Regulation of Blood Flow into a Capillary Bed

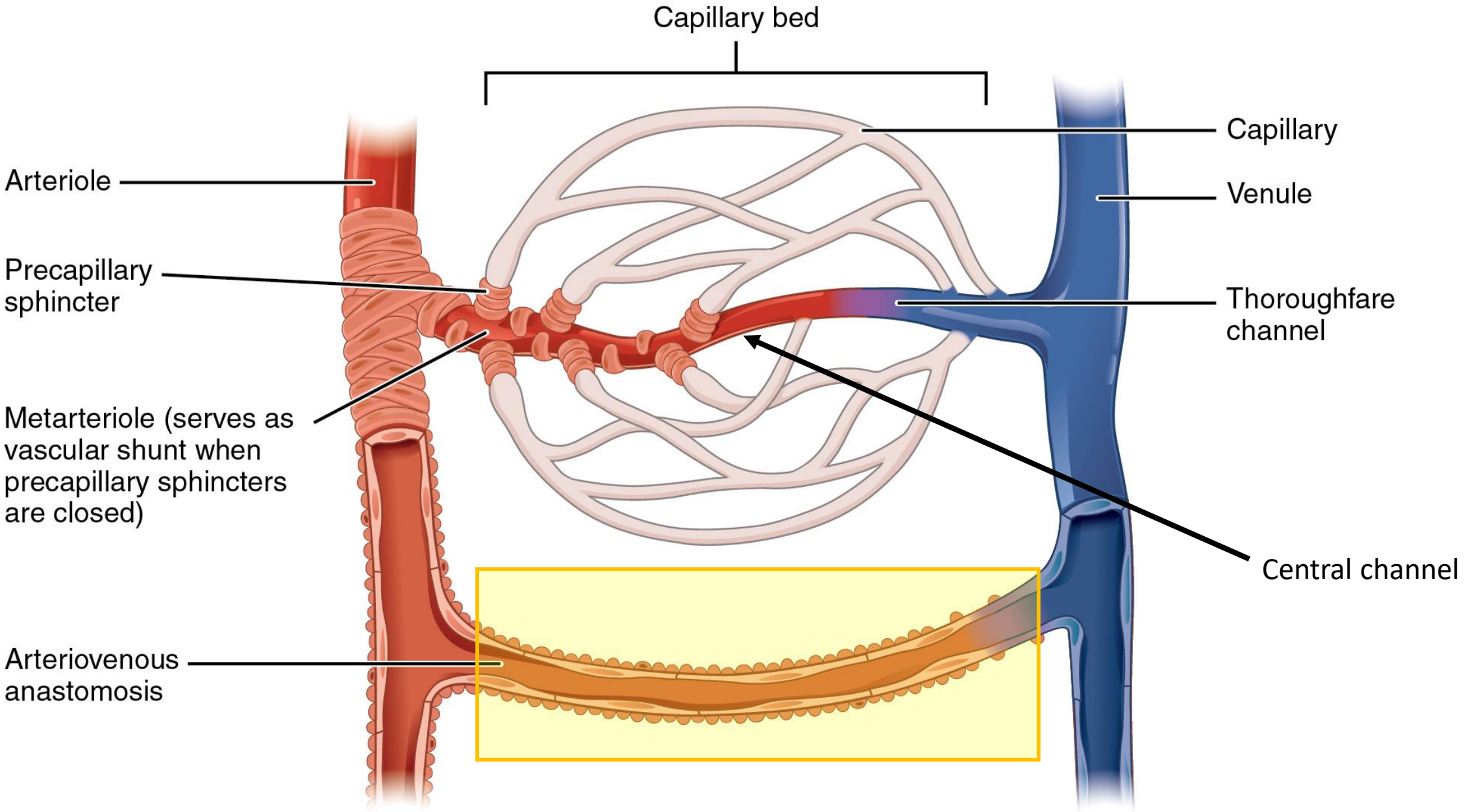
Arteriovenous Anastomoses (Arteriovenous Shunts)

direct vascular connections between arterioles and venules that bypass the capillary bed.

The structures of the arterial and venous ends of the AVA are similar to those of an artery and vein, respectively

The **intermediate segment** has a **thickened tunica m**edia, and its subendothelial layer is composed of **plump polygonal cells** that are modified, longitudinally arranged smooth muscle cells.

When the AVAs are **closed**, the blood passes through the capillary bed; when shunts are **open**, a large amount of blood bypasses the capillary bed and flows through the AVA

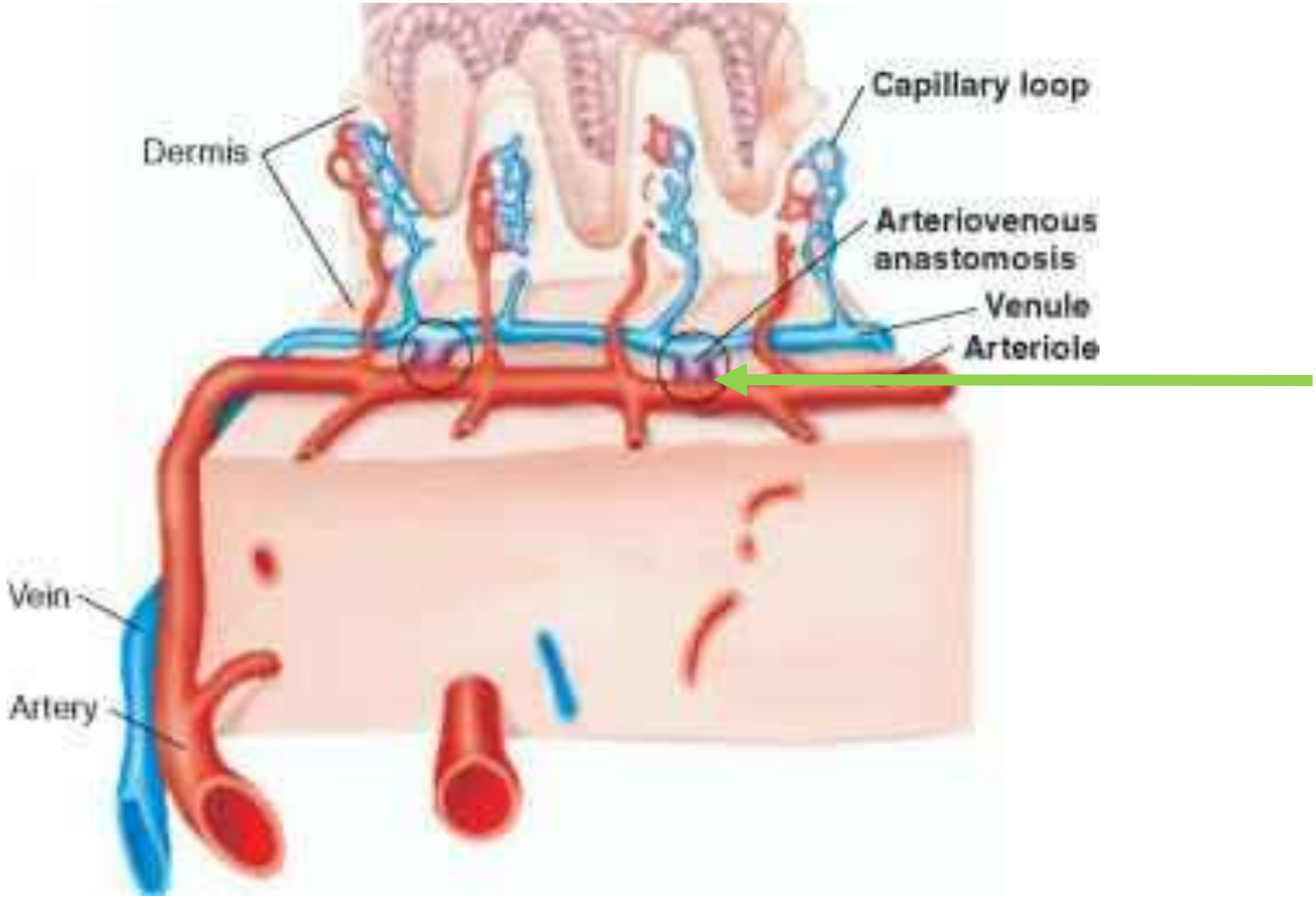

Capillary bed
Capillary
Arteriole
Venule
Precapillary sphincter
Thoroughfare channel
Metarteriole (serves as vascular shunt when precapillary sphincters are closed)
Central channel
Arteriovenous anastomosis

. FUNCTION:

These shunts are useful in **thermoregulation** and are abundant **in skin**.

The **intermediate segments** of the AVAs are richly innervated with **adrenergic and cholinergic nerves**.

The nerves of the AVAs are controlled by the thermoregulatory system in the **brain**.


Capillary loop
Dermis
Arteriovenous anastomosis
Venule
Arteriole
Vein
Artery

Central Channel

Metarterioles form the proximal portion of a central channel, and thoroughfare channels form the distal portion of a central channel.

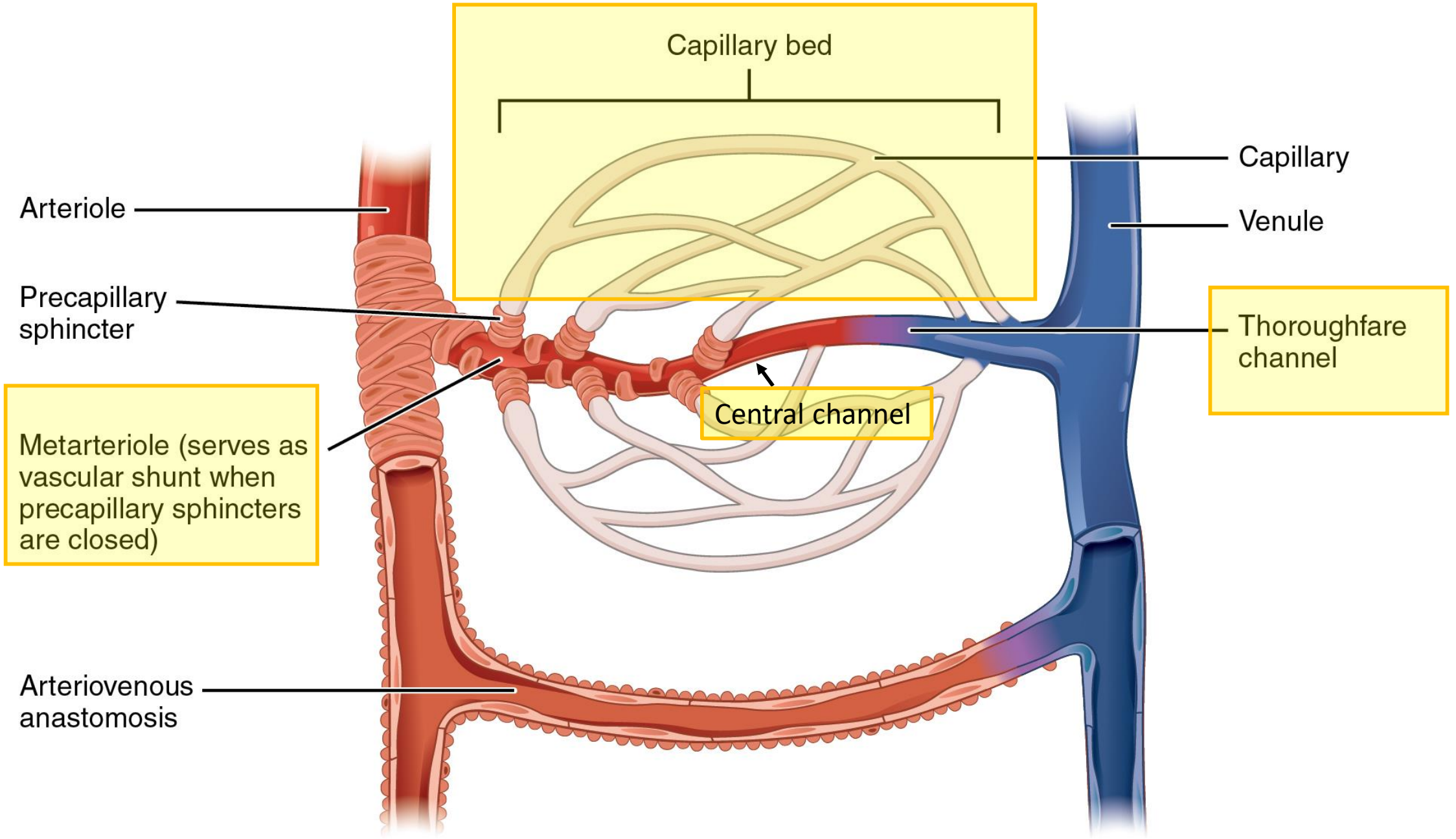
Metarterioles and their continuations, **the central channel, pass through capillary beds conveying blood** from arterioles **to venules.**

The distal portion of the central channel drains into a **thoroughfare channel** that ends in a **small venule (postcapillary venule).**

Metarterioles possess precapillary sphincters, whereas central channels do not.

If the precapillary **sphincters are open**, blood from the **metarterioles** pass into the **capillary bed**, and the capillaries convey their blood to the **central channel** from which the blood enters the t**horoughfare channe**l and then into a **small venule**.

If the precapillary **sphincters are not open**, blood bypasses the capillary bed and goes directly from the **metarteriol**e into the **central channel** then into the **thoroughfare channel** and from there into a **small venule (postcapillary venule**) of the venous system (Fig. 11–13).


Capillary bed
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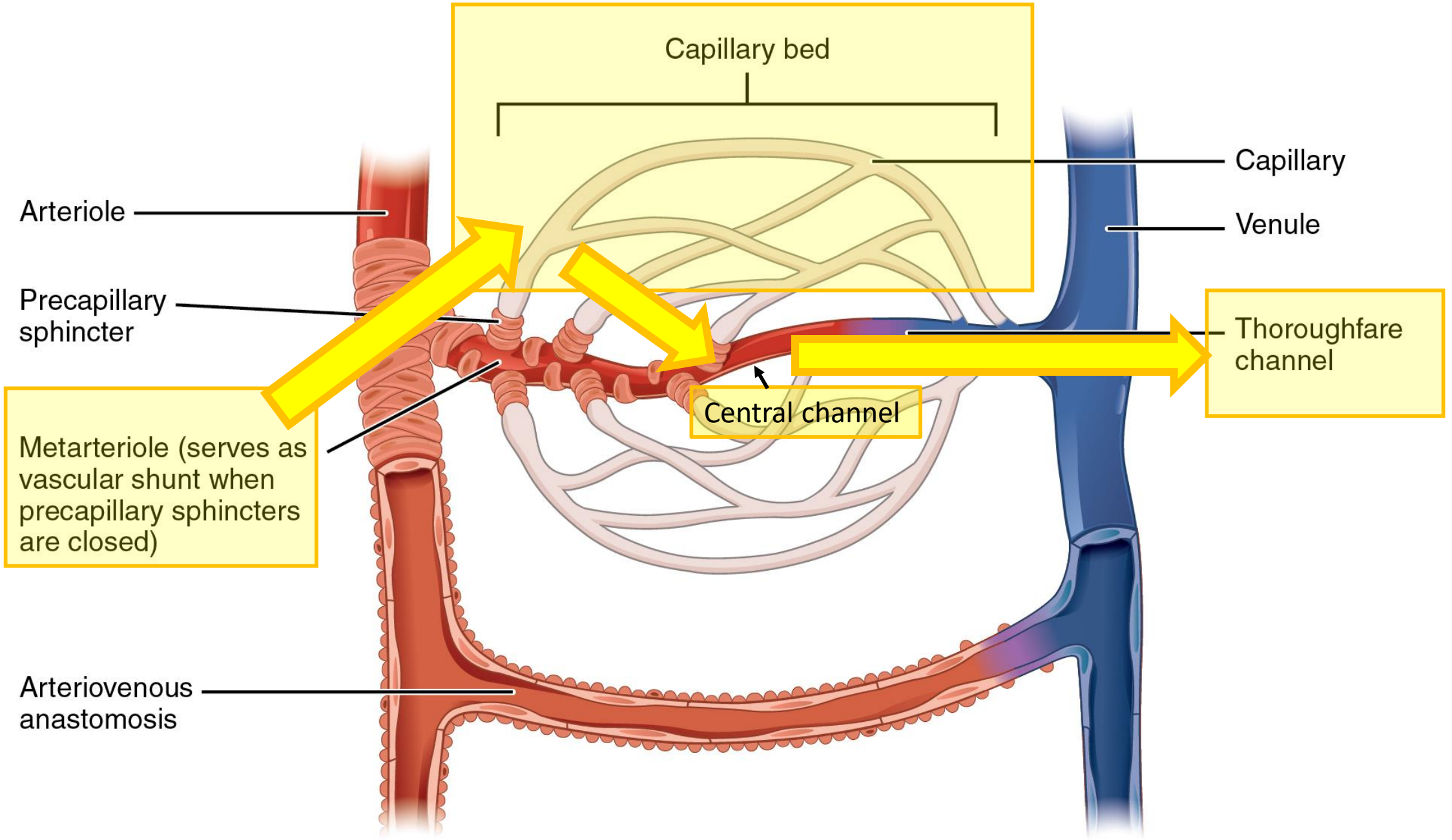
Capillary bed
Capillary
Arteriole
Venule
Precapillary sphincter
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Central channel
Metarteriole (serves as vascular shunt when precapillary sphincters are closed)
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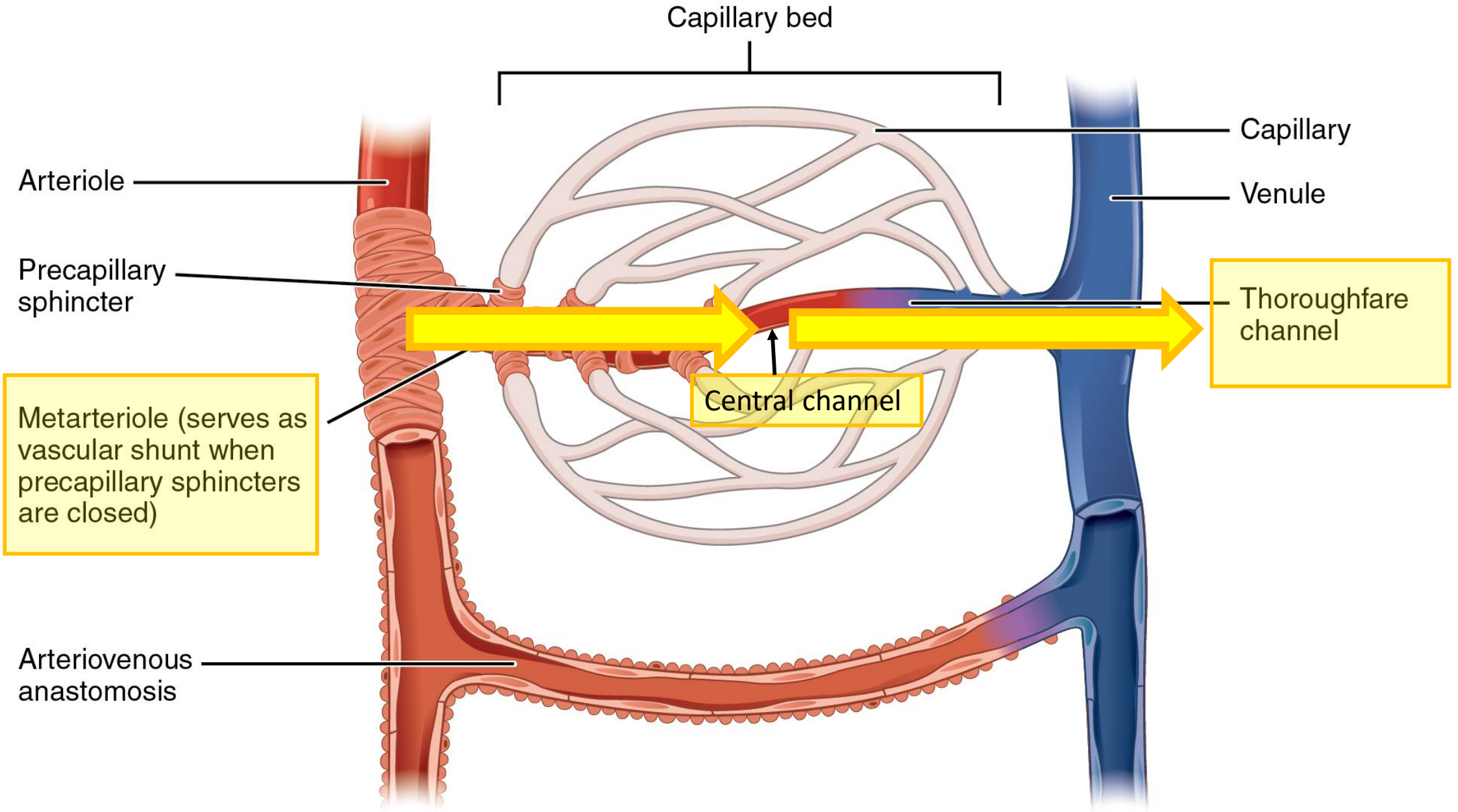
Capillary bed
Capillary
Arteriole
Venule
Precapillary sphincter
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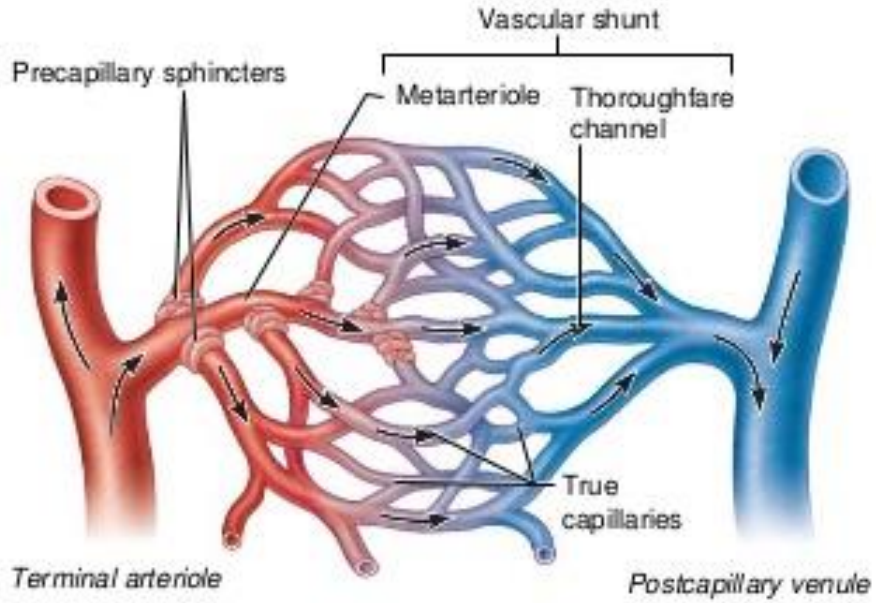
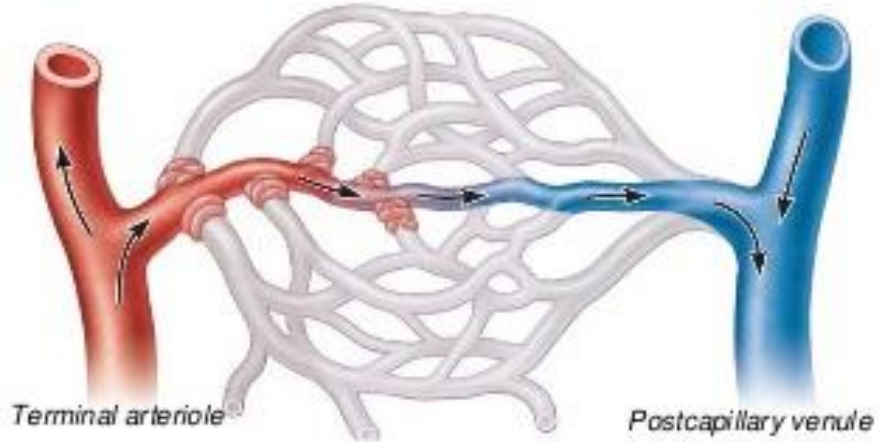
Metarteriole (serves as vascular shunt when precapillary sphincters are closed)
Arteriovenous anastomosis



Active

Sphincters open—blood flows through true capillaries



Rest

Sphincters closed—blood flows through metarteriole – thoroughfare channel and bypasses true capillaries.

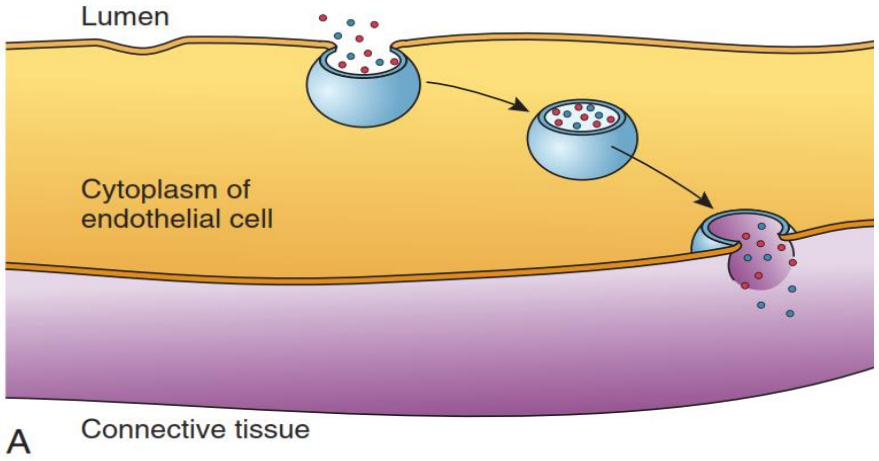
Histophysiology of Capillaries

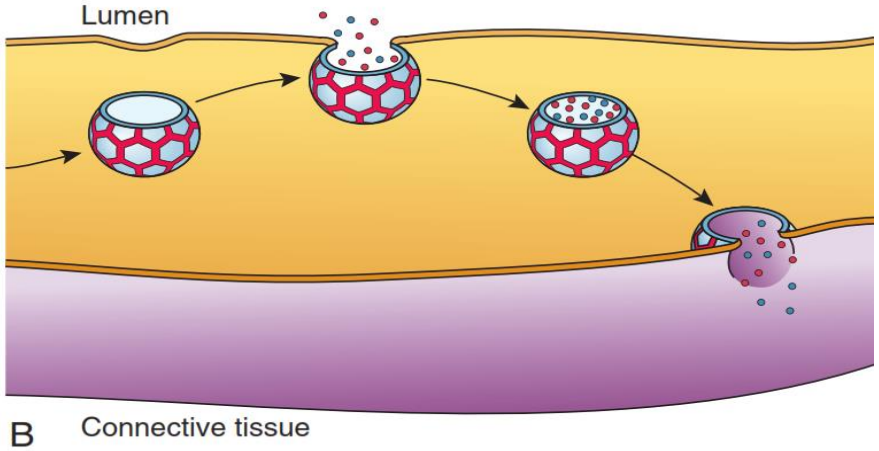
*Capillaries are regions where blood flow is **very slow**, permitting exchange of material between the circulating blood and the extravascular connective tissue.*

The endothelial cells of capillaries may contain two distinct pore systems:

small pores (~9 to 11 nm in diameter) : discontinuities between endothelial cell junctions

large pores (~50 to 70 nm in diameter). : fenestrae and transport vesicles





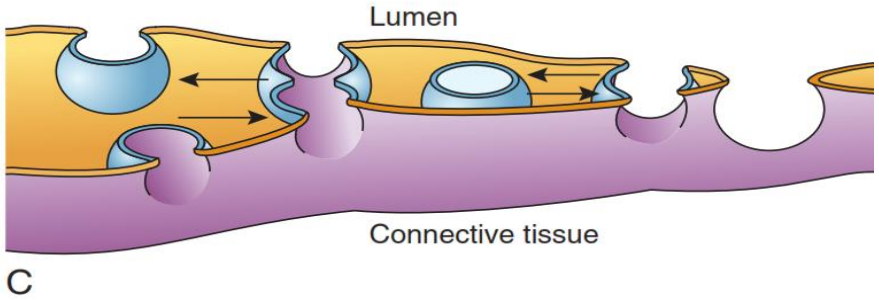


Figure 11–14 Diagram of the various methods of transport across capillary endothelia.

A, Pinocytotic vesicles, which form on the luminal surface, traverse the endothelial cell, and their contents are released on the opposite surface into the connective tissue spaces.

B, ***Trans*** **Golgi network–derived vesicles** ***possessing*** clathrin coats and receptor molecules fuse with the luminal surface of the endothelial cells and pick up specific ligands from the capillary lumen. They then detach and traverse the endothelial cell, fuse with the membrane of the opposite surface, and release their contents into the connective tissue spaces.

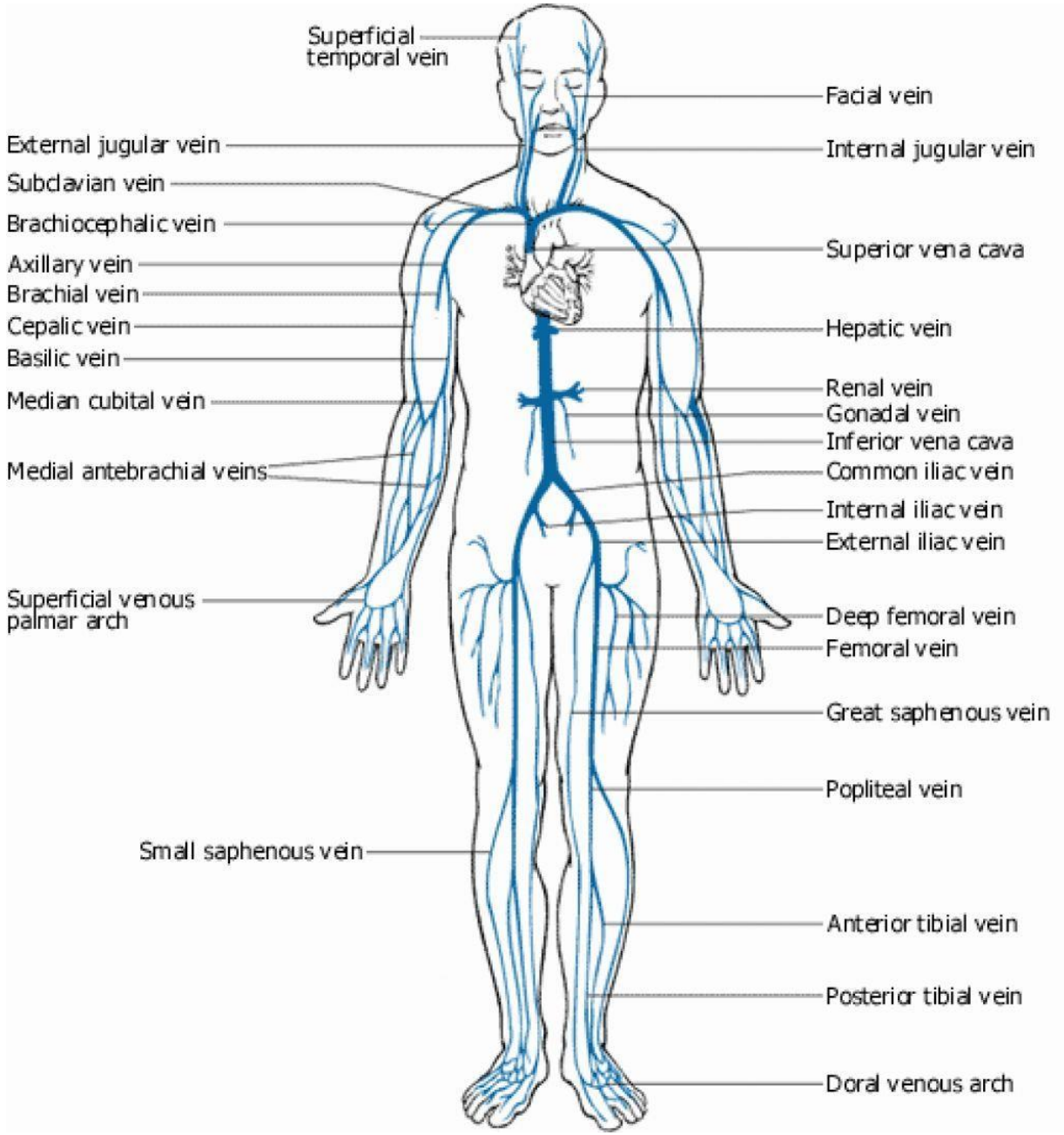
C, In regions where the endothelial cells are highly attenuated, the **Pinocytotic vesicles may fuse** with each other to form transient **fenestrations** through the entire thickness of the endothelial cell, permitting material to travel between the lumen and the connective tissue spaces.

Veins

Veins are vessels that return blood to the heart.

At the discharging ends of capillaries are **small venules**, the beginning of the venous return, which conducts blood away from the organs and tissues and returns it to the heart.

These venules empty their contents into **larger veins**, and the process continues as the vessels become larger and larger back to the **heart**.


Superficial temporal vein
Facial vein
External jugular vein
Internal jugular vein
Subclavian vein
Brachiocephalic vein
Superior vena cava
Axillary vein
Brachial vein
Cepalic vein
Hepatic vein
Basilic vein
Renal vein
Median cubital vein
Gonadal vein
Inferior vena cava
Medial antebrachial veins
Common iliac vein
Internal iliac vein
External iliac vein
Superficial venous palmar arch
Deep femoral vein
Femoral vein
Great saphenous vein
Popliteal vein
Small saphenous vein
Anterior tibial vein
Posterior tibial vein
Doral venous arch

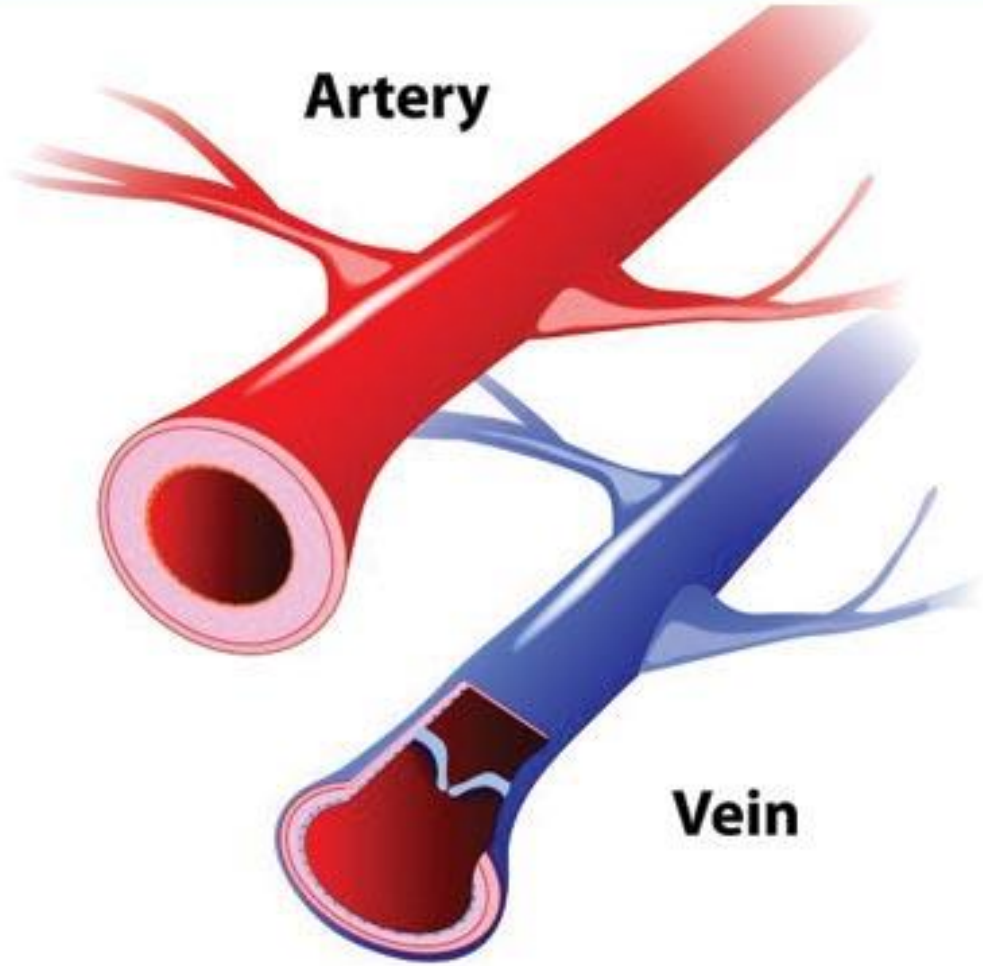
Veins not only **outnumber arteries** but also usually have **larger luminal diameters**; therefore, at any one time, almost **70% of the total blood volume** is in these vessels.

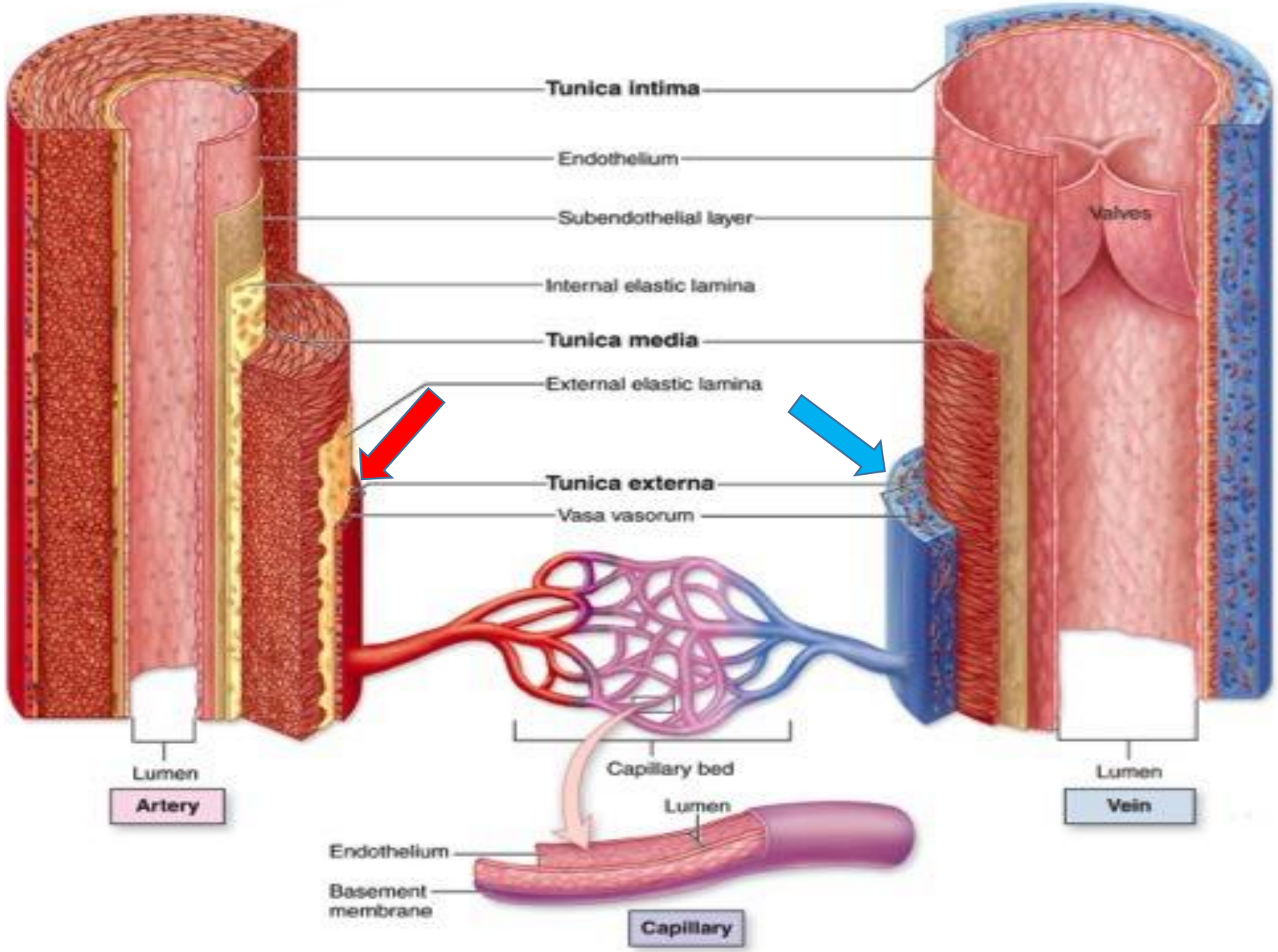
In histological sections, veins **parallel arteries**.

However, their walls are usually **collapsed** because they are **thinner and less elastic than arterial walls** because the venous return is a **low-pressure system**.

Of the three layers, the tunica **adventitia is usually the thickest** in veins, and veins have a richer supply of vasa vasorum than do arteries

Arteries vs Vein



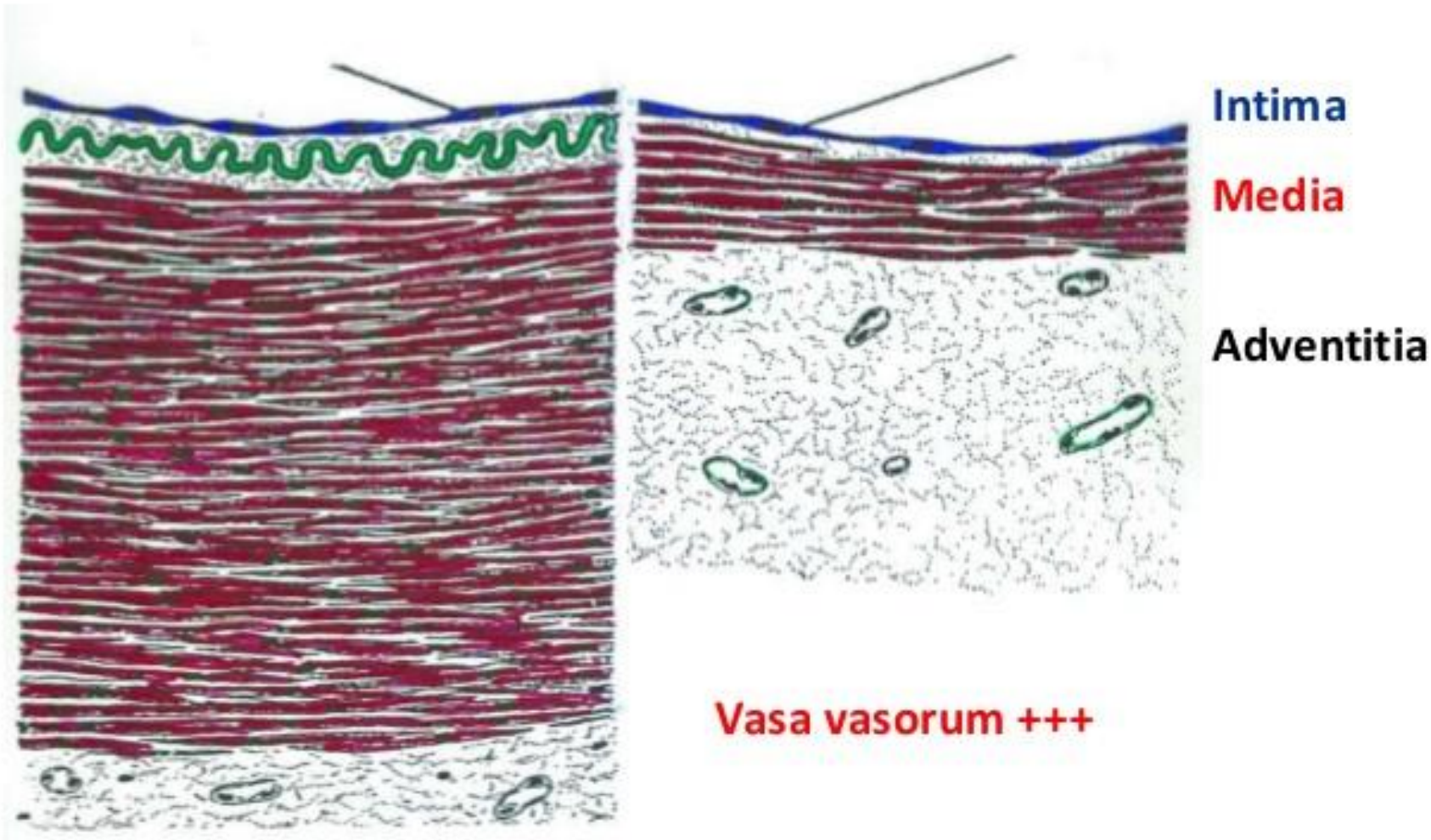



small vein & artery, H&E
(40x obj.)
vein
artery

Structure

Muscular artery

Vein



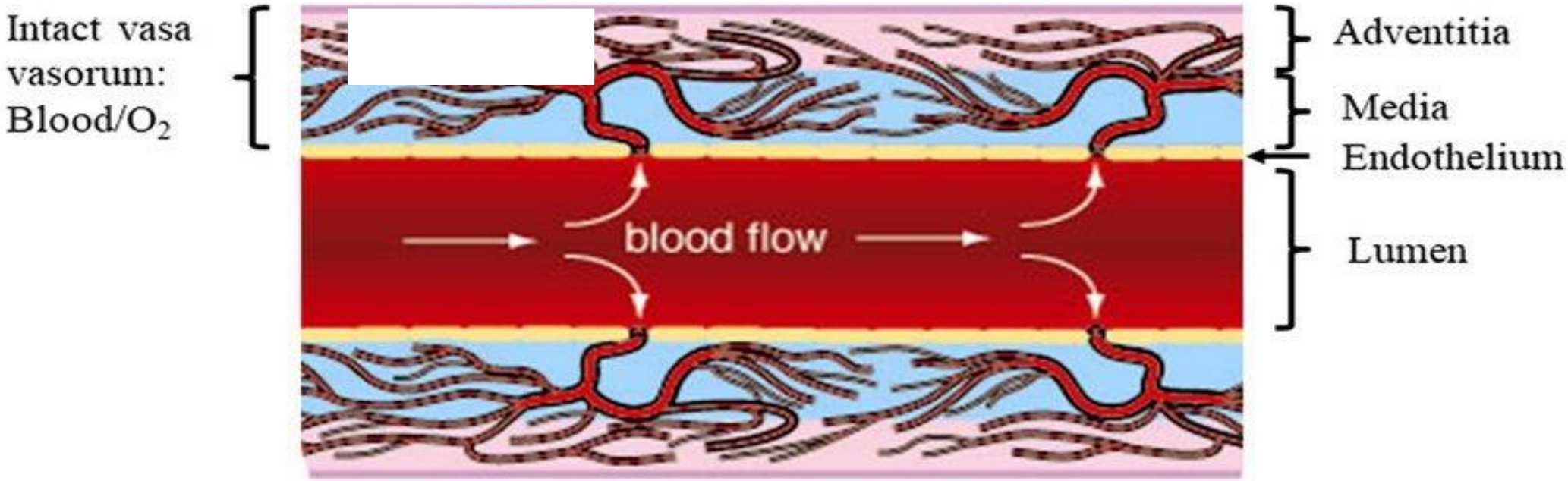
Intima

Media

Adventitia

Vasa vasorum +++

No-touch saphenous vein



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Classification of Veins

*Veins are classified into three groups on the basis of their **diameter and wall thickness**: small, medium, and large.*

Veins are described as having **the same three layers** (i.e., tunicae intima, media, and adventitia) as arteries

The connective tissue components in veins are **more pronounced than in arteries**.

In certain areas of the body, where the structures housing the veins **protect them from pressure** (e.g., retina, meninges, placenta, penis), the veins have **little or no smooth muscle** in their walls

The **boundaries between the tunica intima and the tunica media of most veins are not clearly distinguishable.**

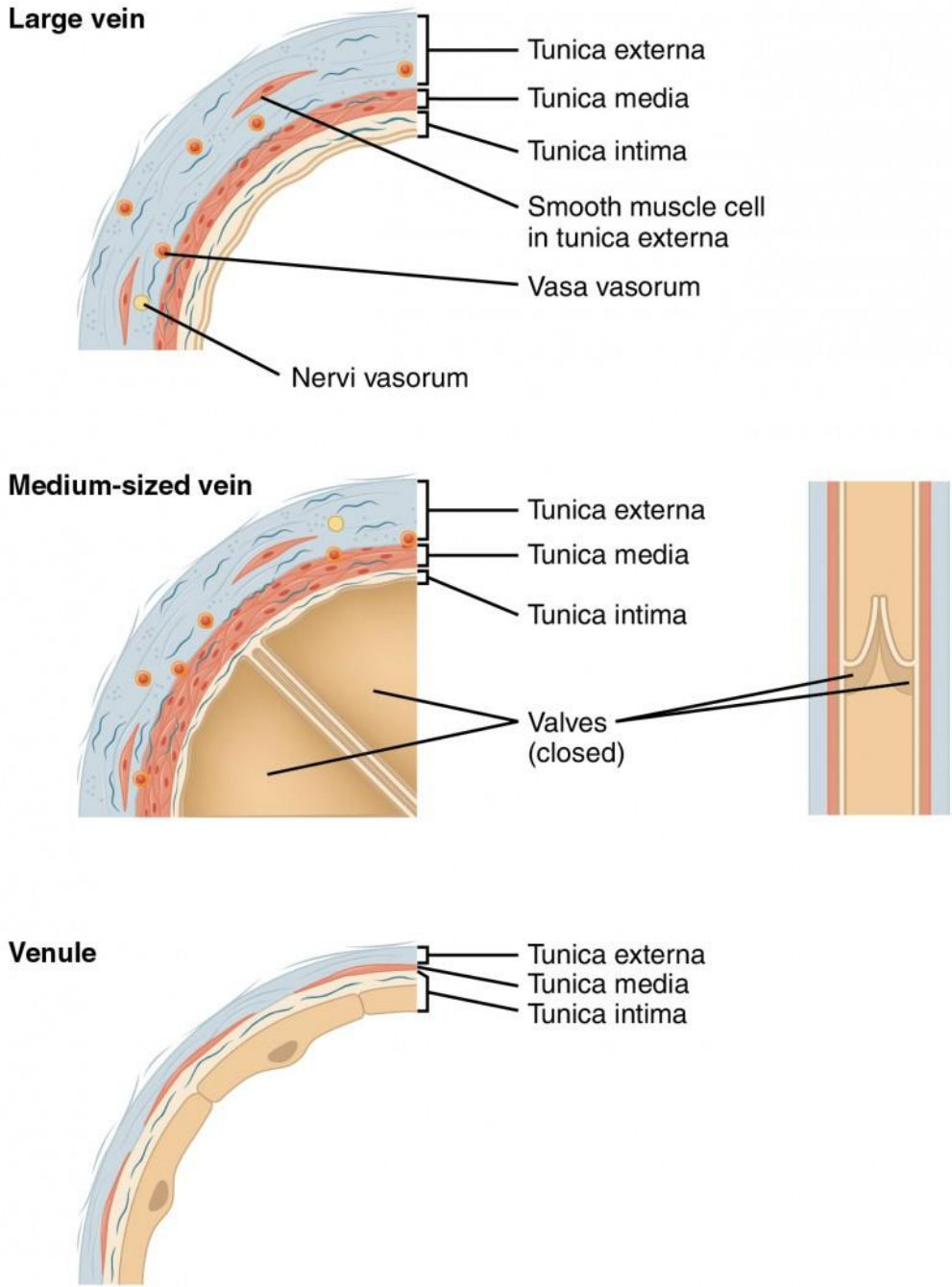
Venules and Small Veins

As the blood pools from the capillary bed, it is discharged into **small venules (postcapillary venules), which are 15 to 20 ▪ m in diameter** :
Their walls are similar to those of capillaries, with a thin endothelium surrounded by reticular fibers and **pericytes.**

Pericytes are replaced by **smooth muscle cells in larger venules (1 mm** in diameter), first as **scattered** smooth muscle cells; then, as venule diameter increases, the smooth muscle cells become more closely spaced, forming a **continuous layer in the largest** venules and small veins.

TABLE 11–2 Characteristics of Veins

Type	Tunica Intima	Tunica Media	Tunica Adventitia
Large veins	Endothelium; basal lamina, valves in some; subendothelial connective tissue	Connective tissue, smooth muscle cells	Smooth muscle cells oriented in longitudinal bundles; cardiac muscle cells near their entry into the heart; collagen layers with fibroblasts
Medium and small veins	Endothelium, basal lamina; valves in some; subendothelial connective tissue	Reticular and elastic fibers, some smooth muscle cells	Collagen layers with fibroblasts
Venules	Endothelium, basal lamina (pericytes, postcapillary venules)	Sparse connective tissue and a few smooth muscle cells	Some collagen and a few fibroblasts


Large vein
Tunica externa
Tunica media
Tunica intima
Smooth muscle cell in tunica externa
Vasa vasorum
Nervi vasorum
Medium-sized vein
Tunica externa
Tunica media
Tunica intima
Valves (closed)
Venule
Tunica externa
Tunica media
Tunica intima

Materials are exchanged between the connective tissue spaces and vessel lumina, not only in the capillaries, but also in the postcapillary venules whose walls are even more permeable.

Indeed, this is the **preferred location for emigration of the leukocytes** from the bloodstream into the tissue spaces

The endothelial cells of venules located in certain lymphoid organs are **cuboidal** rather than squamous and are called ***high-endothelial venules.***
These function in l**ymphocyte recognition** by type-specific receptors on their luminal surface, ensuring that specific lymphocytes **migrate** into the proper regions of the lymphoid parenchyma.

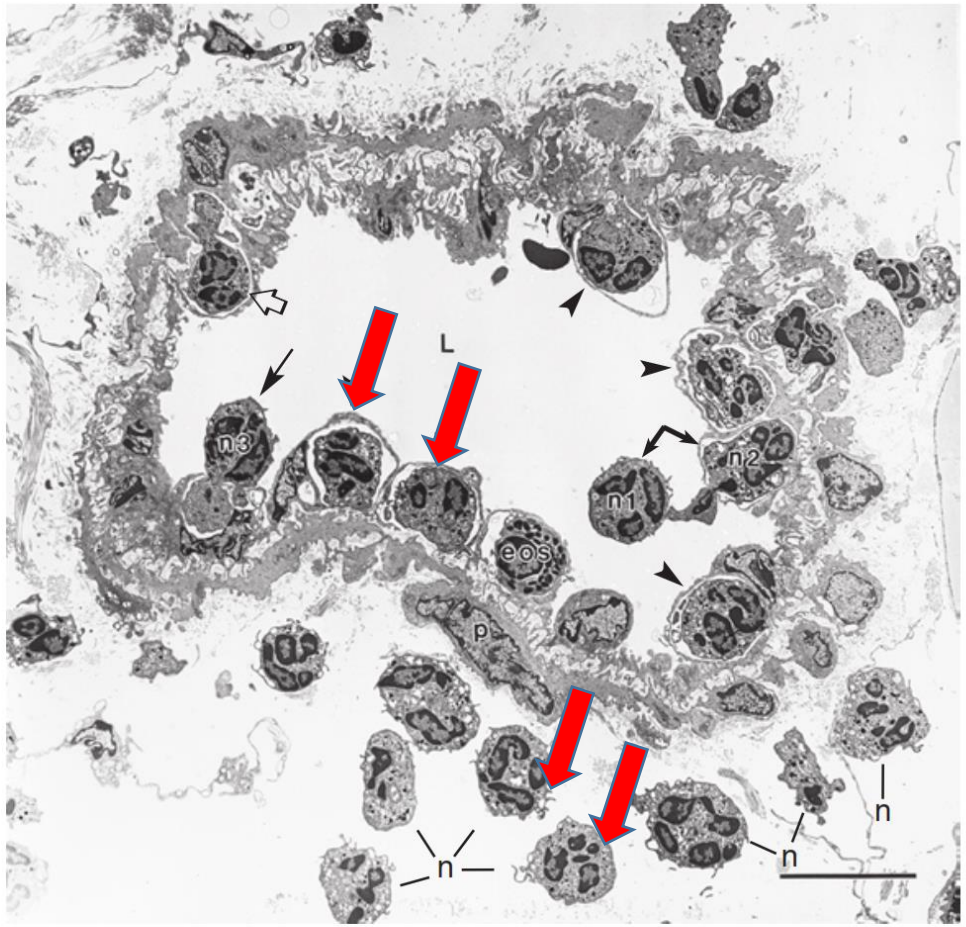


Figure 11–15 Large venule in guinea pig skin harvested 60 minutes after intradermal injection of 10^{-5} M *N*-formyl-methionyl-leucyl-phenylalanine (*F*-MLP). Many neutrophils and a single eosinophil (eos) are captured at various stages of attachment to and extravasation across vascular endothelium and underlying pericytes (p). Two neutrophils *(single joined arrow)*, one in another lumen and another partway across the endothelium, are tethered together. Another neutrophil *(long arrow)* has projected a cytoplasmic process into an underlying endothelial cell (EC). Other neutrophils *(arrowheads)* and the eosinophil have crossed the EC barrier but remain superficial to pericytes, forming dome-like structures that bulge into the vascular lumen. Still another neutrophil *(open arrow)* that has already crossed the endothelium has extended a process into the basal lamina and indents an underlying pericyte. Other neutrophils (some indicated by *n*) have crossed both the EC and pericyte barriers and have

Medium Veins

*Medium veins are less than 1 cm in diameter (*1 and 10 mm)

Medium veins are those draining most of the body, including most of the regions of the extremities.

Their **tunica intima** includes the endothelium and its basal lamina and reticular fibers. Sometimes an **elastic network** surrounds the endothelium, but these elastic fibers do **not form laminae** characteristic of an internal elastic lamina.

The **smooth muscle** cells of the **tunica media** are in a **loosely organized** layer interwoven with collagen fibers and fibroblasts.

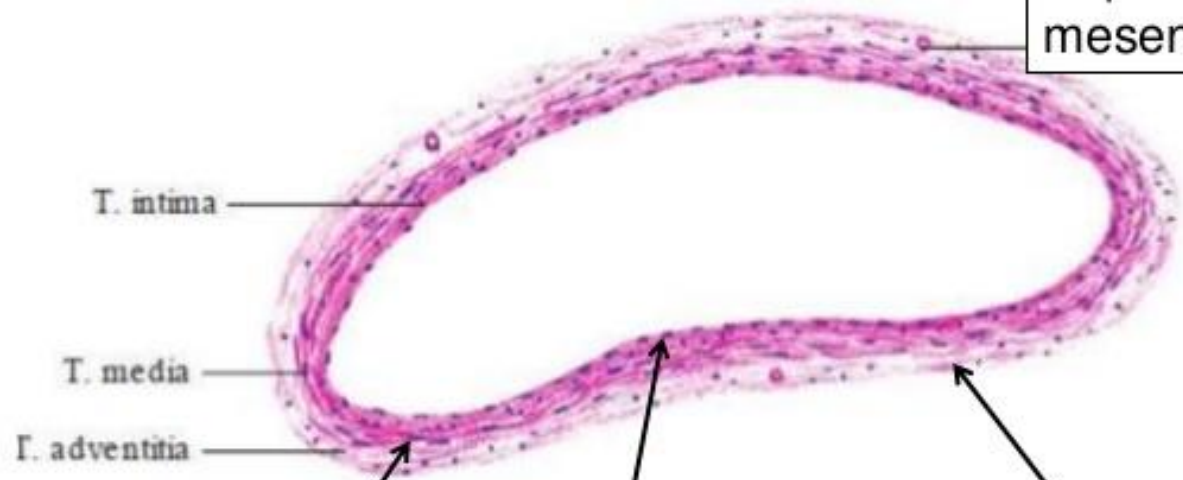
The **tunica adventitia**, the **thickest** of the tunics, is composed of longitudinally arranged collagen bundles and elastic fibers along with a few scattered smooth muscle cells.

Medium - Sized Veins

1–10 mm in diameter

All layers are thinner than large vein

Femoral vein & Superior mesenteric vein



Tunica Intima
Very thin

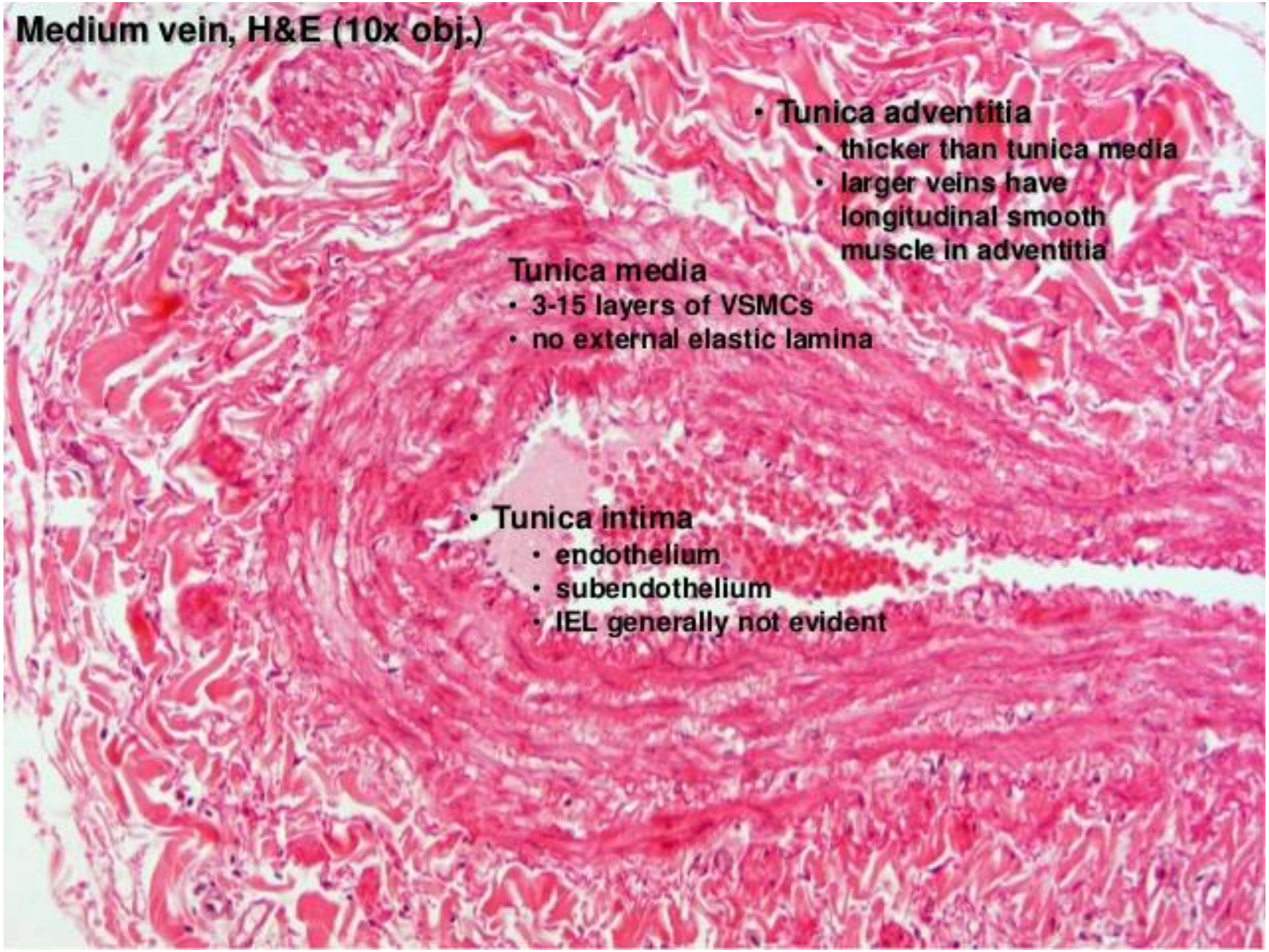
Endothelium & Thin Sub-endothelial CT

Tunica Media
Less muscular

Few smooth muscle fibers

Tunica Adventitia

Well developed & thicker than the media


Medium vein, H&E (10x obj.)
• Tunica adventitia
• thicker than tunica media
• larger veins have longitudinal smooth muscle in adventitia
Tunica media
• 3-15 layers of VSMCs
• no external elastic lamina
• Tunica intima
• endothelium
• subendothelium
• IEL generally not evident

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Large Veins

Large veins return venous blood directly to the heart from the extremities, head, liver, and body wall.

Large veins include the vena cava and the pulmonary, portal, renal, internal jugular, iliac, and azygos veins.

The **tunica intima** of the large veins is **similar to that of the medium** veins, except that large veins have a **thick subendothelial connective tissue** layer containing fibroblasts and a network of elastic fibers.

Although only a few major vessels (e.g., **the pulmonary veins) have a well-developed smooth muscle** layer, most large veins are **without a tunica media**; in its place is a **well developed tunica adventitia.**

An exception are the **superficial veins of the legs**, which have a **well-defined muscular wall**, perhaps to resist the distention caused by gravity.

The tunica adventitia of large veins contains many **elastic fibers, abundant collagen fibers, and vasa vasorum**, whereas the **inferior vena cava** has longitudinally arranged **smooth muscle cells in its adventitia**.

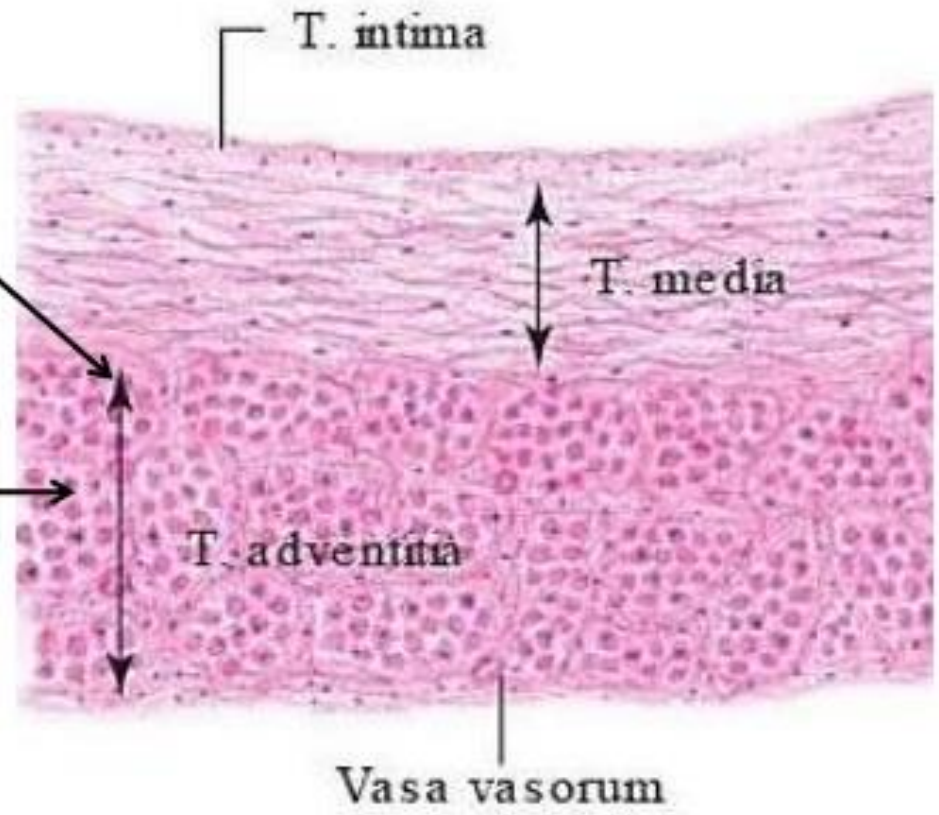
As the pulmonary veins and the vena cava approach the heart, their **adventitia contains some cardiac muscle cells.**

Large Veins ≥1 cm in diameter

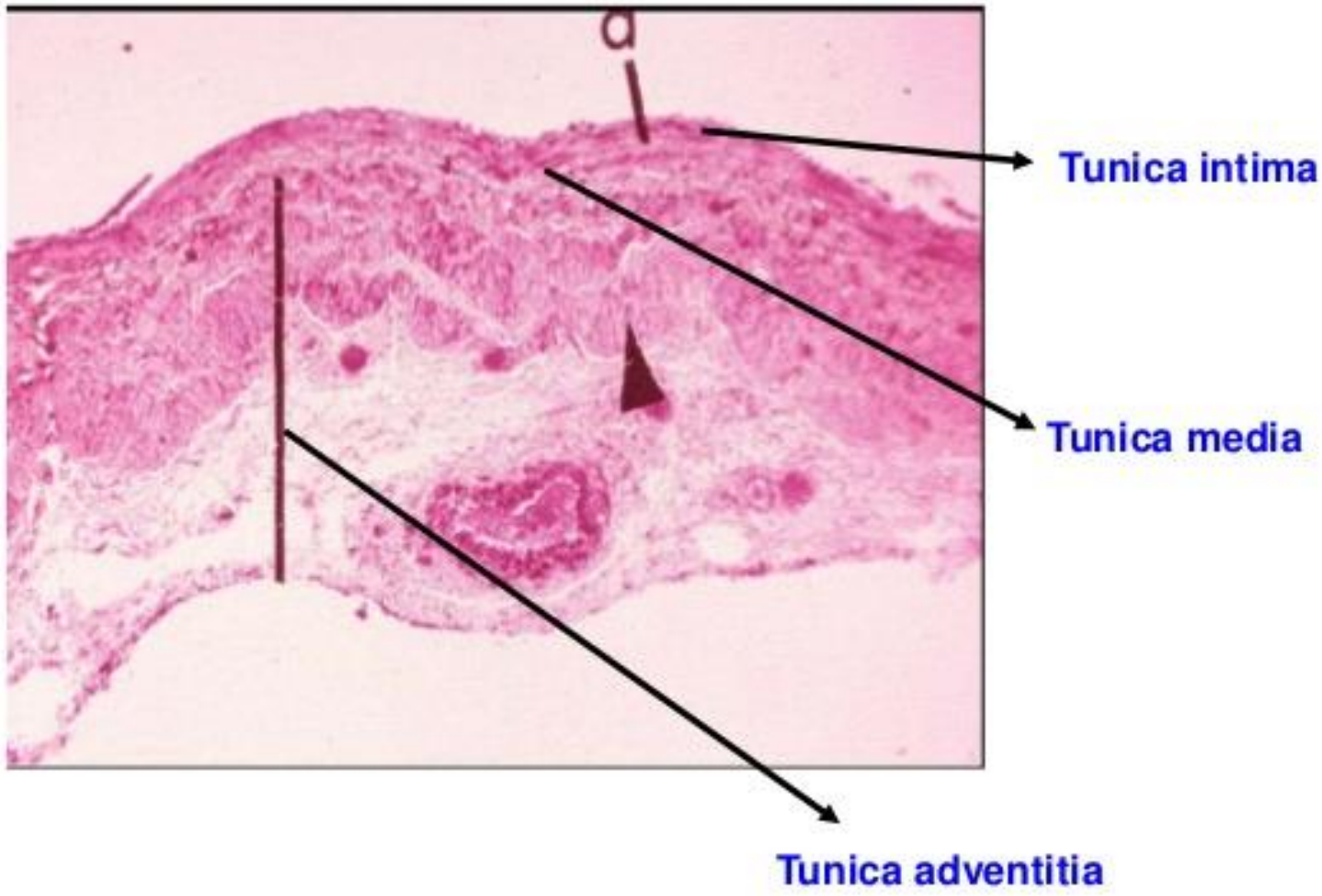
Tunica Adventitia

Longitudinal bundles of smooth muscle

Facilitate shortening & elongation of vena cava with respiration



Large Vein (Inferior Vena Cava)



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Valves of Veins

A venous valve is composed of ***two leaflets****, each composed of a* ***thin fold of the intima*** *(*collagen and elastic
fibers that are continuous with those of the vessel's wall) *jutting out from the wall into the lumen.*

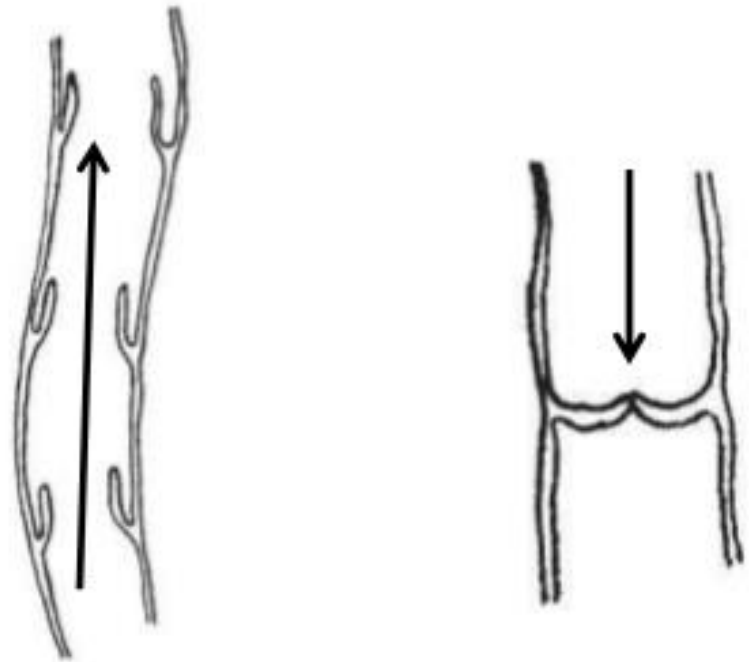
Many **medium** veins have **valves that function to** prevent the backflow of blood. These valves are especially abundant in the veins of the **leg**s, where they act **against the force of gravity**.

.

As blood **flows to the heart**, the valve cusps are d**eflected in the direction** of the blood flow toward the heart.

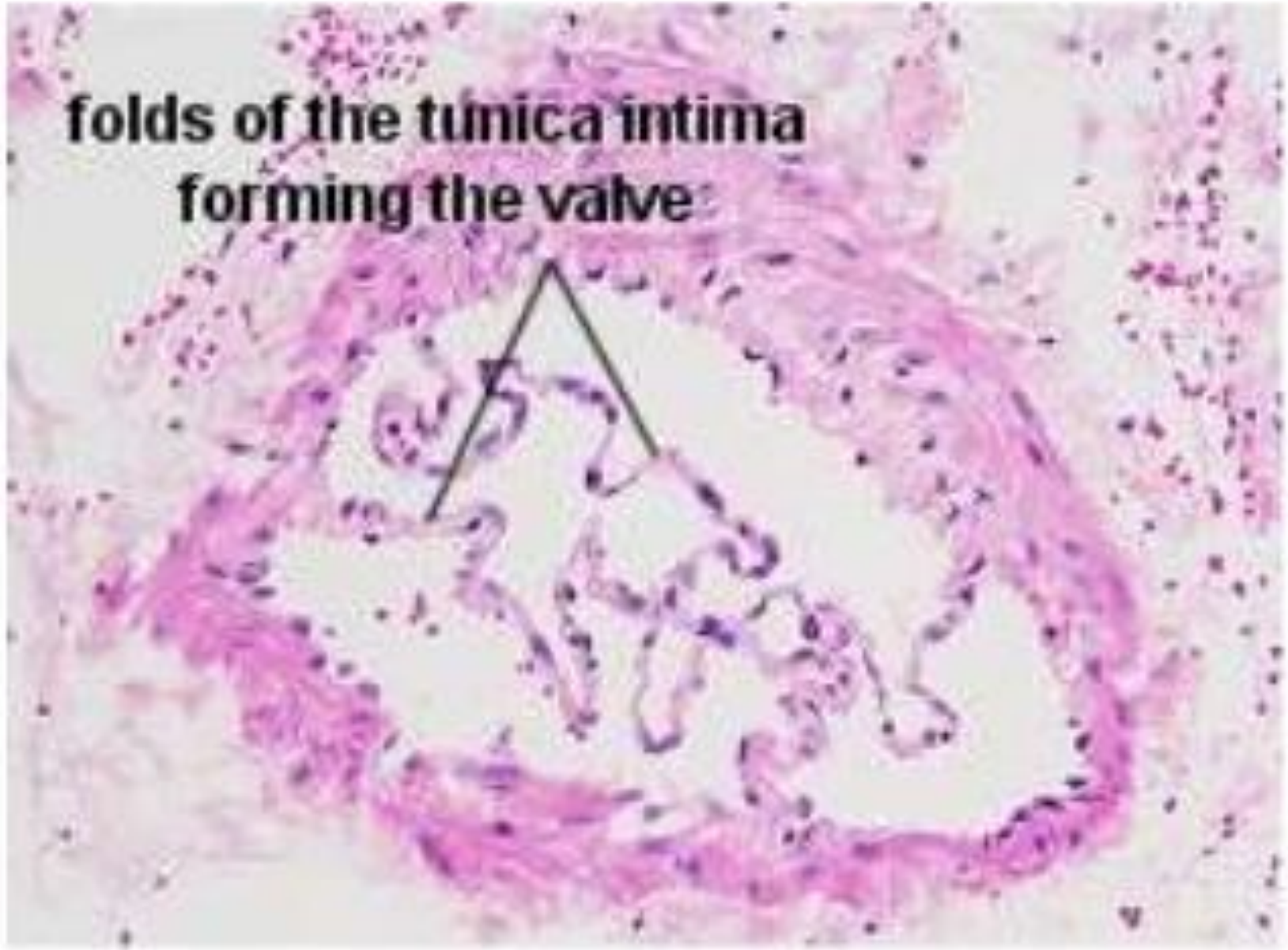
Backward flow of blood forces the cusps to a**pproximate** each other, thus blocking backflow.

Valves of Veins



Valves are absent in

- Very small veins;
- Veins within the cranial cavity & vertebral canal
- Venae cavae; SVC & IVC
- In some other veins

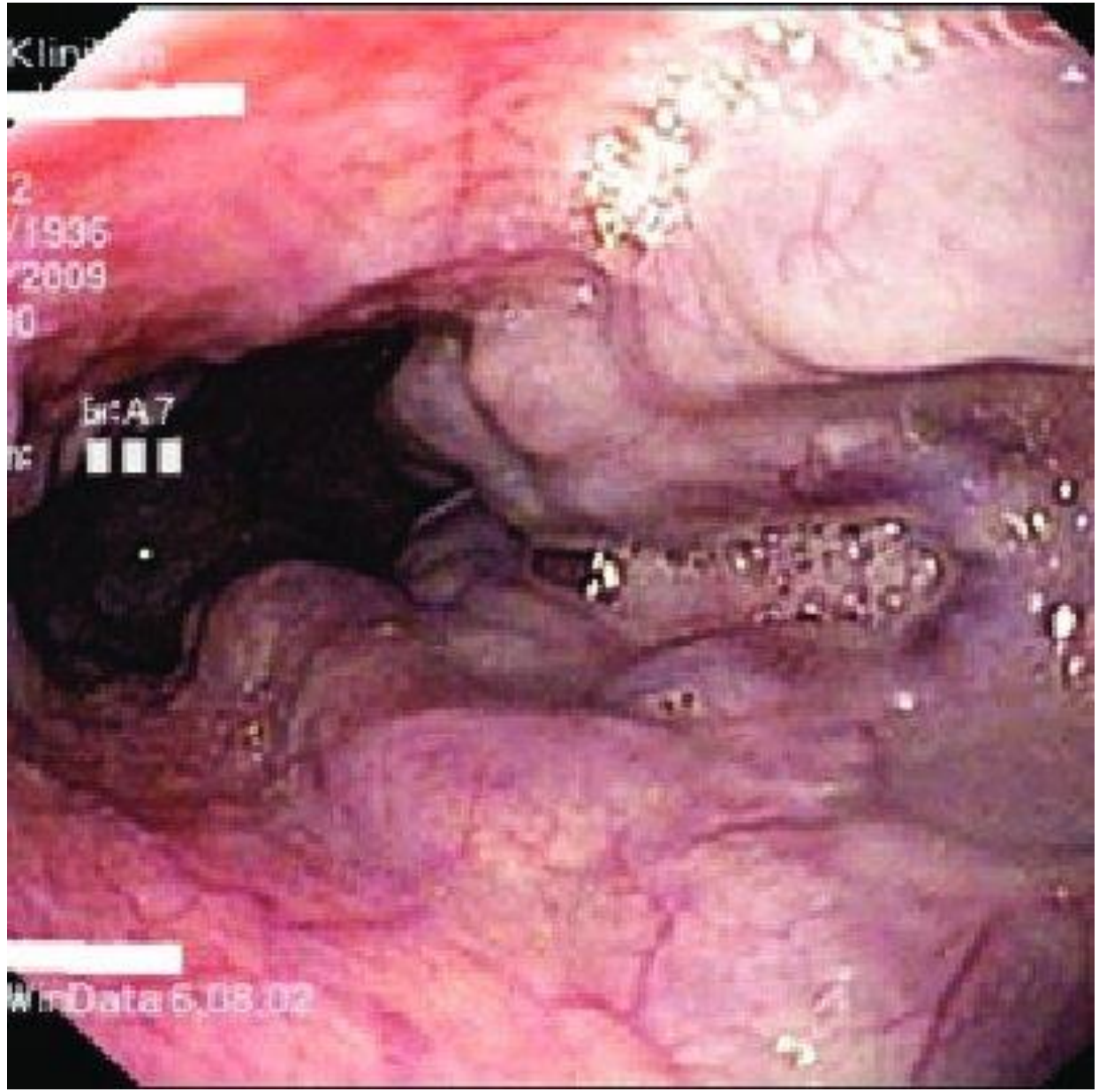

folds of the tunica intima
forming the valve

CLINICAL CORRELATIONS

Varicose veins are abnormally enlarged, tortuous veins usually affecting the superficial veins in the legs of older persons.

This condition results from loss of muscle tone, degeneration of vessel walls, and valvular incompetence.

Varicose veins may also occur in the lower end of the esophagus (**esophageal varices**) or at the terminus Of the anal anal (**hemorrhoids**).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