



BLOOD VESSELS

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Blood Vessels

- ☐ Blood is carried in a closed system of vessels that begins and ends at the heart
- ☐ The three major types of vessels are arteries, capillaries, and veins
- ☐ Arteries carry blood away from the heart, veins carry blood toward the heart
- ☐ Capillaries contact tissue cells and directly serve cellular needs

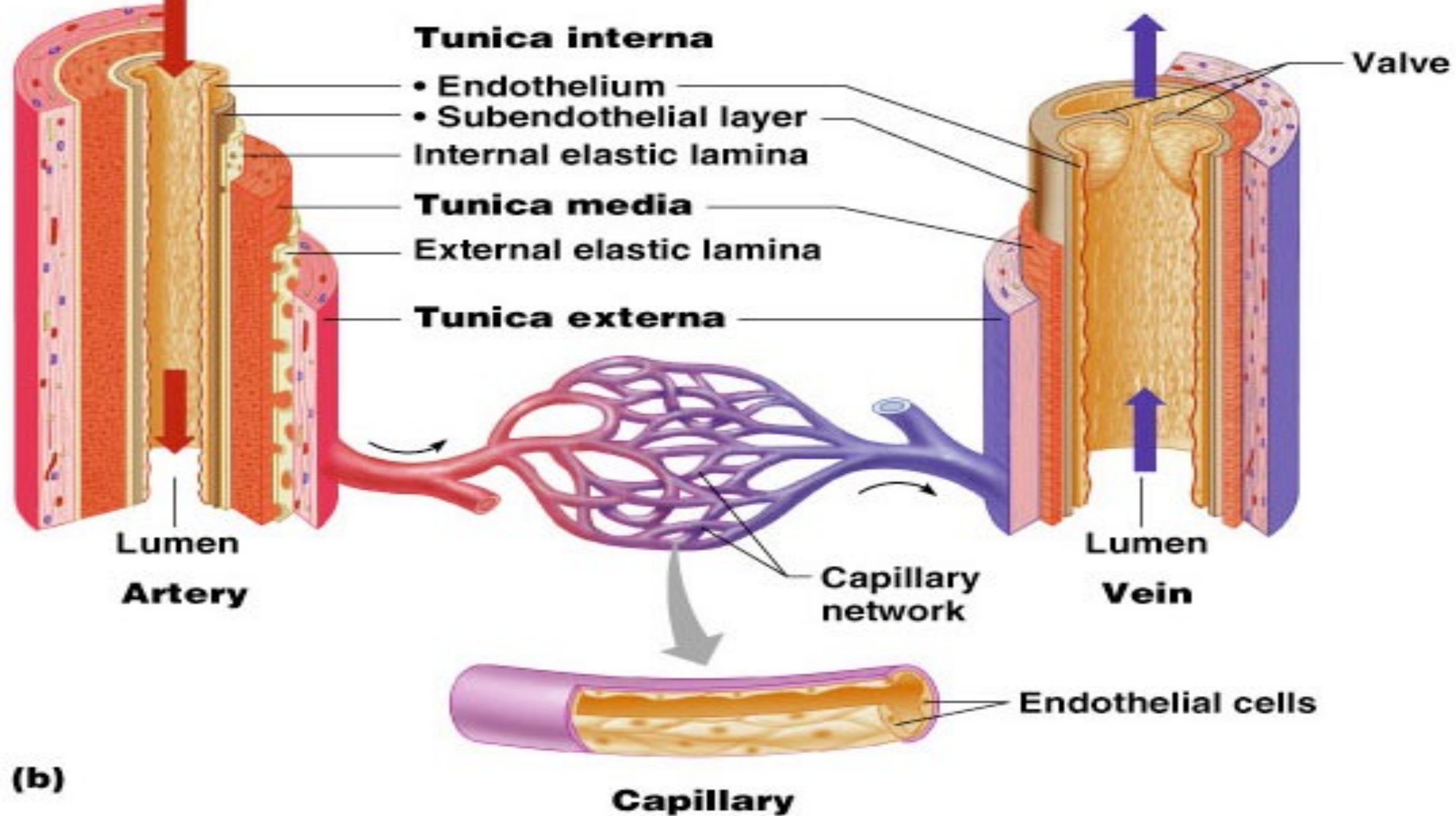


Generalized Structure of Blood Vessels

❑ Layers

- Tunica externa: found in arteries and veins (tunica adventitia)
- Tunica media: found in arteries and veins
- Tunica intima: found in all blood vessels
 - Lining endothelial cells
 - Only lining found in capillary
 - Line entire vascular tree
 - Provide a smooth luminal surface; protect against intravascular coagulation

❑ Lumen – central blood-containing space surrounded by tunics





BLOOD VESSELS

- ❑ Collagen fibers > **STRENGTH**
 - Exhibit woven appearance
 - Have only a limited ability to stretch (2% to 3%) under physiological conditions
 - Strengthen and keep lumen of vessel open



BLOOD VESSELS

- ❑ Elastic fibers > **STRETCH**
 - Form highly elastic networks
 - Fibers can stretch more than 100% under physiological conditions
 - Play important role in creating passive tension to help regulate blood pressure throughout the cardiac cycle
- ❑ Smooth muscle fibers > **CONTRACTION**
 - **Vasodilation vs. Vasoconstriction**
 - Most numerous in elastic and muscular arteries
 - Exert active tension in vessels when contracting

VASODILATATION and VASOCONSTRICTION



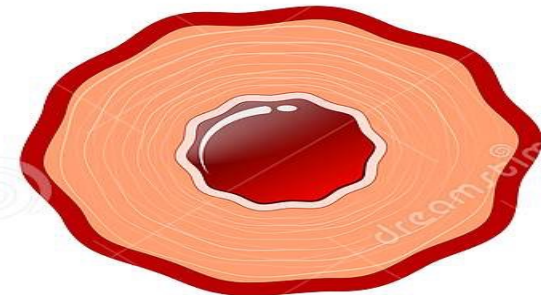
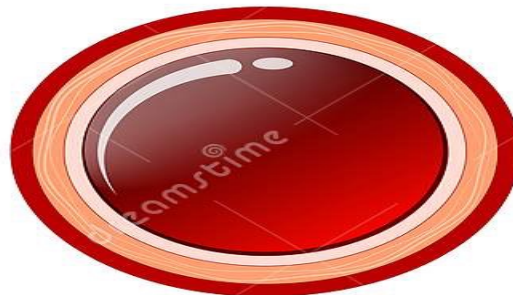
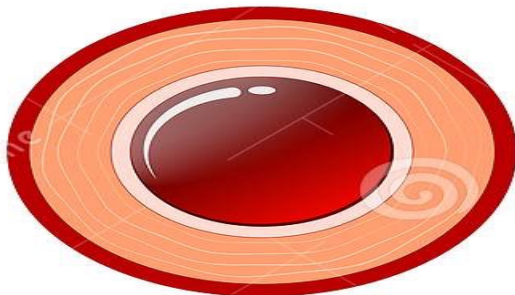
Normal
artery



Vasodilatation
artery



Vasoconstriction
artery



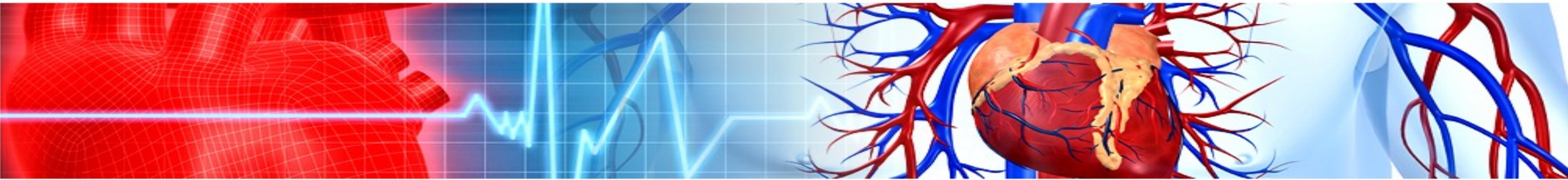


Capillaries are the smallest blood vessels

□ Types of blood vessels

■ Capillaries

- Primary exchange vessels
- Microscopic vessels
- Carry blood from arterioles to venules; together, arterioles, capillaries, and venules constitute the microcirculation
- Not evenly distributed; highest numbers in tissues with high metabolic rate; may be absent in some “avascular” tissues, such as cartilage



- Walls consisting of a thin tunica interna, one cell thick
- Allow only a single RBC to pass at a time



Capillaries

❑ *Smallest blood vessels*

- Diameter from 8 to 10 μm
 - Red blood cells pass through single file
- *Site-specific functions of capillaries*
 - Lungs—oxygen enters blood, carbon dioxide leaves
 - Small intestines—receive digested nutrients
 - Endocrine glands—pick up hormones
 - Kidneys—remove of nitrogenous wastes

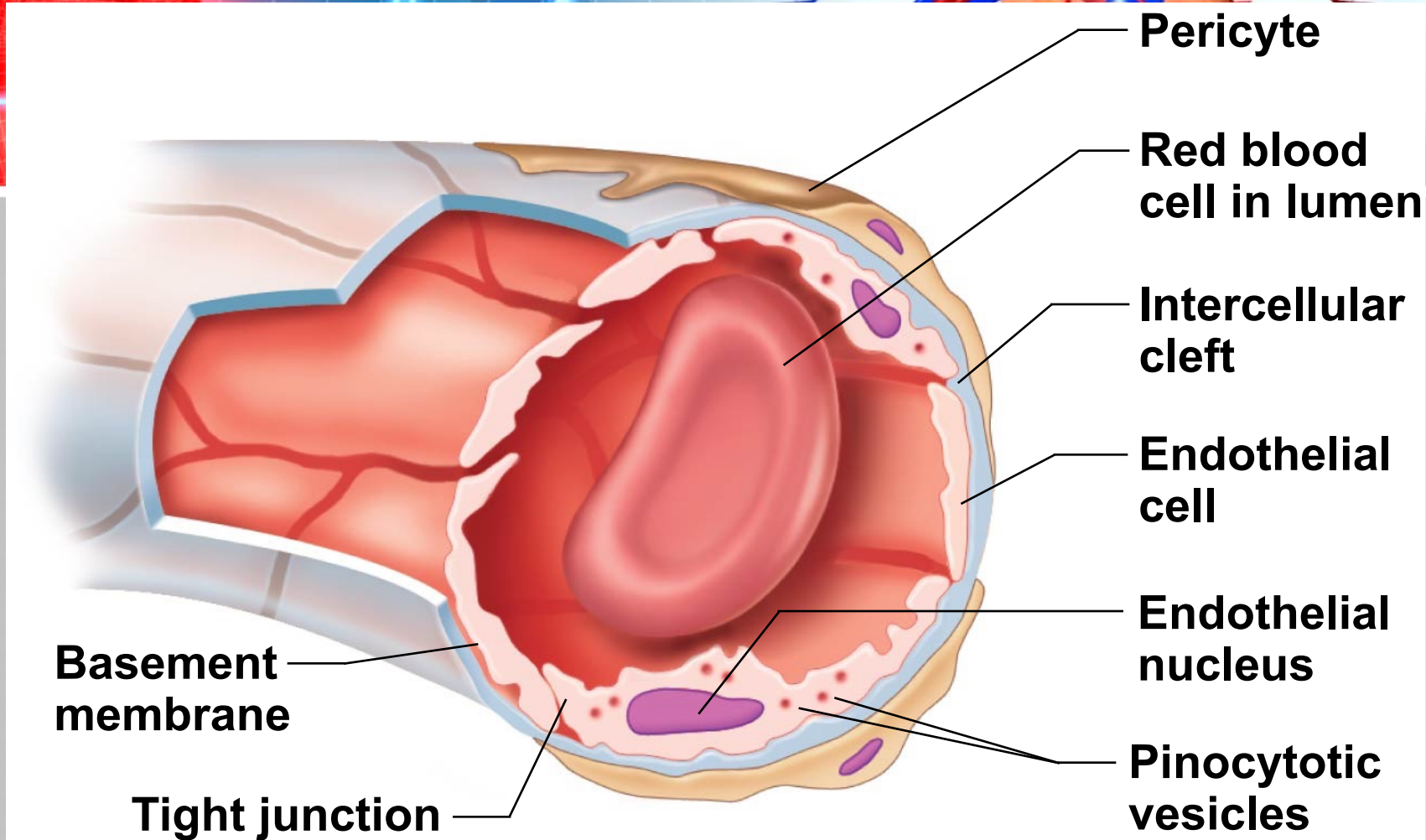




Continuous Capillaries

- ❑ Most common type of capillary
- ❑ Occur in most organs
- ❑ Tight junctions and desmosomes join epithelial cells
- ❑ **Intercellular clefts**
 - Gaps of unjoined membranes
 - Allow small molecules in and out of capillaries

Figure 20.4a Capillary structure.



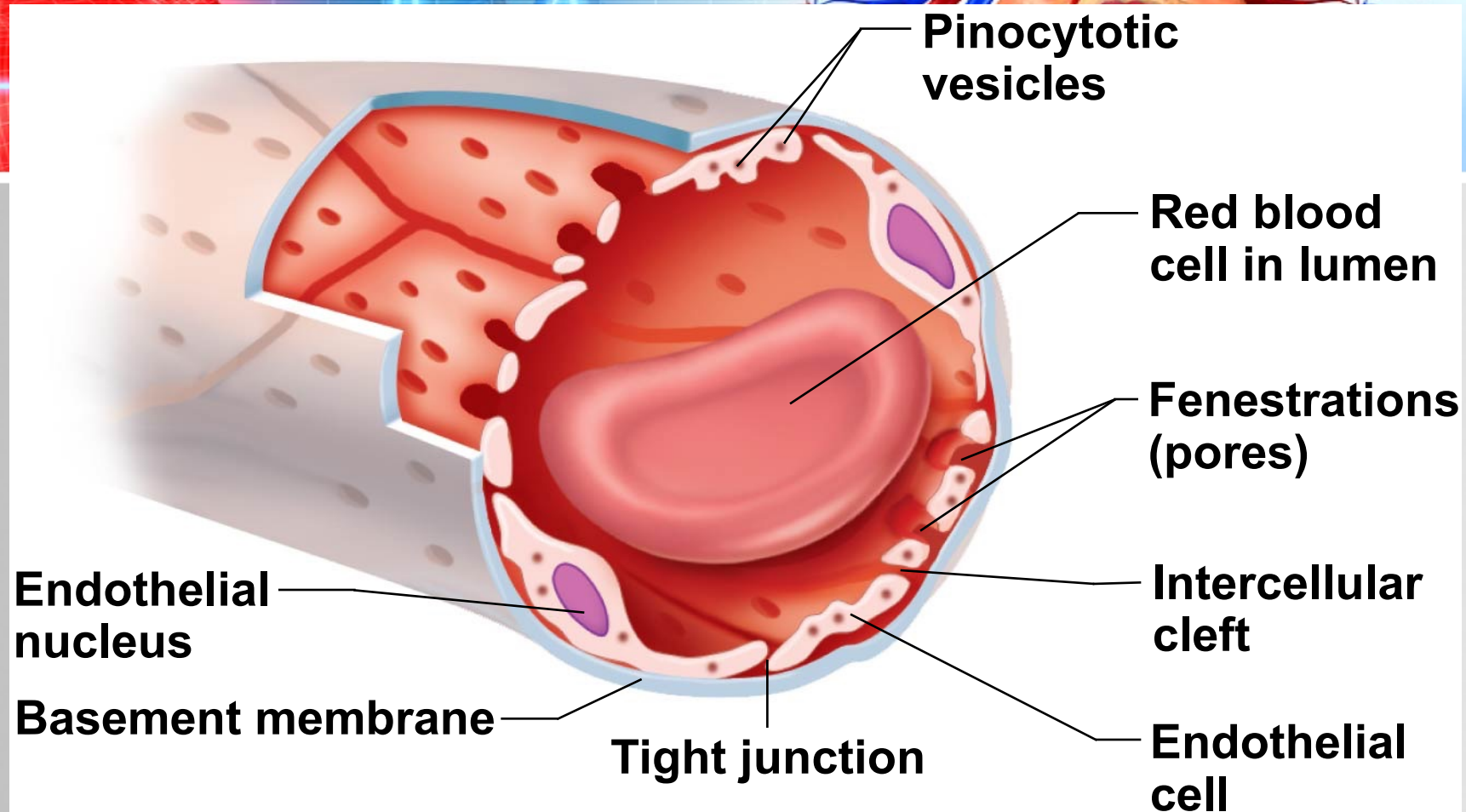
(a) Continuous capillary. Least permeable, and most common (e.g., skin, muscle).

An anatomical illustration of the human heart and its associated blood vessels. The heart is shown in a cross-section, with red arteries and blue veins branching out. The background features a grid pattern and glowing blue lines, suggesting a scientific or medical theme.

Fenestrated Capillaries

- ❑ Joined by tight junctions and desmosomes
- ❑ Have pores in their endothelium
- ❑ Occur where high rates of exchange occur
 - Intestines
 - Glomeruli of kidneys
 - Endocrine glands

Figure 20.4b Capillary structure.



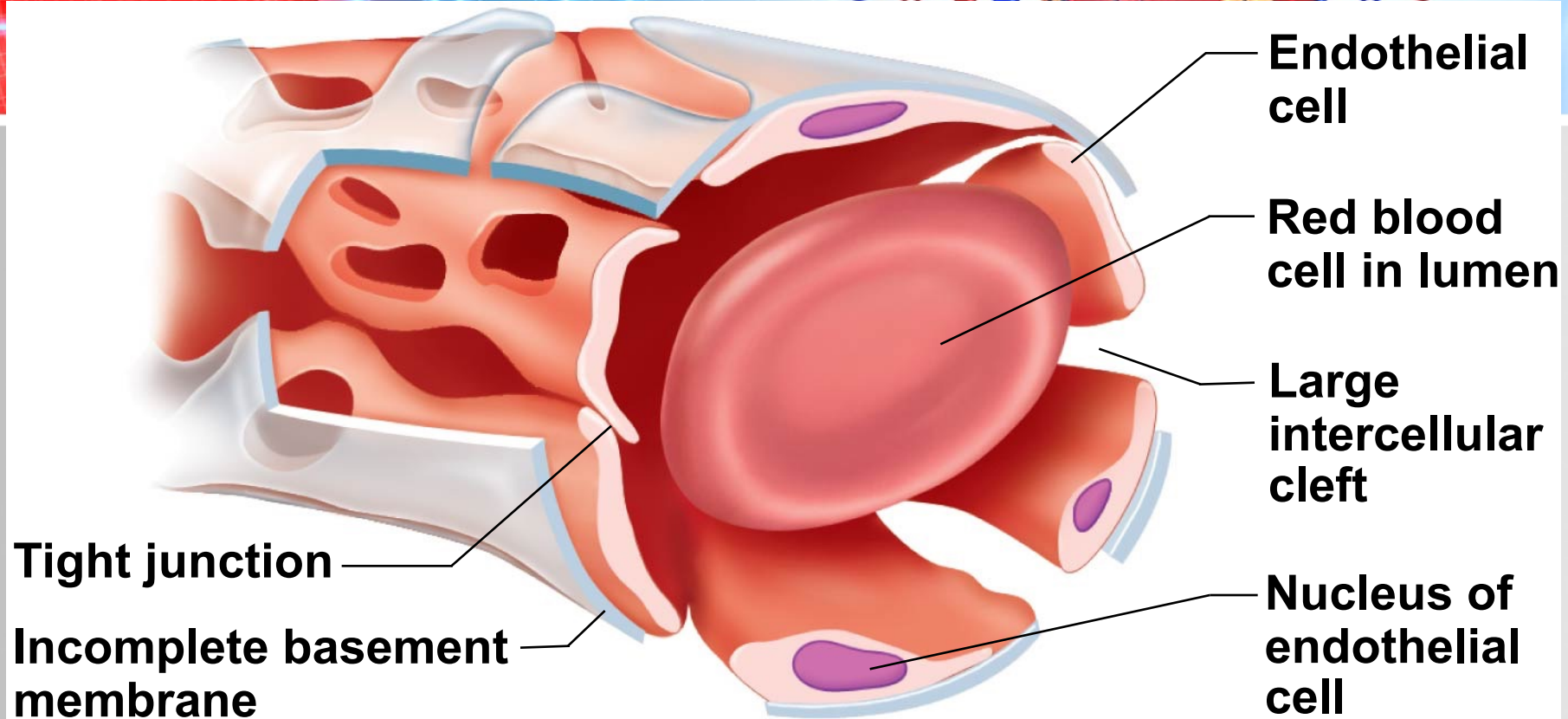
(b) Fenestrated capillary. Large fenestrations (pores) increase permeability. Occurs in areas of active absorption or filtration (e.g., kidney, small intestine).



Sinusoids

- ❑ Wide, leaky capillaries found in some organs
 - Usually fenestrated
 - Intercellular clefts are wide open
- ❑ Occur in bone marrow and spleen
 - Sinusoids have a large diameter and twisted course

Figure 20.4c Capillary structure.



(c) Sinusoid capillary. Most permeable. Occurs in special locations (e.g., liver, bone marrow, spleen).



Low-Permeability Capillaries

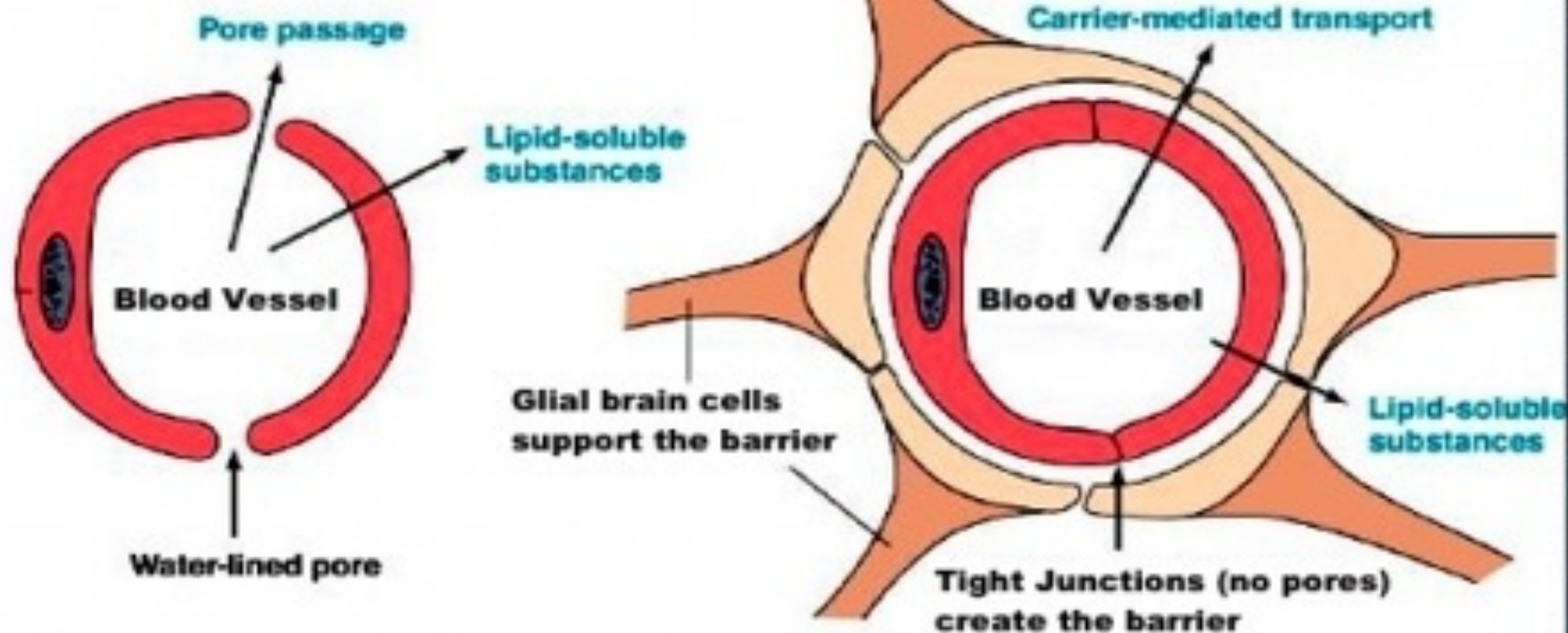
- ❑ Blood brain barrier
 - Capillaries have complete tight junctions
 - No intercellular clefts are present
 - Vital molecules pass through
 - Highly selective transport mechanisms
 - Not a barrier against:
 - Oxygen, carbon dioxide, and some anesthetics
 - Caffeine crosses the blood brain barrier in a few minutes – Thank You God!!!!

The Blood Brain Barrier

Normal Blood Vessels

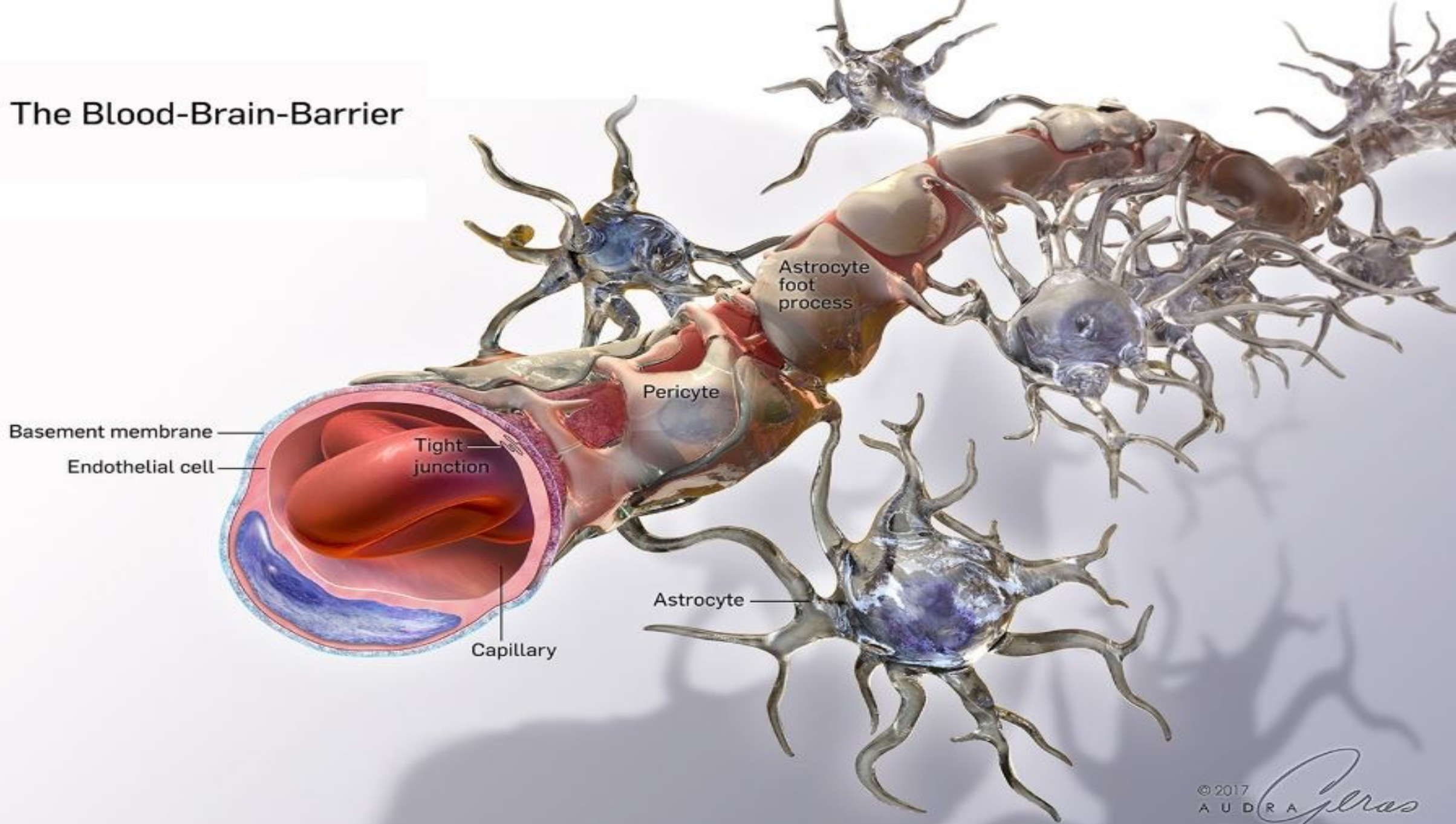
vs.

Brain Blood Vessels



Capillaries in cross section

The Blood-Brain-Barrier



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Caffeine protects against disruptions of the blood-brain barrier in animal models of Alzheimer's and Parkinson's disease

[Xuesong Chen](#), [Othman Ghribi](#), and [Jonathan D. Geiger](#)

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Abstract

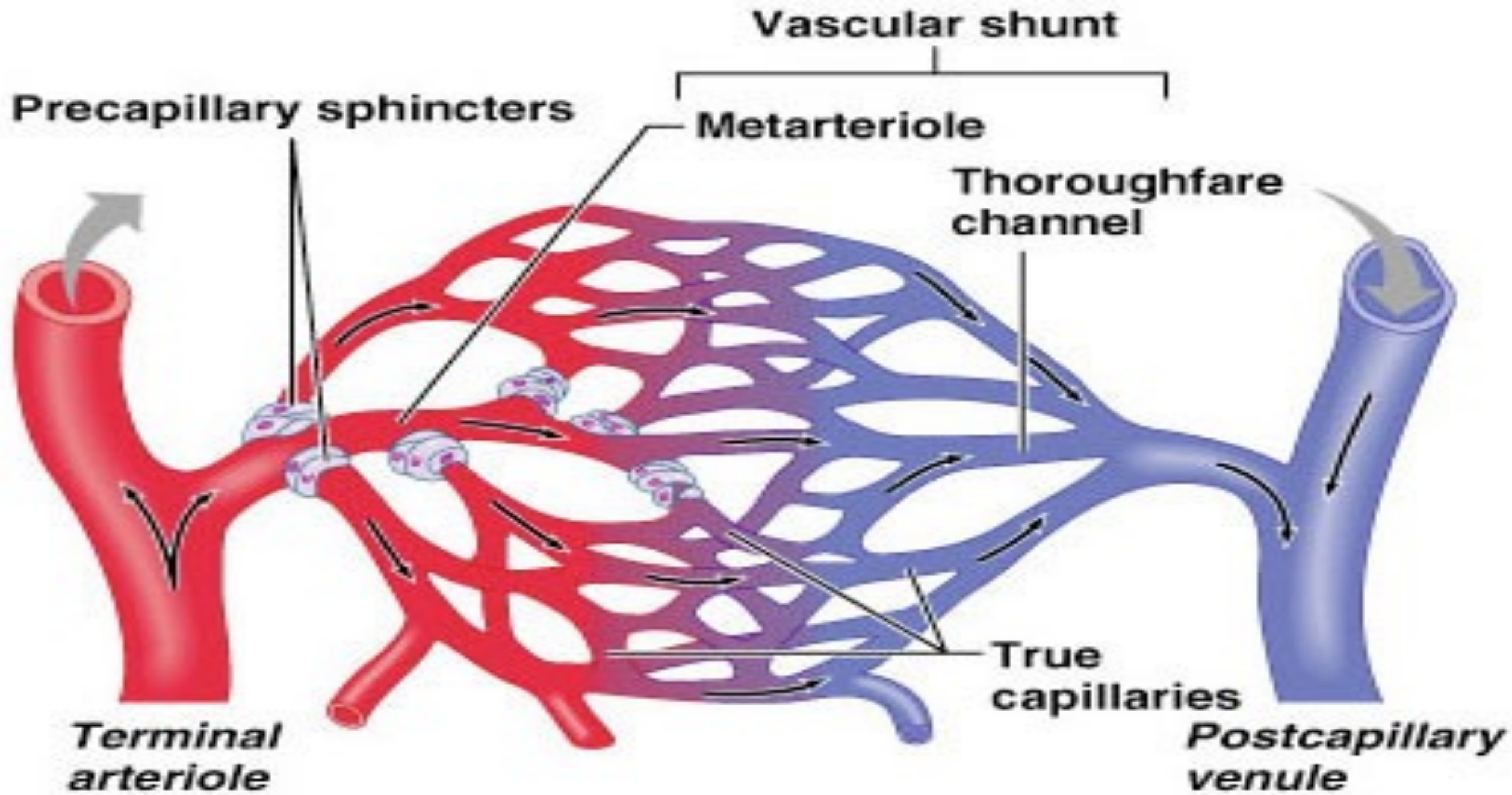
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Sporadic Alzheimer's disease (AD) and Parkinson's disease (PD) are two of the most common neurodegenerative diseases and as such they represent major public health problems. Finding effective treatments for AD and PD represents an unmet and elusive goal largely because these diseases are chronic and progressive, and have a complicated and ill-understood pathogenesis. Although the underlying mechanisms are not fully understood, caffeine, the most commonly ingested psychoactive drug in the world, has been shown in human and animal studies to be protective against AD and PD. One mechanism implicated in the pathogenesis of AD and PD is blood-brain barrier (BBB) dysfunction and we reported recently that caffeine exerts protective effects against AD and PD at least in part by keeping the BBB intact. The present review focuses on the role of BBB dysfunction in the pathogenesis of AD and PD,

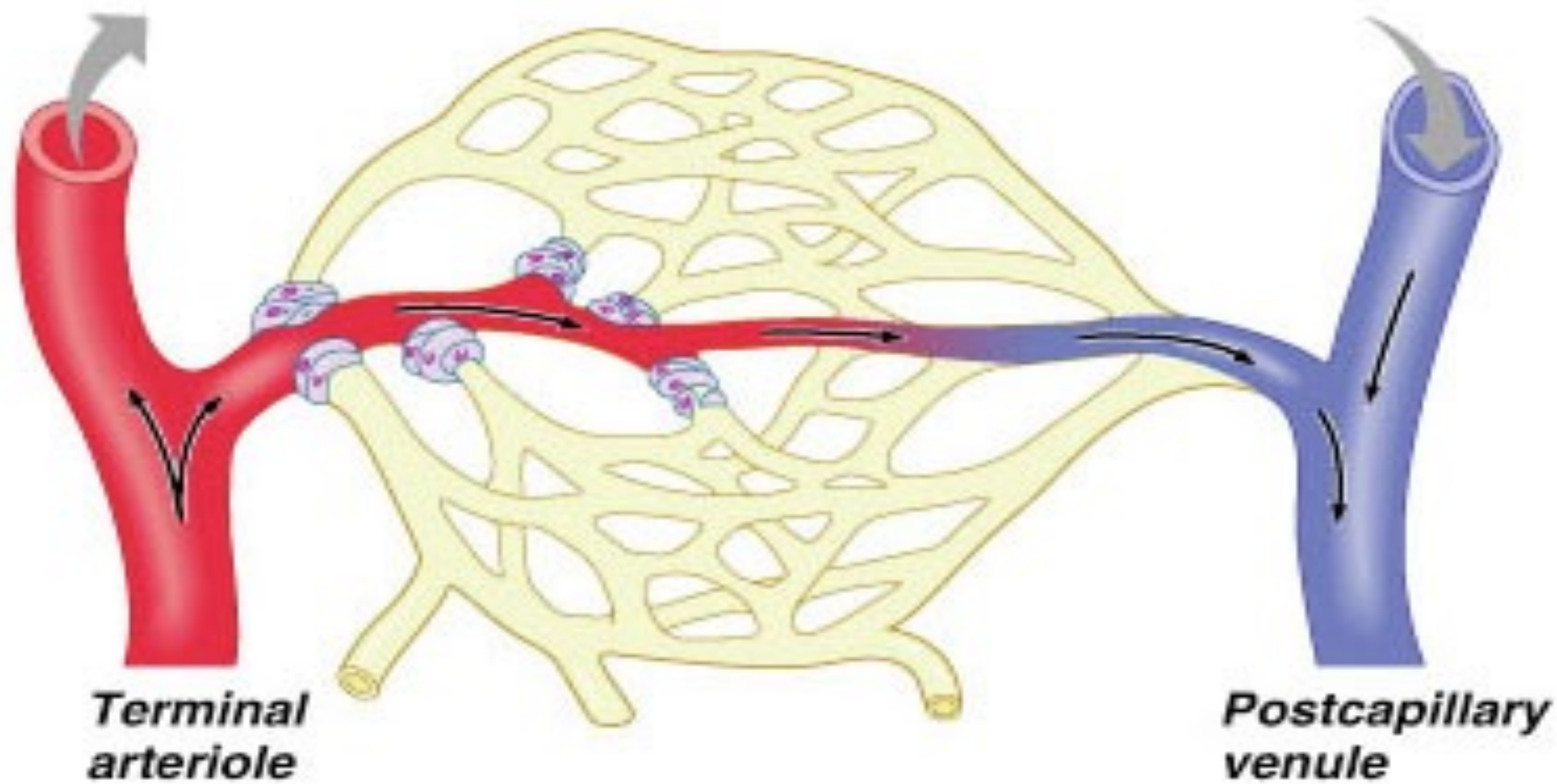


Capillary Beds

- ❑ Network of capillaries running through tissues
- ❑ **Precapillary sphincters**
 - *Regulate the flow of blood to tissues*
 - *Think of sphincters like you do valves Allows for unidirectional flow*
- ❑ Tendons and ligaments—poorly vascularized
- ❑ Epithelia and cartilage—avascular
 - Receive nutrients from nearby connective tissue



(a) Sphincters open



(b) Sphincters closed



Venous System: Veins

- ❑ Veins are capacitance vessels (blood reservoirs) that contain 65% of the blood supply
- ❑ Veins have much lower blood pressure and thinner walls than arteries
- ❑ To return blood to the heart, veins have special adaptations
 - Large-diameter lumens, which offer little resistance to flow
 - Valves which prevent backflow of blood



Venous Vessels

- ❑ Conduct blood from capillaries toward the heart
- ❑ Blood pressure is much lower than in arteries
- ❑ **Venules** are the smallest veins
 - Diameters from 8 to 100 μm
 - Smallest venules—called **postcapillary venules**
- ❑ Venules join to form veins

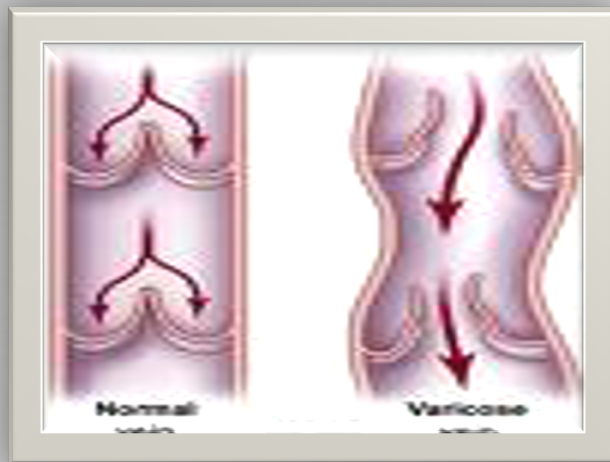


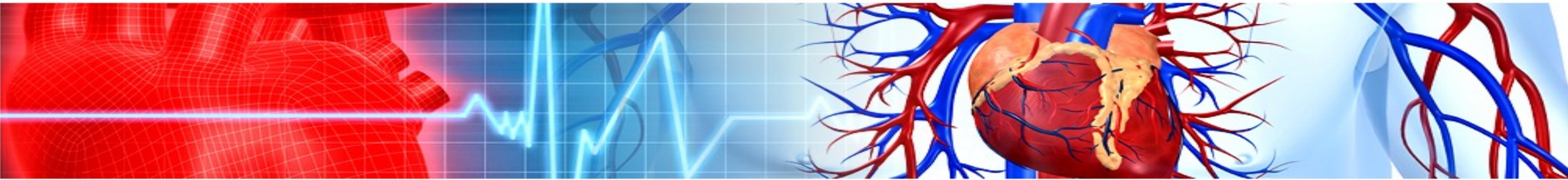
Veins

- ❑ Structural differences from arteries
 - Lumens are larger
 - 65% of blood in veins at any given time
 - Tunica externa is thicker
 - Less elastin in walls
 - Walls are thinner than those of comparable arteries

Varicose veins

- ❑ Varicose veins are veins that are tortuous and dilated because of leaky valves
 - 15% of adult population
 - Heredity, prolonged standing, obesity, pregnancy



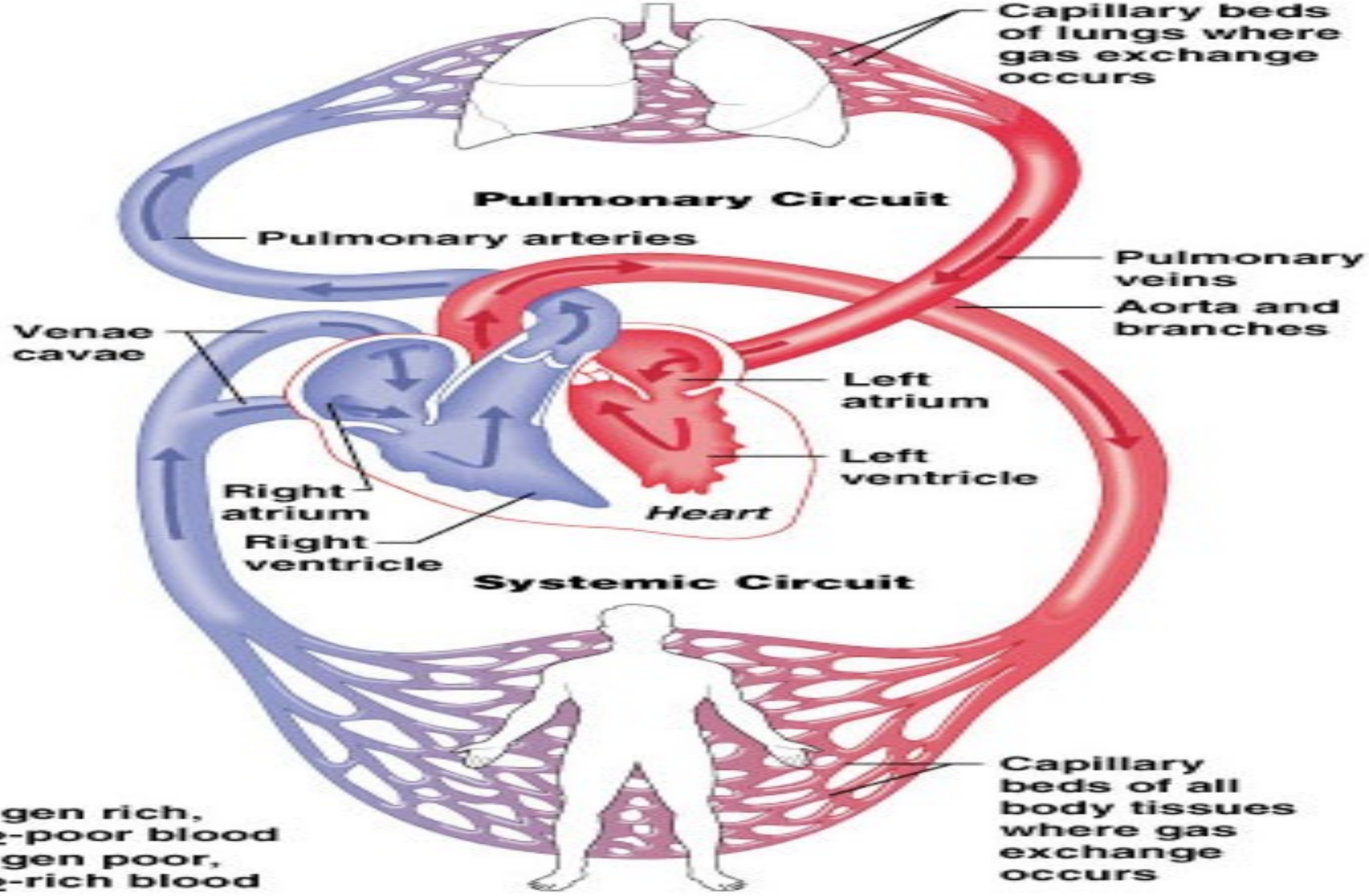




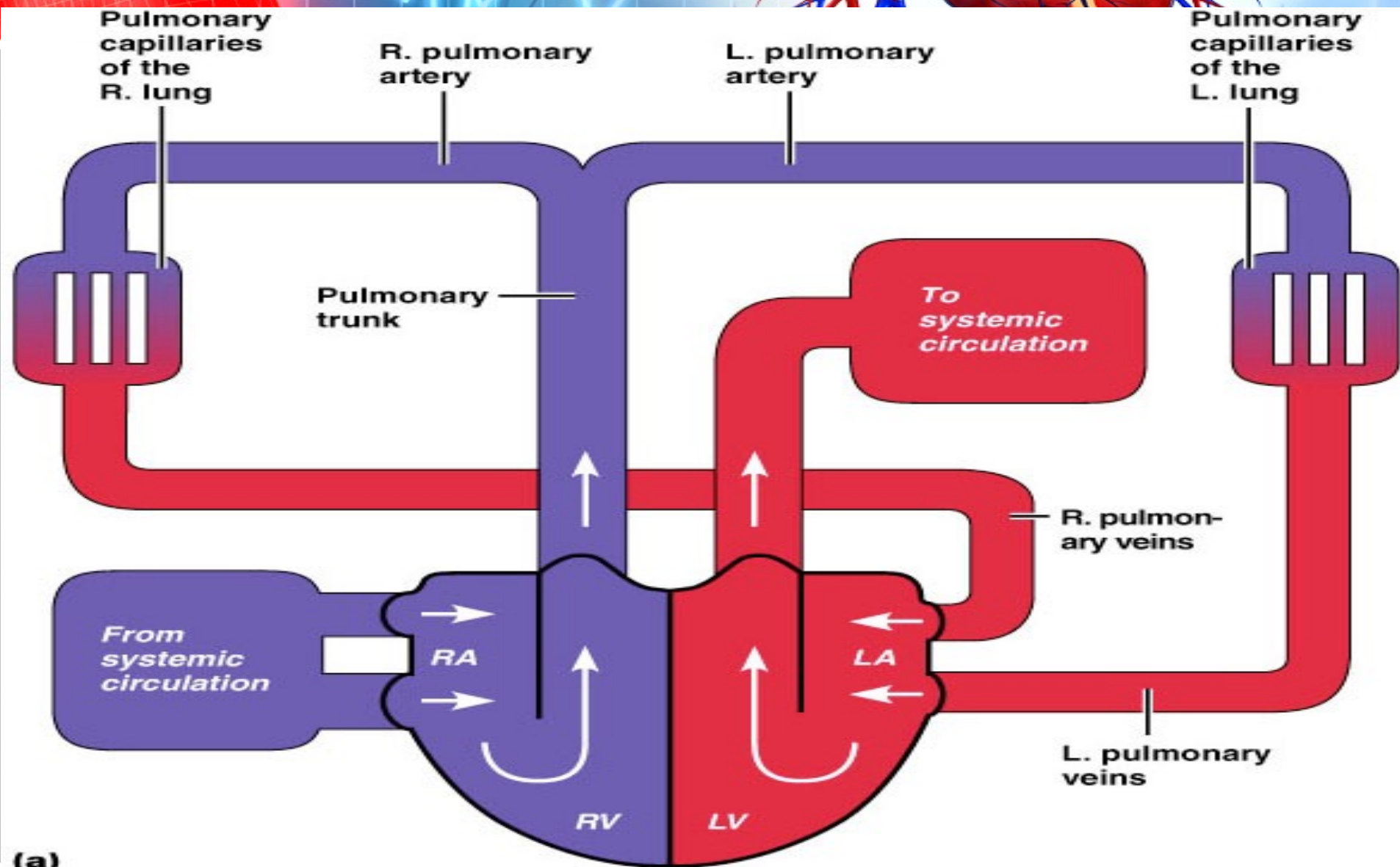
Circulatory Pathways

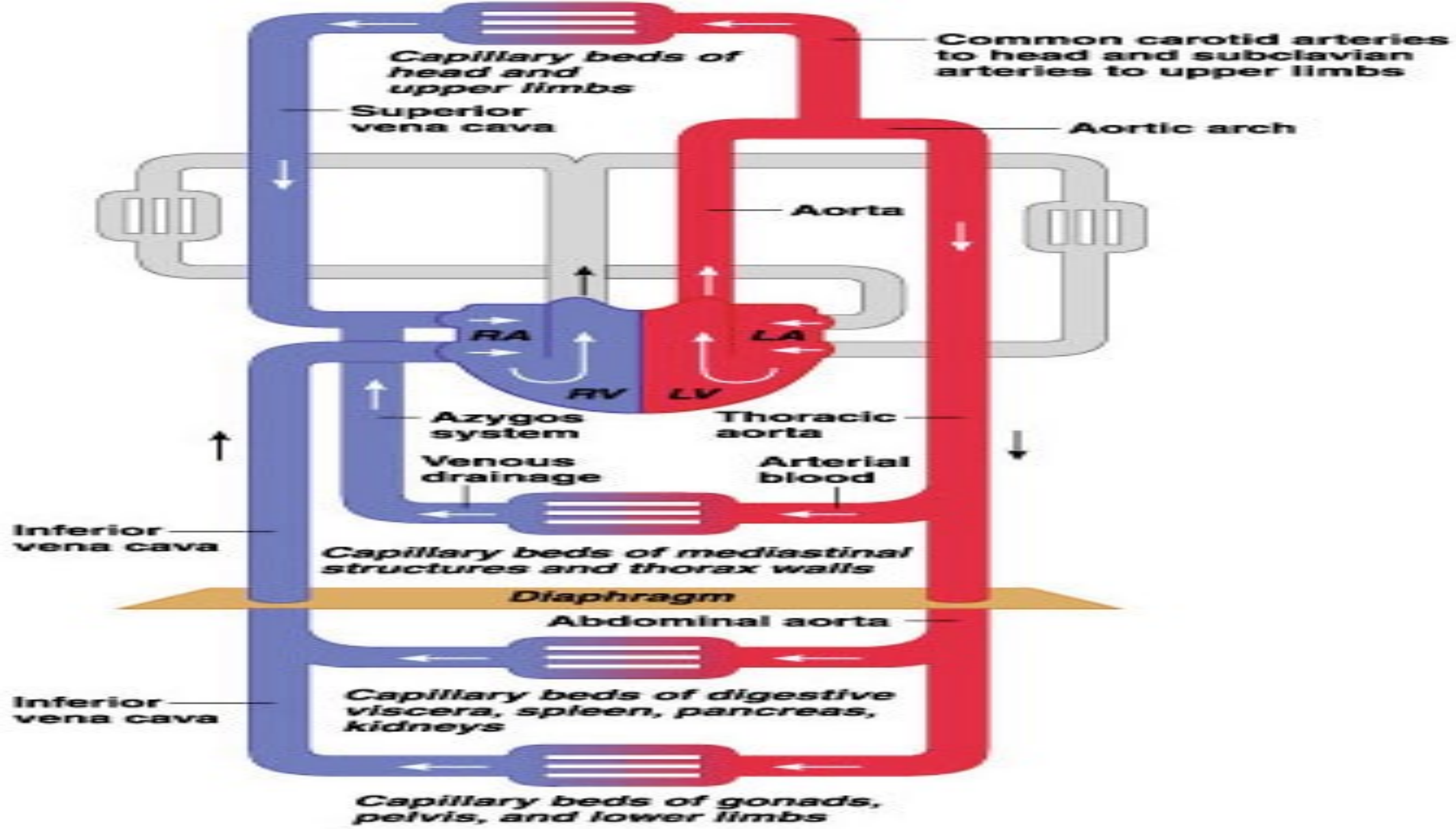
The vascular system has two distinct circulations

- ❑ **Pulmonary circulation – short loop** that runs from the heart to the lungs and back to the heart
- ❑ **Systemic circulation –** routes blood through a **long loop** to all parts of the body and returns to the heart



Pulmonary Circulation





Pulmonary
circulation

Systemic
circulation

Pulmonary
artery

Vena cava

Upper body

Hepatic vein

Renal vein

Lungs

Pulmonary vein

Aorta

Liver

Hepatic artery




Hepatic portal vein

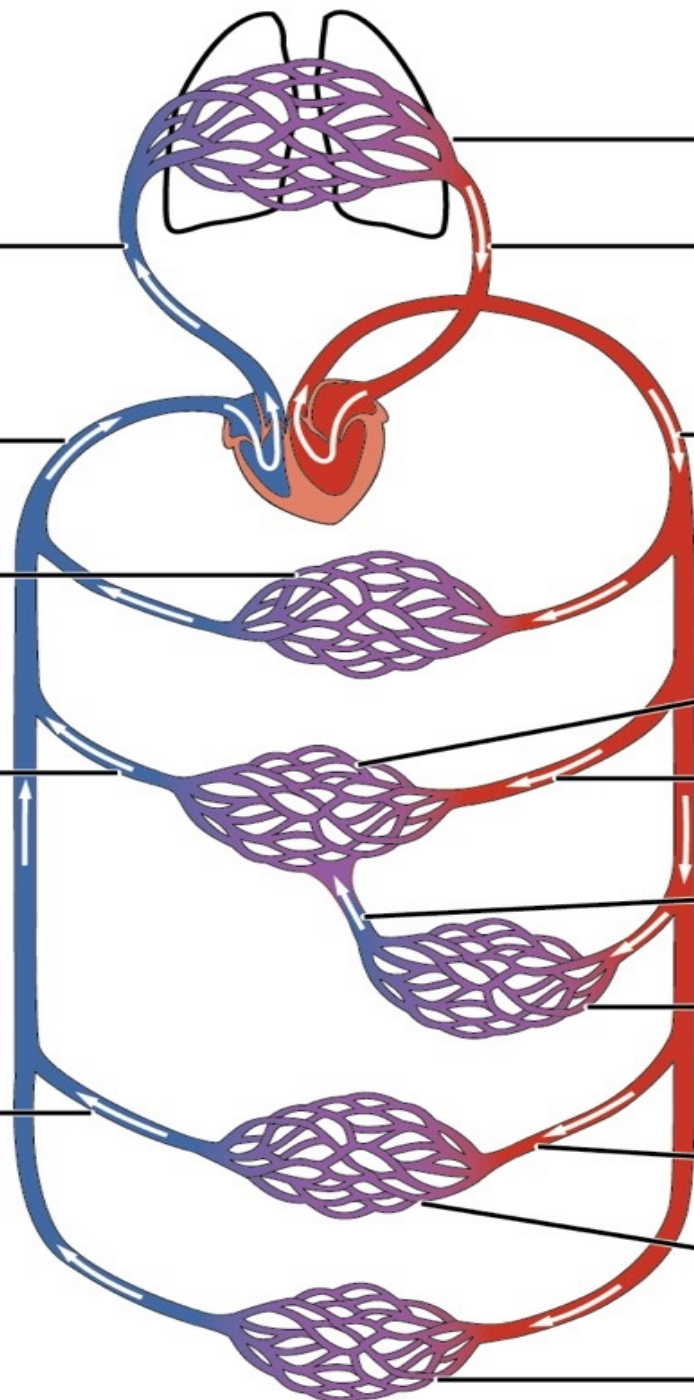
Stomach,
intestines

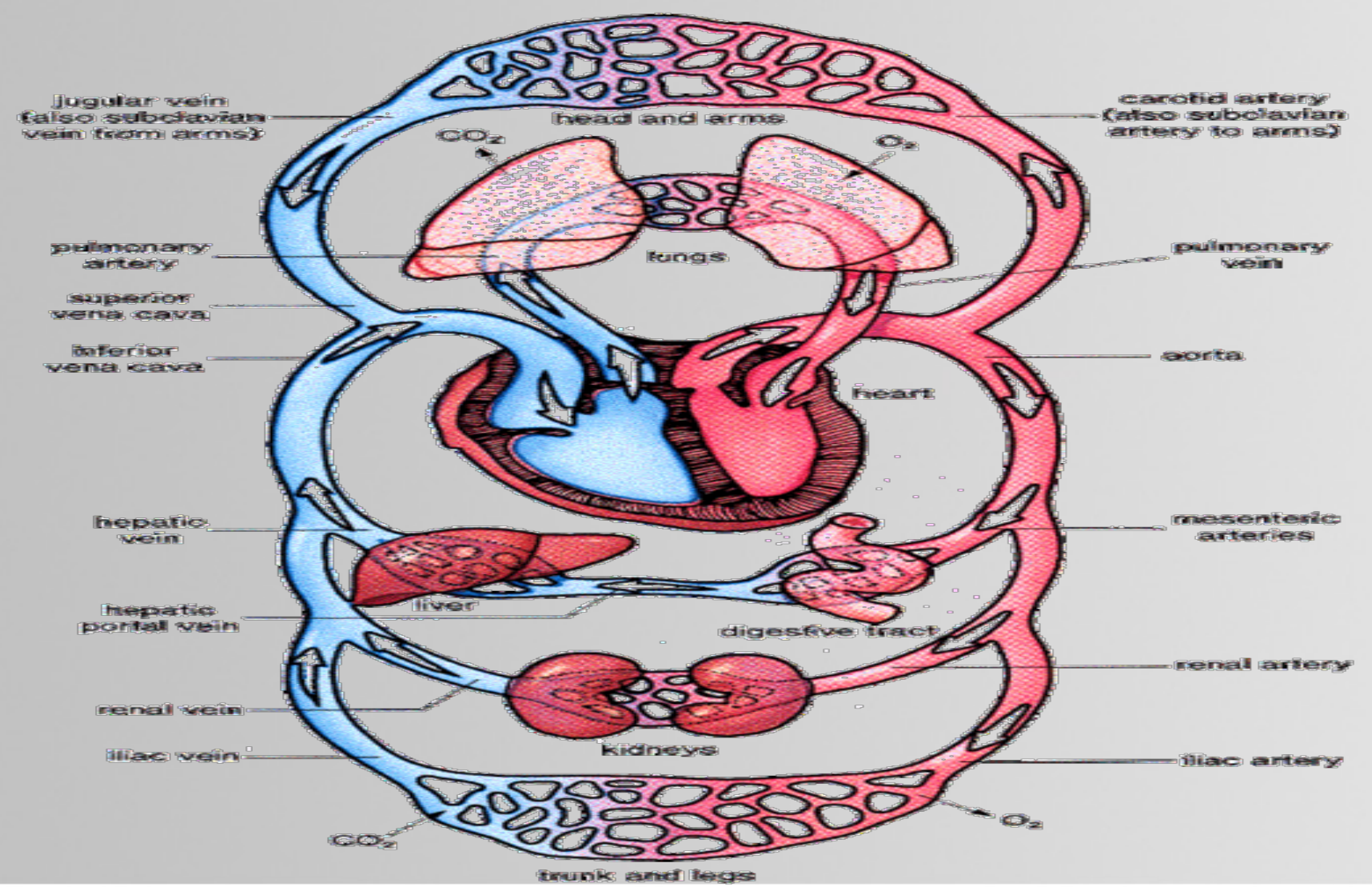
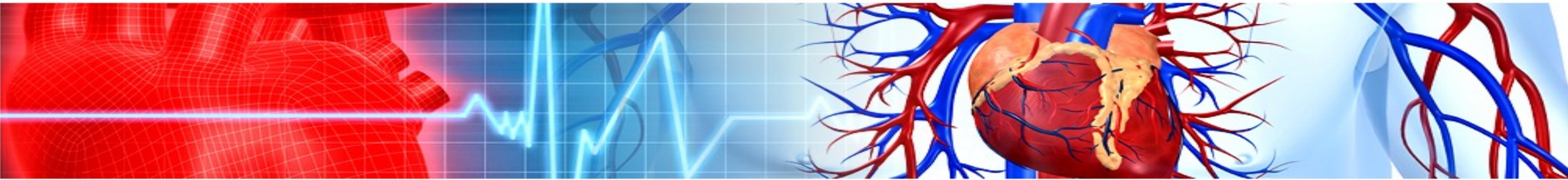
Renal artery

Kidneys

Lower body

-  Vessels transporting oxygenated blood
-  Vessels transporting deoxygenated blood
-  Vessels involved in gas exchange

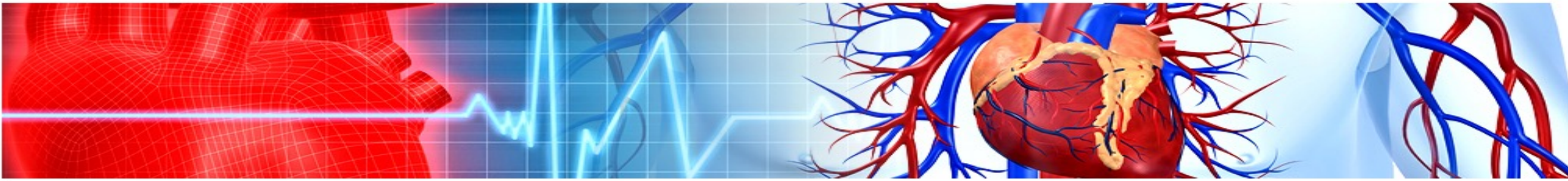






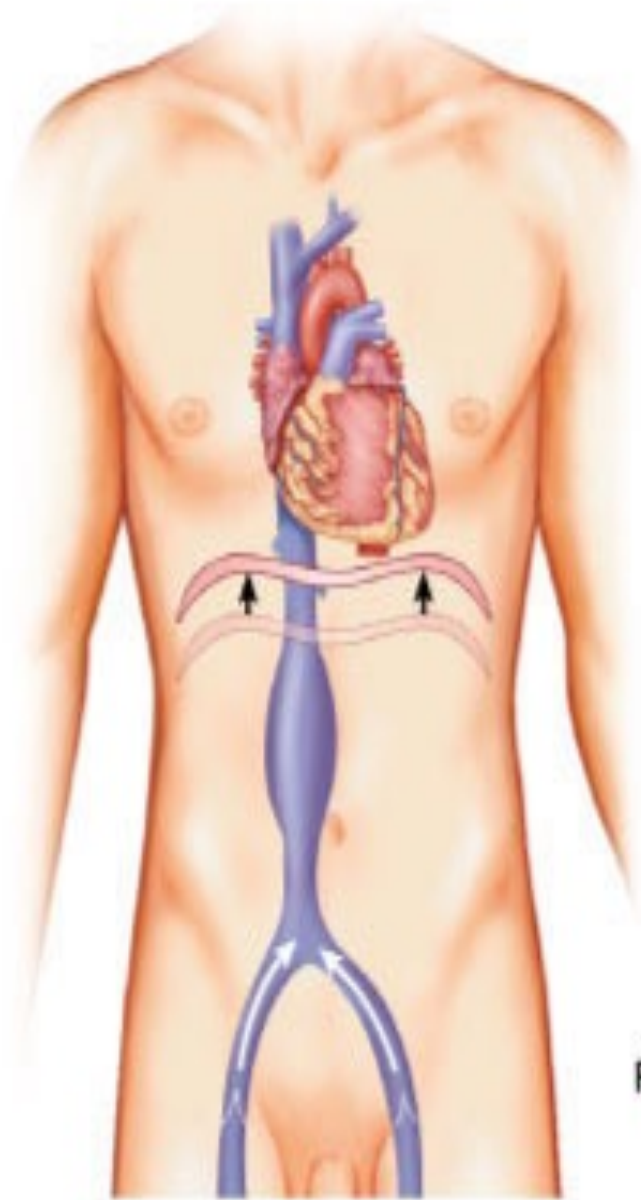
Venous Return to the Heart

- ❑ Venous return: amount of blood returned to the heart by the veins
- ❑ Gravity: the pull of gravity on venous blood while sitting or standing tends to cause a decrease in venous return (orthostatic effect)

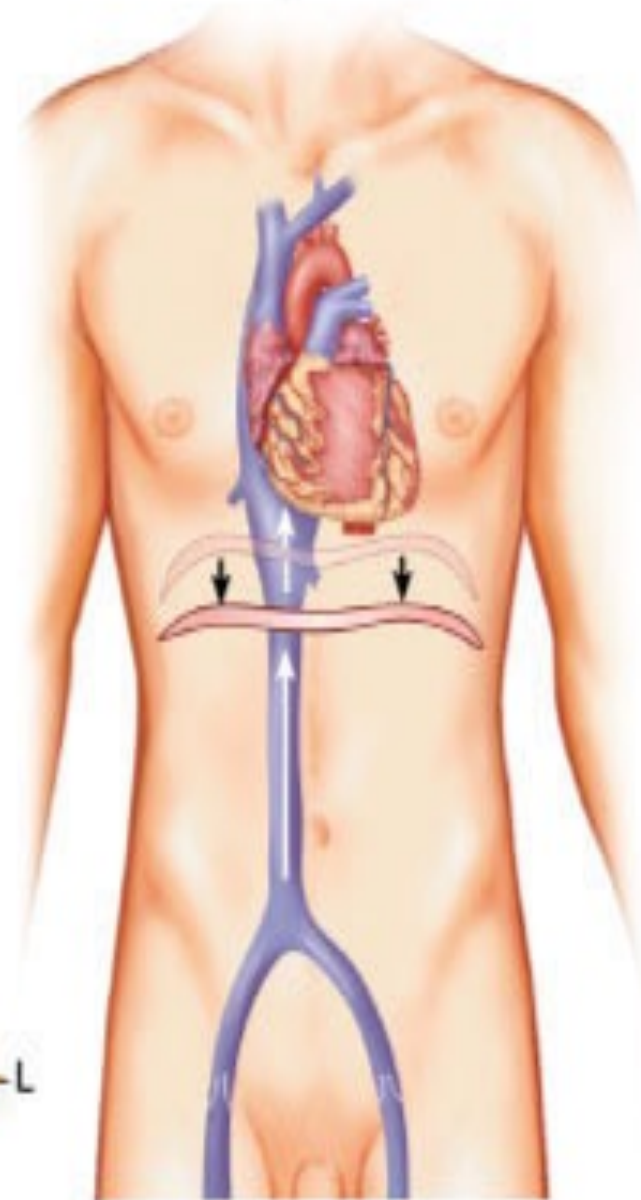


- ❑ Three main mechanisms of venous return to the heart:
 - Respiratory pump mechanism- pressure changes occur in the thoracic and abdominal cavities during inspiration and expiration. This compresses veins and assists blood return to the heart.
 - Skeletal muscle contractions: promote venous return by squeezing veins through a contracting muscle and milking the blood toward the heart
 - One-way valves in veins prevent backflow

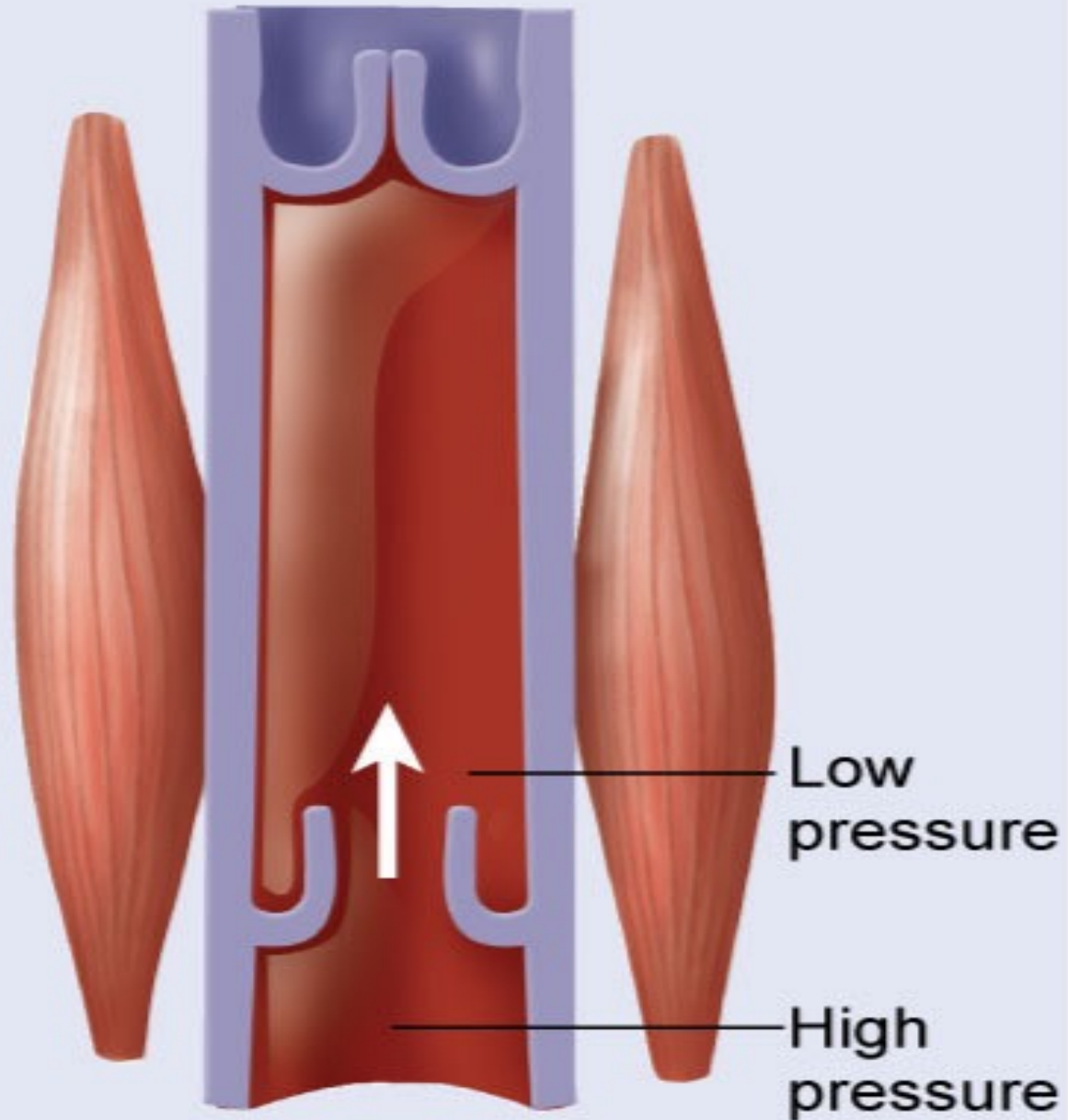
Expiration



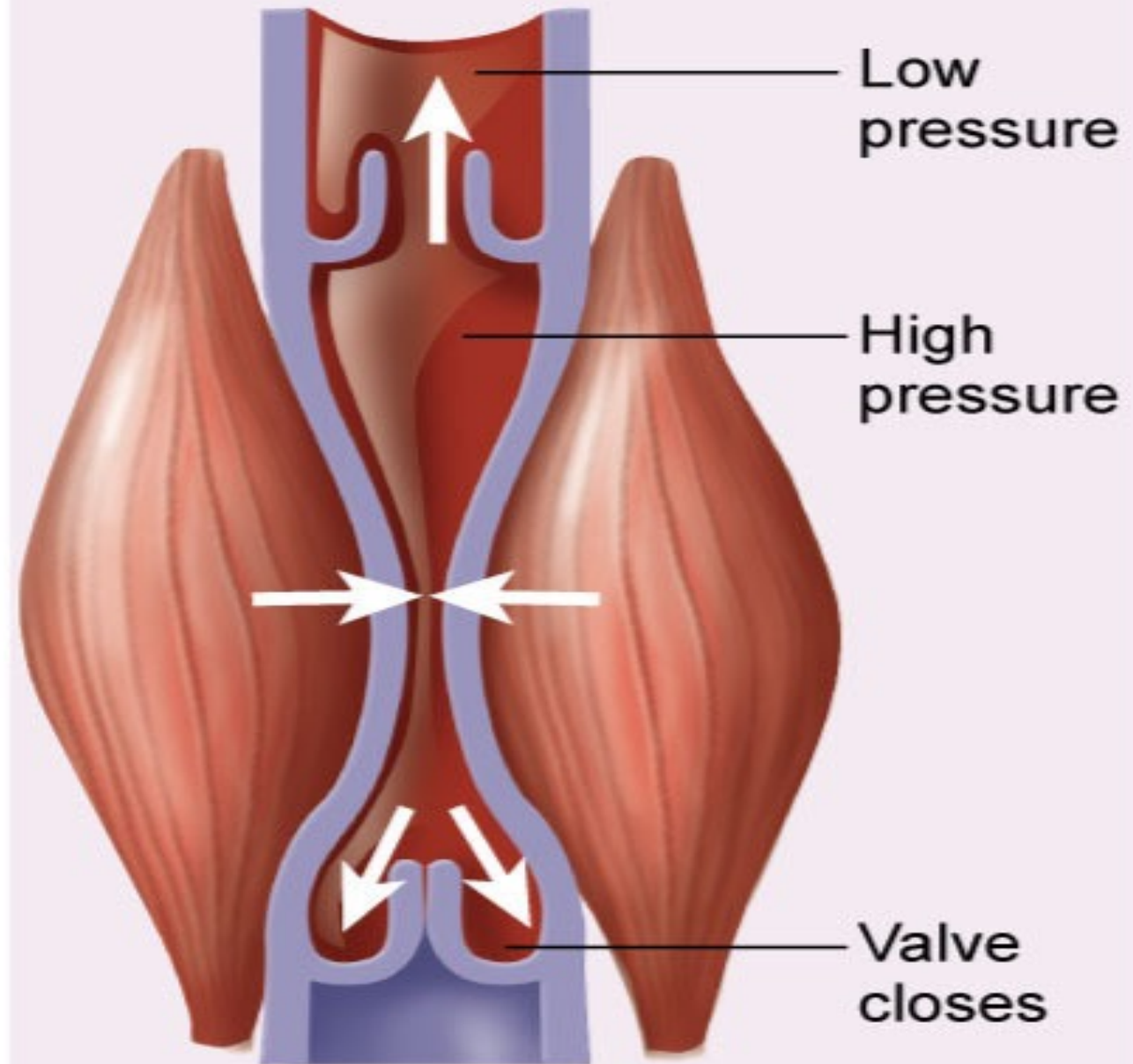
Inspiration



MUSCLES RELAXED



MUSCLES CONTRACTED



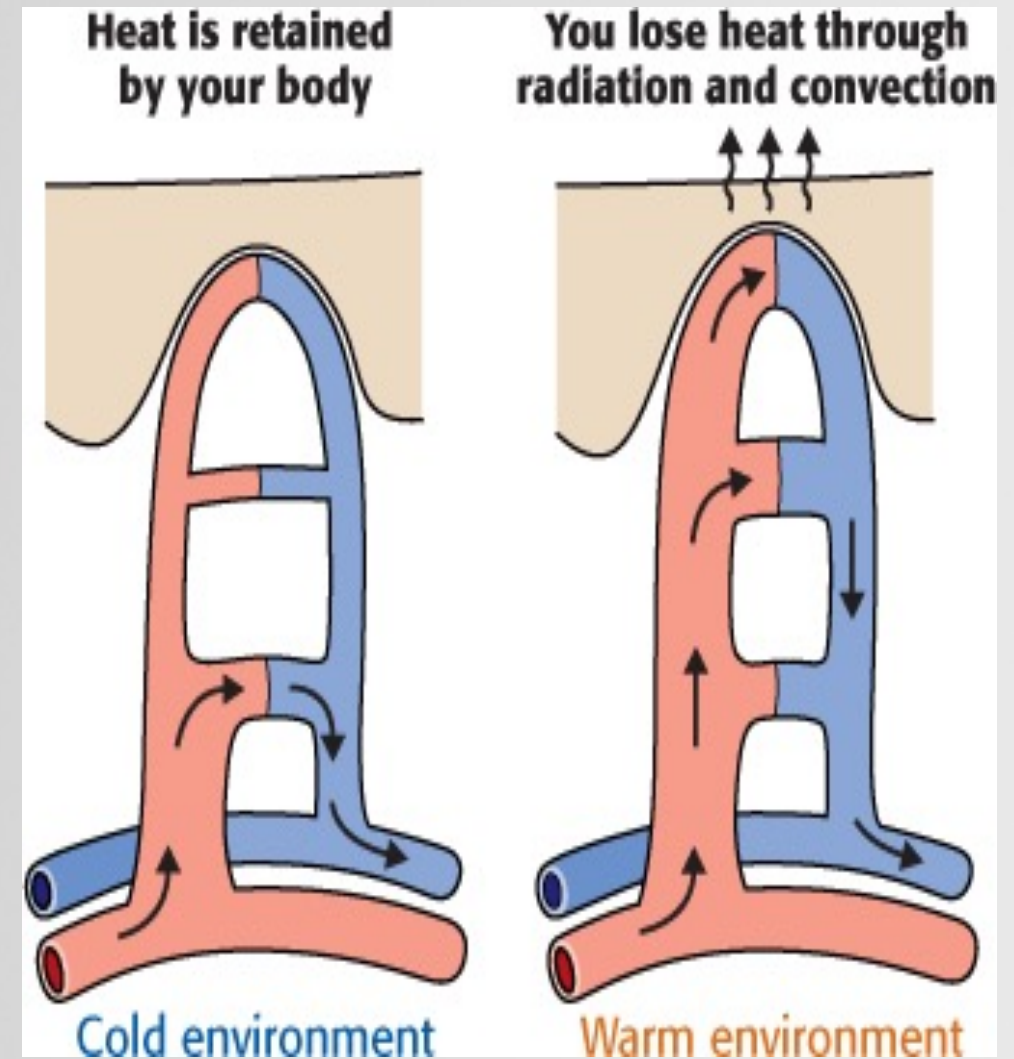


Localized Blood Flow

- ❑ Blood flow to skeletal muscle
 - When muscles become active, hyperemia is directly proportional to greater metabolic activity of the muscle (active or exercise hyperemia)
 - Muscle blood flow can increase tenfold or more during physical activity as vasodilation occurs

Localized Blood Flow

- ❑ Blood flow to skin
 - Helps maintain body temperature
 - Provides a blood reservoir





Localized Blood Flow

- ❑ Blood flow to the brain
 - Is constant, as neurons are intolerant of ischemia
 - Brain is extremely sensitive to declines in pH
 - The brain can regulate its own blood flow in certain circumstances, such as ischemia caused by a tumor
 - The brain is vulnerable under extreme systemic pressure changes
 - MAP below 60mm Hg can cause syncope (fainting)
 - MAP above 160 can result in cerebral edema



Localized Blood Flow

- ❑ Blood flow to the lungs
 - Blood flow in the pulmonary circulation is unusual in that:
 - The pathway is short
 - Arteries/arterioles are more like veins/venules (thin-walled, with large lumens)



Measuring Blood Pressure

- ❑ Arterial blood pressure
 - Measured with a sphygmomanometer and stethoscope; listen for Korotkoff sounds as the pressure in the cuff is gradually decreased
 - Systolic blood pressure: force of the blood pushing against the artery walls while ventricles are contracting
 - Diastolic blood pressure: force of the blood pushing against the artery walls when ventricles are relaxed
 - Pulse pressure: difference between systolic and diastolic blood pressure



Measuring Blood Pressure

- ☐ The first sound heard is recorded as the systolic pressure
- ☐ The pressure when sound disappears is recorded as the diastolic pressure



Variations in Blood Pressure

- ☐ Blood pressure cycles over a 24-hour period
- ☐ BP peaks in the morning due to waxing and waning levels of retinoic acid
- ☐ Extrinsic factors such as age, sex, weight, race, mood, posture, socioeconomic status, and physical activity may also cause BP to vary



Alterations in Blood Pressure

- ❑ Hypotension – low BP in which systolic pressure is below 100 mm Hg
- ❑ Hypertension – condition of sustained elevated arterial pressure of 140/90 or higher
 - Transient elevations are normal and can be caused by fever, physical exertion, and emotional upset
 - Chronic elevation is a major cause of heart failure, vascular disease, renal failure, and stroke



Hypertension

- ❑ Hypertension maybe transient or persistent
- ❑ Primary or essential hypertension – risk factors in primary hypertension include diet, obesity, age, race, heredity, stress, and smoking – **95% (Lifestyle related)**
- ❑ Secondary hypertension – due to identifiable disorders, including excessive renin secretion, arteriosclerosis, and endocrine disorders – **5%**



Developmental Aspects

- ❑ Blood vessels are trouble-free during youth
- ❑ Vessel formation occurs:
 - As needed to support body growth
 - For wound healing
 - To rebuild vessels lost during menstrual cycles
- ❑ With aging, varicose veins, atherosclerosis, and increased blood pressure may arise