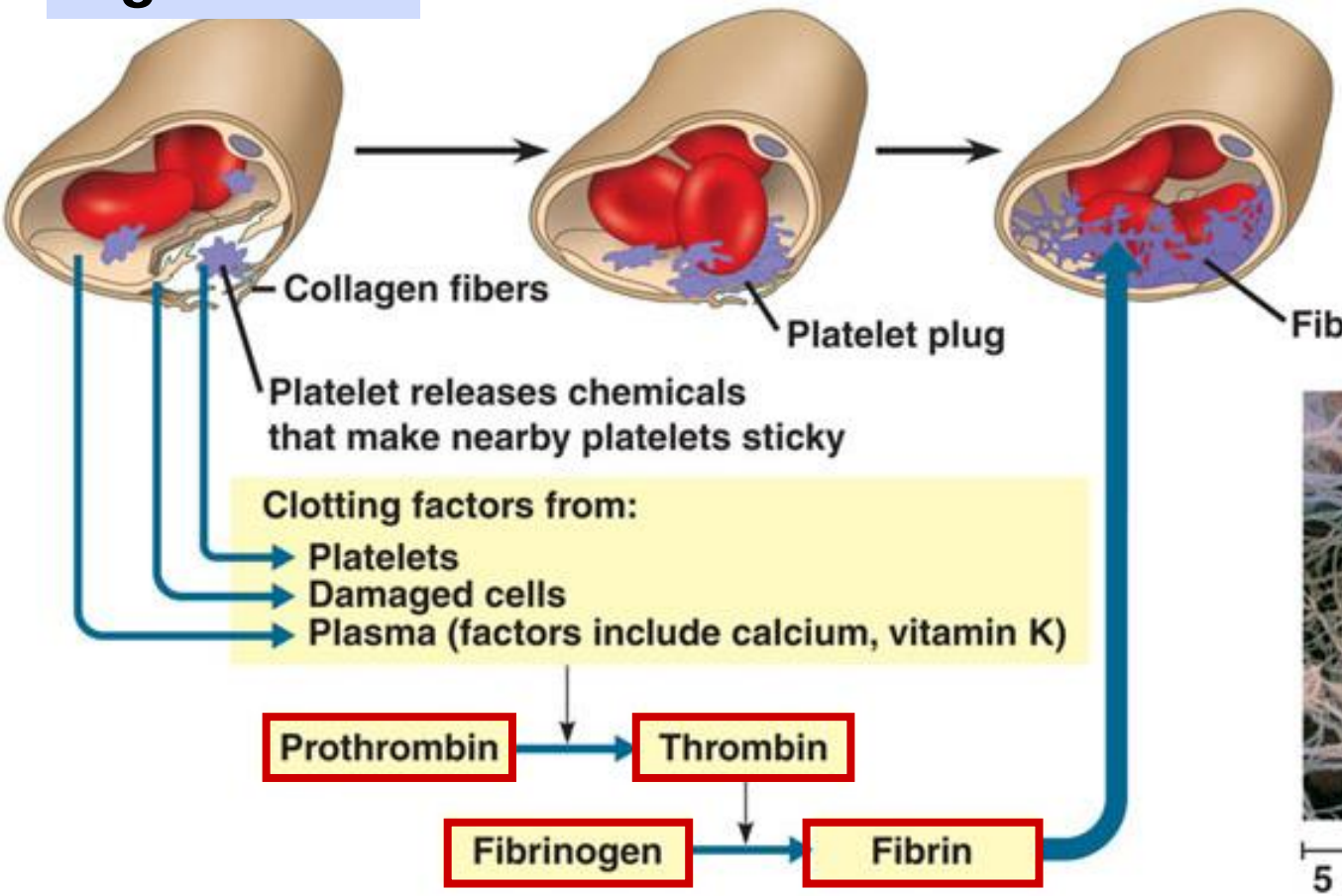
- **5-6 million RBC in tiny drop of human blood**
- **5 liters of blood in body = 25 trillion RBC**
  - produce ~3 million RBC every second in bone marrow to replace cells lost
  - each RBC 250,000 molecules hemoglobin
  - each Hb molecule carries 4 O_2
  - each RBC carries 1 million O_2

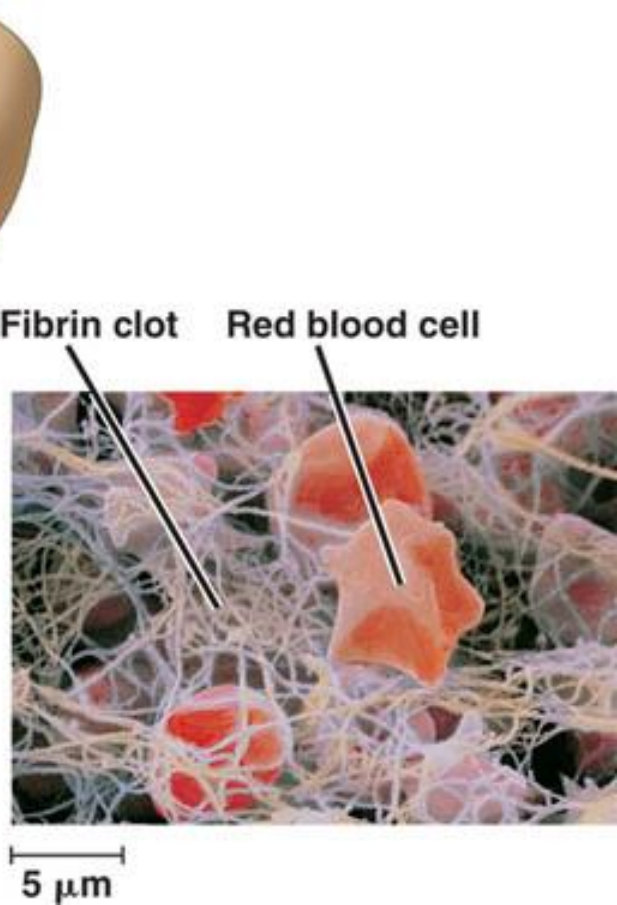
Blood clotting

chemical emergency signals

platelets seal the hole

fibrin protein fibers build clot





Cardiovascular disease

- **Atherosclerosis & Arteriosclerosis**
  - **deposits inside arteries (plaques)**
    - develop in inner wall of the arteries, narrowing their channel
  - **increase blood pressure**
  - **increase risk of heart attack, stroke, kidney damage**