Cardiovascular system

Ch 12 – pg. 217

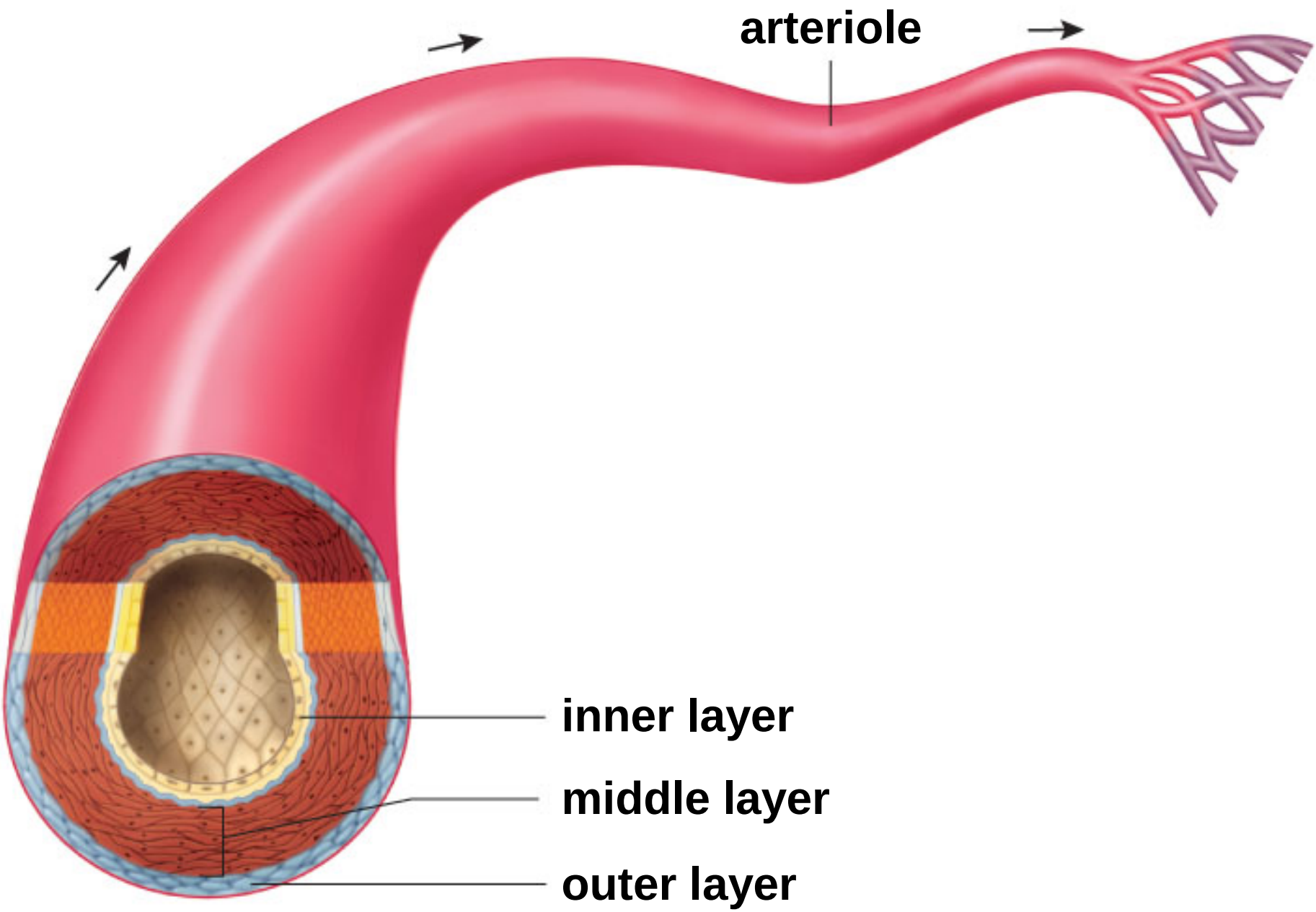
12.1 Blood vessels

3 types:

1. Arteries (and arterioles)
2. Capillaries
3. Veins (and venules)

Arteries

- Have 3 layers: inner=epithelium; middle=muscle; outer=connective tissue
- **FUNCTION:** To carry blood away* from the heart to the capillaries
- Smaller arteries branch into a number of arterioles
  - Really small arteries, barely visible to the naked eye
- Arteries are elastic, and can dilate and contract
- This characteristic affects blood pressure
- When arteries & arterioles are dilated, blood pressure lowers

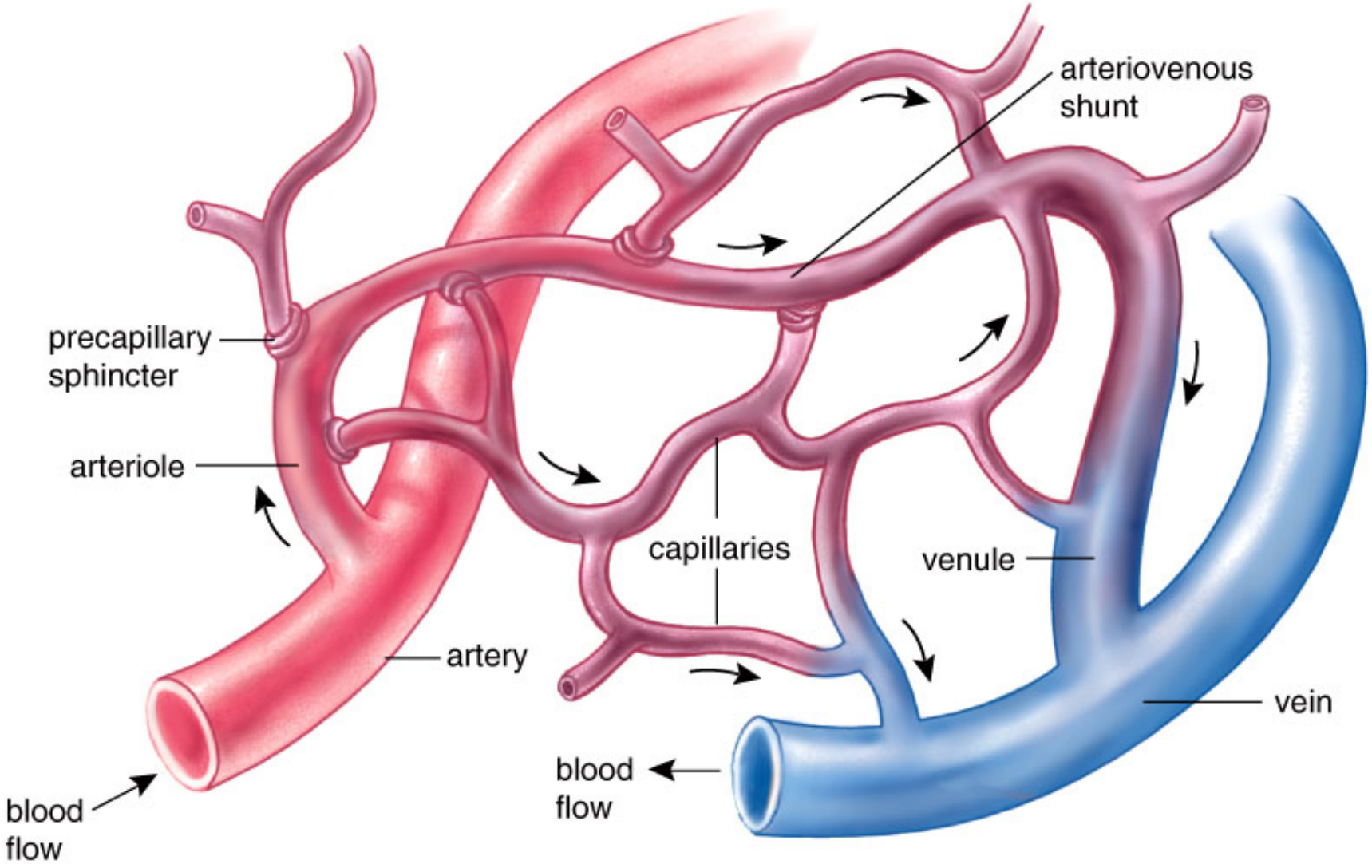


a. Artery

Capillaries

- Join arteries to veins
- Form vast networks – called “capillary beds”
- Are extremely narrow and have thin walls
- The exchange of nutrients and gases between the blood and tissues occurs in the capillaries
- Capillary beds can close or open
  - Ex. After eating, beds serving the digestive system are open, while beds serving the muscles are mostly closed

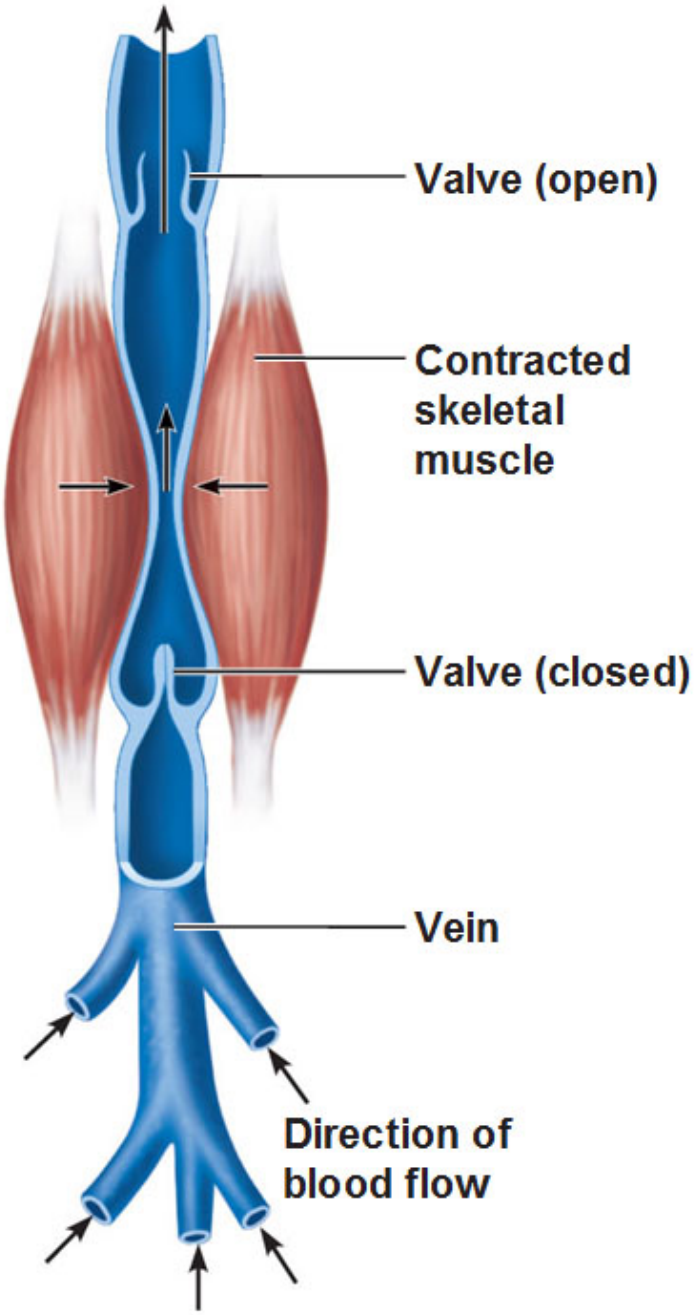
Anatomy of a capillary bed



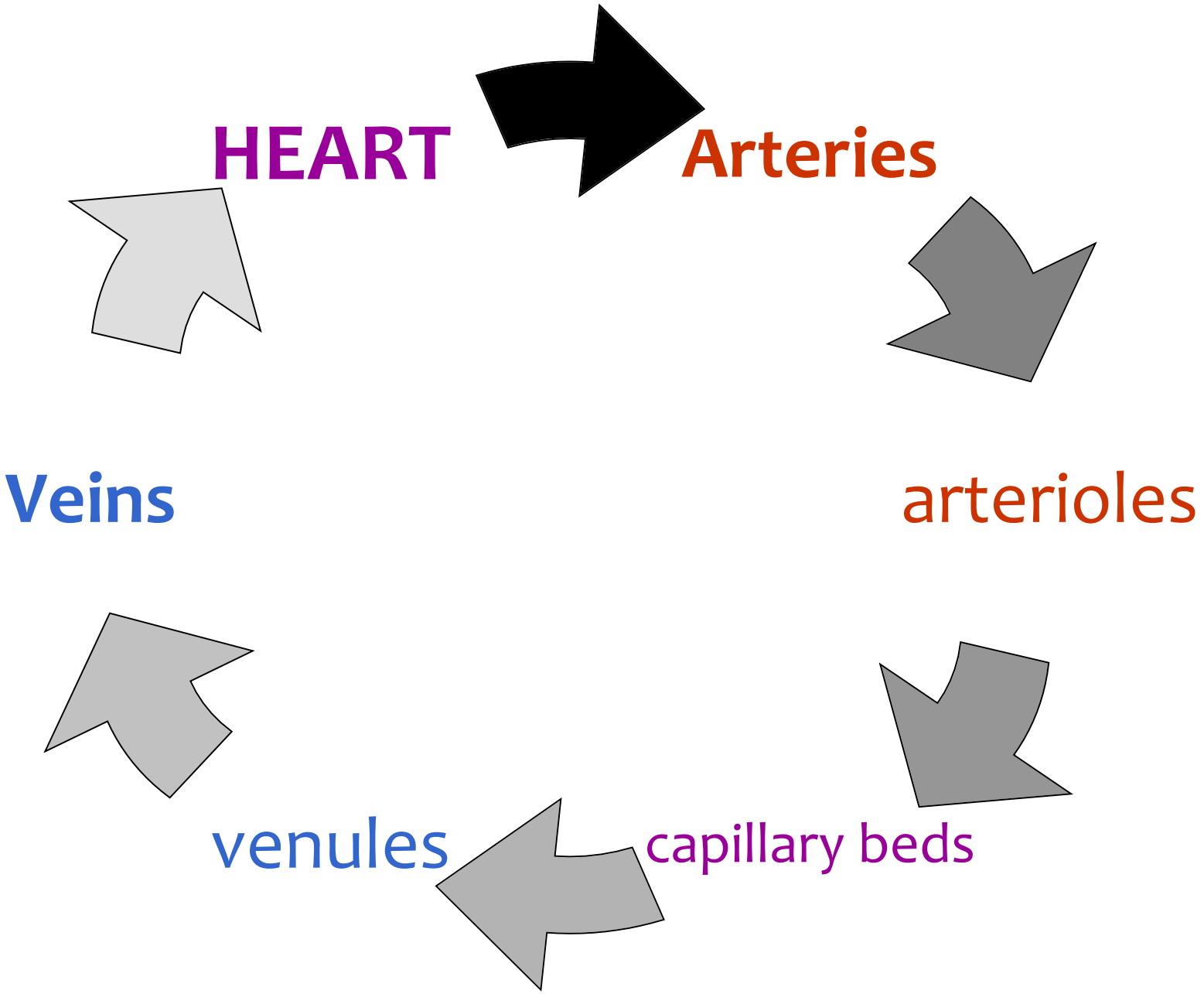
- Fig 12.2

Veins

- Veins and venules take blood from the capillary beds to the heart
- A vein's structure also consists of 3 layers, but there is far less muscle and connective tissue
- Often have valves which prevents the back-flow of blood
  - Open valves allow blood to flow toward the heart – closed valves prevent blood from flowing backwards
  - Veins that have to move blood against gravity (like those in your legs) have lots of valves
- Blood flow in veins is due primarily to skeletal muscle contractions
- Because the walls of veins are thinner, they are more elastic
- The largest veins in the body are called the Inferior and Superior vena cava
  - They deliver O_2 poor blood to the heart!


Valve (open)
Contracted skeletal muscle
Valve (closed)
Vein
Direction of blood flow

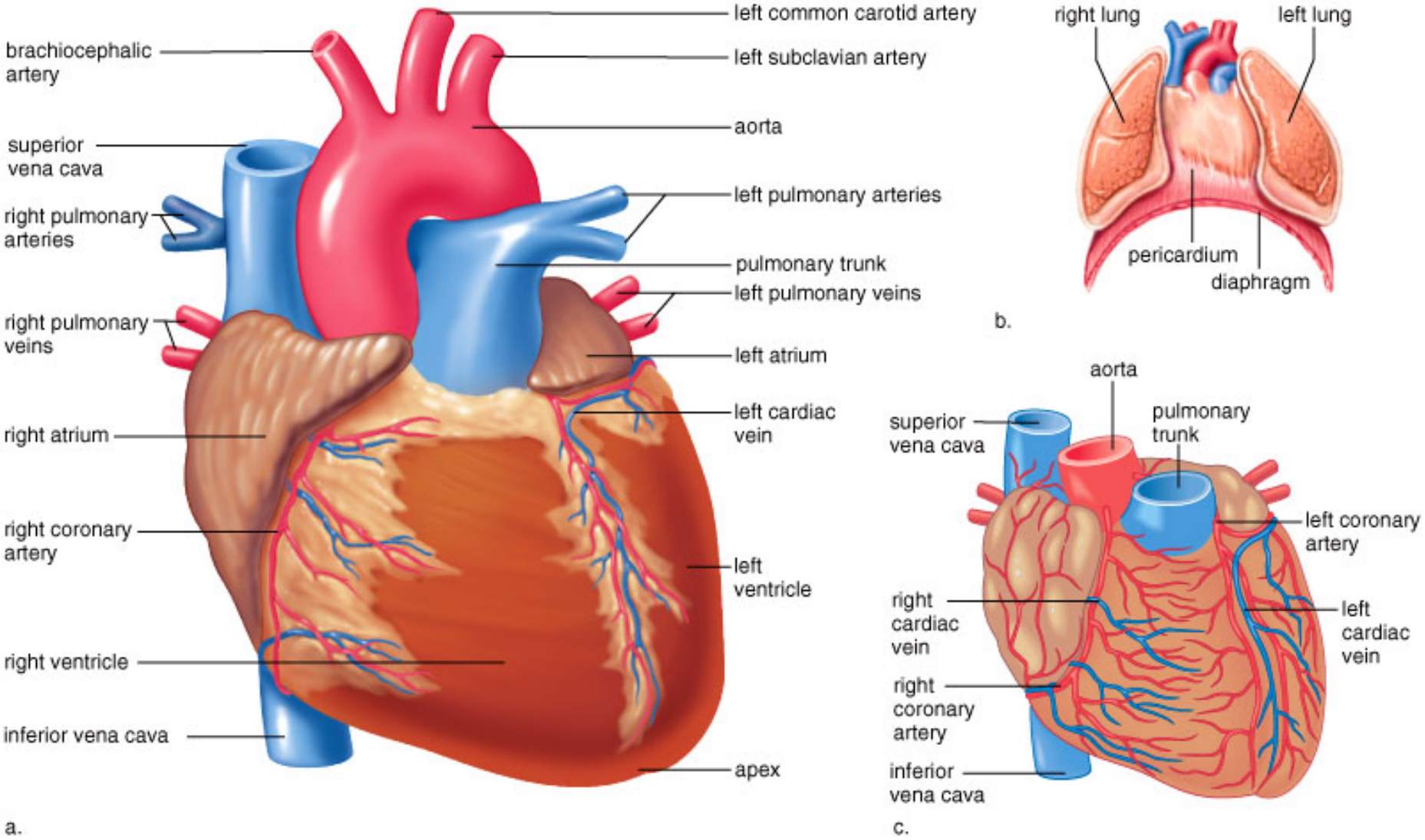
The flow:



12.2 Human heart

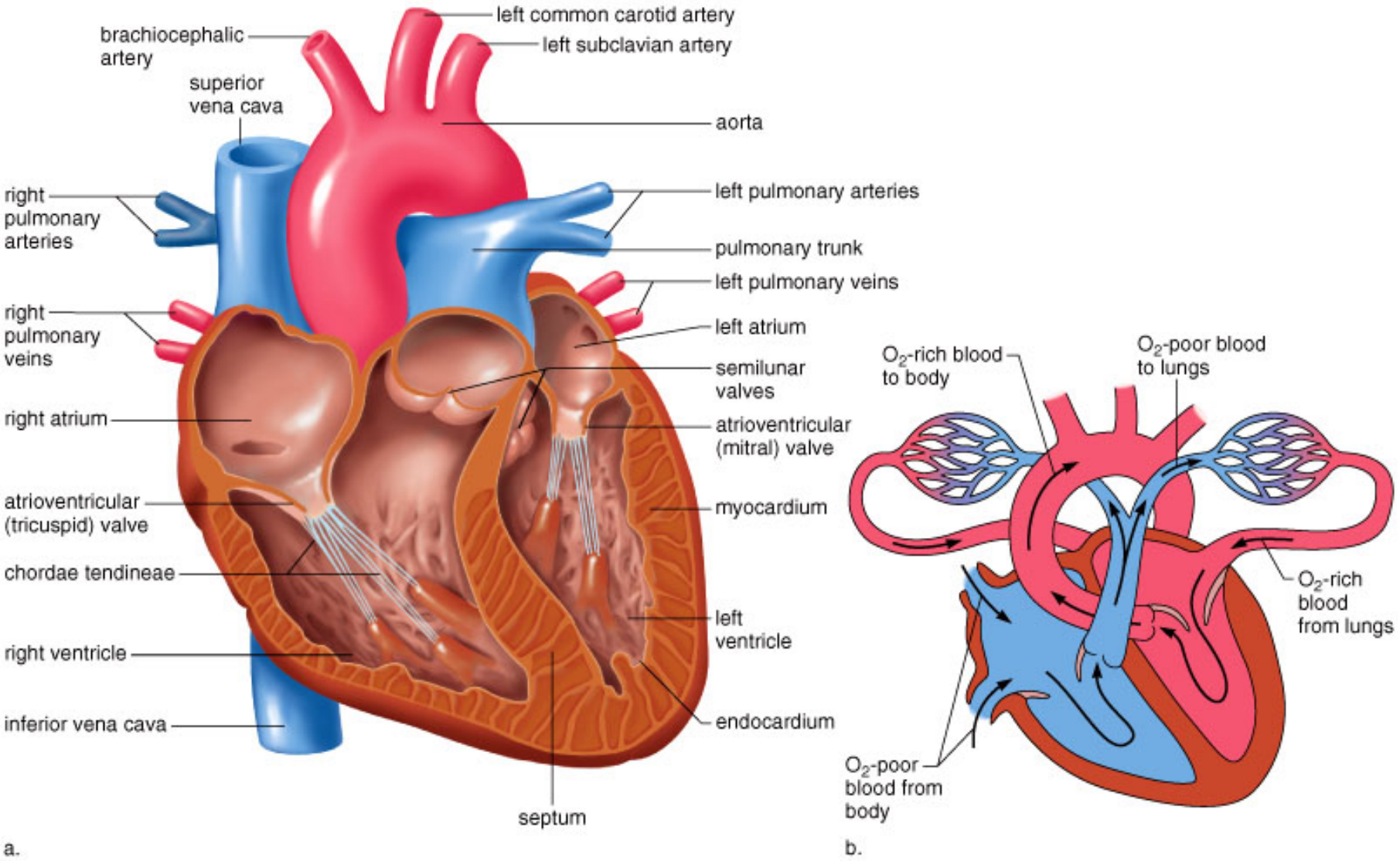
- Cone-shaped, muscular organ about the size of a fist
- Located between the lungs, right behind the breastbone
- Tilted slightly to the left
- Lies within the pericardium
- Major portion = myocardium
  - Consists mostly of cardiac muscle
- Internally, the septum separates the heart into a left and right side
- The heart has four chambers: 2 upper thin-walled atria and 2 lower thick-walled ventricles
- The right ventricle pumps blood to the lungs
- The left ventricle pumps blood to the body

External heart anatomy



- Fig 12.3

Internal view of the heart



- Fig

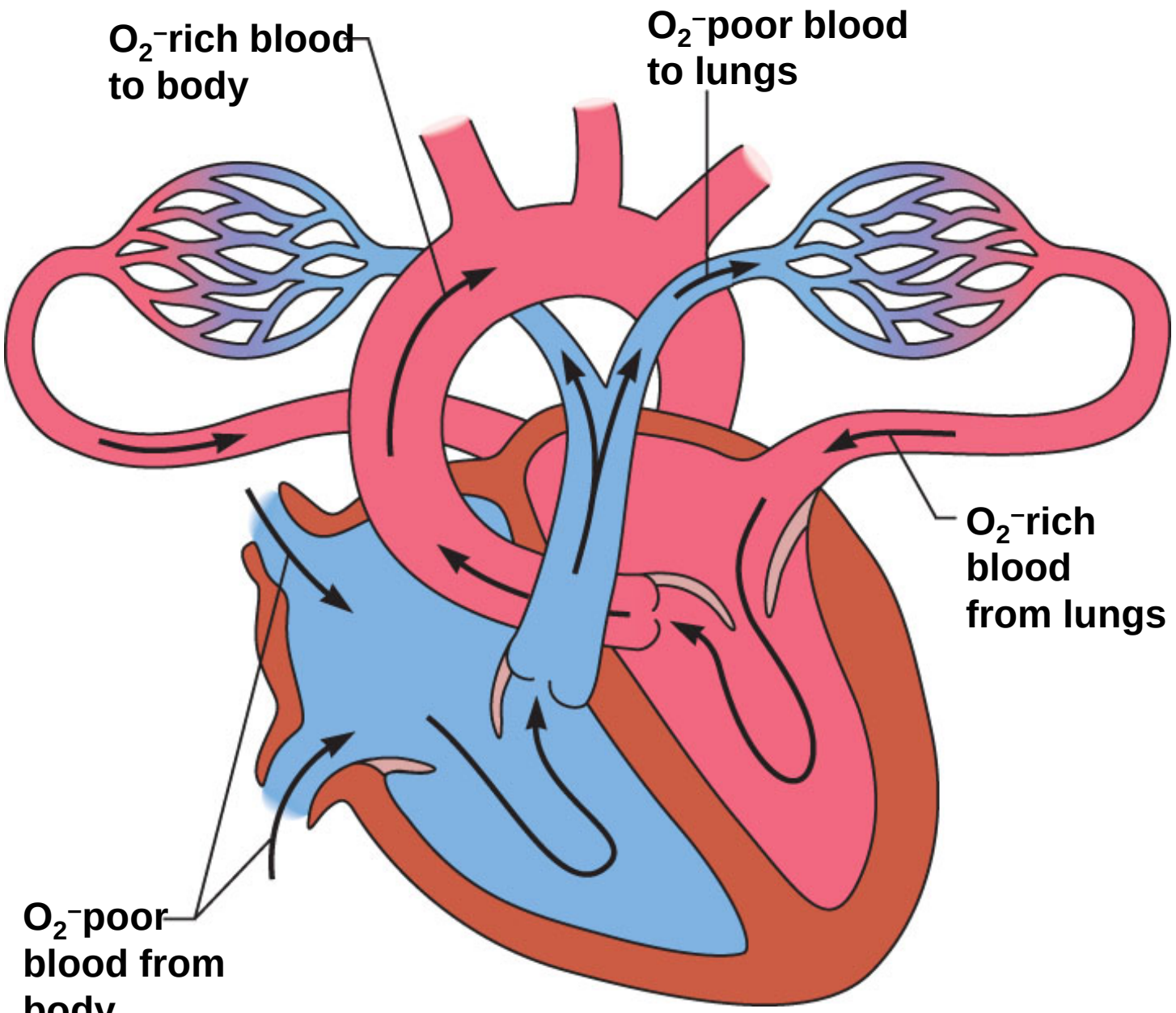
The valves…

- There are two types of valves in the heart:

1. The ones that separate the atria from the ventricles
   - Called ATRIOVENTRICULAR valves
   - ***Tricuspid*** (R. atrium / R. ventricle) and ***Bicuspid*** (L. atrium/ L. ventricle) valves
2. The ones that separate the ventricles from major blood vessels
   - ***Pulmonary semilunar valve*** → between R. ventricle and pulmonary artery
   - ***Aortic semilunar valve*** → between L. ventricle and aorta

Path of blood through the heart…

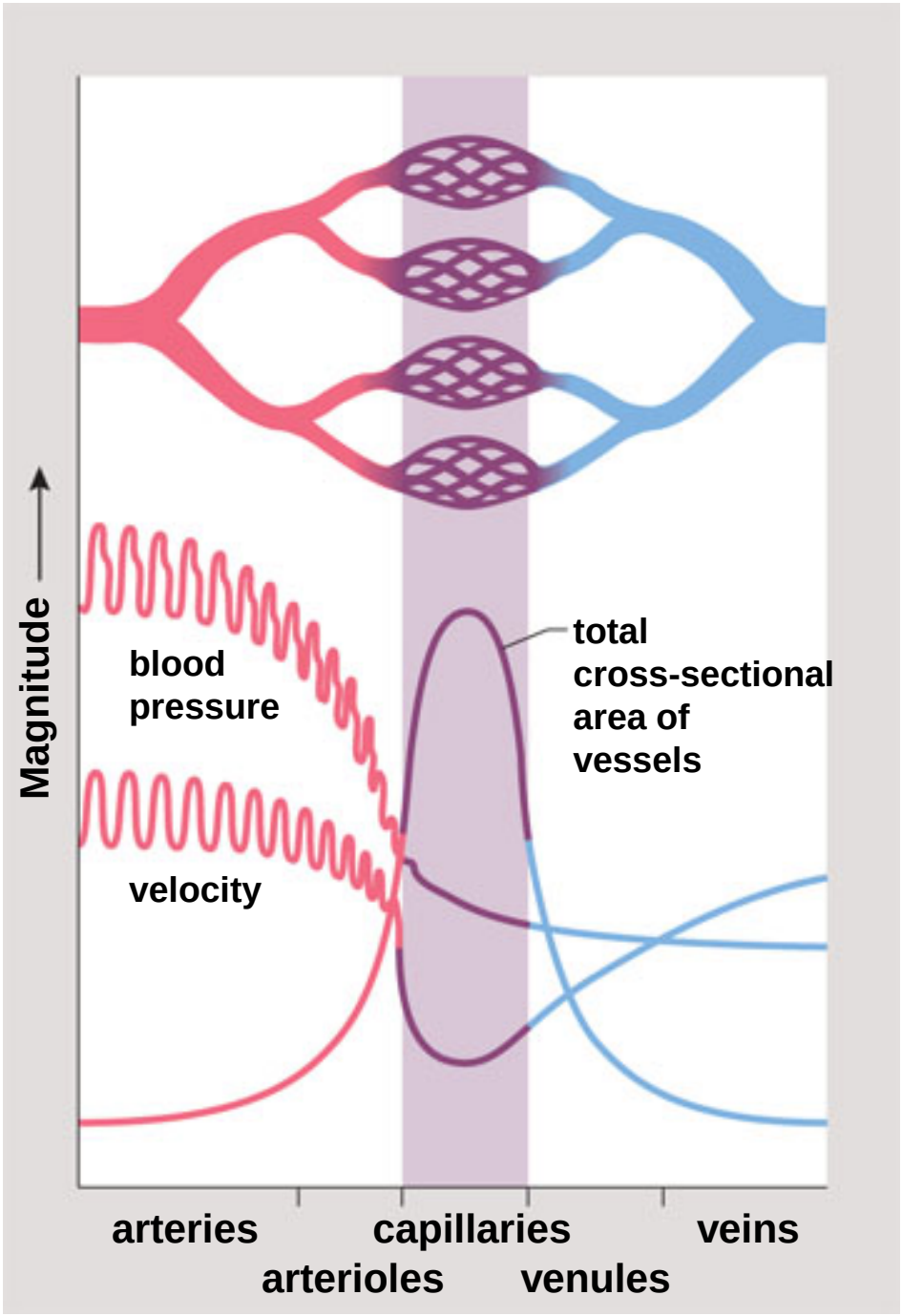
- Sup. and Inf. Vena Cava bring O2 poor blood to right atrium
- Blood flows through tricuspid valve into right ventricle
- From right ventricle it flows through pulmonary semilunar valve into pulmonary arteries
- To the lungs
- Back to left atrium through pulmonary veins (O2 rich)
- Through bicuspid valve into left ventricle
- Through aortic semilunar valve into aorta
- Blood is distributed throughout body



b.

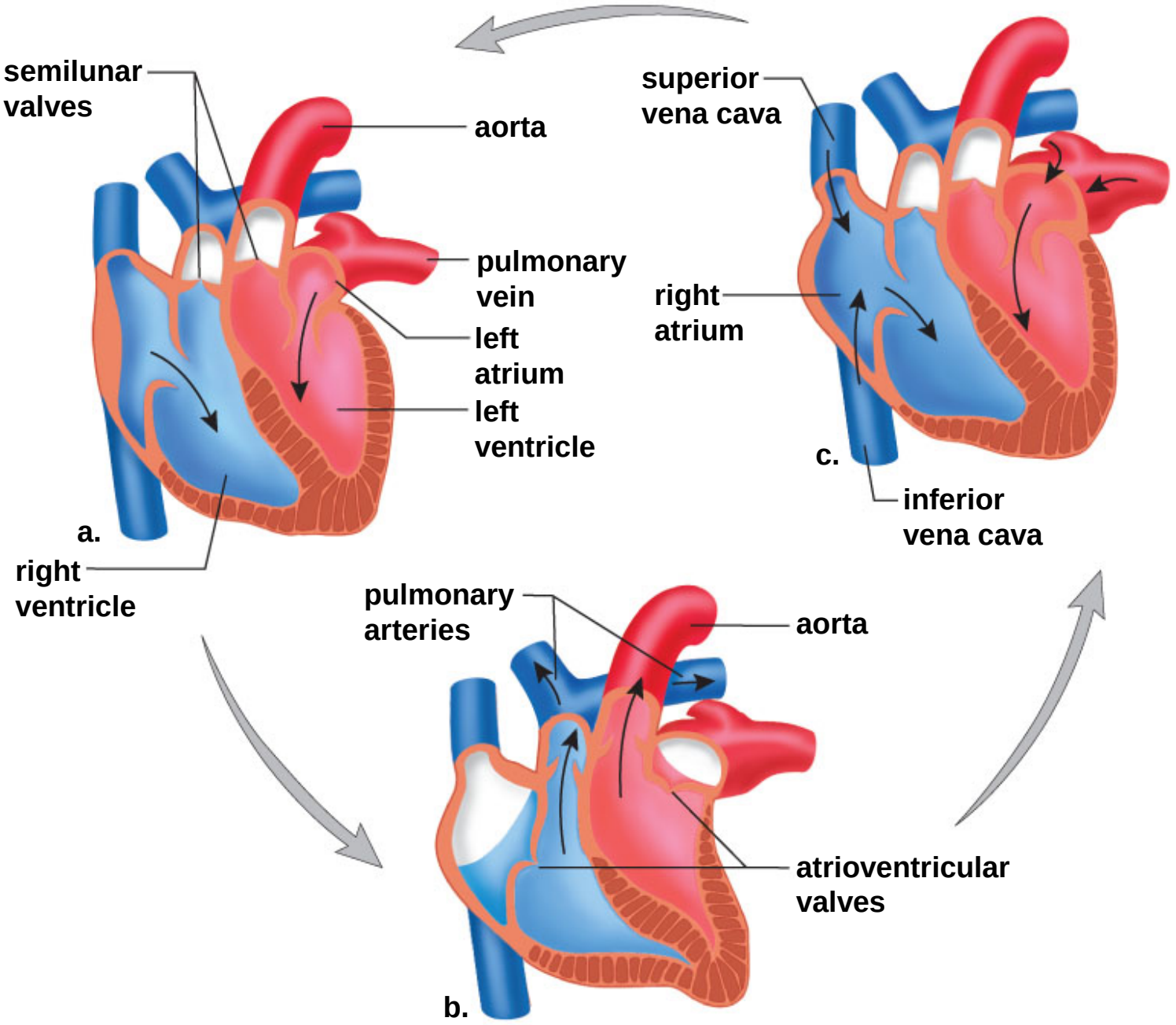
Your pulse / Blood pressure

- The walls of the left ventricle are thicker because it has to pump blood to the whole body
- The pumping of the heart sends blood out under pressure
- Blood pressure is greatest in the aorta
- It gradually decreases as the cross-sectional area of the arteries and arterioles increases
- Your ***pulse*** is a wave effect that passes down the walls of arteries when the aorta expands and then recoils with each ventricular contraction



Heartbeat…

- Each heart beat is called a cardiac cycle
  - First, the right and left atria contract at the same time
  - Then, the right and left ventricles contract at the same time
  - Then all four chambers relax
- SYSTOLE = the contraction of the heart muscle
- DIASTOLE = the relaxation of the heart muscle
- The “Lub” sound is heard when atrioventricular valves close
- The “Dub” sound is heard when the semilunar valves close

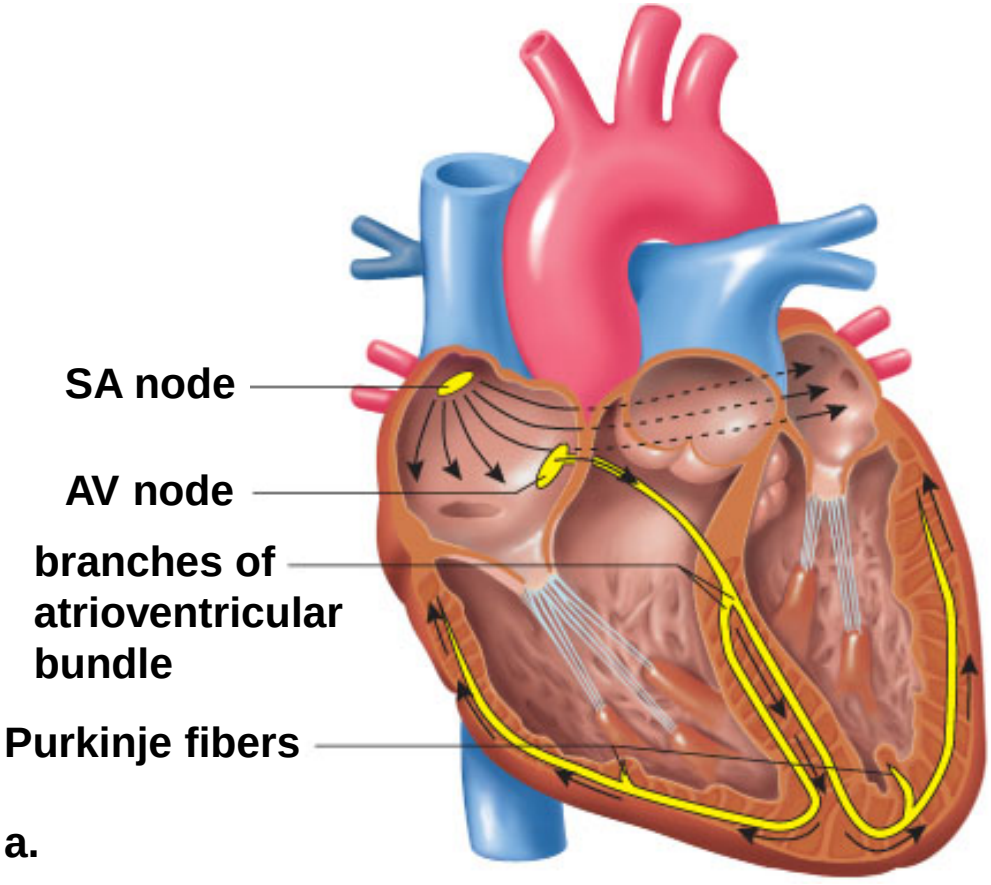


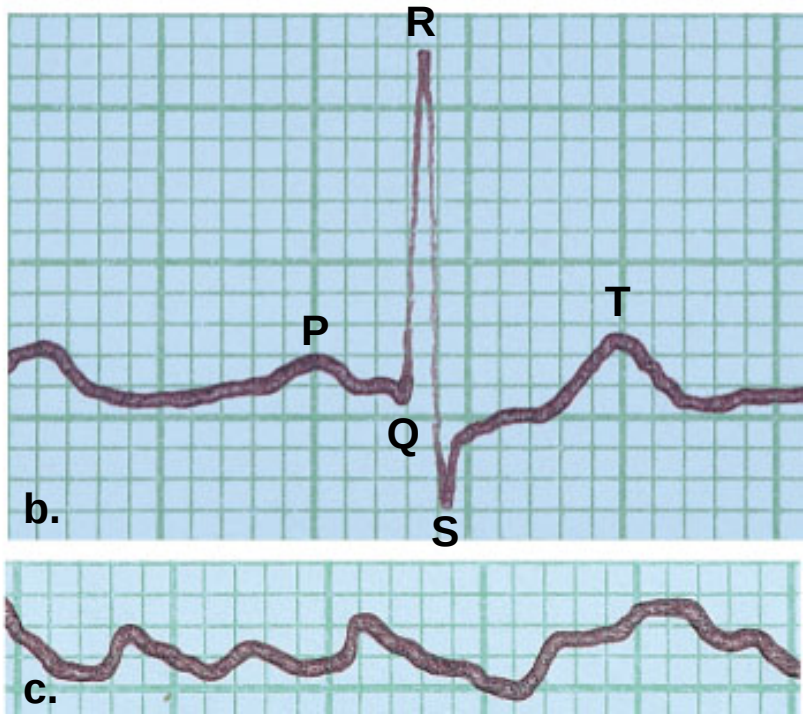
Intrinsic control of heartbeat

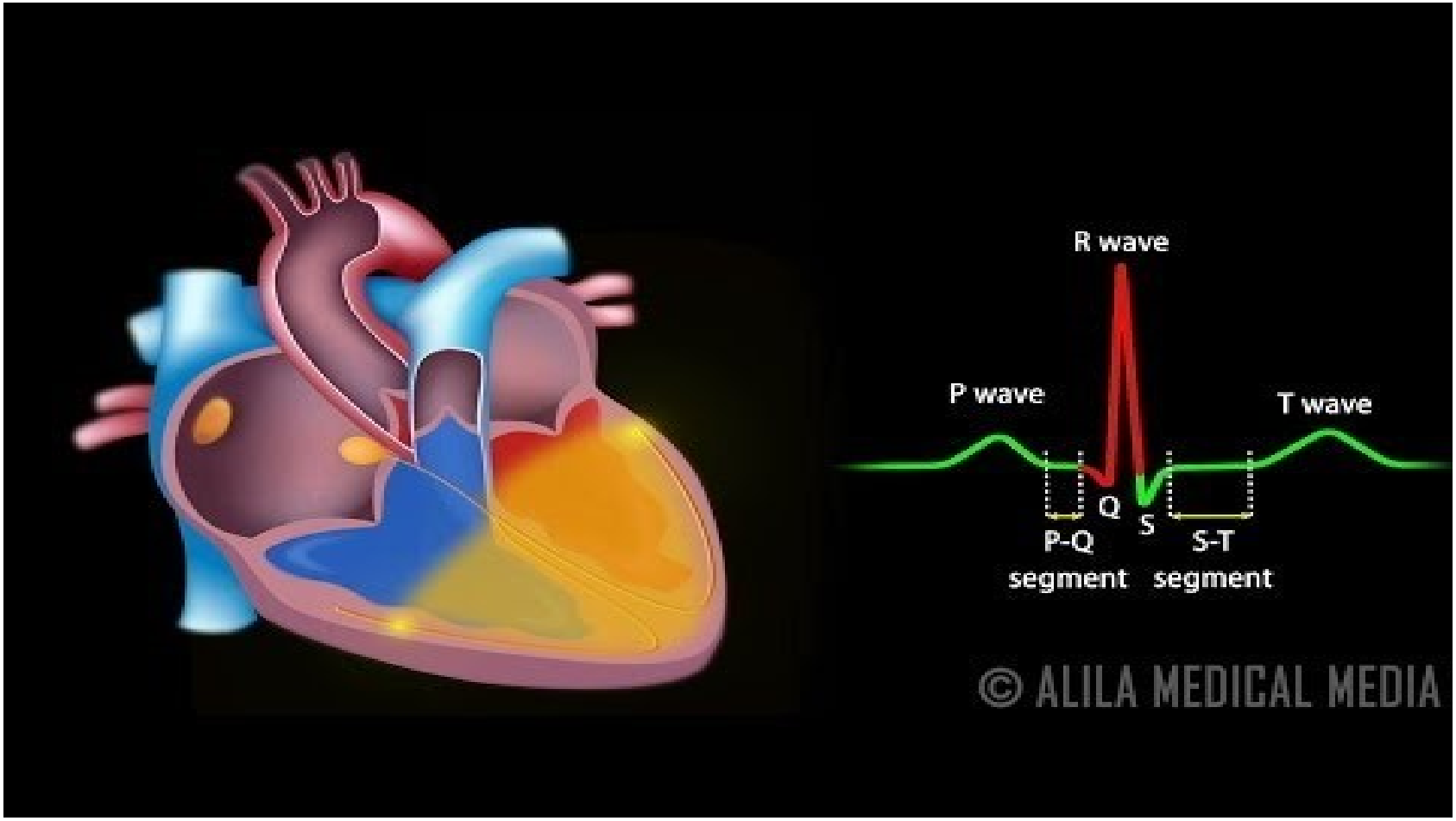
- The rhythmic contractions of the heart are controlled by an intrinsic conduction system called nodal tissue
  - Part muscular and part nervous tissue, the nodal tissue sends electrical impulses that stimulate the contraction of the atria and ventricles
- SA node = sinoatrial node
  - Located in the upper dorsal wall of the right atrium
- AV node = atrioventricular node
  - Located in the base of the right atrium very near the septum

Intrinsic control of heartbeat

- The SA node initiates the heart beat by stimulating the atria to contract
- It sends out an excitatory impulse every 0.85 seconds
- When the impulses reach the AV node, there is a slight delay
- Then the AV node sends an electrical impulse through specialized cardiac muscle fibers called ***PURKINJE FIBRES***
- The signal then initiates ventricular contraction
- SA node is AKA the ***cardiac pacemaker*** → it is what keeps the beat regular






R wave
P wave
T wave
Q
S
P-Q
segment
S-T
segment
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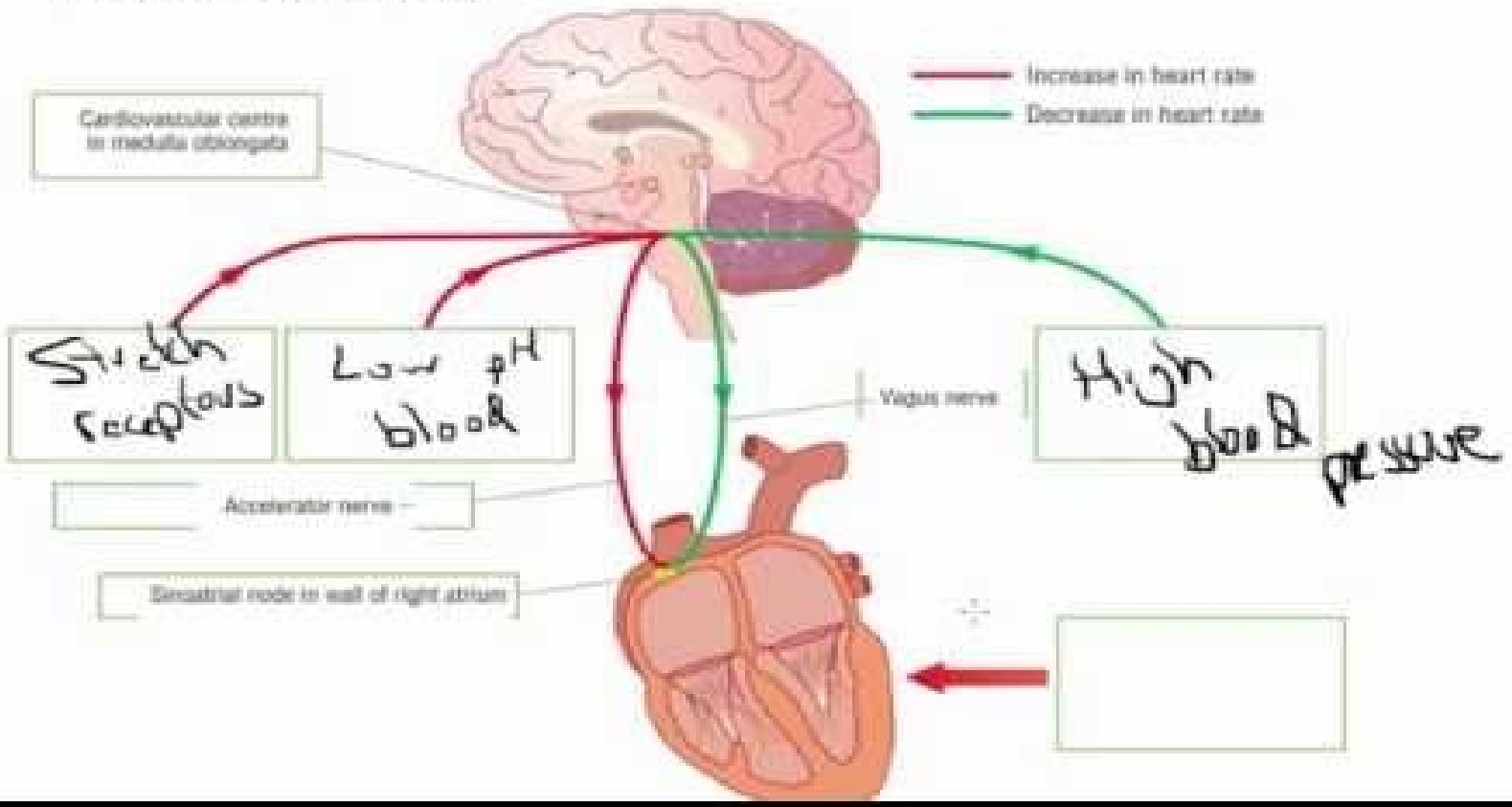
Extrinsic control of Heartbeat

- Nervous system control via the autonomic nervous system → a portion of the nervous system that controls organ systems
  - The parasympathetic nervous system can slow SA and AV nodal activity when we are inactive
  - The sympathetic nervous system can speed SA and AV nodal activity when we are excited or more active
- Hormonal control via epinephrine (adrenaline) and norepinephrine (noradrenaline)
  - Secreted by the adrenal glands
  - Can also stimulate the heart

The control of heart rate

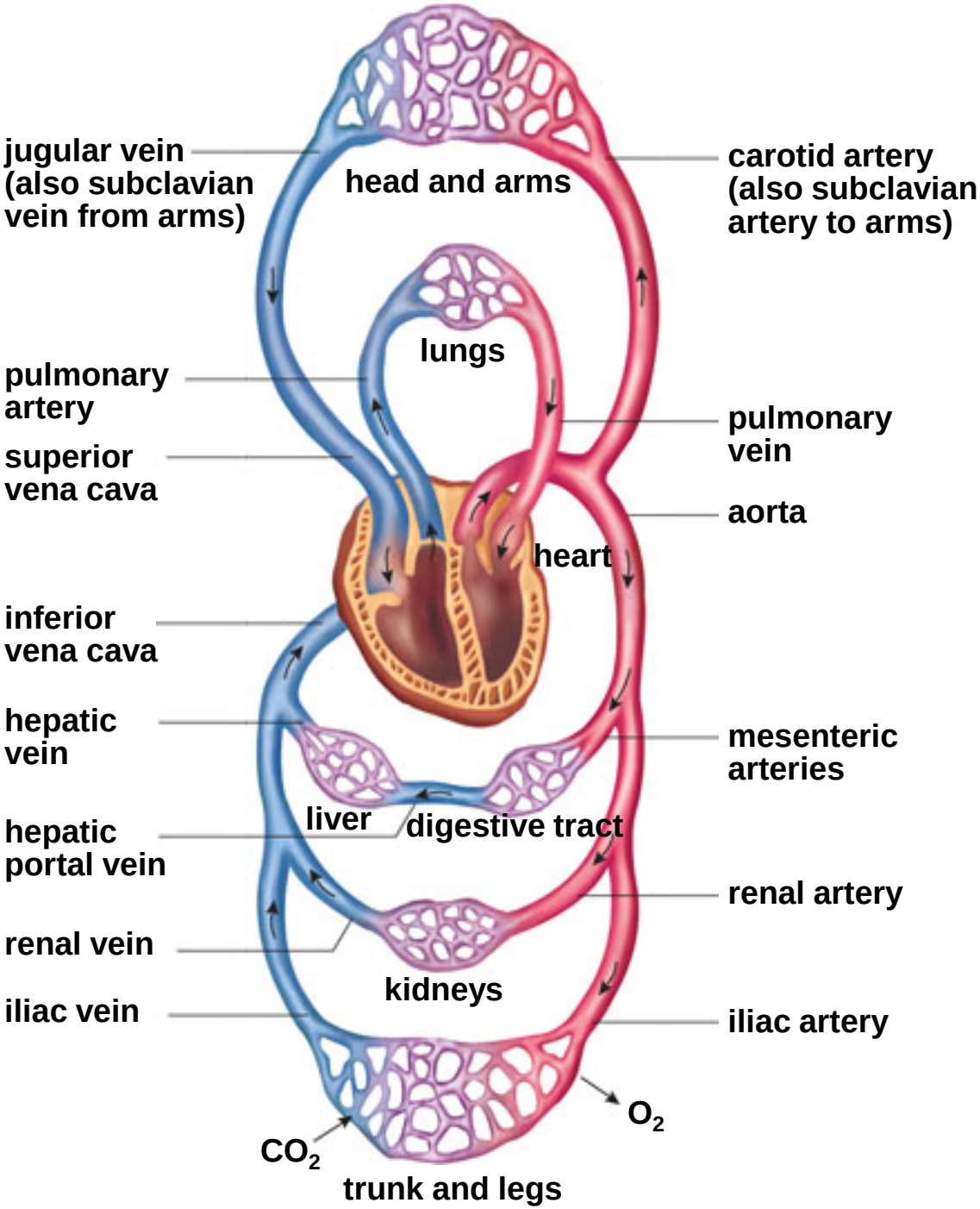


12.3 The vascular pathways

Includes two circuits:

1. PULMONARY CIRCUIT
   - Circulates blood through the lungs

2. SYSTEMIC CIRCUIT
   - Circulates blood through the body tissues

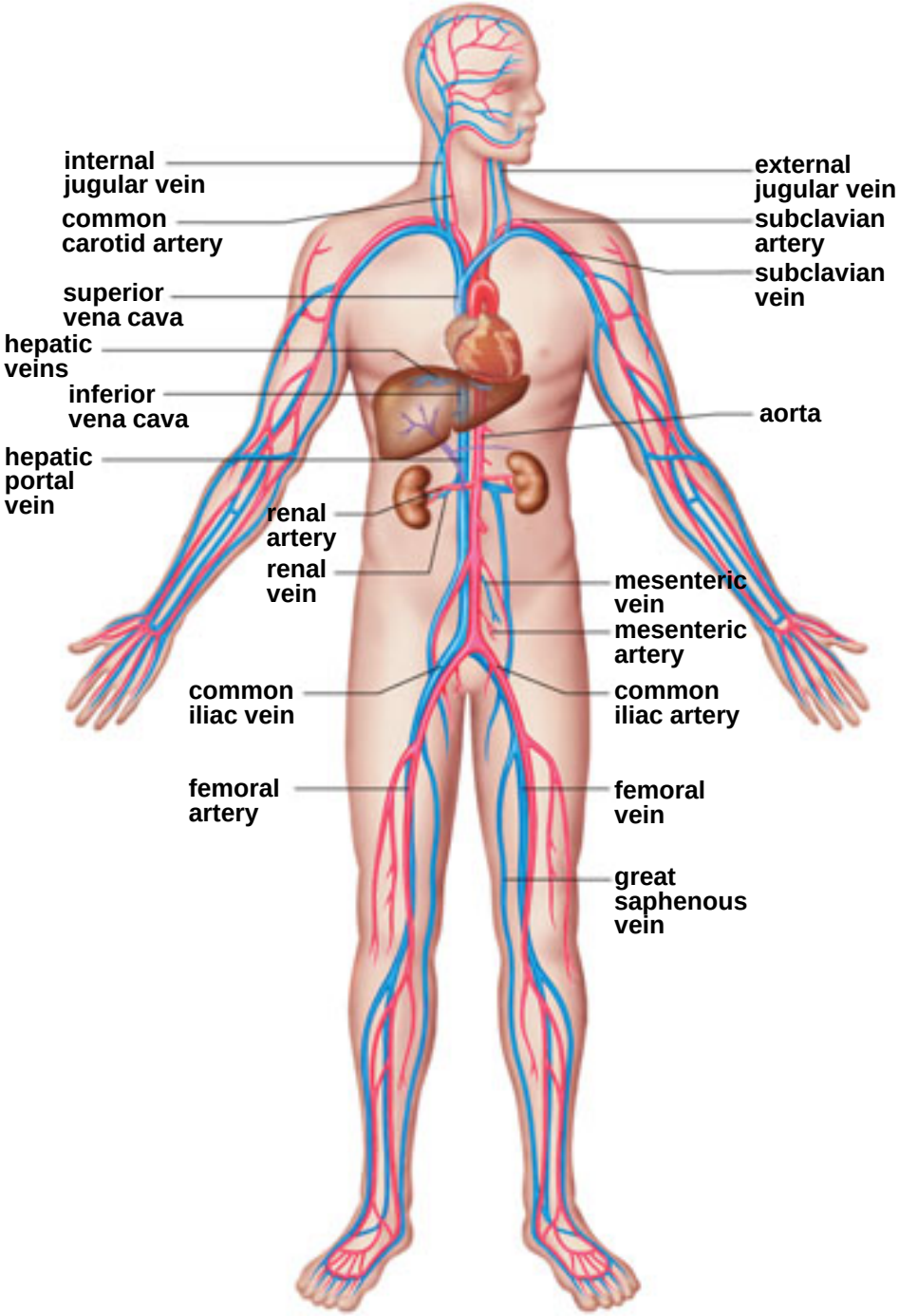


The pulmonary circuit

- Consists of the pulmonary arteries, arterioles, capillary beds, venules, and veins
- O_2 poor blood is transported from the right ventricle to the lungs
- At the pulmonary capillaries, CO_2 diffuses out of the blood and O_2 diffuses into the blood
- O_2 rich blood is then transported back to the left atrium of the heart!

The systemic circuit

- Consists of 6 major arteries and 6 major veins
- Largest artery = aorta
- Largest veins = vena cavae
  - Superior collects blood from head, chest & arms
  - Inferior collects blood from lower body regions



The major vessels

Arteries:

- ***Aorta:*** branches into all other major arteries
- ***Mesenteric arteries:*** services the intestines
- ***Renal artery:*** services the kidneys
- ***Iliac artery:*** services the legs
- ***Pulmonary artery:*** brings O2 poor blood to lungs
- ***Subclavian artery:*** services the arms and chest
- ***Carotid artery:*** services neck and head

The major vessels

Veins:

- ***Sup/Inf. Vena cavae:*** brings O_2 poor blood to heart
- ***Iliac vein:*** collects blood from the legs
- ***Renal vein:*** collects blood from the kidneys
- ***Hepatic vein:*** collects blood from the liver
- ***Hepatic portal vein:*** brings blood from small intestine to the liver (begins and ends in a capillary bed – from capillaries in villi to capillary bed in liver)
- ***Pulmonary vein:*** brings O_2 rich blood back to heart
- ***Jugular vein:*** collects blood from the neck and head

Blood pressure

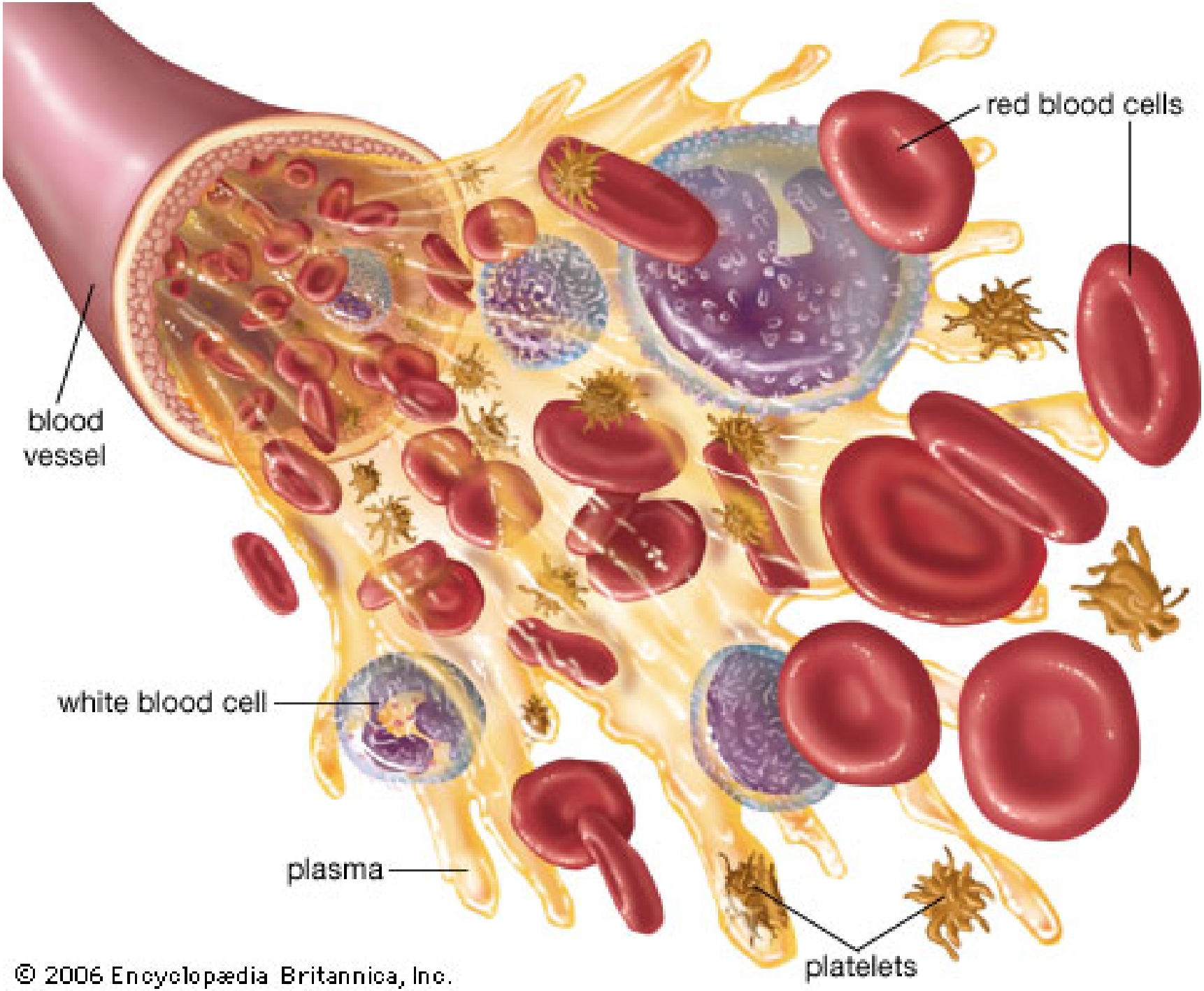
- We measure both systolic and diastolic pressure
- Device used = SPHYGMOMANOMETER
  - Measures the amount of pressure needed to stop flow of blood through an artery
  - Normally measured at the brachial artery (arm)
- Blood pressure is highest in arteries near the heart
- It lowers in the capillary beds and it lowest in the veins
  - This is why skeletal muscle contractions is necessary to help blood back to the heart from your limbs!

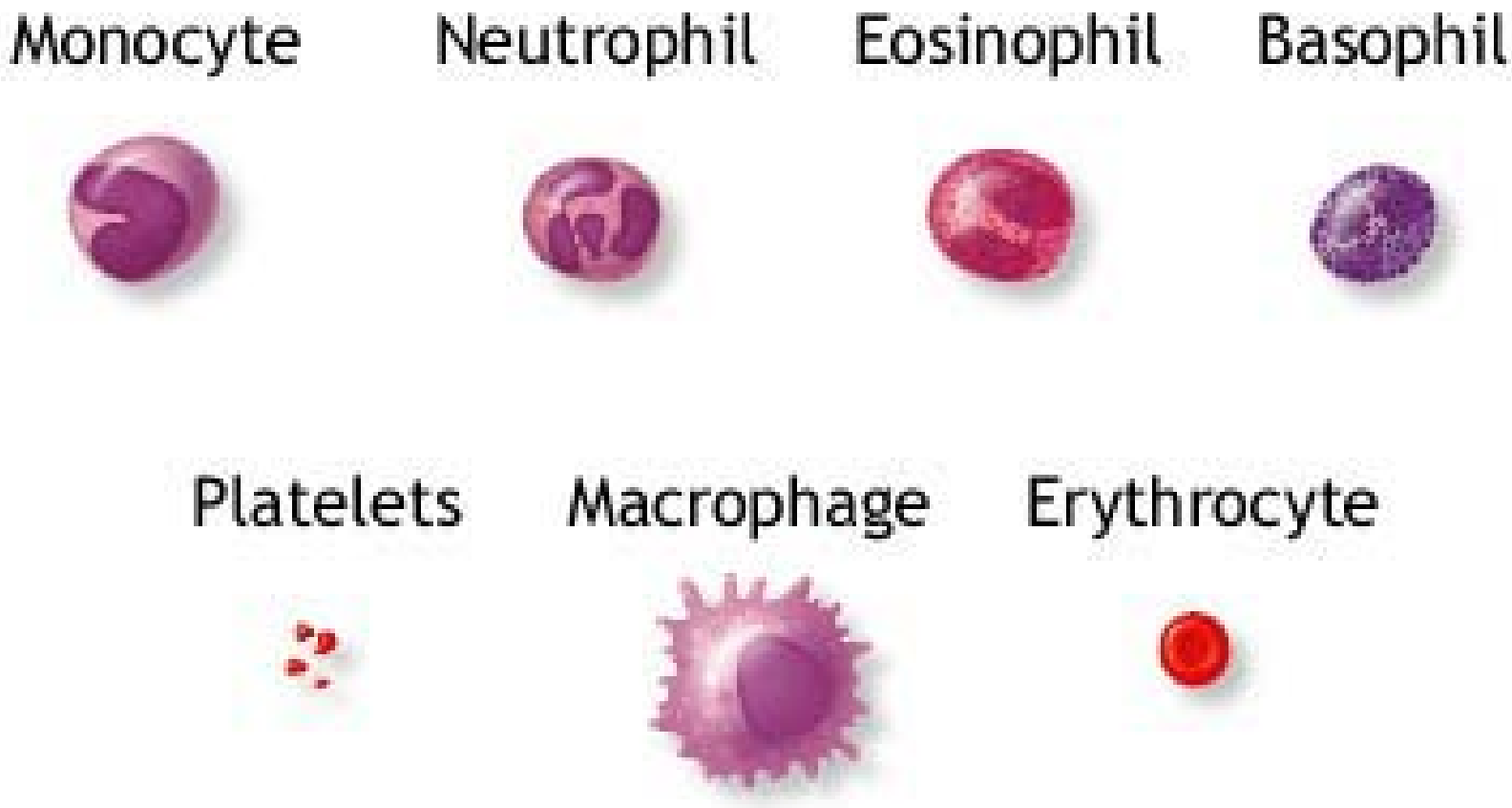
12.4 Components of Blood

- Blood can be separated into two components:
  - Formed elements: RBCs, WBCs, and platelets
  - Plasma: liquid portion; contains plasma proteins

- Blood functions in a few ways:
  - Regulatory: regulates body temperature
  - Protective: WBCs make up part of the body's immune system
  - Essential materials are transported in blood:
    - Gases
    - Nutrients
    - Wastes
    - Hormones

FORMED ELEMENTS	Function and Description	Source
Red Blood Cells (erythrocytes)  4 million–6 million per mm^3 blood	Transport O_2 and help transport CO_2 7–8 µm in diameter Bright-red to dark-purple biconcave disks without nuclei	Red bone marrow
White Blood Cells (leukocytes) 5,000–11,000 per mm^3 blood	Fight infection	Red bone marrow
Granular leukocytes		
• Neutrophils  40–70%	10–14 µm in diameter Spherical cells with multilobed nuclei; fine, pink granules in cytoplasm; phagocytize pathogens	
• Eosinophils  1–4%	10–14 µm in diameter Spherical cells with bilobed nuclei; coarse, deep-red, uniformly sized granules in cytoplasm; phagocytize antigen-antibody complexes and allergens	
• Basophils  0–1%	10–12 µm in diameter Spherical cells with lobed nuclei; large, irregularly shaped, deep-blue granules in cytoplasm; release histamine, which promotes blood flow to injured tissues	



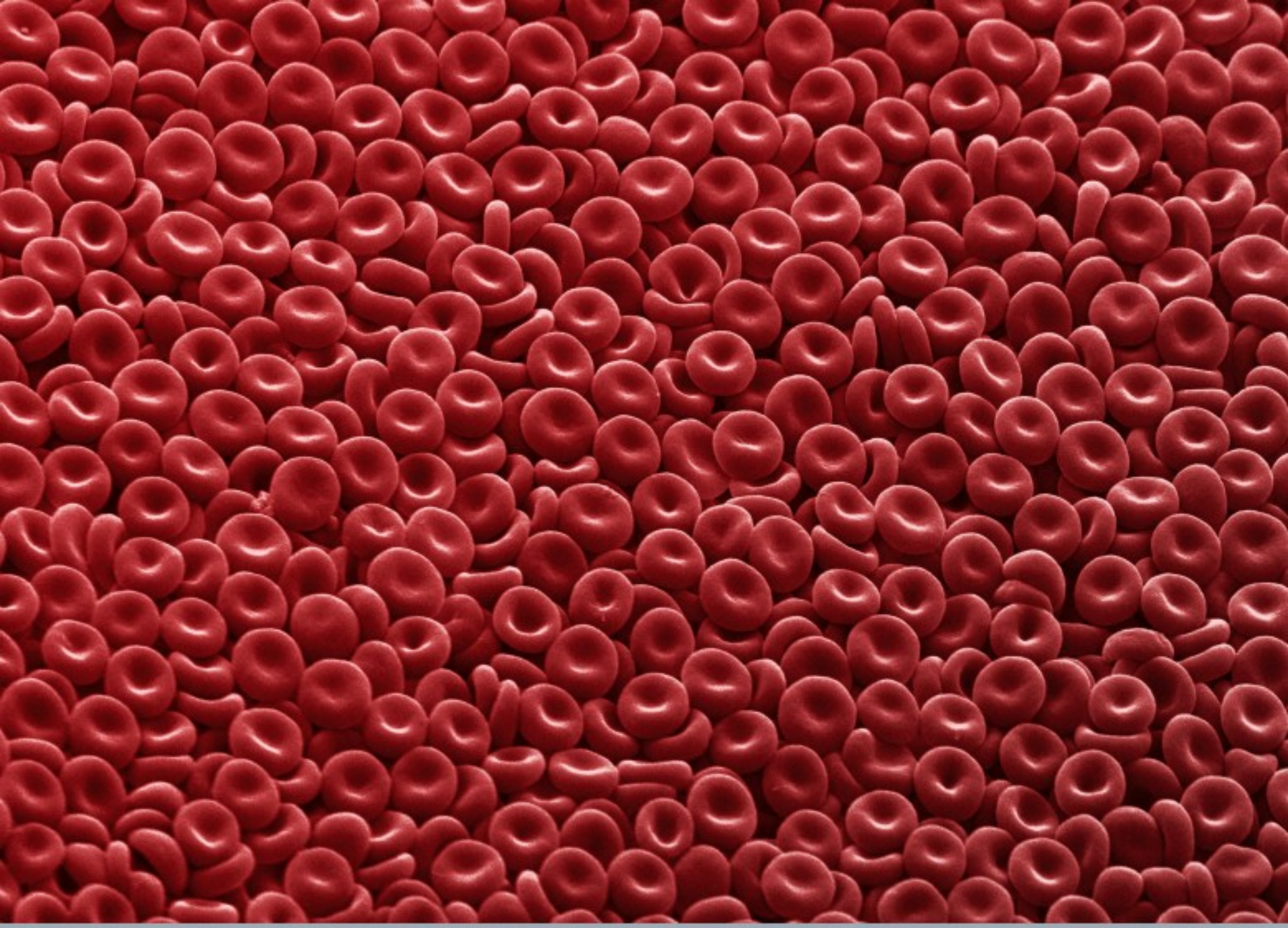

Monocyte
Neutrophil
Eosinophil
Basophil
Platelets
Macrophage
Erythrocyte

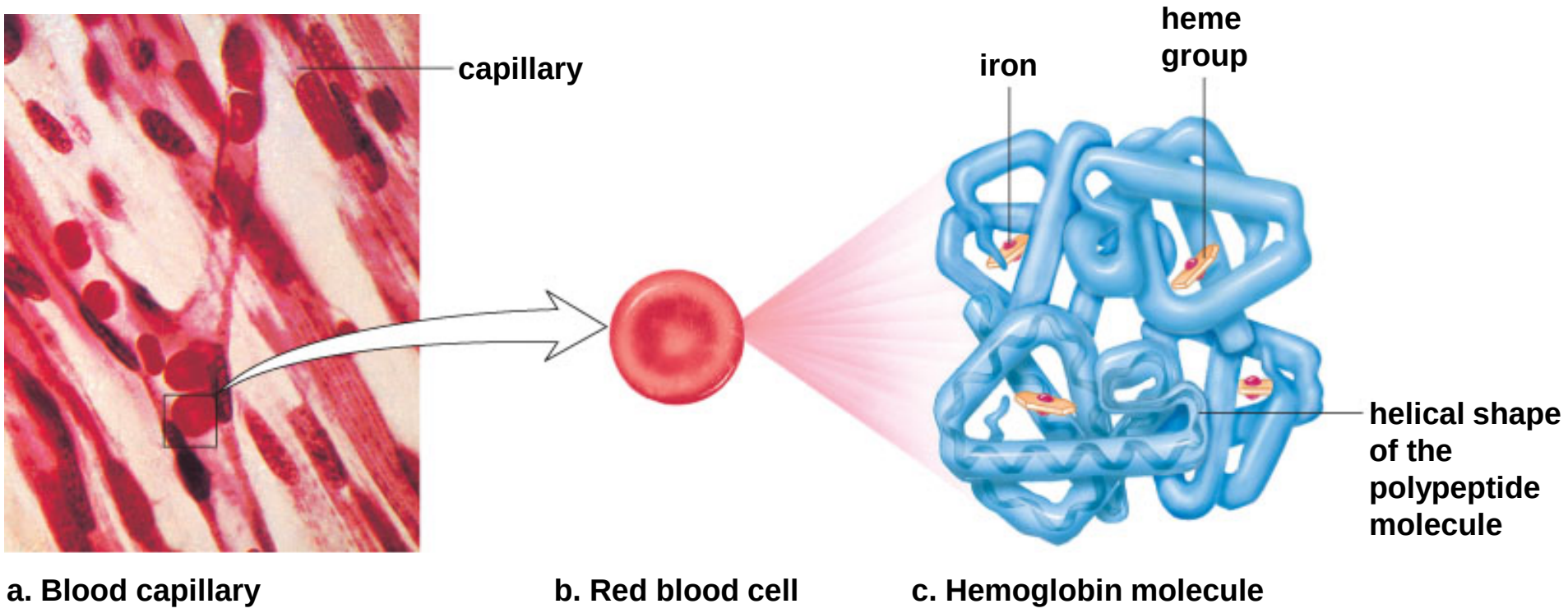
Plasma proteins…

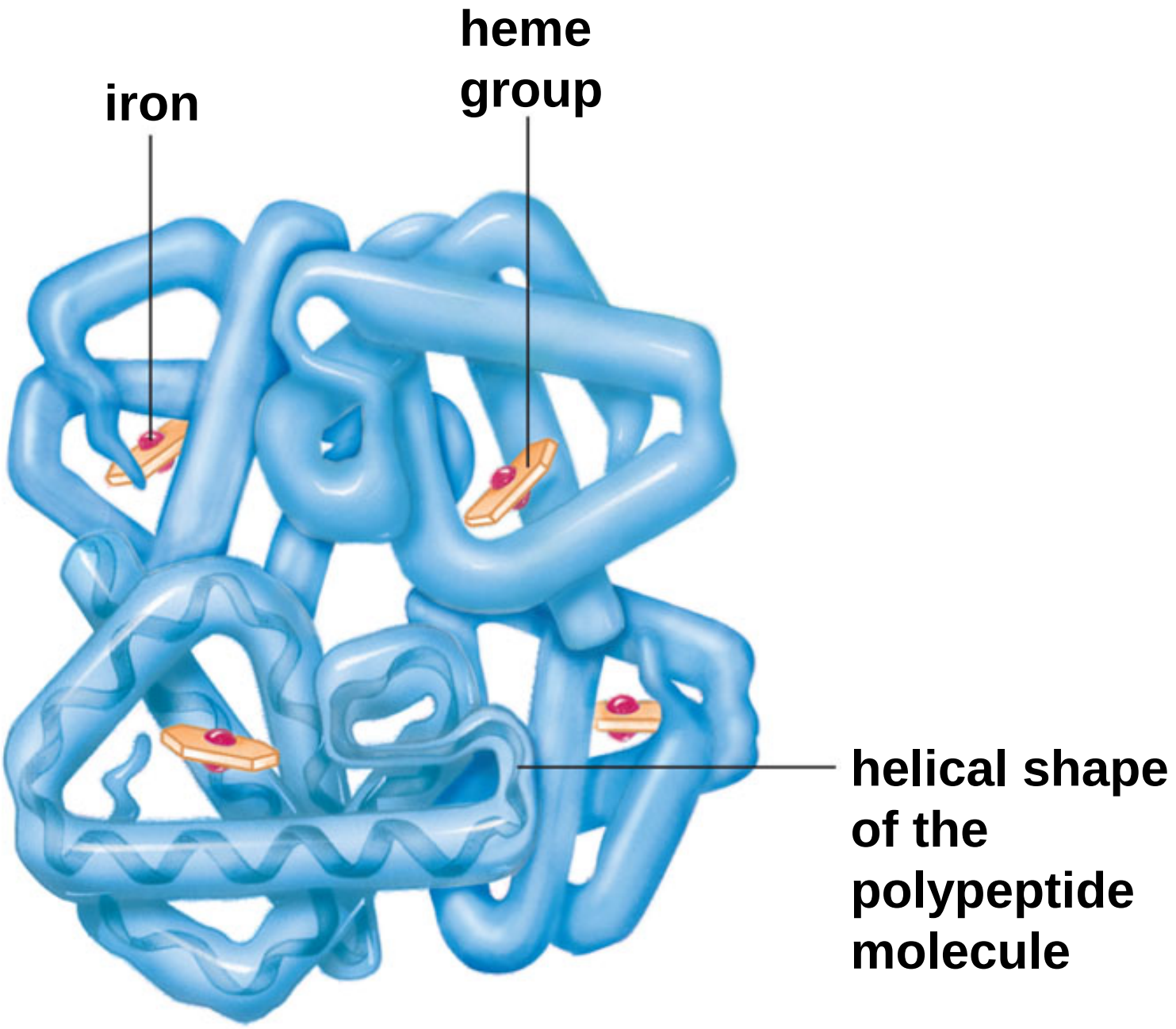
- Make up 7-8% of plasma
- Assist in transporting large molecules in blood
- Ex. Albumin – a blood protein, transports bilirubin a product of the breakdown of hemoglobin
- Lipoproteins transport cholesterol
- Fibrinogen aids in blood clotting
- Immunoglobulins (antibodies) fight infection
- Maintain blood volume – keep blood hypertonic to tissue fluid and H_2O automatically diffuses into capillaries

The role of RBCs

- ***AKA: Erythrocytes***
- ***Shape = Bi-concave disc***
- Manufactured in red bone marrow of the skull, ribs, vertebrae, and ends of long bones
- RBCs lack nuclei – so only survive ~120 days
- RBCs are destroyed/recycled in the liver and spleen
- Contain hemoglobin – an iron-containing protein pigment that gives them their red colour
  - Hb consists of 4 polypeptide chains
  - The iron-portion of Hb acquires oxygen in the lungs and gives it up in the tissues → oxyhemoglobin
  - Hb also carries CO_2 from the tissue back to the lungs → carbaminohemoglobin



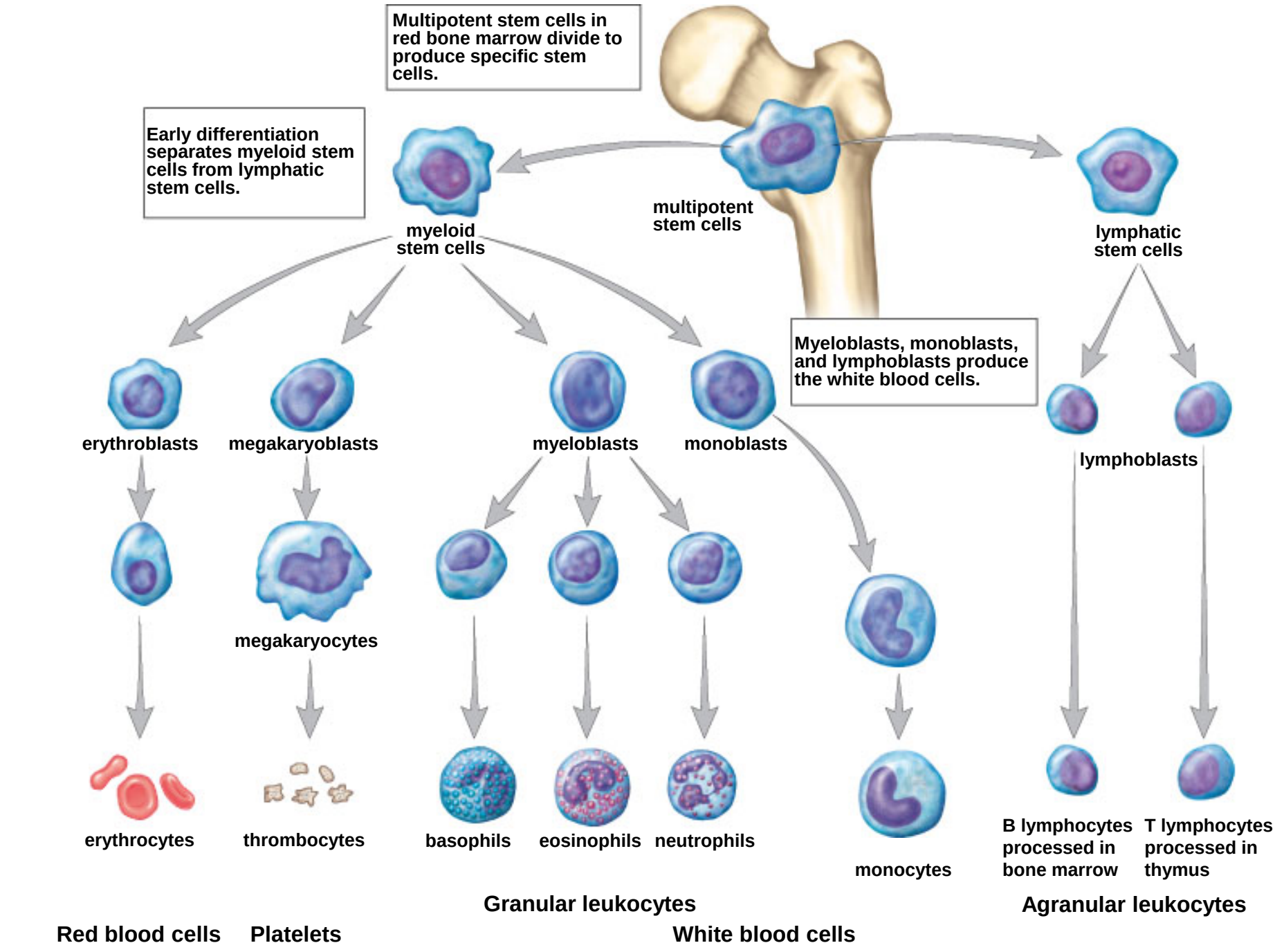




c. Hemoglobin molecule

The role of WBCs

- ***AKA: Leukocytes***
- They are larger, have a nucleus, lack hemoglobin, appear translucent
- Not as numerous
- They fight infection and help immunity
- ***6 types of WBCs:***
  - Neutrophils
  - Eosinophils
  - Basophils
  - Lymphocytes
  - Monocytes → Macrophages

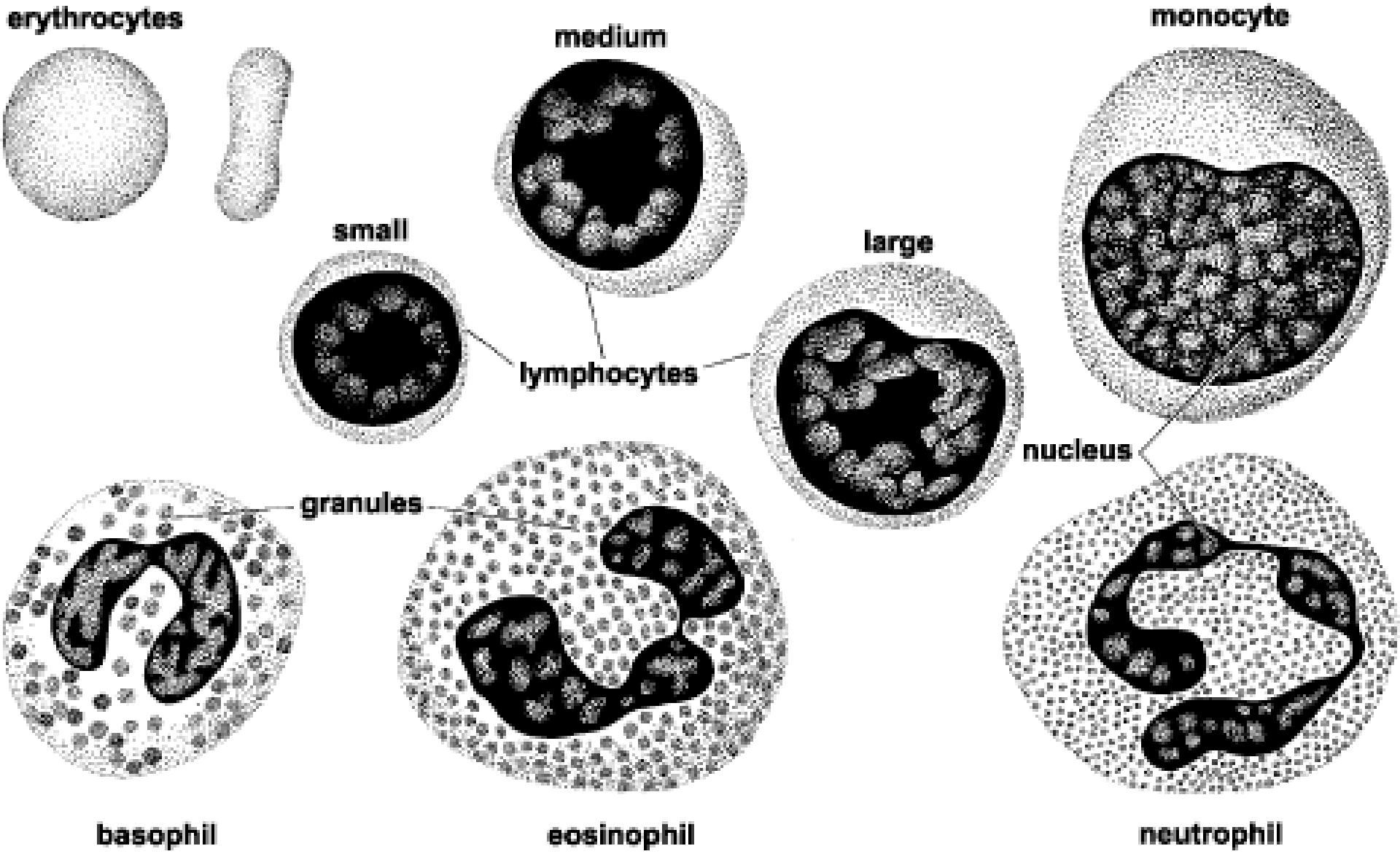


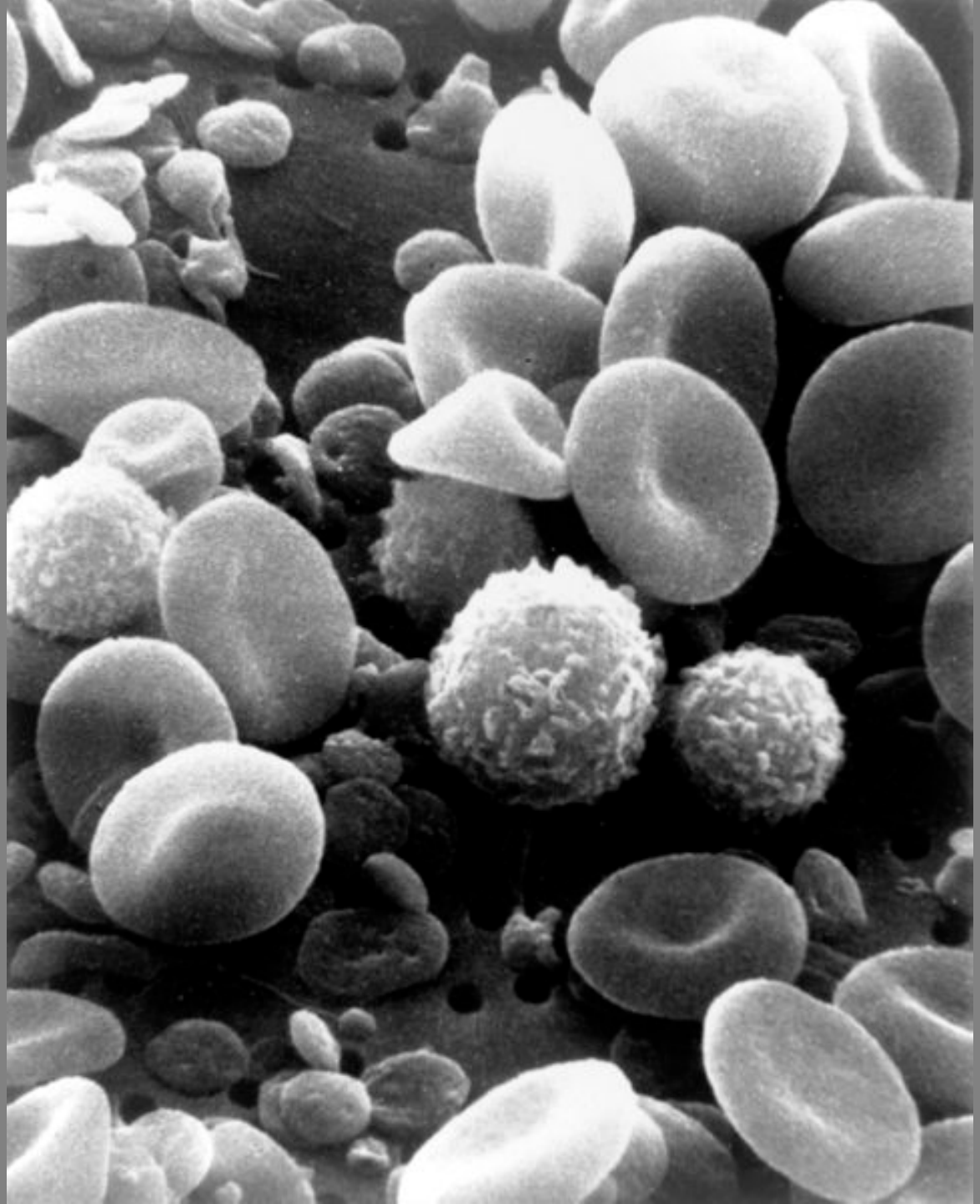
Granulocytes:

- Have granules in their cytoplasm = lysosomes
- Have multi-lobed nuclei
- ***Neutrophils***
  - Phagocytize bacteria
- ***Eosinophils***
  - Phagocytize antigen-antibody complexes
- ***Basophils***
  - Congregate in tissues
  - Release histamine – cause inflammation

Agranulocytes:

- Don't have granules
- ***Lymphocytes*** – circular nucleus
  - B-lymphocytes produce antibodies
  - T-lymphocytes kill virus-containing cells
- ***Monocytes*** – indented nucleus
  - Phagocytic cells
  - Become macrophages – upon entering the tissues
- Both are produced in lymphoid tissue
  - Found in spleen, lymph nodes and tonsils


erythrocytes
medium
monocyte
small
large
lymphocytes
nucleus
granules
basophil
eosinophil
neutrophil



The role of platelets

- They are fragments of bone marrow cells called megakaryocytes
- Involved in blood clotting
  - AKA: Coagulation

Blood clotting

- Clotting occurs when a blood vessel gets damaged
- The damaged area along with platelets release prothrombin activator
- Prothrombin is converted to thrombin
- Thrombin acts as an enzyme and activates fibrinogen by cleaving it to form fibrin molecules
- Fibrin threads wind around the platelets forming a plug at the site of damage
- RBCs join the clot giving it a red colour

Antibodies and Antigens:

- Antibodies are Y-shaped proteins made by lymphocytes
- They are specific to particular antigens
- They combine with antigens to form antibody-antigen complexes
- These complexes are then engulfed by phagocytic white blood cells

Capillary-Tissue Fluid Exchange

- There are two forces acting on the walls of capillaries influence fluid exchange
  - Blood pressure and osmotic pressure
- **Blood pressure** is due to the force of the blood flowing through the vessels
  - Tends to push H_2O into tissues from blood vessels
- **Osmotic pressure** is due to the tonicity of the blood – due to plasma proteins and salts
  - Tends to draw H_2O into blood vessels from tissues

Capillary-Tissue Fluid Exchange

- At the arterial end of a cap. bed the blood pressure is greater than the osmotic pressure
  - .: fluids are pushed into the tissue
- In the middle of the capillary bed, the blood pressure is equal to the osmotic pressure
  - .: O_2, CO_2, amino acids, and glucose are free to diffuse/move down their gradient
- At the venule end of the cap. bed the blood pressure is lower than the osmotic pressure
  - .: H_2O is drawn into the blood from the tissues

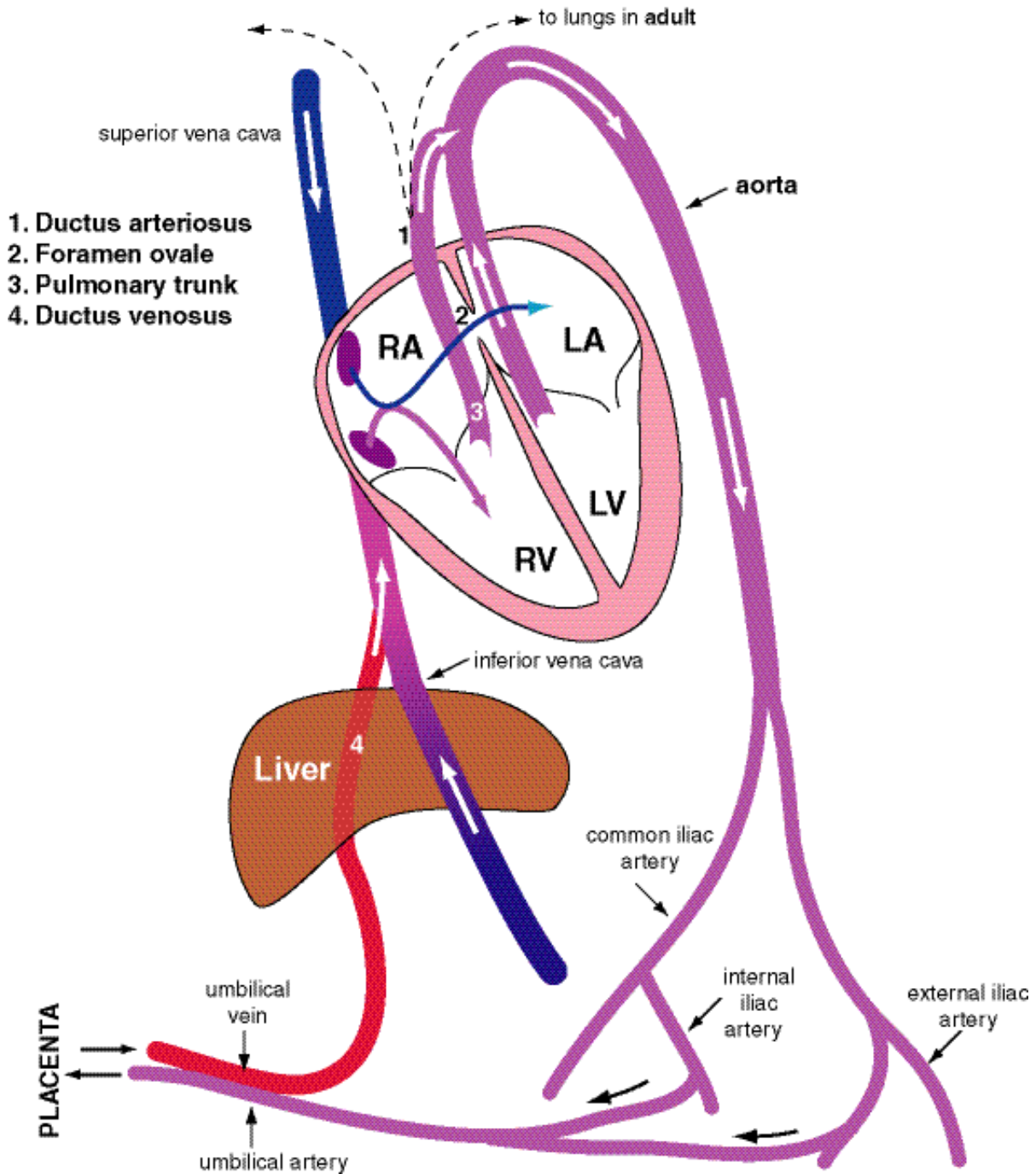
The Lymphatic System

- A network of lymph vessels and lymphoid organs throughout the body
- Functions to drain excess fluid (lymph) from the tissues and move it back into the circulatory system
  - Meets circ. system at right and left subclavian veins.
- It also collects lipids in lacteals found in the villi of the small intestine and transports them to the bloodstream.
- Lymph vessels are similar to veins because they rely on muscular contractions (of skeletal muscle) to move fluid and they have one-way valves!

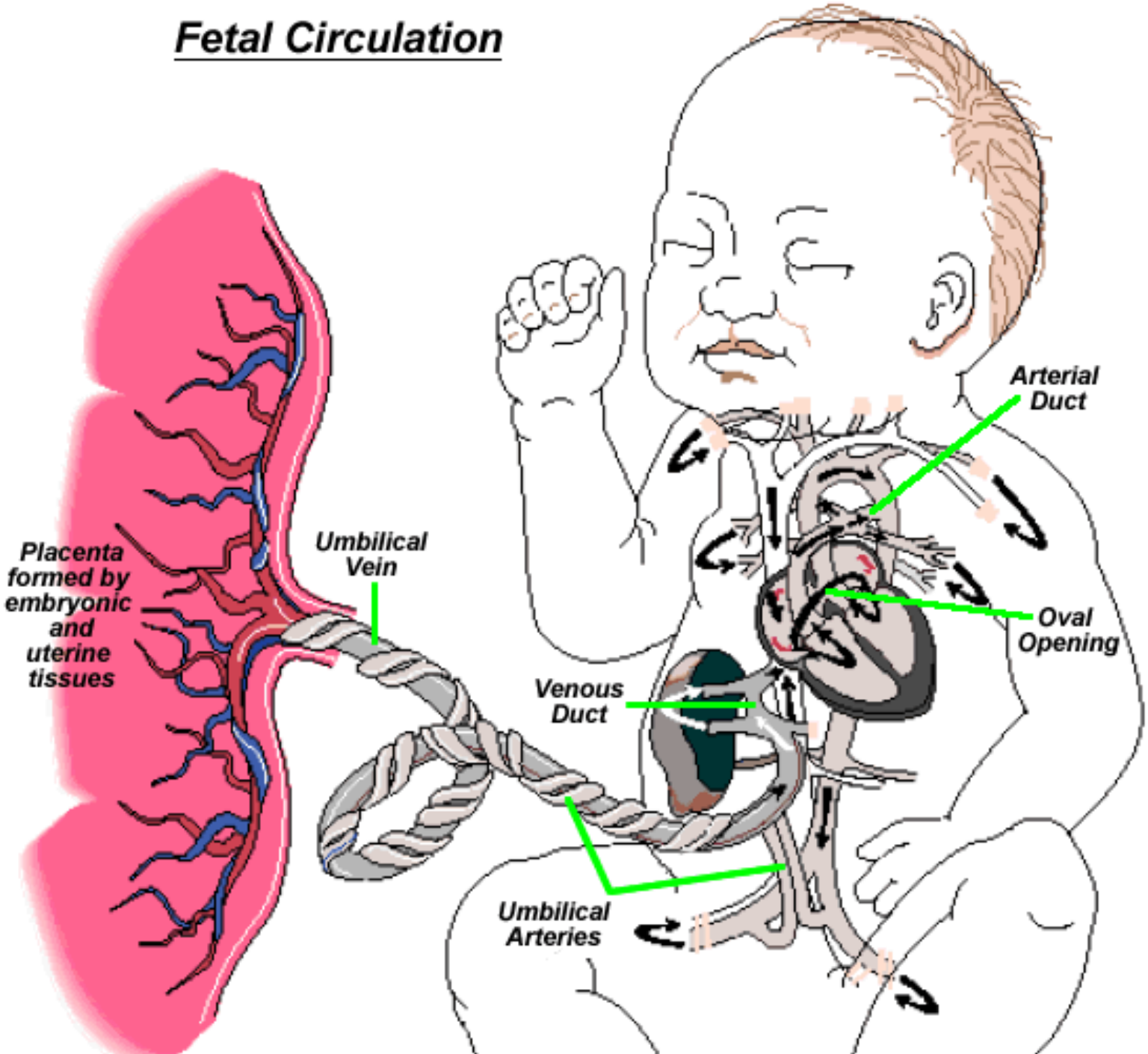
Fetal circulatory system

- Has some features not present in adults
- The fetus does not use its lungs for gas exchange
- **OVAL OPENING:** a shunt that directs blood from the right atrium into the left atrium (bypassing the lungs)
- **ARTERIAL DUCT** shunts any blood in the pulmonary trunk into the aorta
- **UMBILICAL ARTERIES** carry deoxygenated blood and wastes to placenta (from fetus)
  UMBILICAL VEIN carries O2 and nutrient rich blood to the fetus (from placenta)
  - **VENOUS DUCT** joins with the umbilical vein in the liver which merges with the inferior V.C. bringing blood to the heart

Fetal Circulation



Fetal Circulation



Your assignment:

- Study for your test _____!
- Complete provincial pkg., reading assignment, etc…
- Finish your PLOs/CUE CARDS!