Blood Vessels and Circulatory system

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§ Introduction of Blood Vessels

1. **Closed circulatory system**– Def. Blood flows in a continuous circuit through the body under pressure generated by the heart.

The average adult has over 60,000 miles (aprox.1 lac)of blood vessels in their body

2. Three principal categories of blood vessels:
   - **Arteries:** efferent vessels
   - **Capillaries:**
   - **Veins:** afferent vessels

Five types of blood vessels:

(1) Arteries (2) Arterioles(3) Capillaries(4) Veins(5) Venules

(1) Arteries

- *Carry blood away from the heart to body tissues*
- *Two large arteries are: _aorta_ and _pulmonary trunk_ branch out from the heart go to small arteries*

(2) Arterioles

Small arteries found in organs, branch out into capillaries

(3) Capillaries

Microscopic vessels that branch off of arterioles in organs

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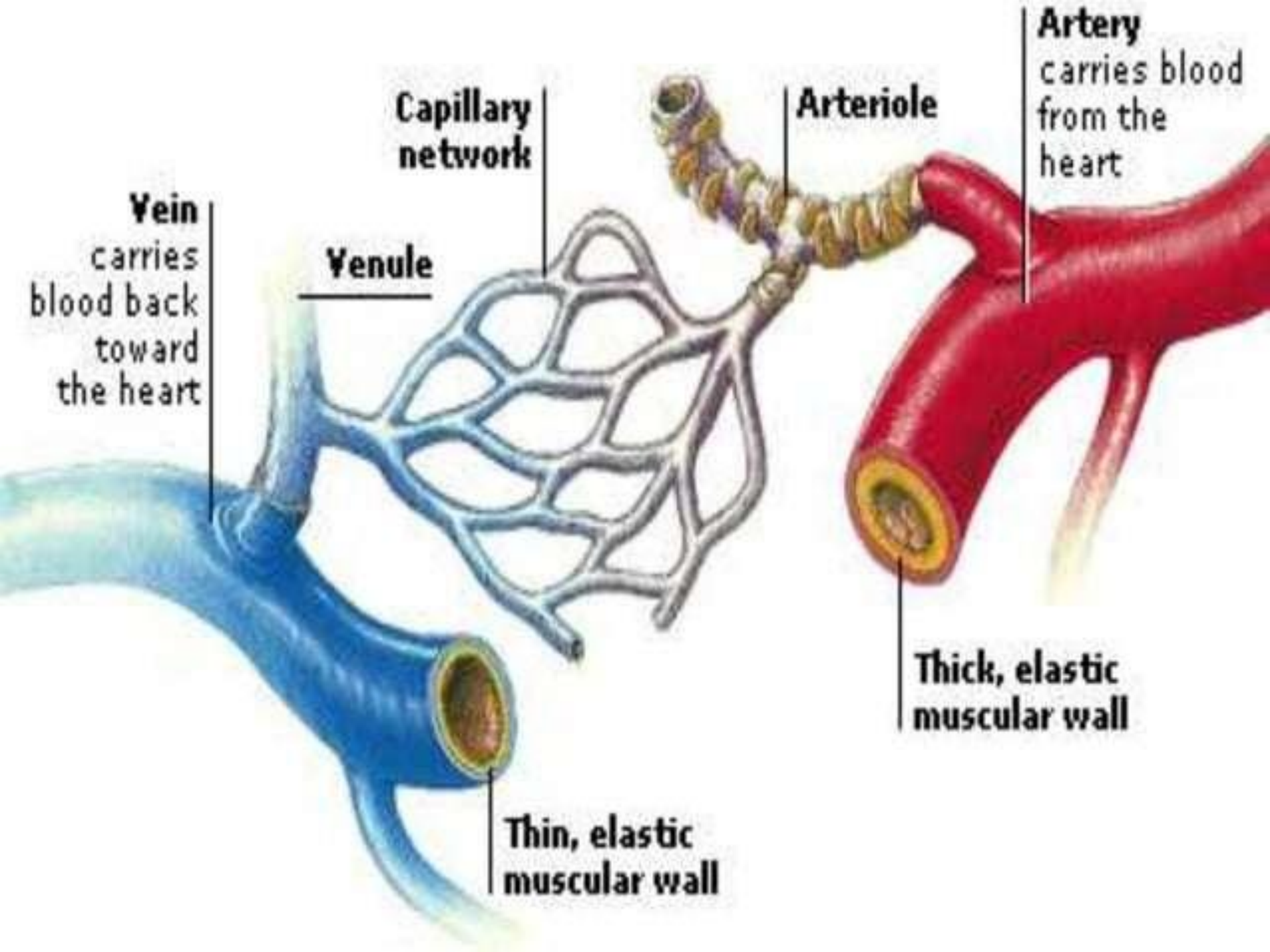
4) Veins

Small veins formed by groups of capillaries within a tissue that reunite

(5) Venules

Larger vessels formed by merging venules; convey blood from tissues back to the heart


Artery
carries blood
from the
heart
Arteriole
Capillary
network
Vein
carries
blood back
toward
the heart
Venule
Thick, elastic
muscular wall
Thin, elastic
muscular wall

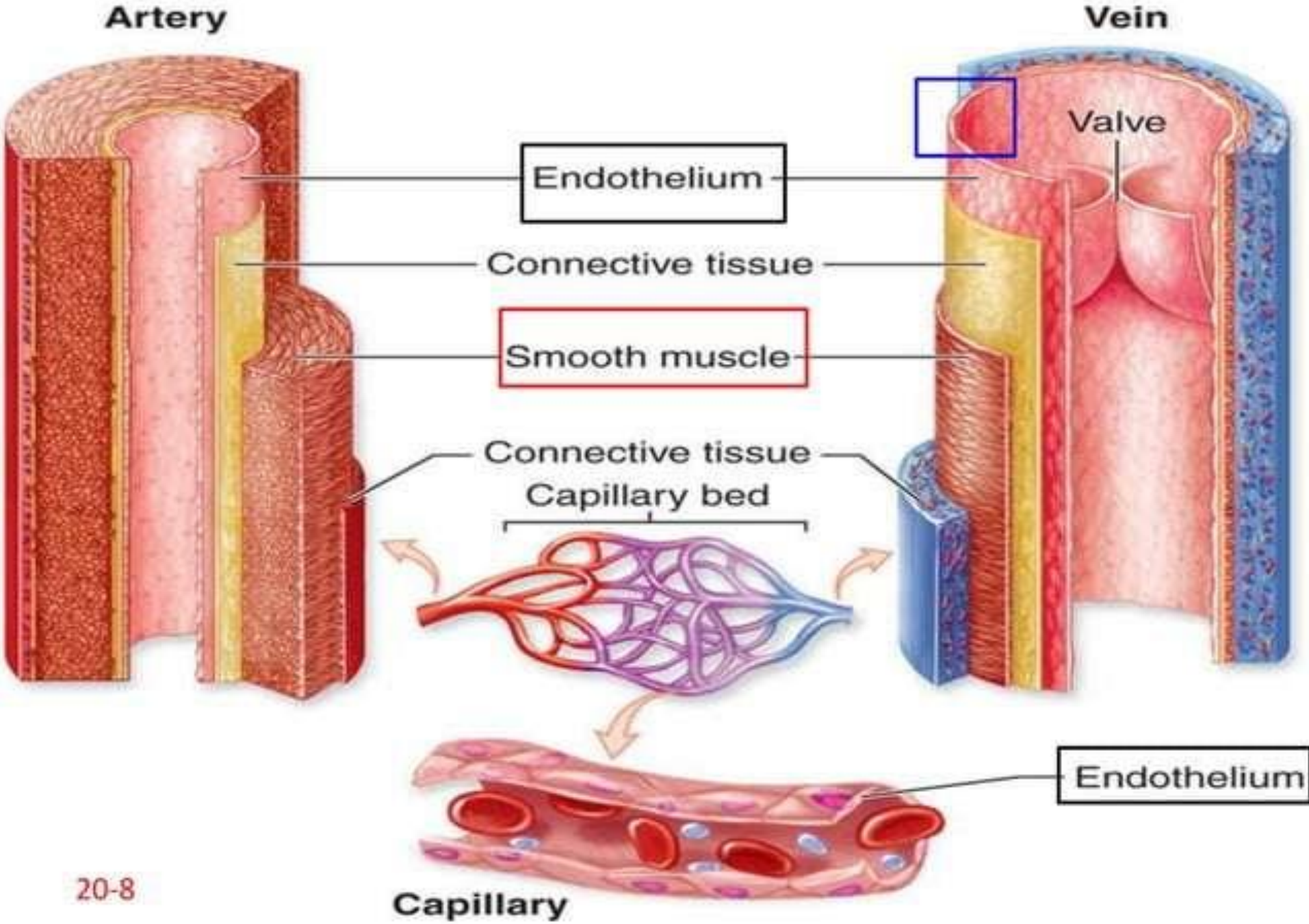
Distribution of Blood Volume

Systematic arteries and arterioles	15%
Systematic veins and venules	60%
Systematic capillaries	5%
Pulmonary blood vessels	12%
Heart chambers	8%

- Veins and venules contain so much blood, thus certain veins serve as blood reservoirs from which stored blood can be diverted to other parts of the body

Arteries and Arterioles

- The lumen is the hollow space through which the blood flows.
- Three layers surrounding the lumen:
  - Tunica interna
  - Tunica media
  - Tunica externa



The vessel wall

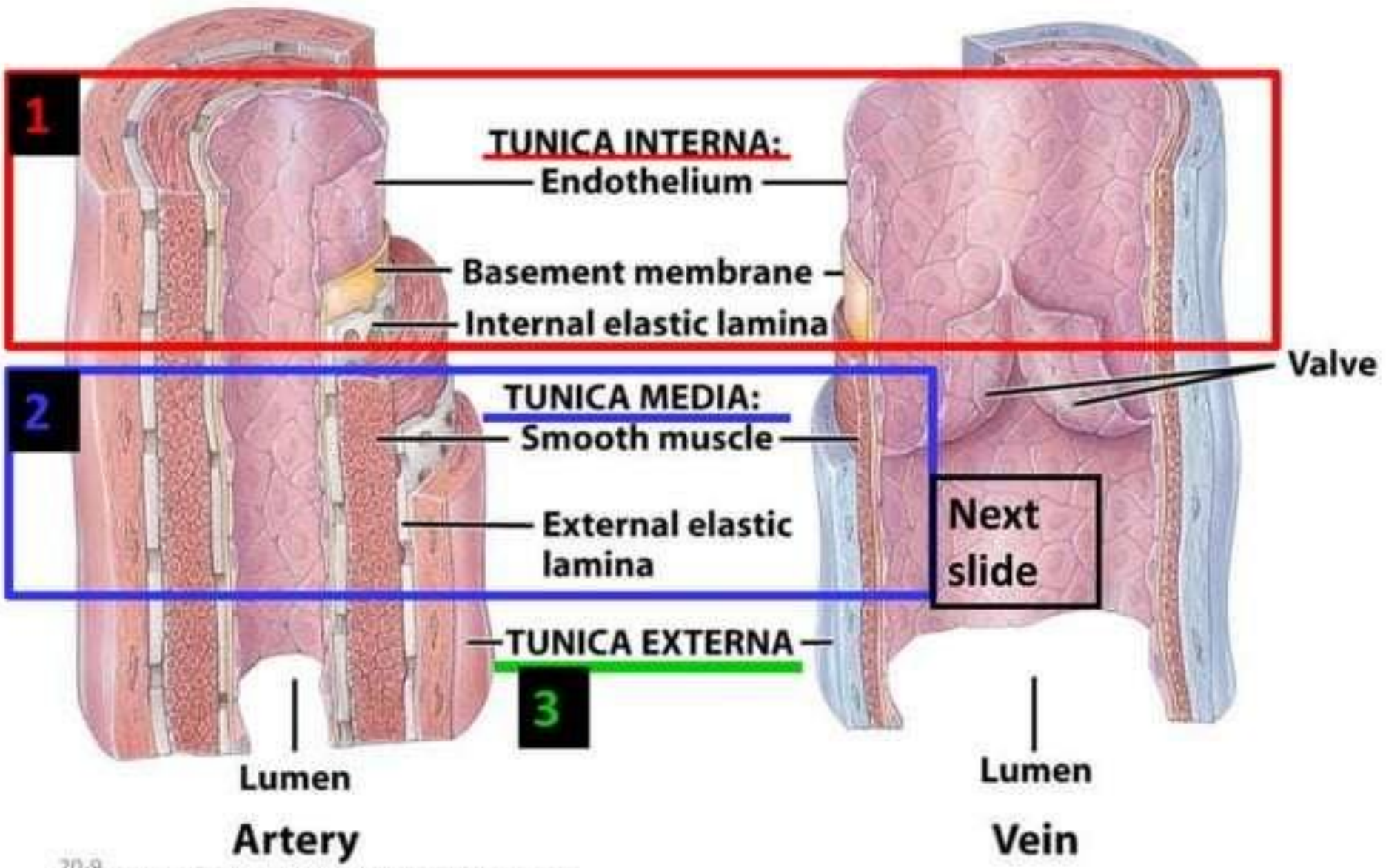


Figure 21-1ab Principles of Anatomy and Physiology, 11/e

1. Innermost layer (tunica interna/intima)

A. **Structures:** lines the inside of the vessel and is exposed to the blood; consists of--

- Endothelial cells– histology?
- Basement membrane
- Connective tissue (sparse)

B. Functions of the endothelial cells—

- Selectively permeable barrier
- Secrets chemicals--?
- Repels blood cells and platelets

3. Outermost layer (tunica externa /advertitia)

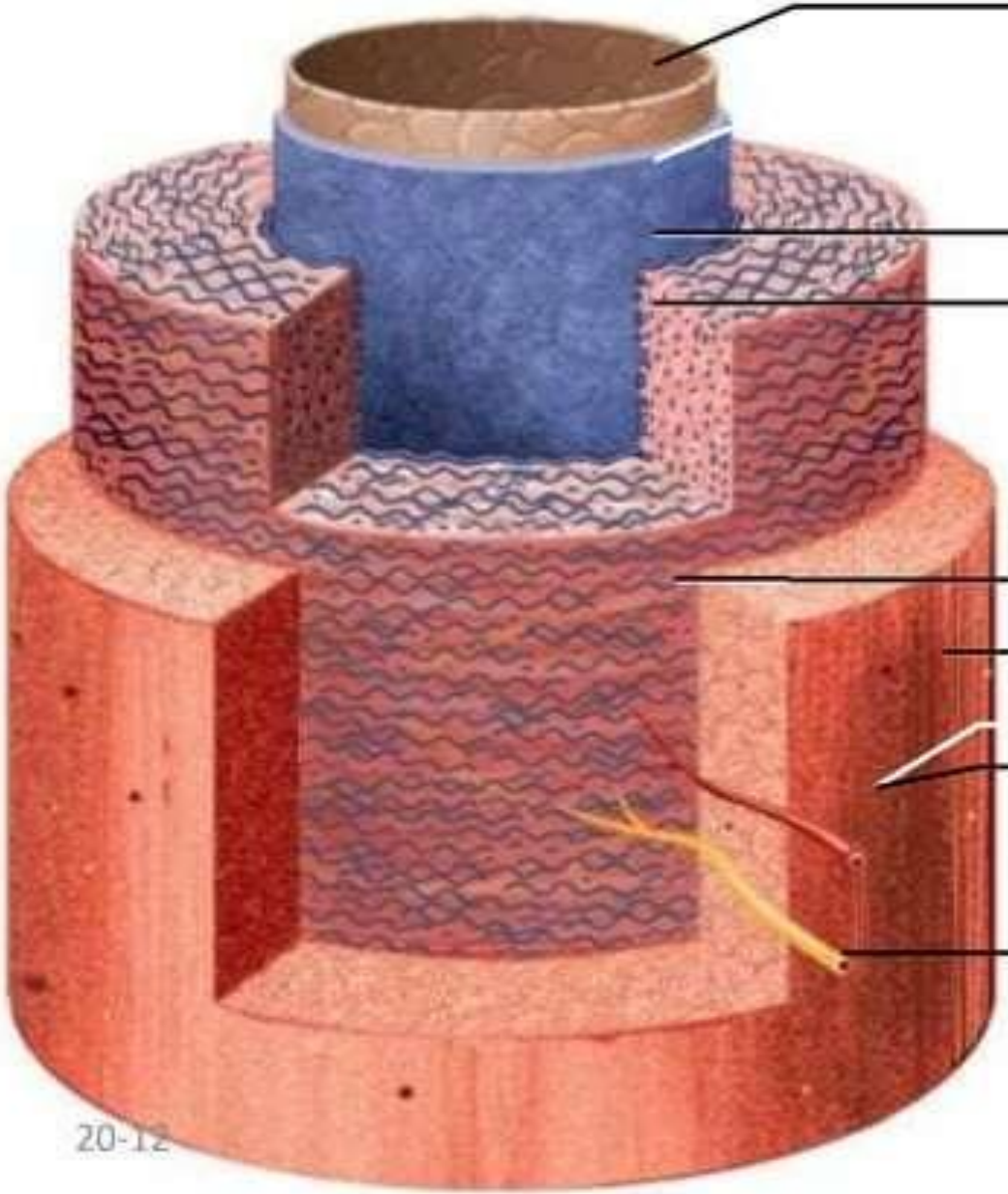
A. Structures:

- Largely loose connective tissue (collagen fibers)

B. Functions:

- Protection & anchoring
- Provide passage for--
  - Vasa vasorum— vessels of the vessels

Conducting (large) artery



Lumen

Tunica interna:

Endothelium

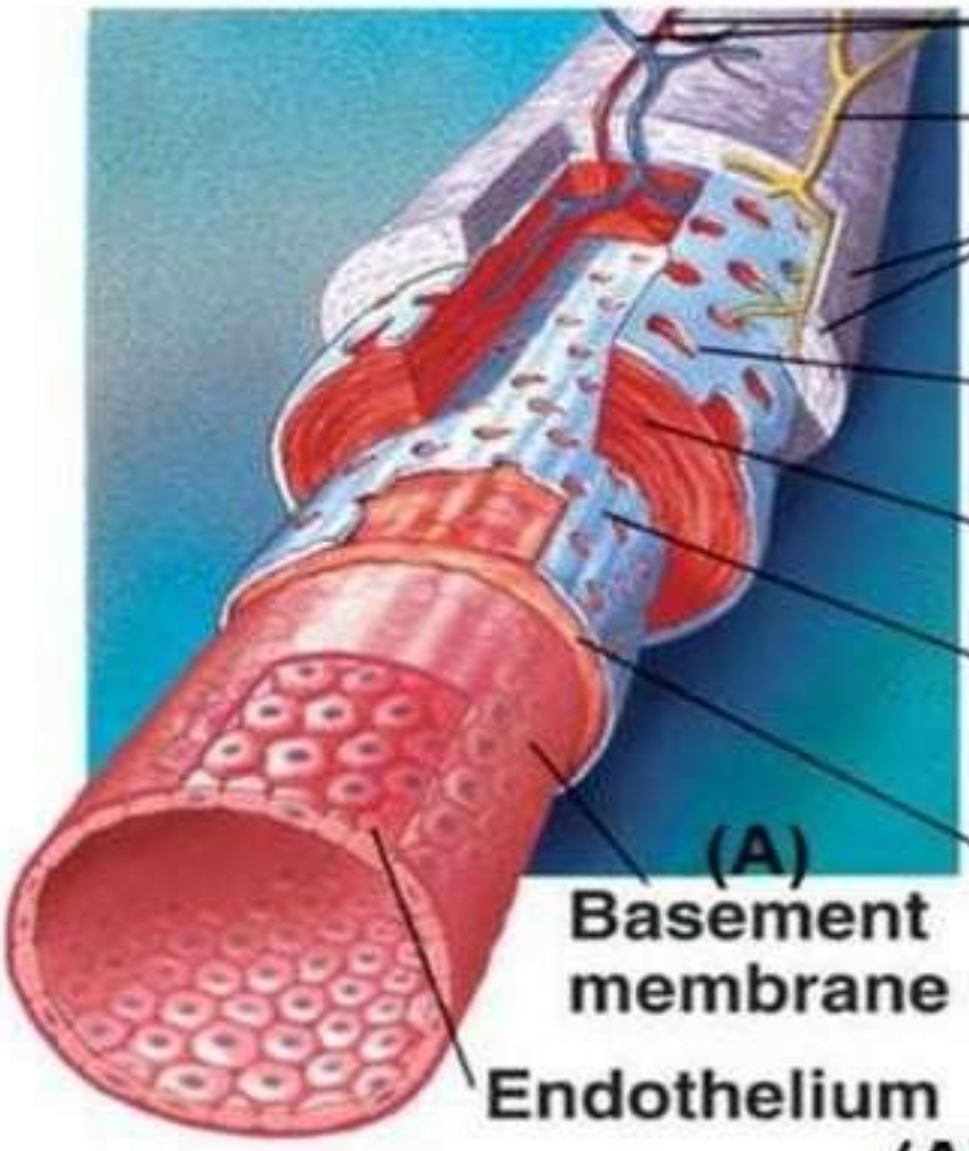
Basement membrane

Tunica media

Tunica externa

Vasa Vasorum

Nerve



(A): Tunica interna

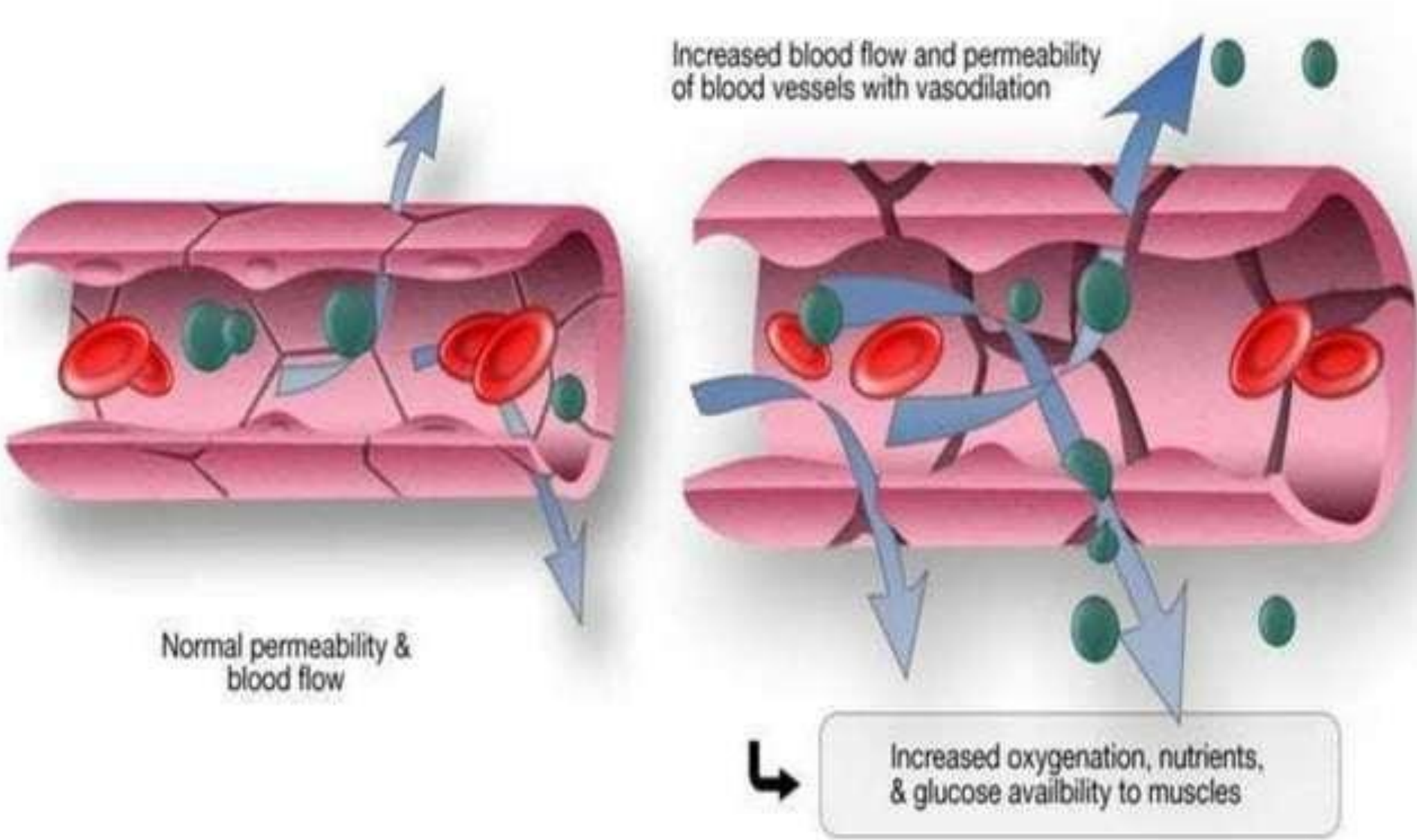
(B): Tunica media

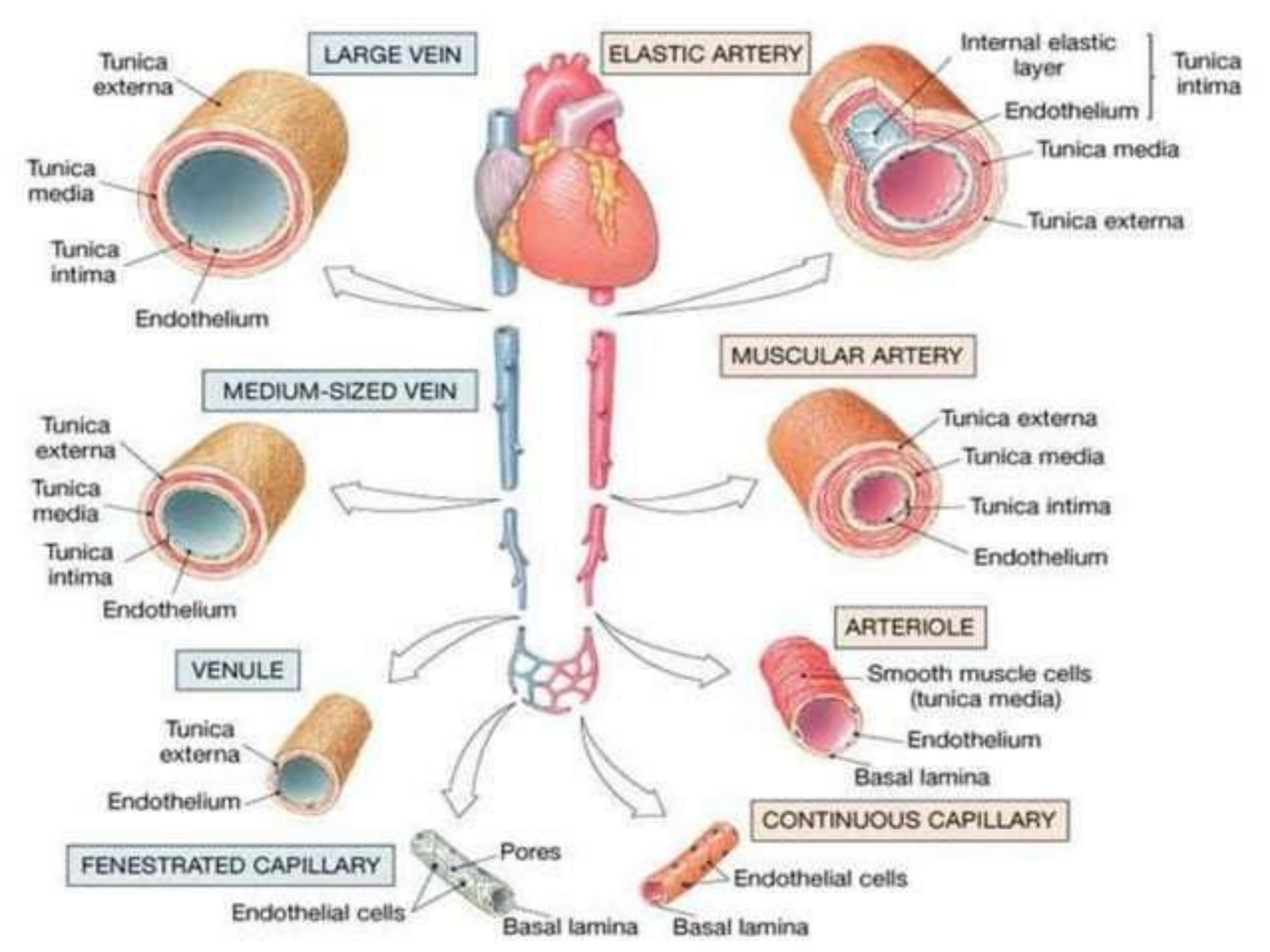
- **Vasoconstriction** → decrease in the size of the lumen

Constriction of vessels decreases blood flow

Cut-away view of vessel

Vasodilation → increase in the size of the lumen




LARGE VEIN
Tunica externa
Tunica media
Tunica intima
Endothelium
ELASTIC ARTERY
Internal elastic layer
Endothelium
Tunica intima
Tunica media
Tunica externa
MEDIUM-SIZED VEIN
Tunica externa
Tunica media
Tunica intima
Endothelium
MUSCULAR ARTERY
Tunica externa
Tunica media
Tunica intima
Endothelium
VENULE
Tunica externa
Endothelium
ARTERIOLE
Smooth muscle cells (tunica media)
Endothelium
Basal lamina
FENESTRATED CAPILLARY
Pores
Endothelial cells
Basal lamina
CONTINUOUS CAPILLARY
Endothelial cells
Basal lamina

Capillaries

❖**Connect** arterioles and venules

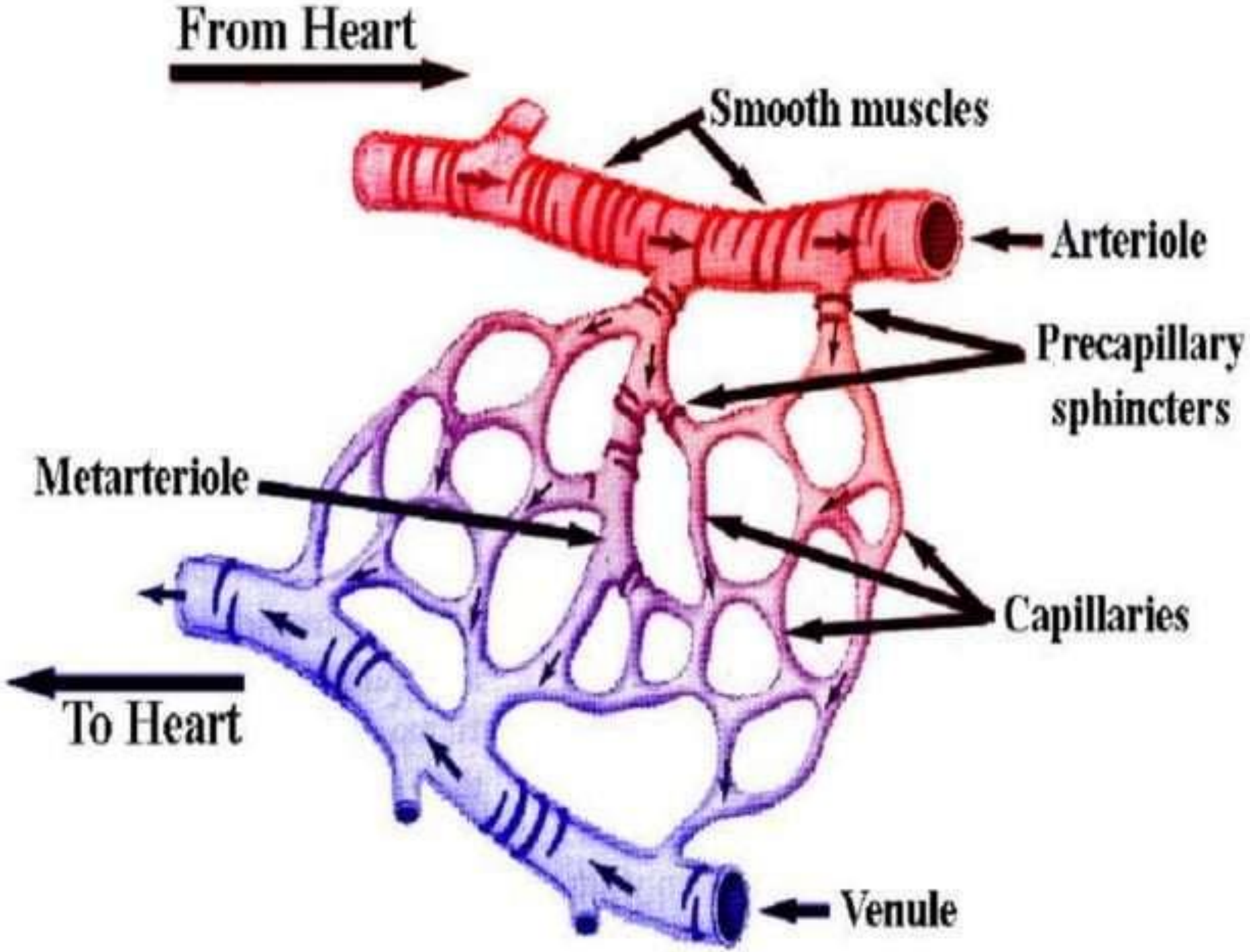
•**exchange** vessels→ permit exchange of nutrients and waste between body cells and blood

❖Areas with **high** metabolic requirements have extensive capillary networks

• **Example.** muscles, liver, kidneys, nervous system

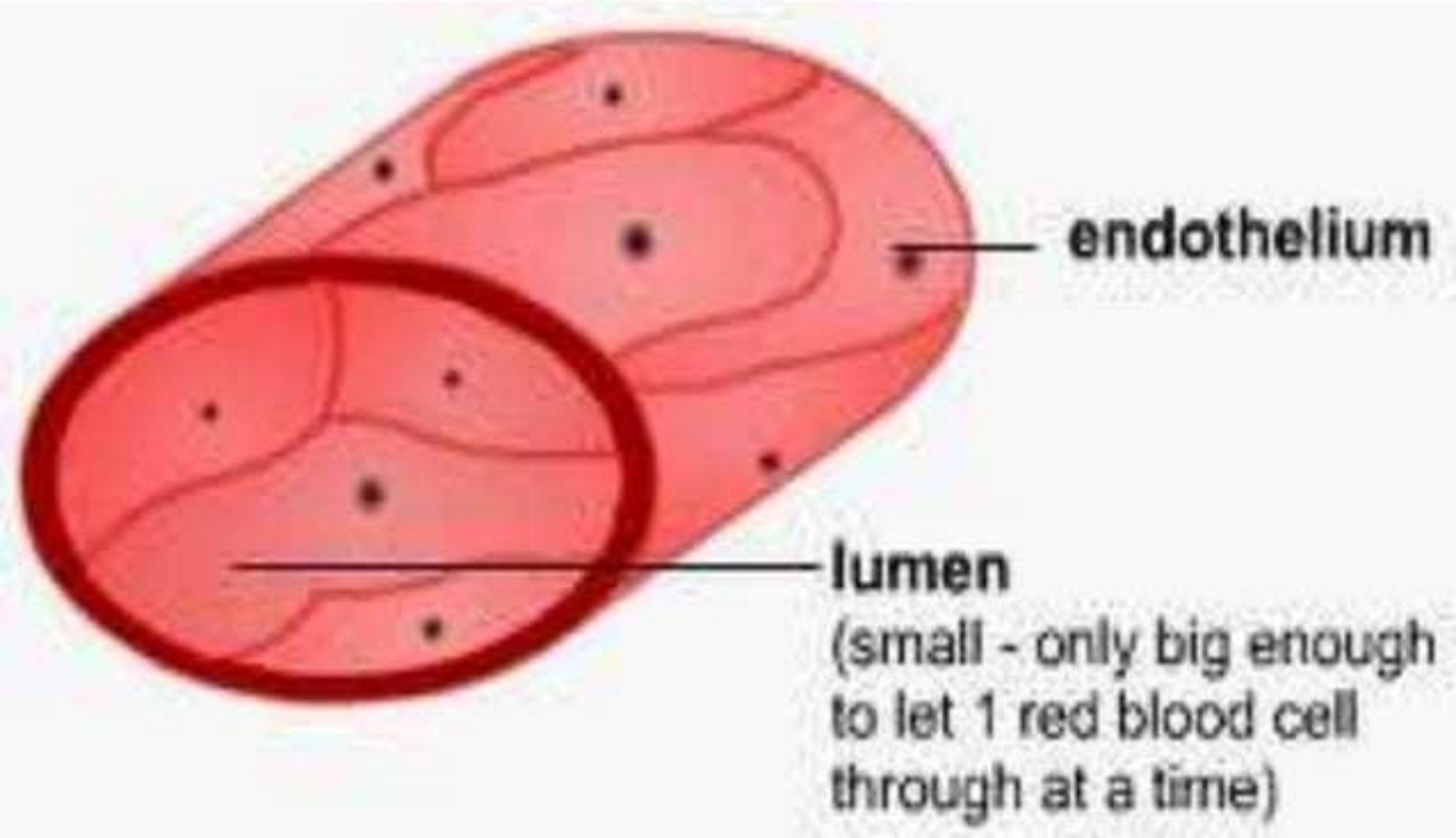
❖Areas with very low metabolic requirements lack capillaries

• **Example.** cornea and lens of the eye, nails, hair follicles, cuticles, cartilage


From Heart
Smooth muscles
Arteriole
Precapillary sphincters
Metarteriole
Capillaries
To Heart
Venule

Structure of Capillaries

Walls consist of single layer of endothelial cells



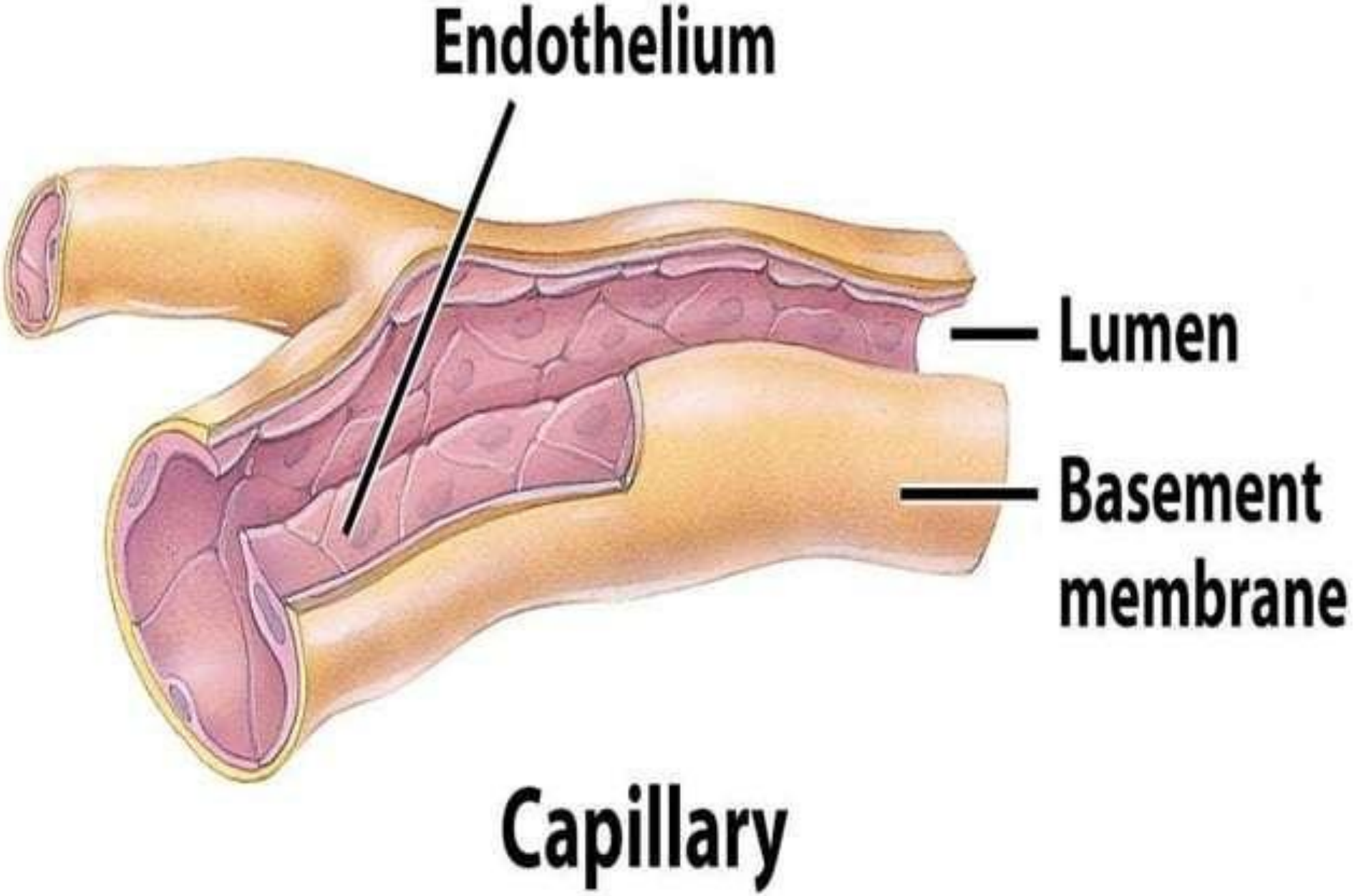
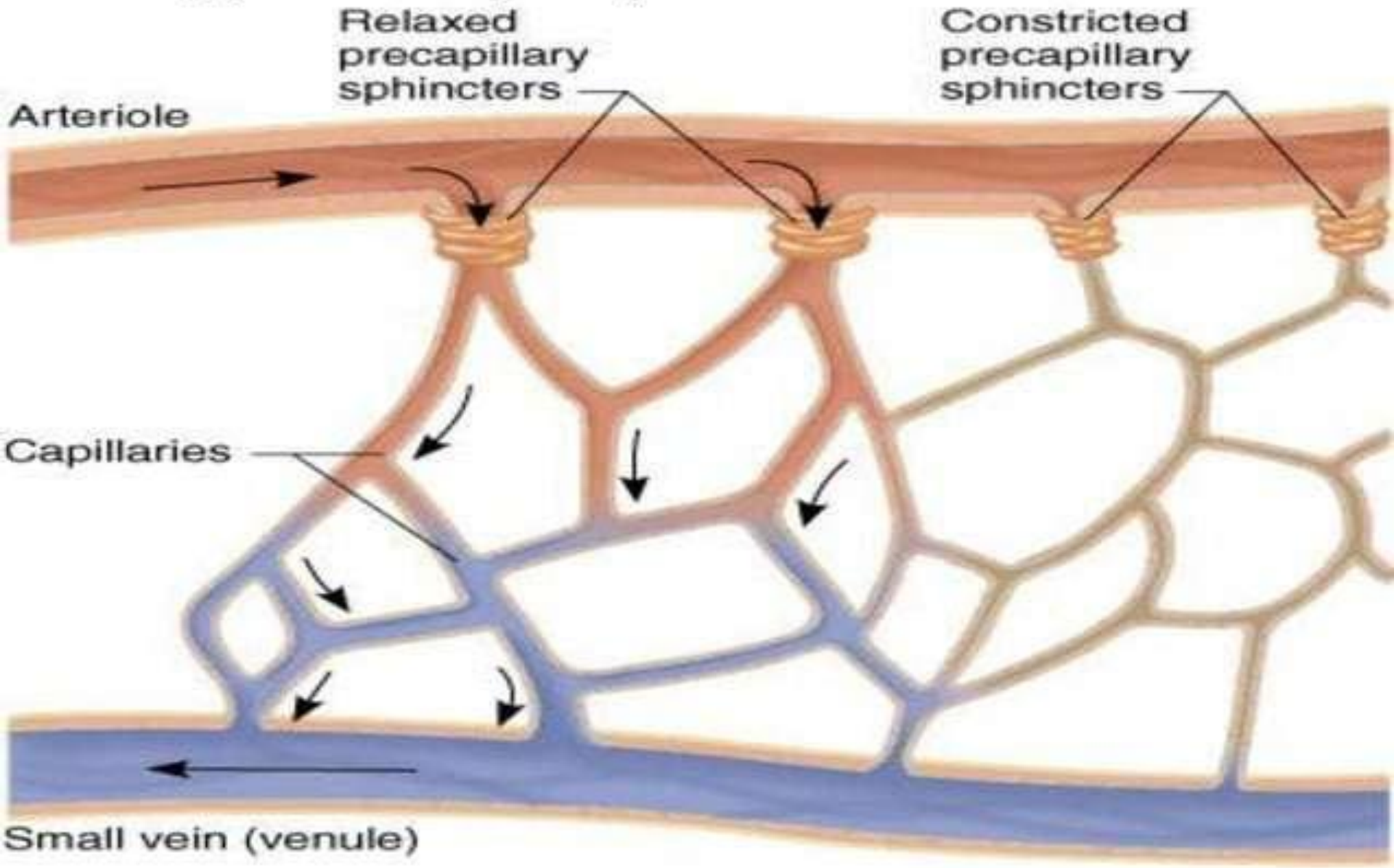


Figure 21-1c Principles of Anatomy and Physiology, 11/e

Precapillary sphincters→ rings of smooth muscle at meeting point of capillary to arteriole



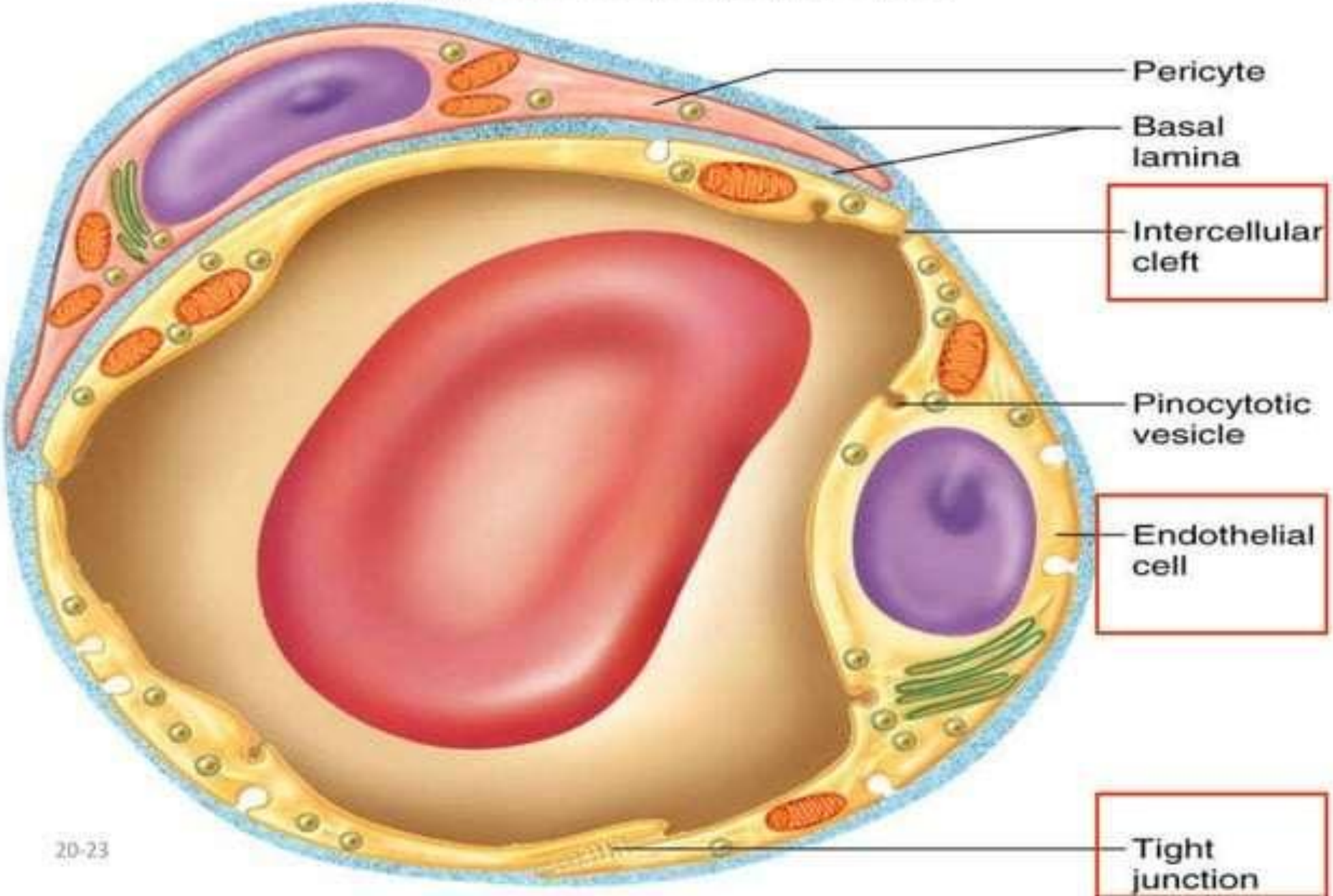
3 Types of Capillaries

1. Continuous capillaries-

   occur in most tissues, ex. Skeletal muscle

   – endothelial cells have tight junctions with intercellular clefts (allow passage of solutes)
   – What molecules can pass– ex. glucose
   – What molecules can not – protein, formed elements of the blood

Continuous capillary

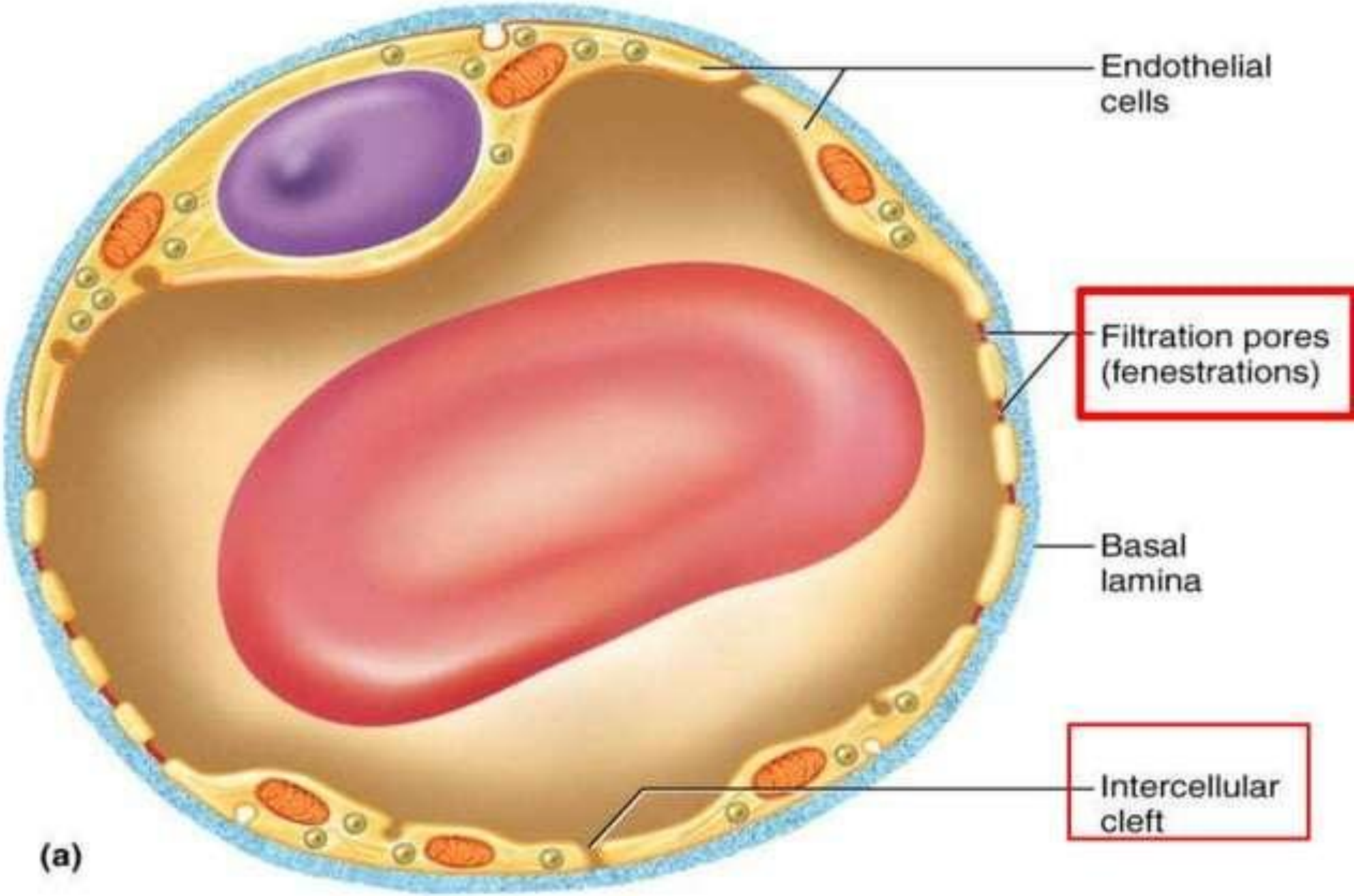


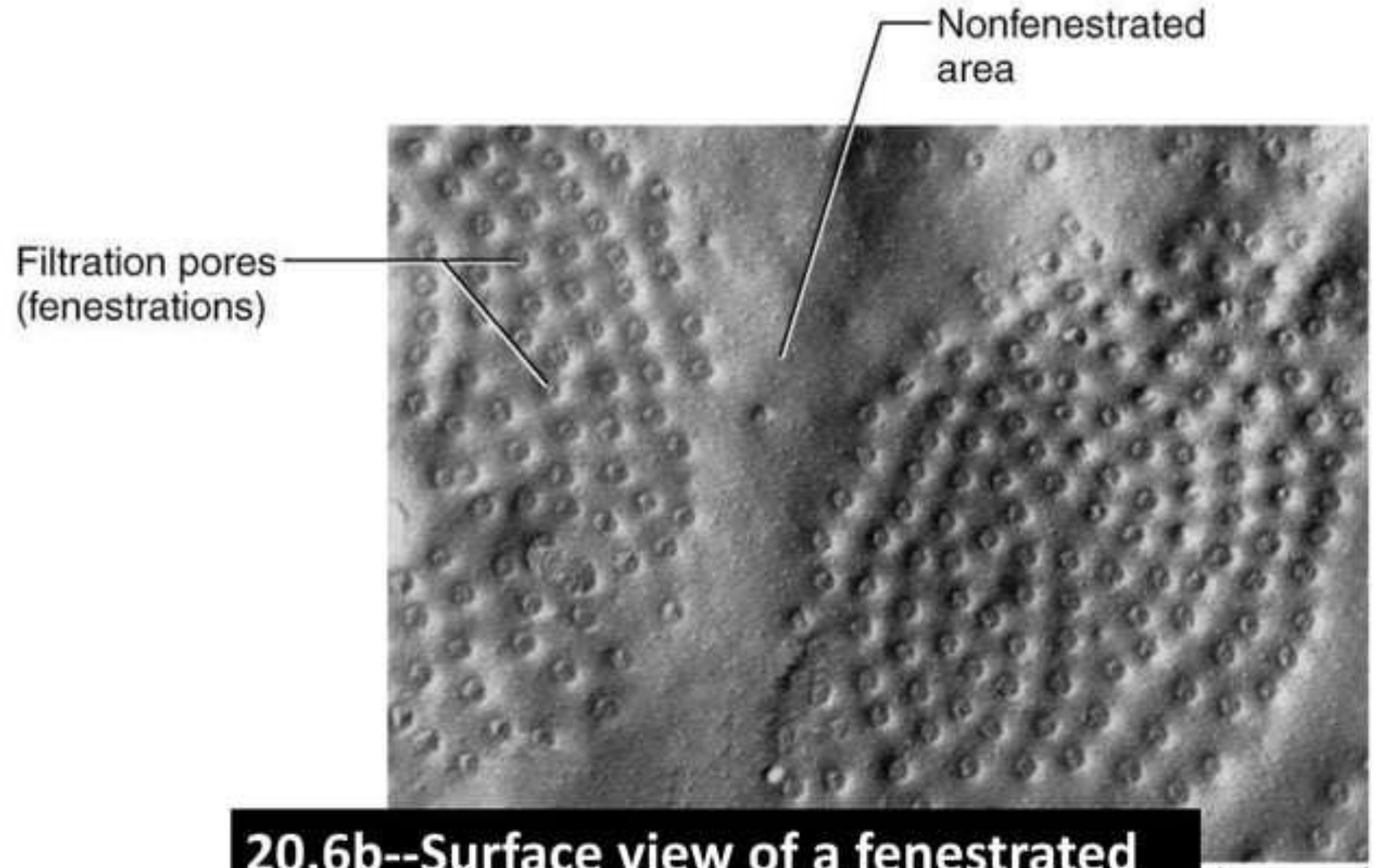
Types of Capillaries

2. Fenestrated capillaries

- Structure – have on endothelial cells
- filtration pores – spanned by very thin glycoprotein layer - allows passage of molecules such as _____
- Locations-- organs that require rapid absorption or filtration - kidneys, small intestine etc.

Fenestrated Capillary



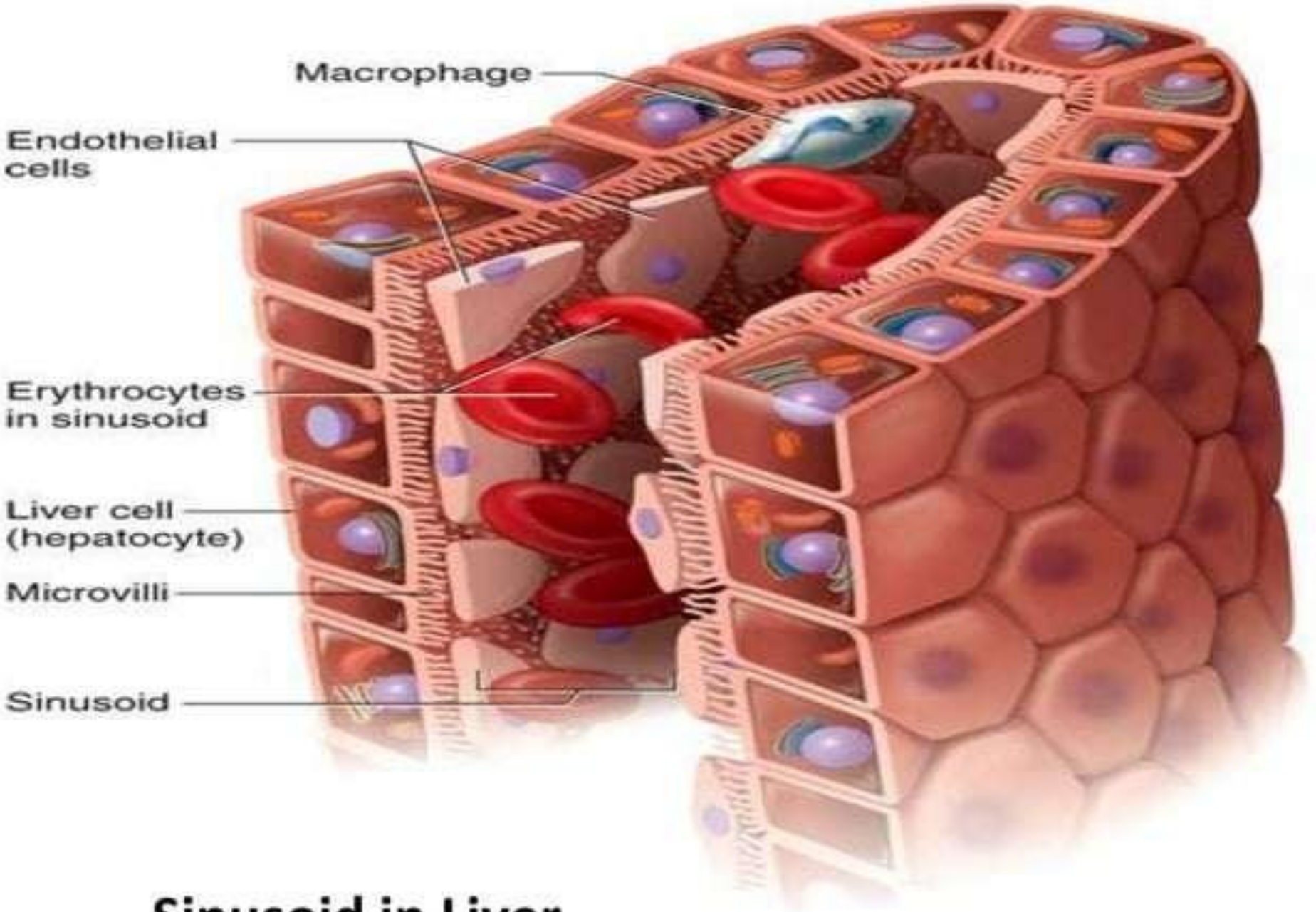


20.6b--Surface view of a fenestrated endothelial cell

Types of Capillaries

3. Sinusoids (discontinuous) capillaries-

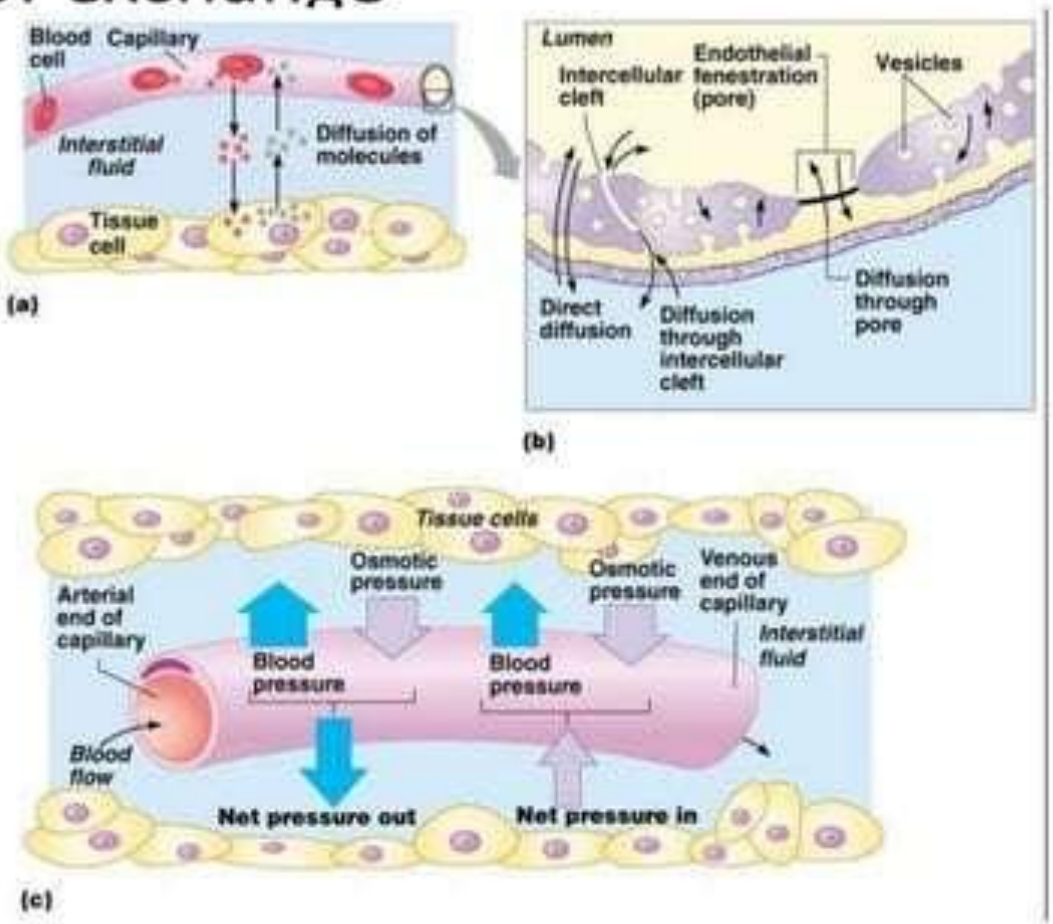
- Structure– endothelial cells separated by wide gaps; **no basal lamina**
- Conform to the shape of the surrounding tissue
- Molecules can pass– proteins and blood cells
- Locations-- liver, bone marrow, spleen, lymphatic organs



Sinusoid in Liver

Capillary Exchange

- Two methods of exchange
  - Diffusion
  - Bulk Flow



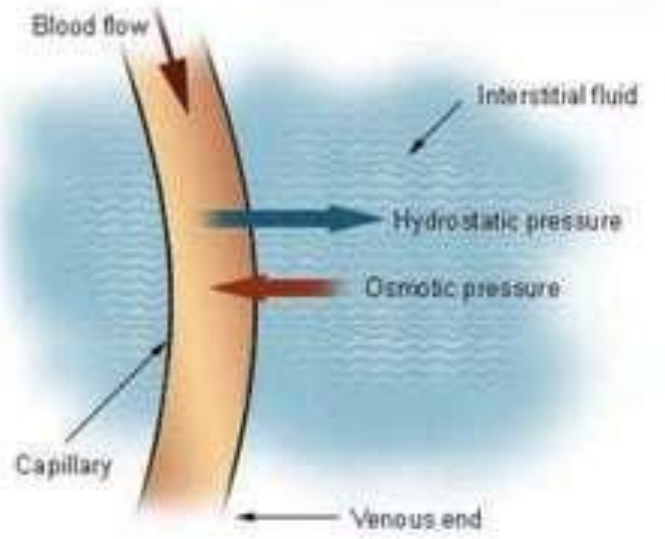
Diffusion

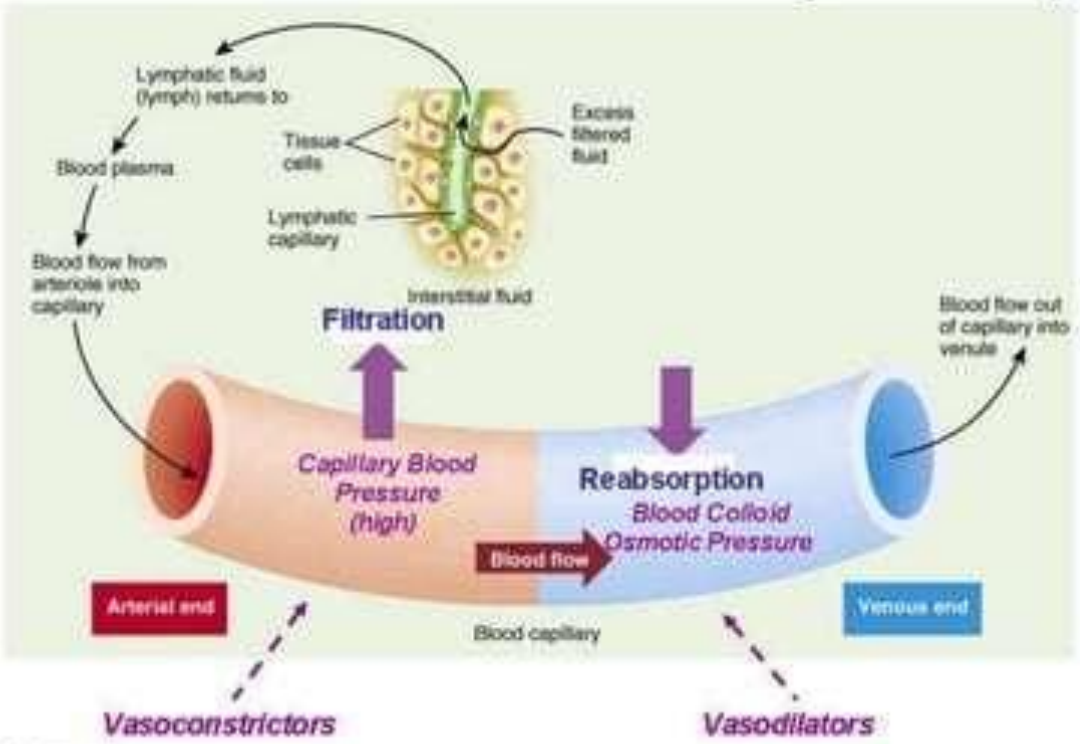
- Oxygen and nutrients → down the gradient into interstitial fluid and then into body cells
- Carbon dioxide and waste → down the gradient from interstitial fluids into the blood for removal
- Glucose
- Amino acids
- Hormones

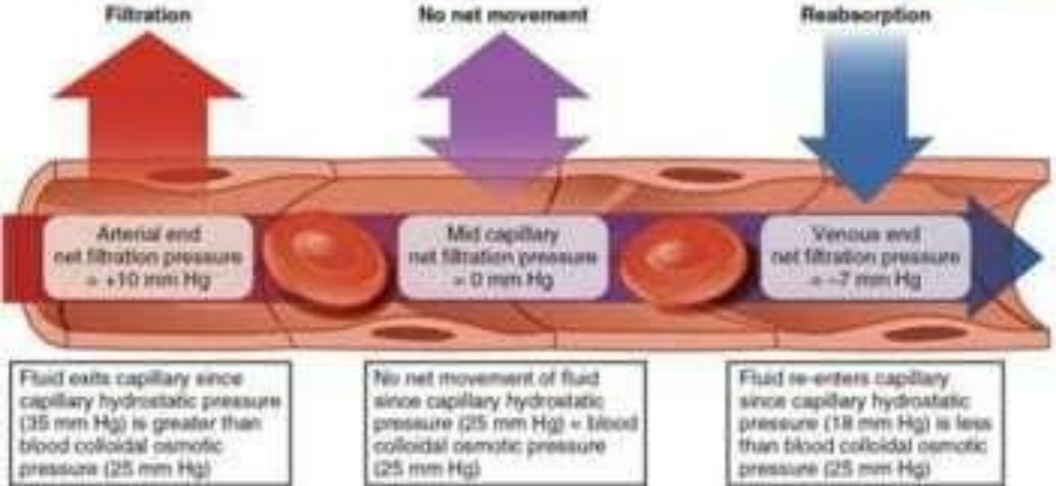
- Plasma proteins usually remain in blood; too large to pass through
  - Exceptions:
    - Sinusoids the smallest blood vessels in the liver have very large gaps in between their endothelial cells to allow proteins (fibrinogen, main clotting protein, and albumin) to enter bloodstream

- Other areas are very selective:
  - Blood-brain barrier refers to the tightness of endothelial layer found in brain; allows only a few substances to enter and leave

Bulk Flow (Filtration and Reabsorption)





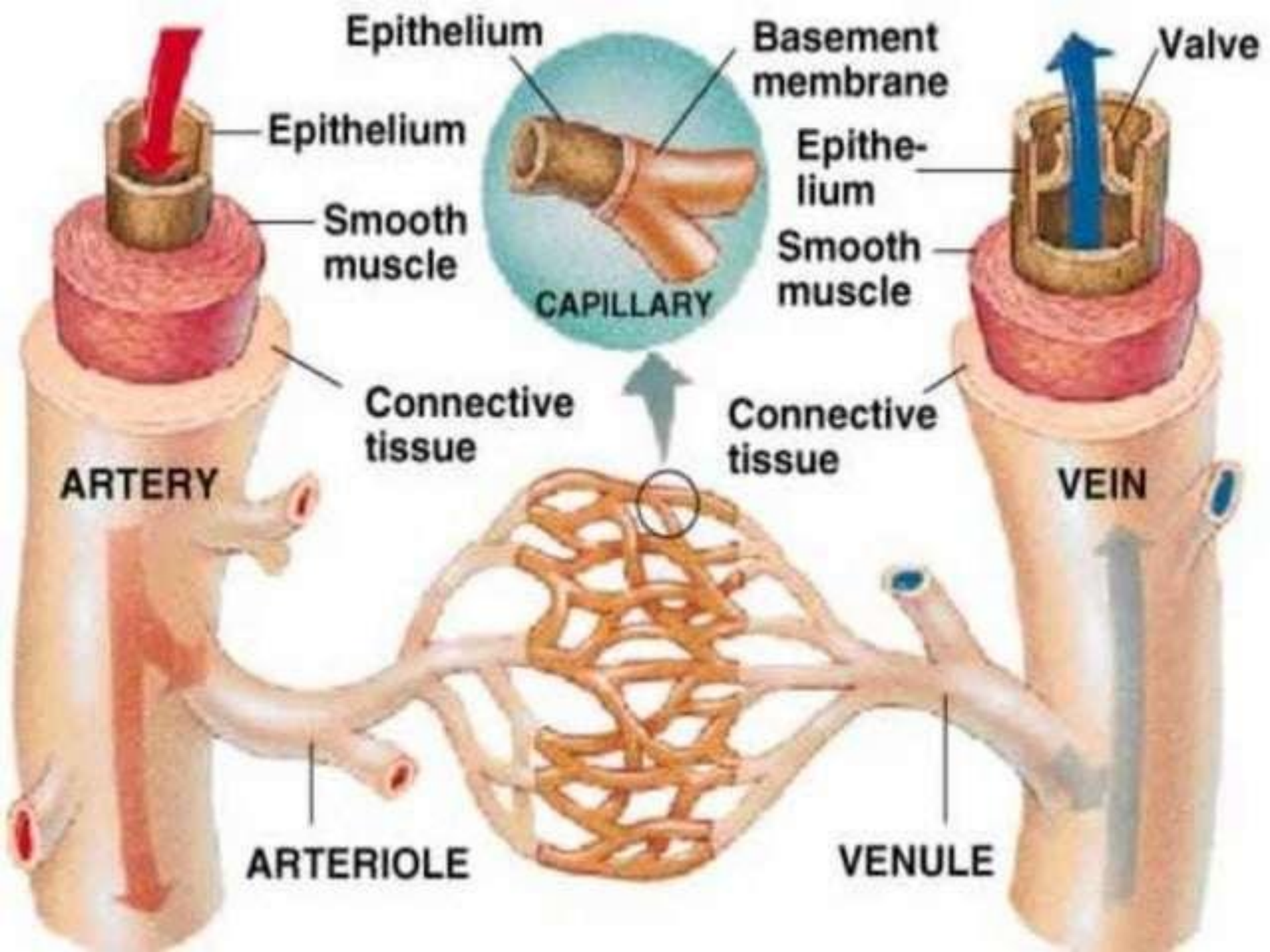


Venules and Veins

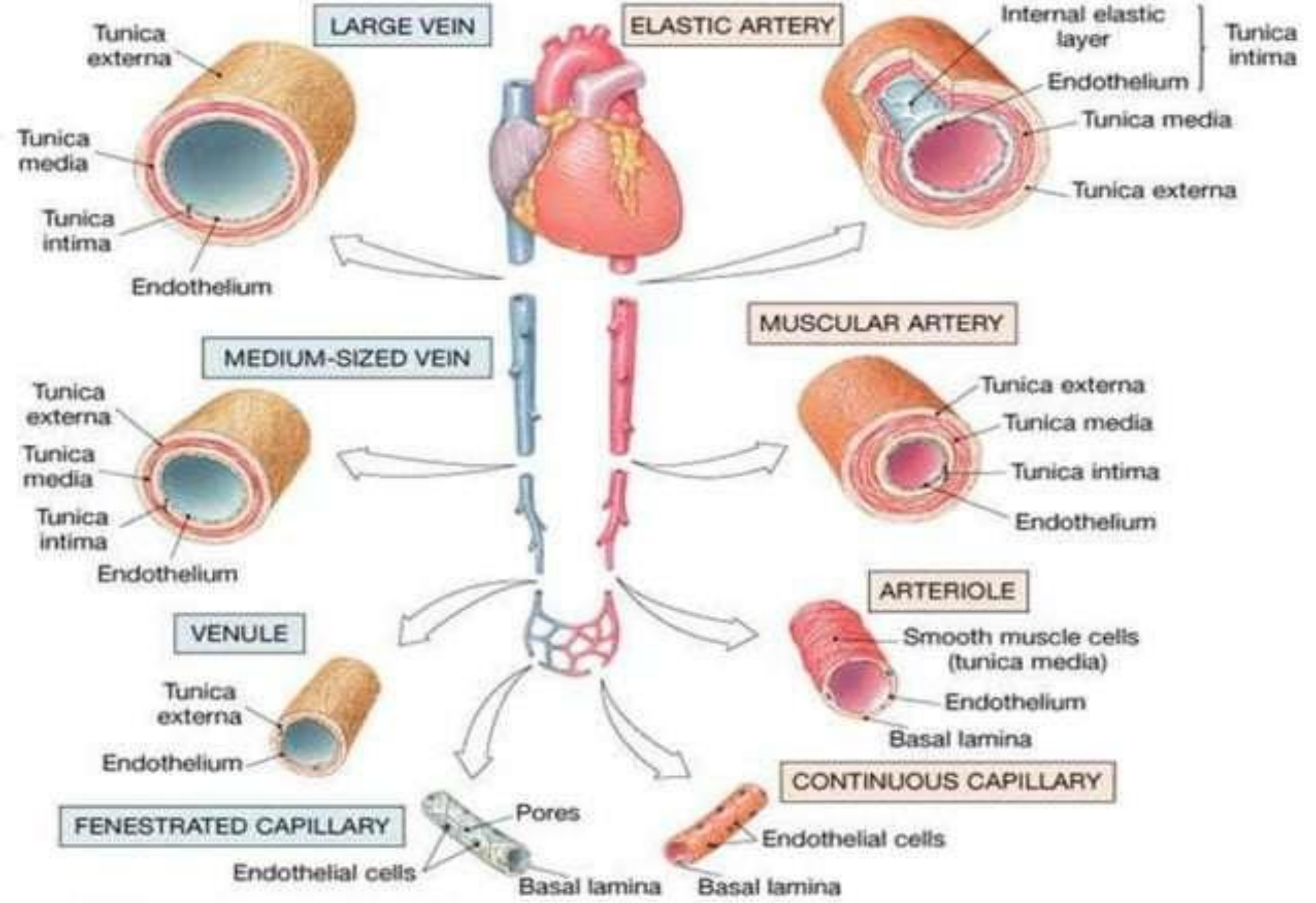
- Capillaries unite to form venules (small veins)
- Venules receive blood from capillaries and empty it into veins
- Veins return blood to the heart
- Greater capacity for blood containment than arteries do
- thinner walls—due to less muscular and elastic tissue; why?
- lower blood pressure: 10 mm Hg with little fluctuation

Structure of Venules and Veins

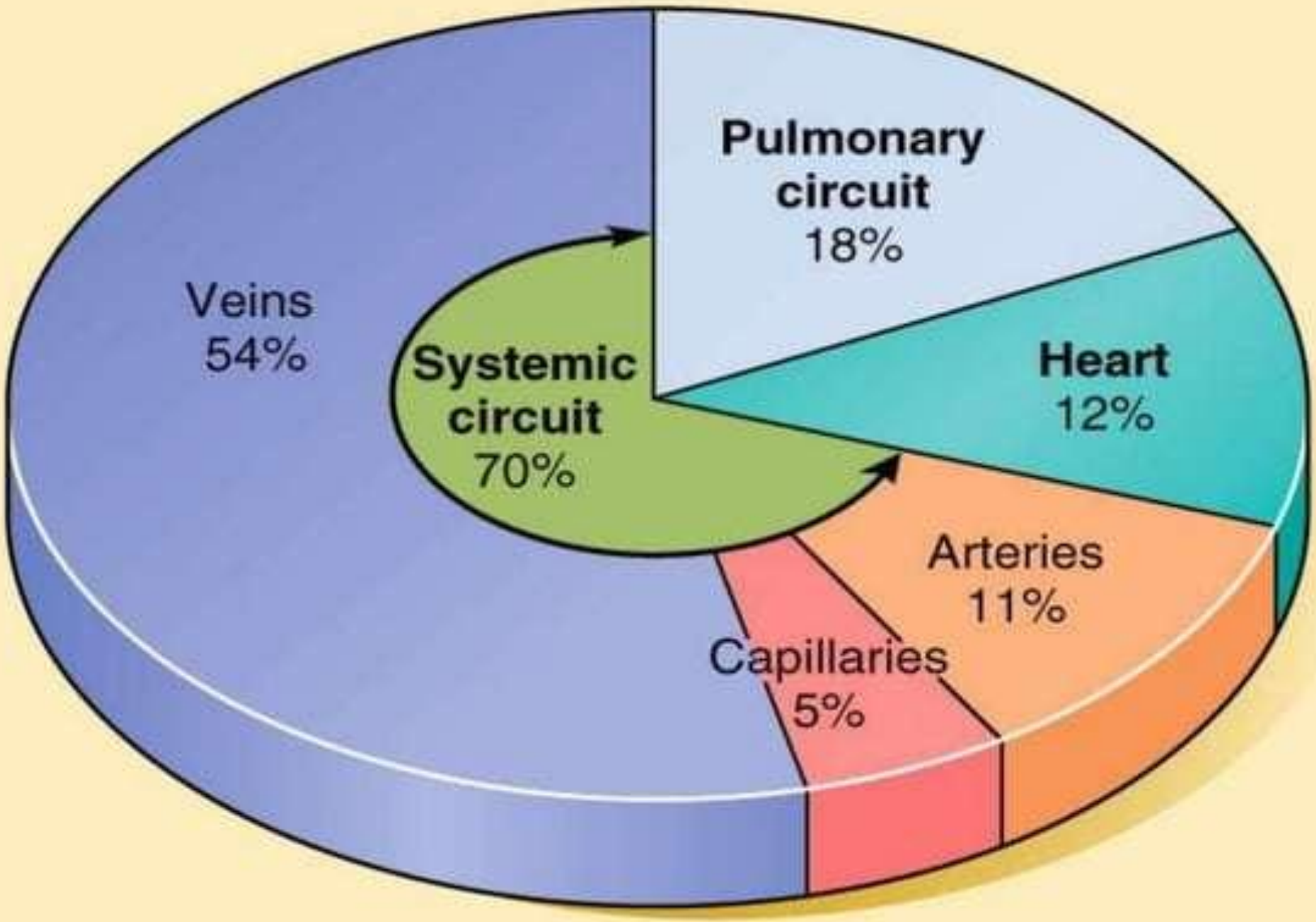
- **Venules**
  - little veins; walls thinner at capillary end, thicker as they progress toward heart
- **Veins**
  - structural similar to arteries; middle and inner layers thinner than arteries, outer layers are the thickest


Epithelium
Basement membrane
Valve
Epithelium
Epithe-lium
Smooth muscle
Smooth muscle
CAPILLARY
Connective tissue
Connective tissue
ARTERY
VEIN
ARTERIOLE
VENULE

Generally, lumen of veins wider than that of corresponding artery



Distribution of Blood



§ Types of veins-- Smallest to largest vessels (A)

1. Postcapillary venules-- only tunica intima
   - Receive blood from capillaries
   - more porous than capillaries
2. Muscular venules-- receive blood from #1
   - have tunica media (1-2 layers of smooth muscle) + thin tunica externa
3. Medium veins–
   - Most have individual names, Examples-- radius or ulna veins
   - Many have venous valves

§ Types of veins-- Smallest to largest vessels (B)

4. Venous sinuses--
   - veins with thin walls, large lumens, no smooth muscle; vasomotion– yes/no? (Circle one)
   - Examples– coronary sinus of the heart and the dural sinuses of the brain
5. Large veins--
   - Greater than 10 mm (diameters)
   - Venae cavae, pulmonary veins, internal jugular veins

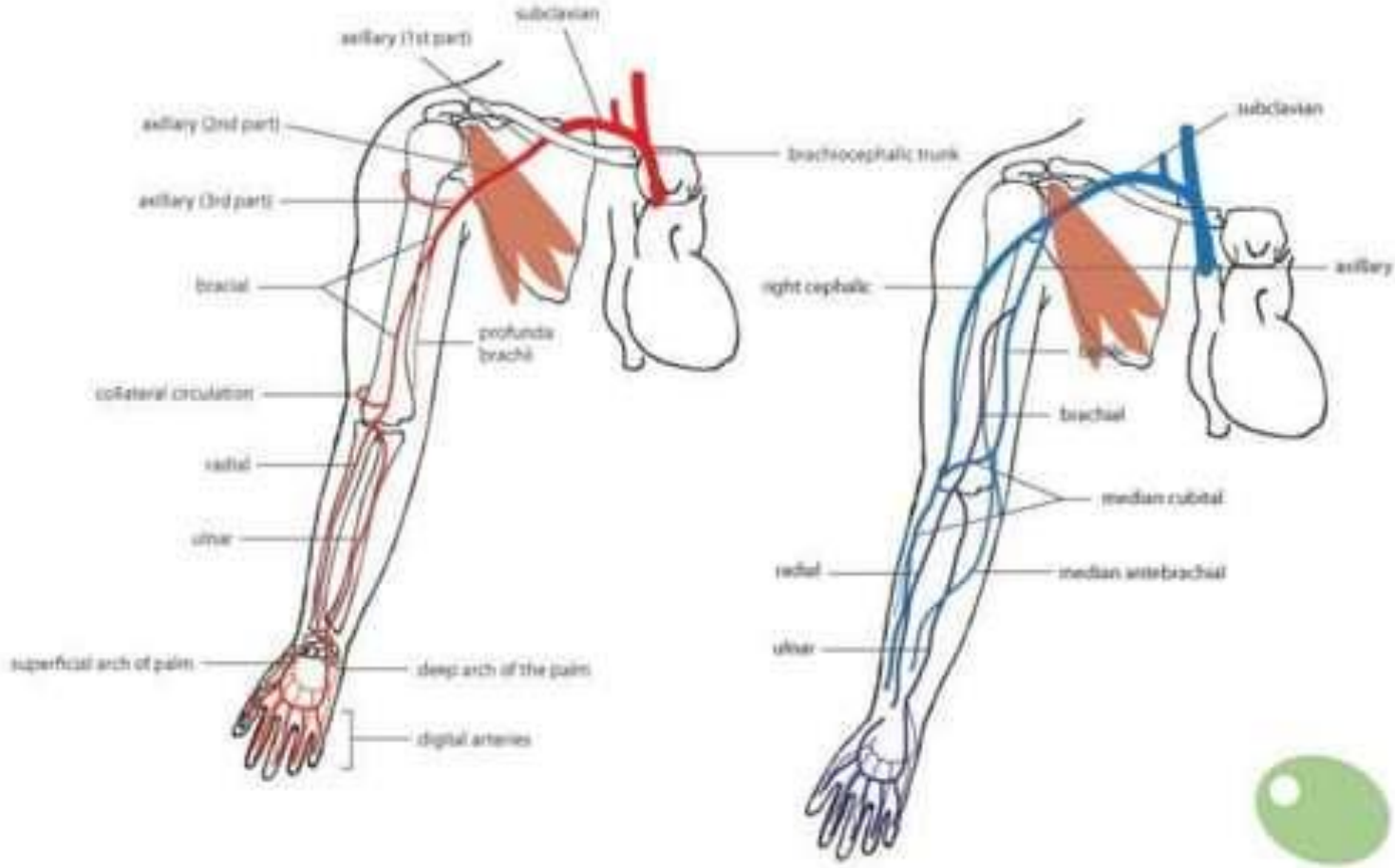
Inner layer forms valves to prevent backflow of blood

- Sometimes this causes problems

- Varicose veins
  - Weak venous valves
  - Gravity forces blood backwards through the valve increasing venous blood pressure
  - Increased pressure pushes the vein's wall outward
  - Veins receive repeated overloads, walls lose elas stretch become flabby

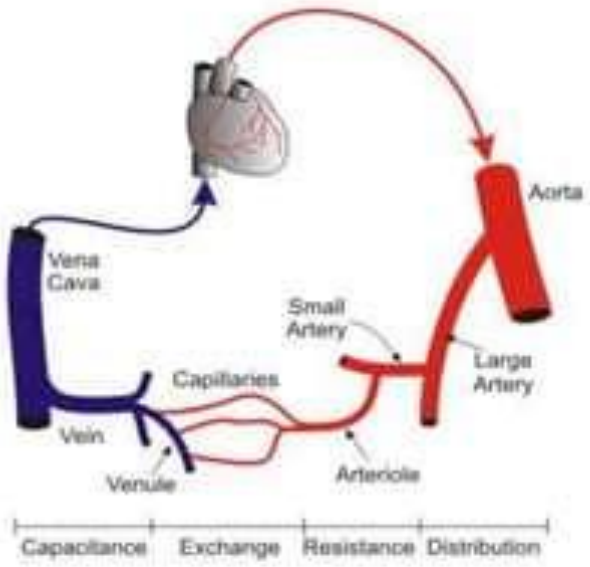
Blood flows out of a vein slowly and more rapidly out of an artery

- WHY should you not start an IV in an artery???

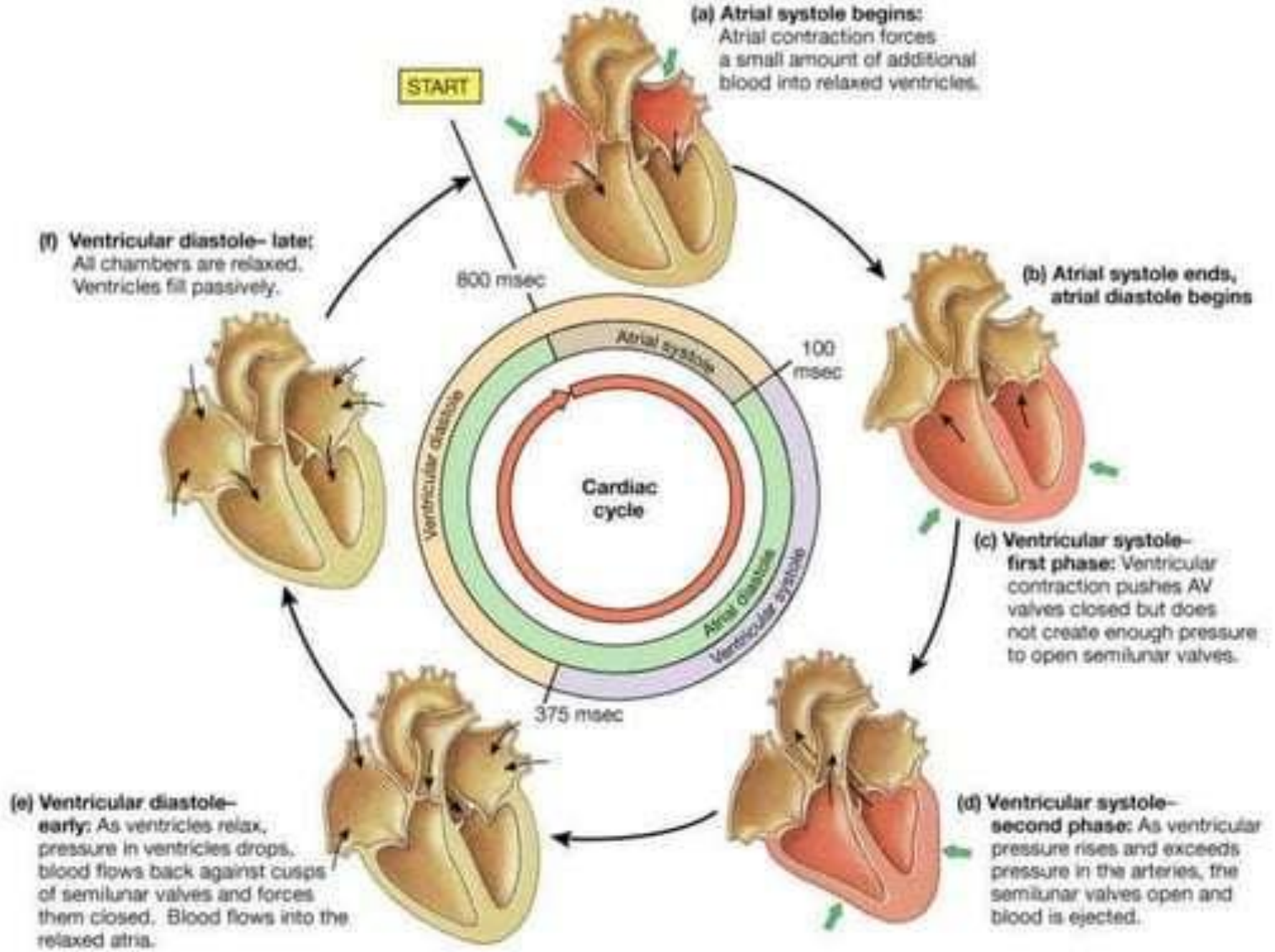


Venous Return

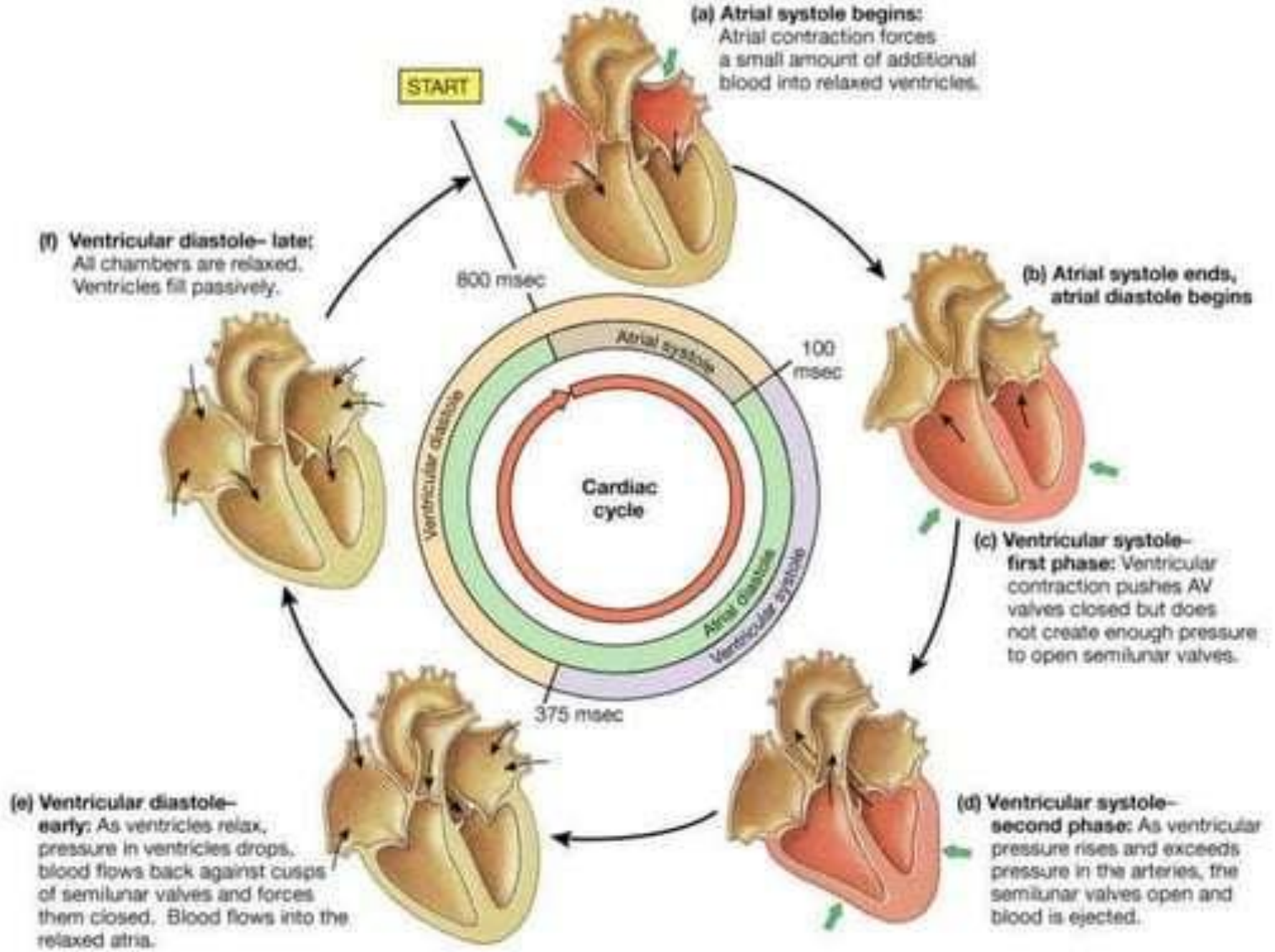
- Volume of blood flowing back to heart through veins, occurs through pressure generated in three ways:
  - **Contractions of the heart**
  - **Skeletal muscle pump**
  - **Respiratory pump**



Contractions of the Heart

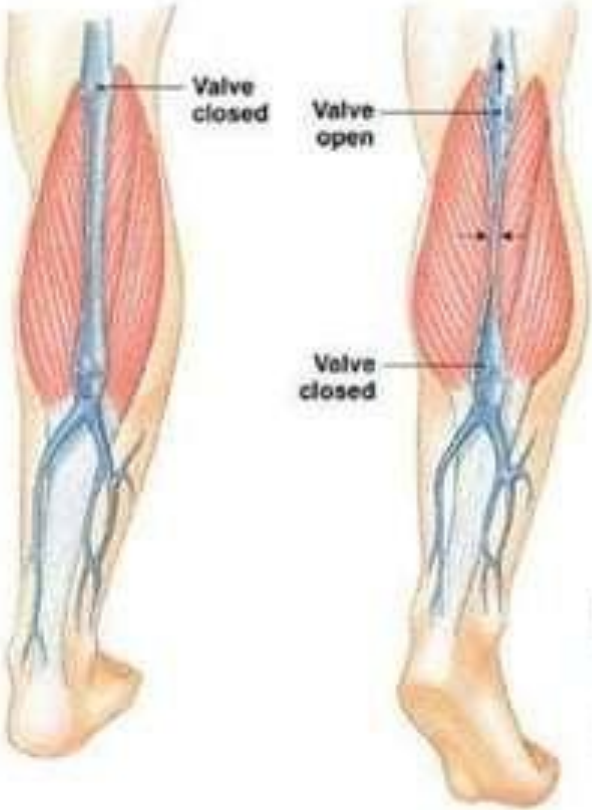


Contractions of the Heart

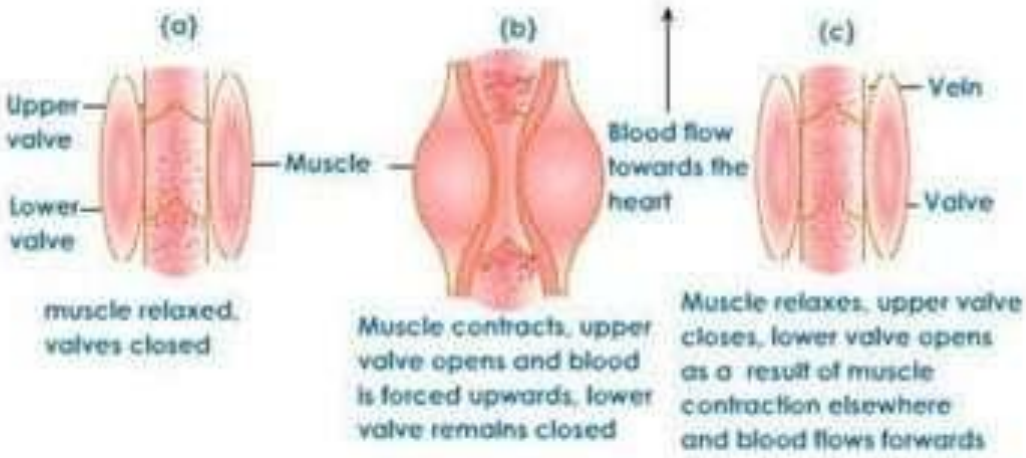


Skeletal Muscle Pump

Valves in the veins prevent backflow of blood.



When the skeletal muscles compress the veins, they force blood toward the heart (the skeletal muscle pump).



Respiratory Pump