

THE CIRCULATORY SYSTEM:

The circulatory system includes both the blood and lymphatic vascular systems.

I-The blood vascular system is composed of the following structures:

*i)*The **heart**, an organ whose function is to pump the blood.

*ii)*The **arteries**, a series of efferent vessels that become smaller as they branch, and whose function is to carry the blood, with its nutrients and oxygen, to the tissues.

*iii)*The **capillaries**, the smallest blood vessels, constituting a complex network of thin tubules that branch profusely in almost every organ and through whose walls the interchange between blood and tissues takes place.

*iv)*The **veins**, which result from the convergence of capillaries into a system of larger channels that continue enlarging as they approach the heart, toward which they convey the blood to be pumped again.

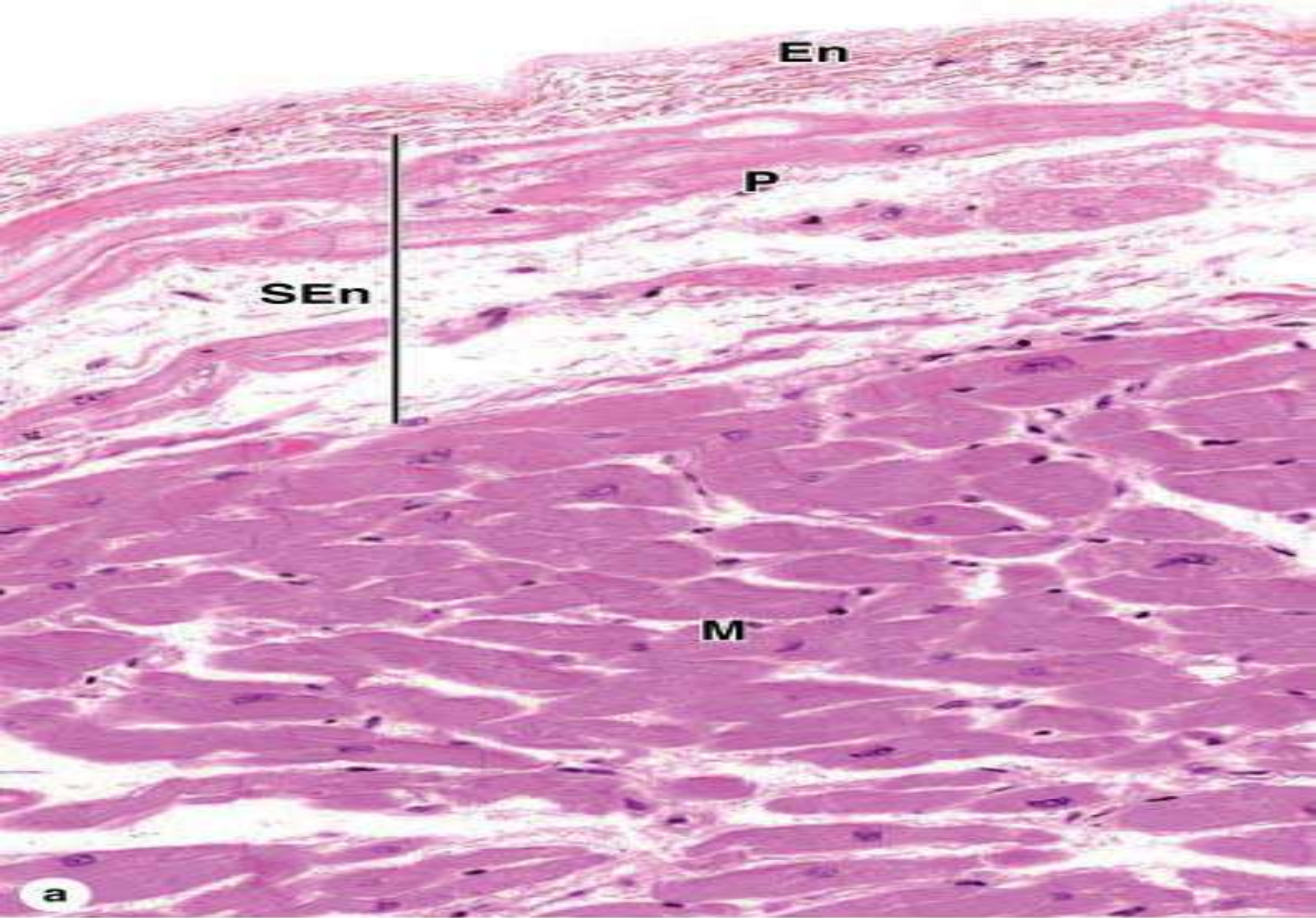
HEART:

- 1-The heart is a muscular organ that contracts rhythmically, pumping the blood through the circulatory system. The right and left **ventricles** pump blood to the lungs and the rest of the body respectively; right and left **atria** receive blood from the body and the pulmonary veins respectively.
- 2-The walls of all four heart chambers consist of three major layers or tunics: the internal endocardium; the middle myocardium; and the external epicardium.

1)The endocardium :

*a)*consists of a single layer of squamous endothelial cells on a thin layer of loose connective tissue containing elastic and collagen fibers as well as some smooth muscle cells.

*b)*Connecting this subendothelial layer to the myocardium is additional connective tissue (often called the **subendocardial layer**) containing veins, nerves, and branches of the impulse-conducting system of the heart.



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition*: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

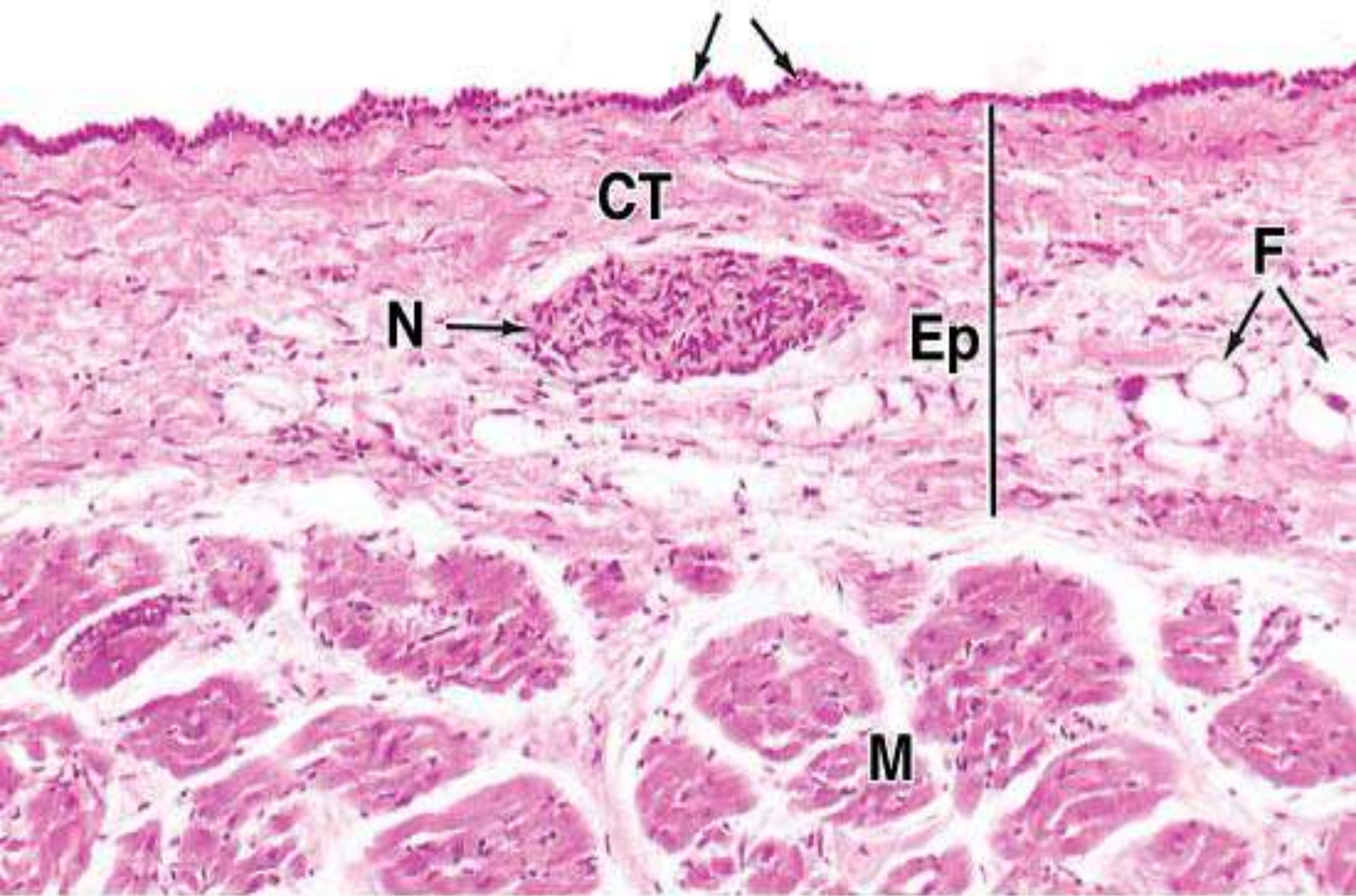
II)The myocardium :

*a)*It is the thickest of the tunics and consists of cardiac muscle cells arranged in layers that surround the heart chambers in a complex spiral.

*b)*The myocardium is much thicker in the ventricles than in the atria. The arrangement of these muscle cells is extremely varied, so that in sections cells are seen to be oriented in many directions.

III)the pericardium:

*a)*The heart is covered externally by simple squamous epithelium (mesothelium) supported by a thin layer of connective tissue that constitutes the **epicardium**.

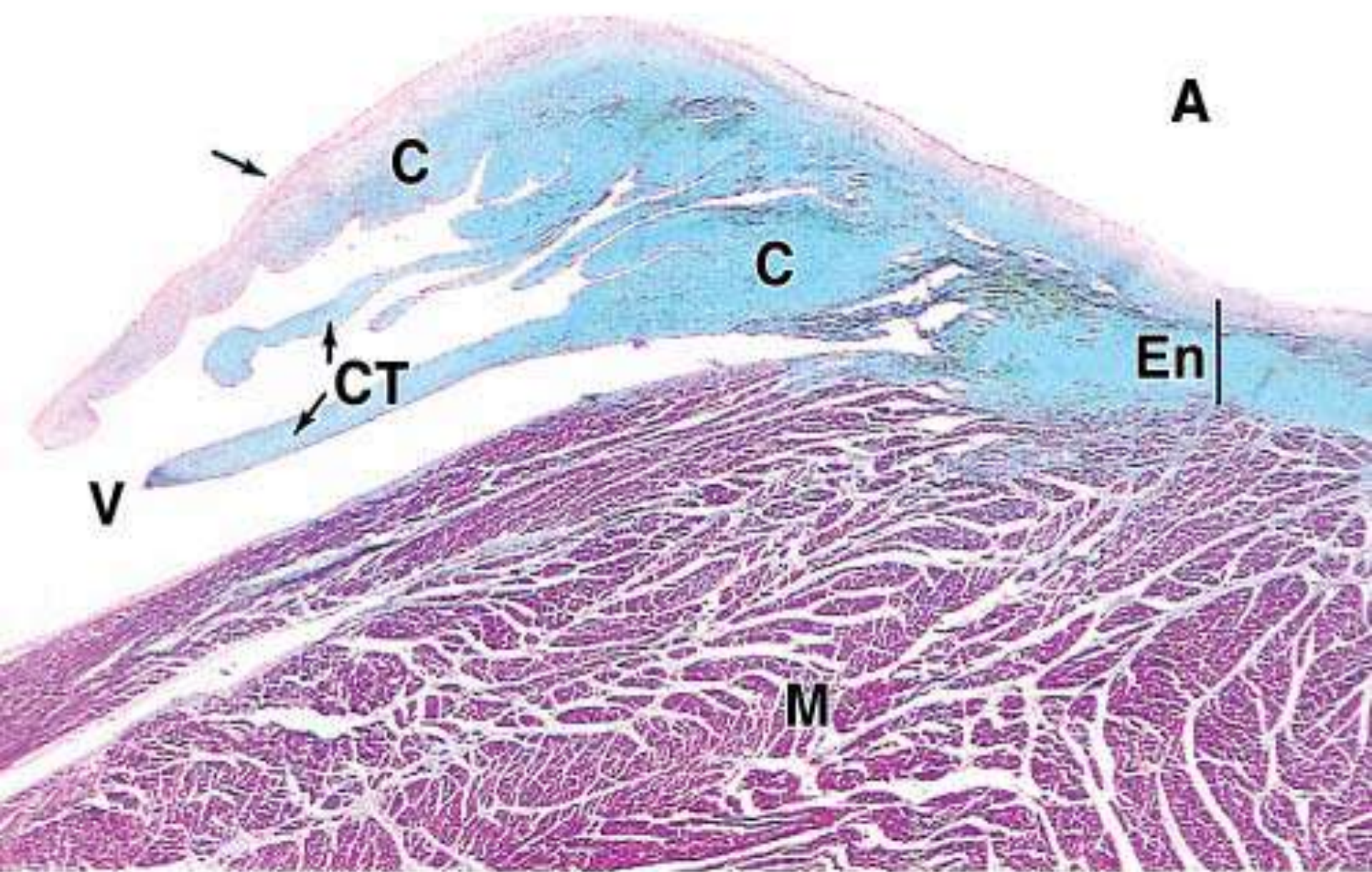


Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition*: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

b) A subepicardial layer of loose connective tissue contains veins, nerves, and many adipocytes. The epicardium corresponds to the visceral layer of the **pericardium**, the serous membrane in which the heart lies.

c) In the space between the pericardium's visceral layer (epicardium) and its parietal layer is a small amount of lubricant fluid that facilitates the heart's movements.



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

STRUCTURAL PLAN OF BLOOD VESSELS:

Blood vessels are usually composed of the following layers, or tunics .

I-The tunica intima :

a)Its has one layer of endothelial cells supported by a thin subendothelial layer of loose connective tissue with occasional smooth muscle cells.

b) In arteries, the intima is separated from the media by an **internal elastic lamina**, the most external component of the intima. This lamina, composed of elastin, has holes (fenestrae) that allow the diffusion of substances to nourish cells deep in the vessel wall.

c)As a result of the loss of blood pressure and contraction of the vessel at death, the **tunica intima** of arteries may have a slightly **folded** appearance in tissue sections.

II-The tunica media:

- a)** the middle layer, consists chiefly of concentric layers of helically arranged smooth muscle cells.
- b)** Interposed among the smooth muscle cells are variable amounts of elastic fibers and lamellae, reticular fibers of collagen type III, proteoglycans, and glycoproteins, all of which is produced by these cells.
- c)** In arteries, the media has a thinner **external elastic lamina**, which separates it from the tunica adventitia.

III)The tunica adventitia or tunica externa consists principally of type I collagen and elastic fibers . This adventitial layer is gradually continuous with the stromal connective tissue of the organ through which the blood vessel runs.

Vase Vasorum:

1-large vessels usually have vasa vasorum and branched profusely in the adventitia and the outer part of media . The vasa vasorum provide metabolites to the adventitia and the media.

2-In large vessels since the layer are too thick to be nourished solely by diffusion from the blood in the lumen . These vessels more frequent in veins than in arteries.

3-Vasa vasorum arises from the branches of the artery they supply or from adjacent arteries .

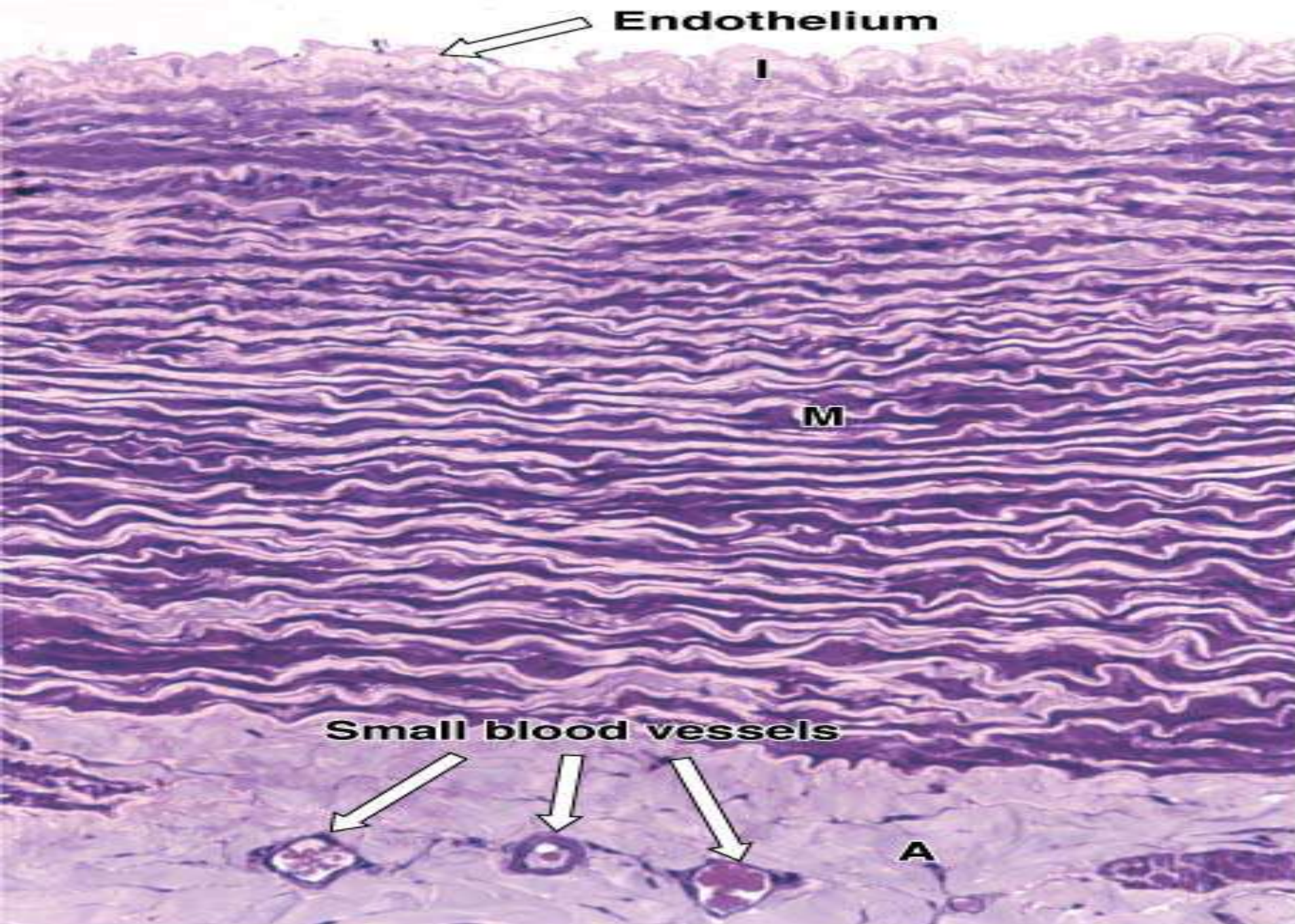
I-Large Elastic Arteries:

1-Large elastic arteries help to stabilize the blood flow. The elastic arteries include the aorta and its large branches. Freshly dissected, they have a yellowish color from the elastin in the media.

2-The intima is thicker than the corresponding tunic of a muscular artery. An internal elastic lamina, although present, may not be easily discerned, since it is similar to the elastic laminae of the next layer .

3-The media consists of elastic fibers and a series of concentrically arranged, perforated elastic laminae whose number increases with age (there are about 40 in the newborn, 70 in the adult). Between the elastic laminae are smooth muscle cells, reticular fibers, proteoglycans, and glycoproteins.

4-The tunica adventitia is relatively underdeveloped.



II-Muscular Arteries:

1-The muscular arteries can control blood flow to organs by contracting or relaxing the smooth muscle cells of the tunica media. The intima has a very thin subendothelial layer and the internal elastic lamina, the most external component of the intima, is prominent .

2- The tunica media may contain up to 40 layers of more prominent smooth muscle cells which are intermingled with a variable number of elastic lamellae (depending on the size of the vessel) as well as reticular fibers and proteoglycans.

3- An external elastic lamina, the last component of the media, is present only in the larger muscular arteries.

4-The adventitia consists of connective tissue. Lymphatic capillaries, vasa vasorum, and nerves are also found in the adventitia and these structures may penetrate to the outer part of the media.

Endothelium



M

Small blood vessels

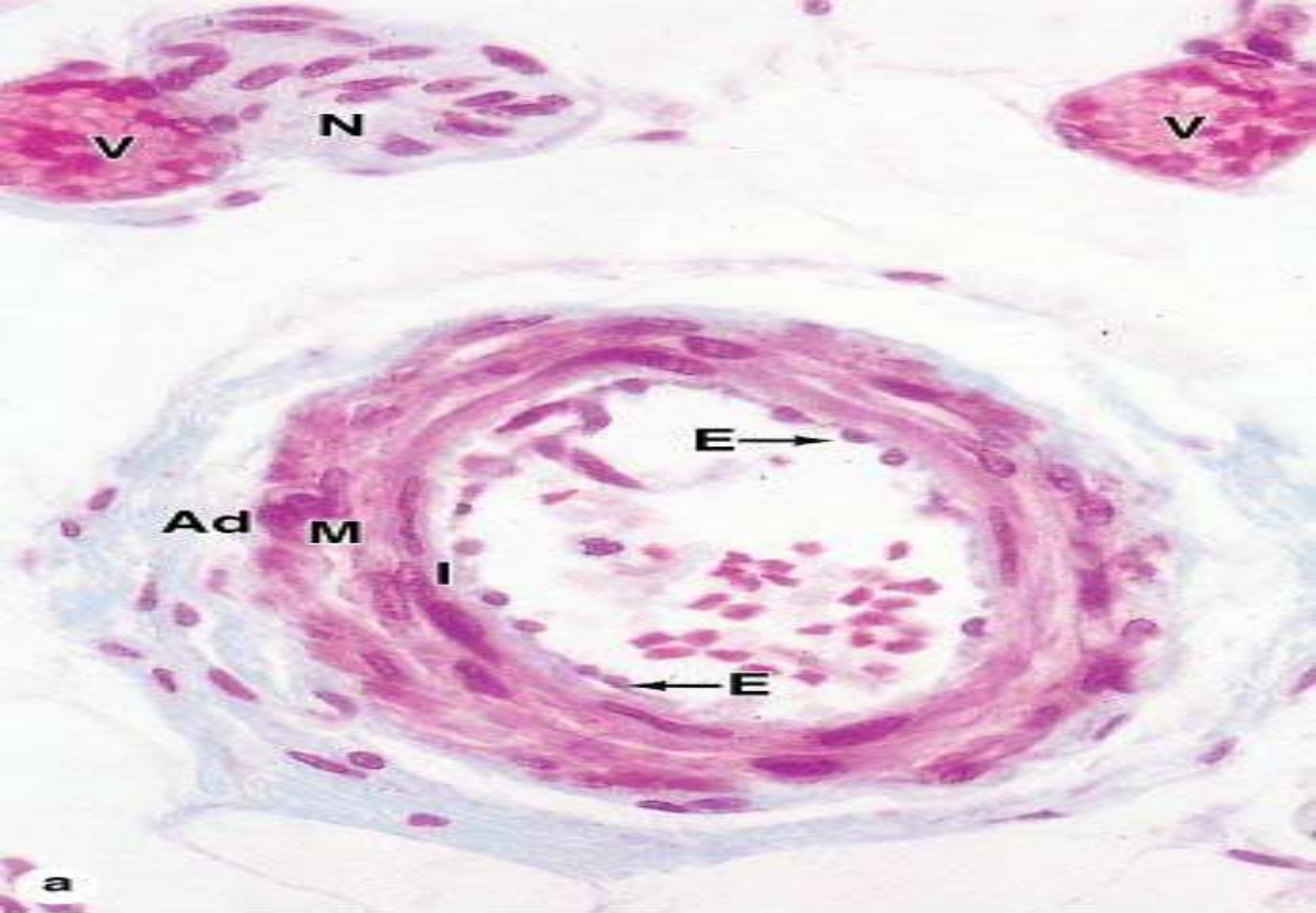


III-Arterioles:

1-Muscular arteries branch repeatedly into smaller and smaller arteries, until reaching a size with only two or three medial layers of muscle.

2-The smallest arteries branch as **arterioles**, which have one or two smooth muscle layers and indicate the beginning of an organ's **microvasculature** exchanges between blood and tissue fluid occur.

3-Arterioles are generally less than 0.5 mm in diameter, with lumens approximately as wide as the wall is thick.



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

Capillaries :

1-They composed of a single layer of endothelial cells of mesenchymal origin . The average diameter of capillaries is small . When cut transversely their walls are observed to consist of portion of one to three cells , the external surfaces of these cells usually rest on a basal lamina, a product of endothelial origin .

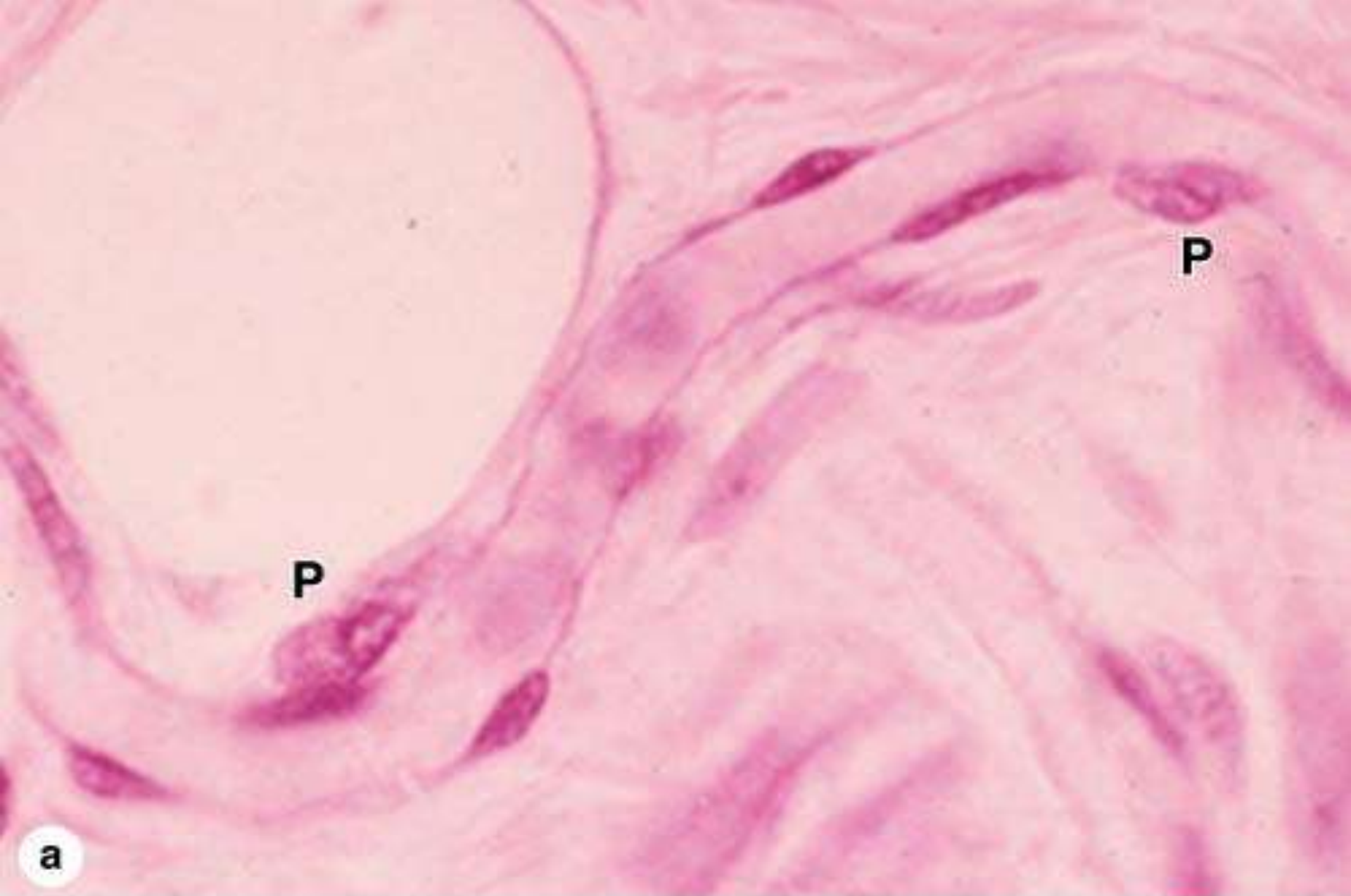
2-In general, endothelial cell are polygonal and elongated in the direction of blood flow , nucleus causes the cell to bulge into the capillary lumen .

3-Junction between endothelial cell of venules are the loosest . At these locations there is a characteristic loss of fluid from circulatory system occur during the inflammatory response leading to edema.

4-At various location along capillaries and post capillary venule are cells of mesenchymal origin with long cytoplasmic processes that partly surround the endothelial cells .

5-These cells are called pericytes , which are present at various location along the capillaries and post capillary (small venules) and these cells are presence of : myosin , actin , and tropomysin in pericytes strongly suggest that these cells have a contractile function.

6- After tissue injuries , pericytes proliferate and differentiate to form new blood vessels and connective tissue cell, thus participating in the repair process .



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

Types of capillaries :

Capillaries have structural variations to permit different levels of metabolic exchange between blood and surrounding tissues (depending on the structure of endothelial cell and present or absent of basal lamina), capillaries can be grouped into three major categories :

- 1-Continuous or somatic capillaries.
- 2- Fenestrated or visceral capillaries.
- 3-Discontinuous sinusoidal capillaries.

Function of capillaries :

I-Selective permeability barrier capillaries and post capillaries venules exchange vessels . at these sites the O_2 and CO_2 substrates and metabolites are transferred from blood to the tissues and the tissues to the blood. The permeability of capillaries wall vary in size and charge of permeating molecules and with structure of endothelial cells .

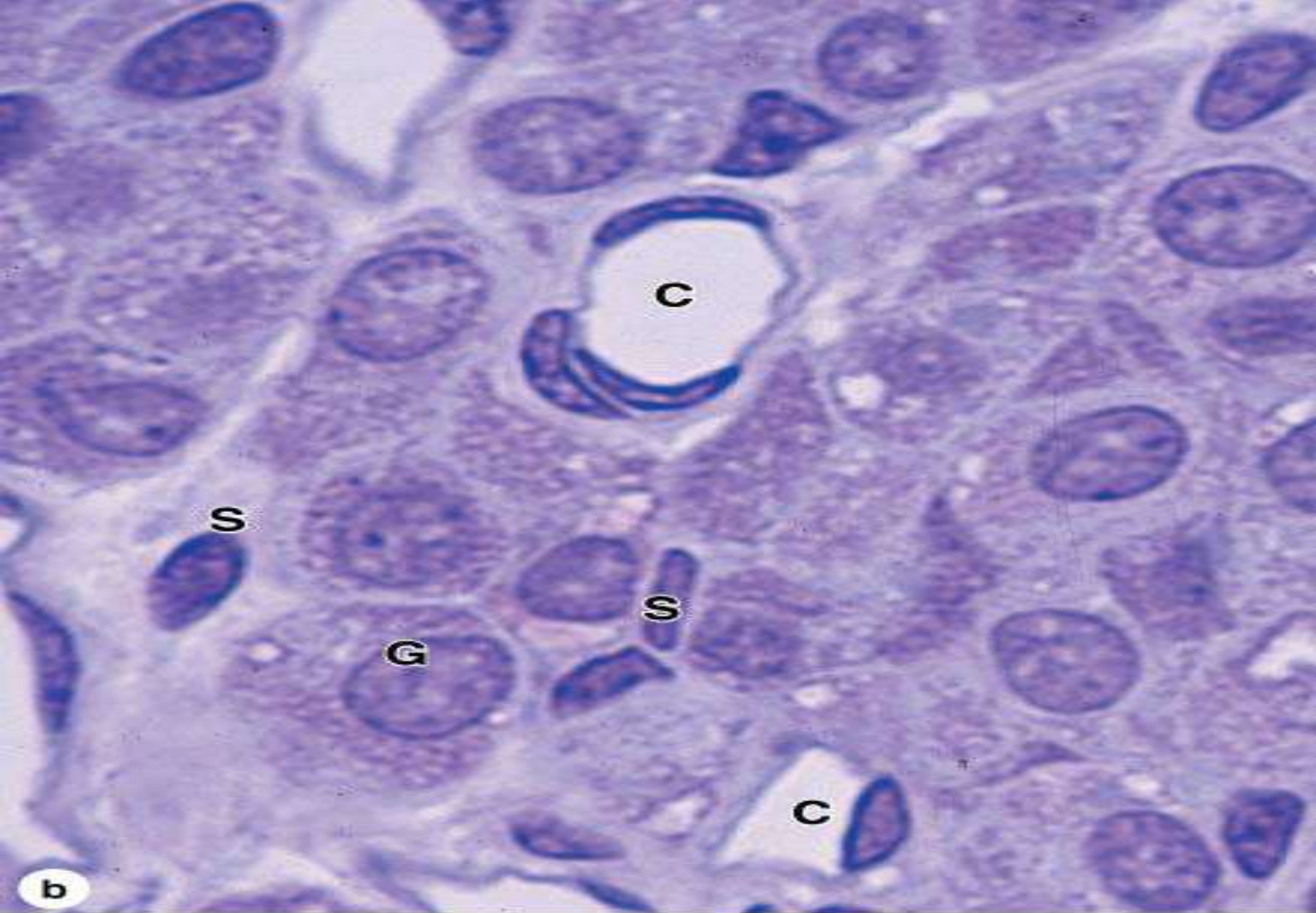
II-Metabolic function :

- 1- **Activation** : like conversion of angiotensin I (inactive) to angiotensin II (active) .
- 2- **Inactivation** conversion of Bradykinin , serotonin , prostaglandins , nor epinephrine , thrombin to biologically inert compounds .
- 3-**Lipolysis** : break down of lipoprotein by enzyme to triglyceride and cholesterol these are substance for steroid hormone synthesis in membrane structure .
- 4-Production of vasoconstriction factors.
- 5-Non thrombogenic action .

The Carotid bodies :

1- These are more structure encountered near the bifurcation of the common carotid artery, are chemoreceptor's sensitive to low oxygen tension , high carbon dioxide concentration in the blood .

2- carotid bodies have :-Type 1 cells and type 2cells. Type 2 cells are supporting cells, whereas type 1 cells contain dopamine,serotonin and adrenaline .

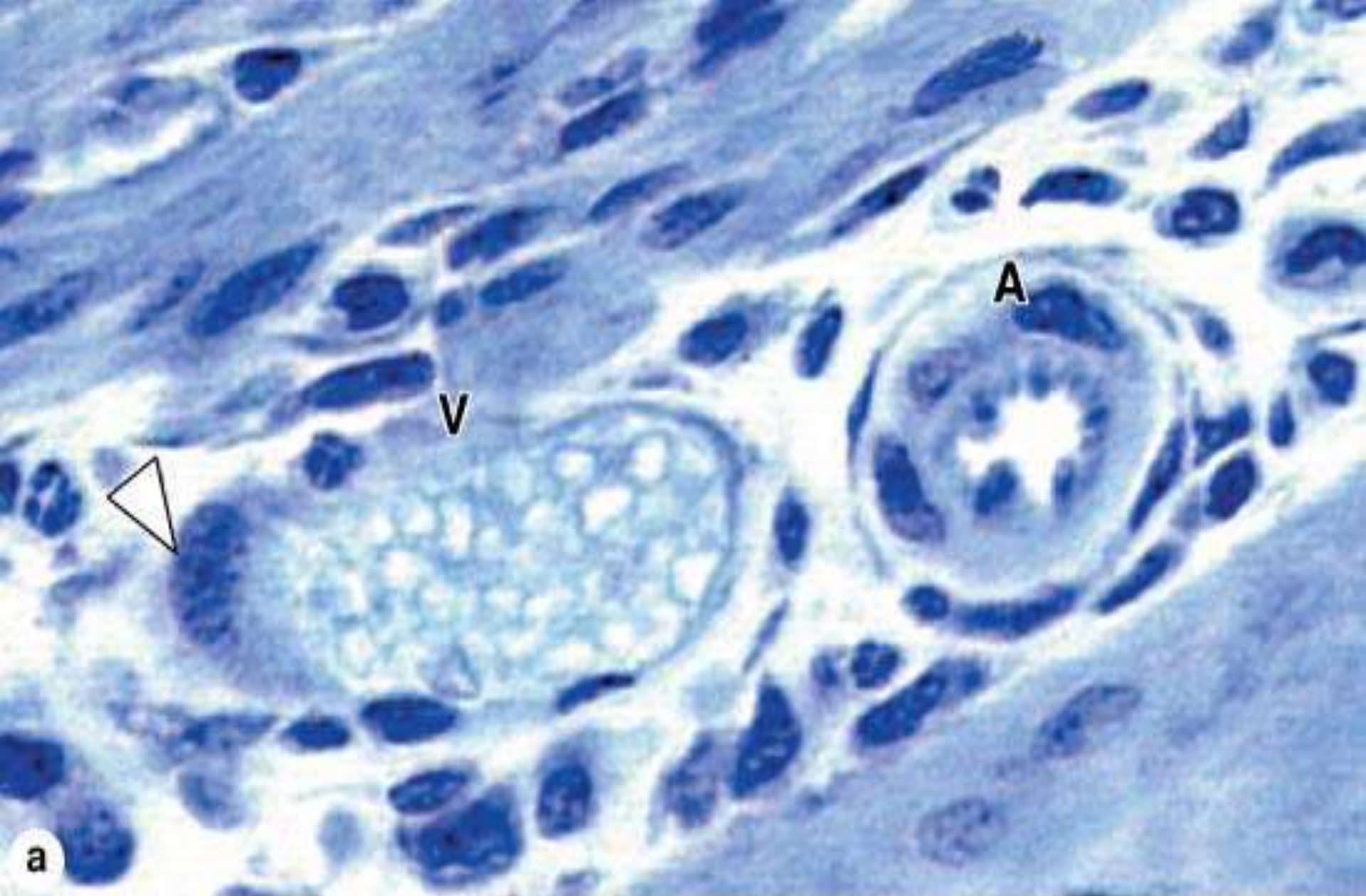


Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

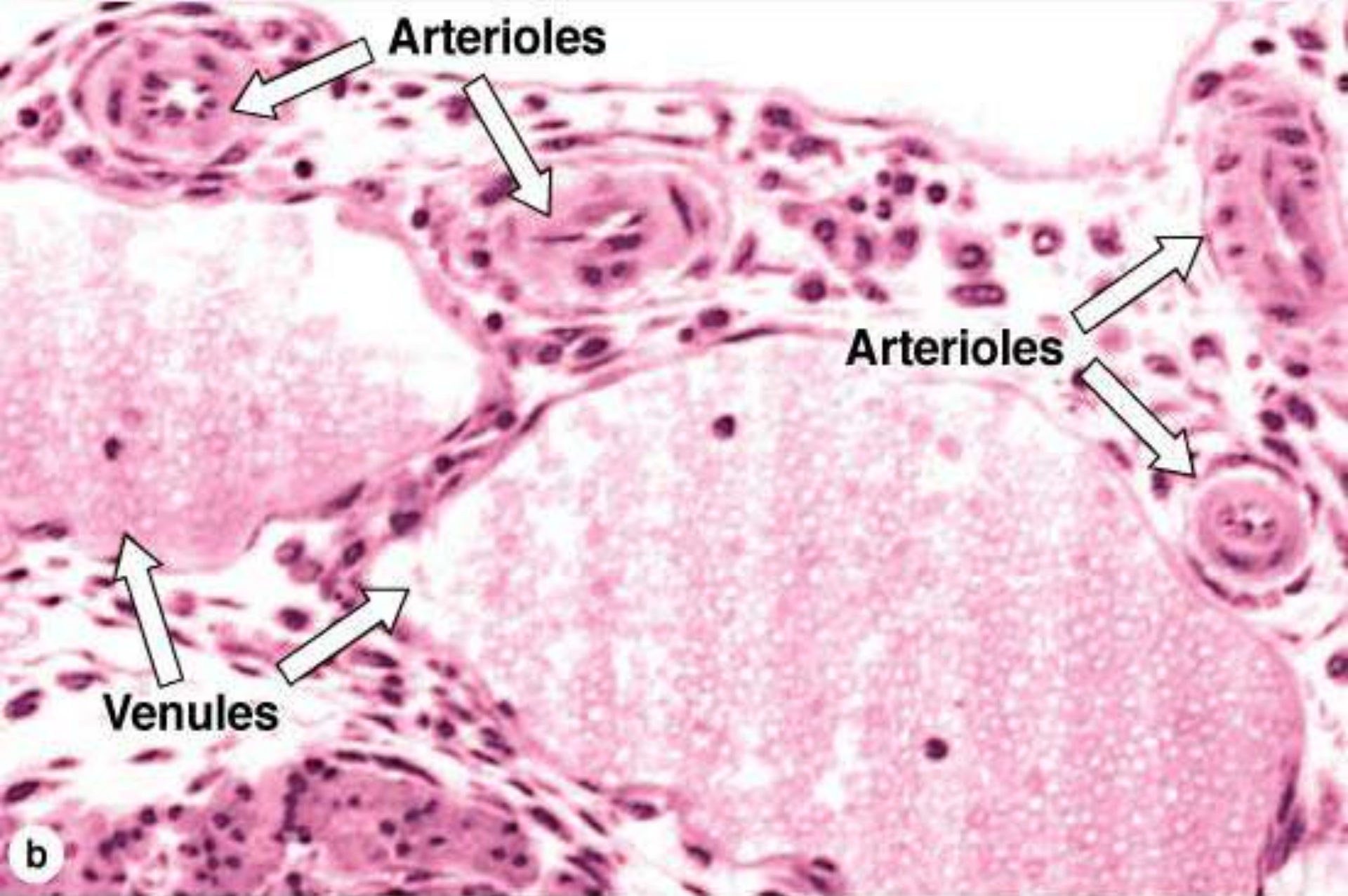
Venules:

- 1-The transition from capillaries to venules occurs gradually. The immediate **postcapillary venules** are similar structurally to capillaries, with pericytes.
- 2-Postcapillary venules participate in the exchanges between the blood and the tissues and are the primary site at which white blood cells leave the circulation at sites of infection or tissue damage.
- 3-These venules converge into larger **collecting venules** which have more contractile cells. With greater size the venules become surrounded by recognizable tunica media with two or three smooth muscle layers and are called **muscular venules**.
- 4-A characteristic feature of all venules is the large diameter of the lumen compared to the overall thinness of the wall.



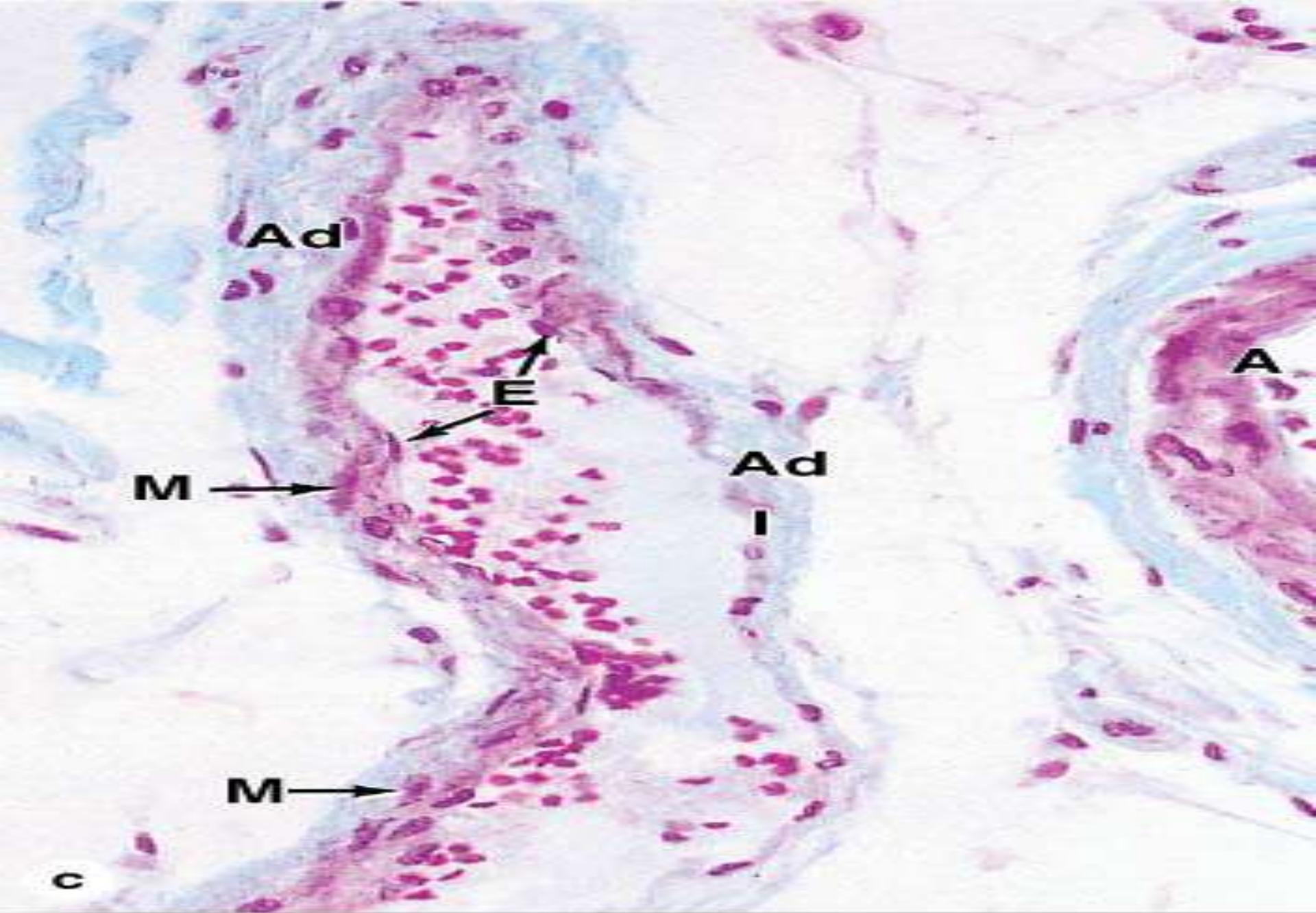
Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

Veins:

- 1-Blood entering veins is under very low pressure and moves toward the heart by contraction of the tunica media and external compressions from surrounding muscles and other organs.
- 2- Valves project from the tunica intima to prevent back-flow of blood. Most veins are **small or medium veins** , with diameters less than one centimeter.
- 3- Such veins are usually located in parallel with corresponding muscular arteries.
- 4-The intima usually has a thin subendothelial layer and the media consists of small bundles of smooth muscle cells intermixed with reticular fibers and a delicate network of elastic fibers. The collagenous adventitial layer is well-developed.

5-The big venous trunks, paired with elastic arteries close to the heart, are **large veins** . Large veins have a well-developed tunica intima, but the tunica media is relatively thin, with few layers of smooth muscle and abundant connective tissue.

6-The adventitial layer is thick in large veins and frequently contains longitudinal bundles of smooth muscle. Both the media and adventitia contain elastic fibers, but elastic laminae like those of arteries are not present.

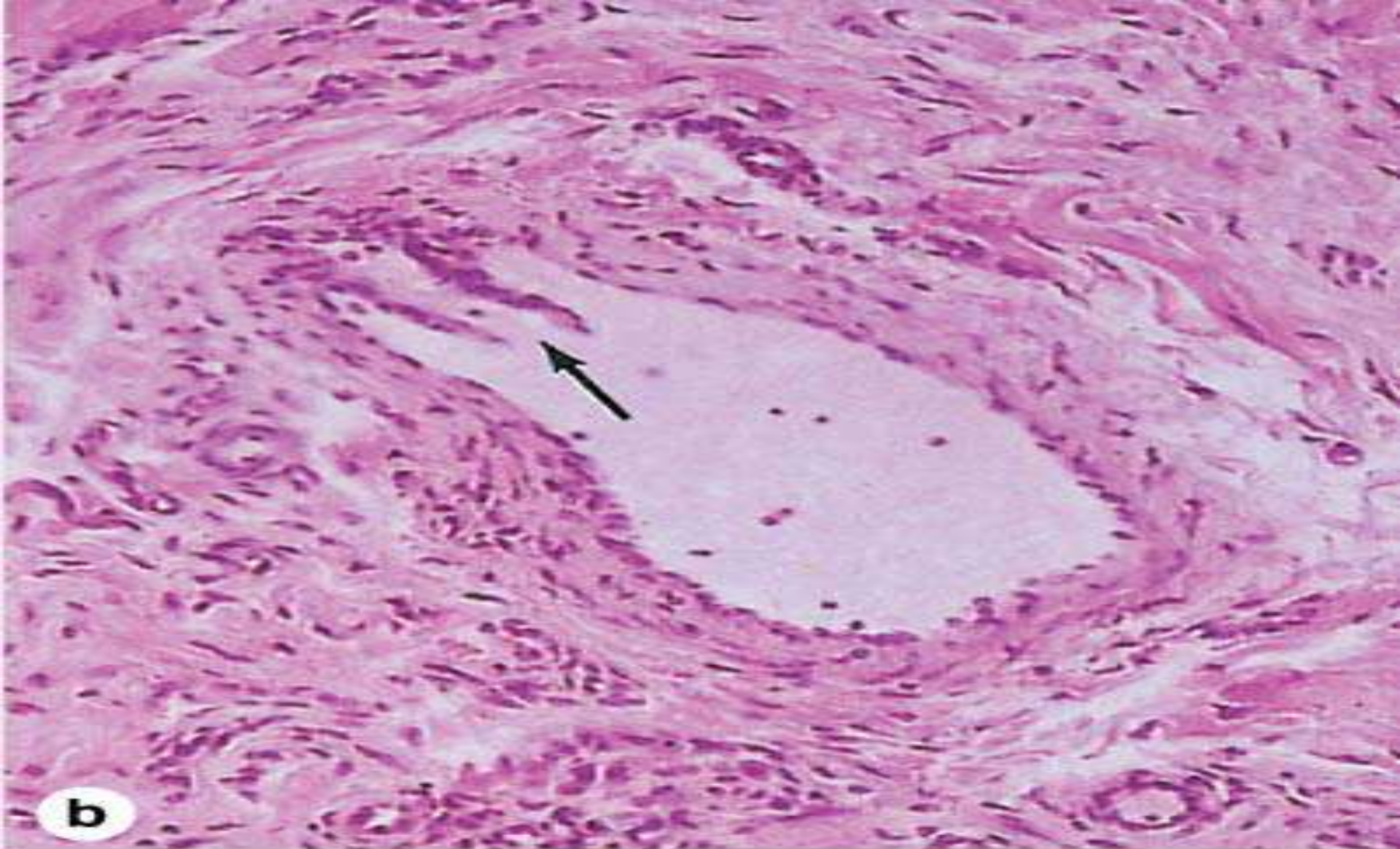
7-Most veins have valves, but these are most prominent in large veins. Valves consist of paired semilunar folds of the tunica intima projecting across part of the lumen . They are rich in elastic fibers and are lined on both sides by endothelium. The valves, which are especially numerous in veins of the legs, help keep the flow of venous blood directed toward the heart.



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

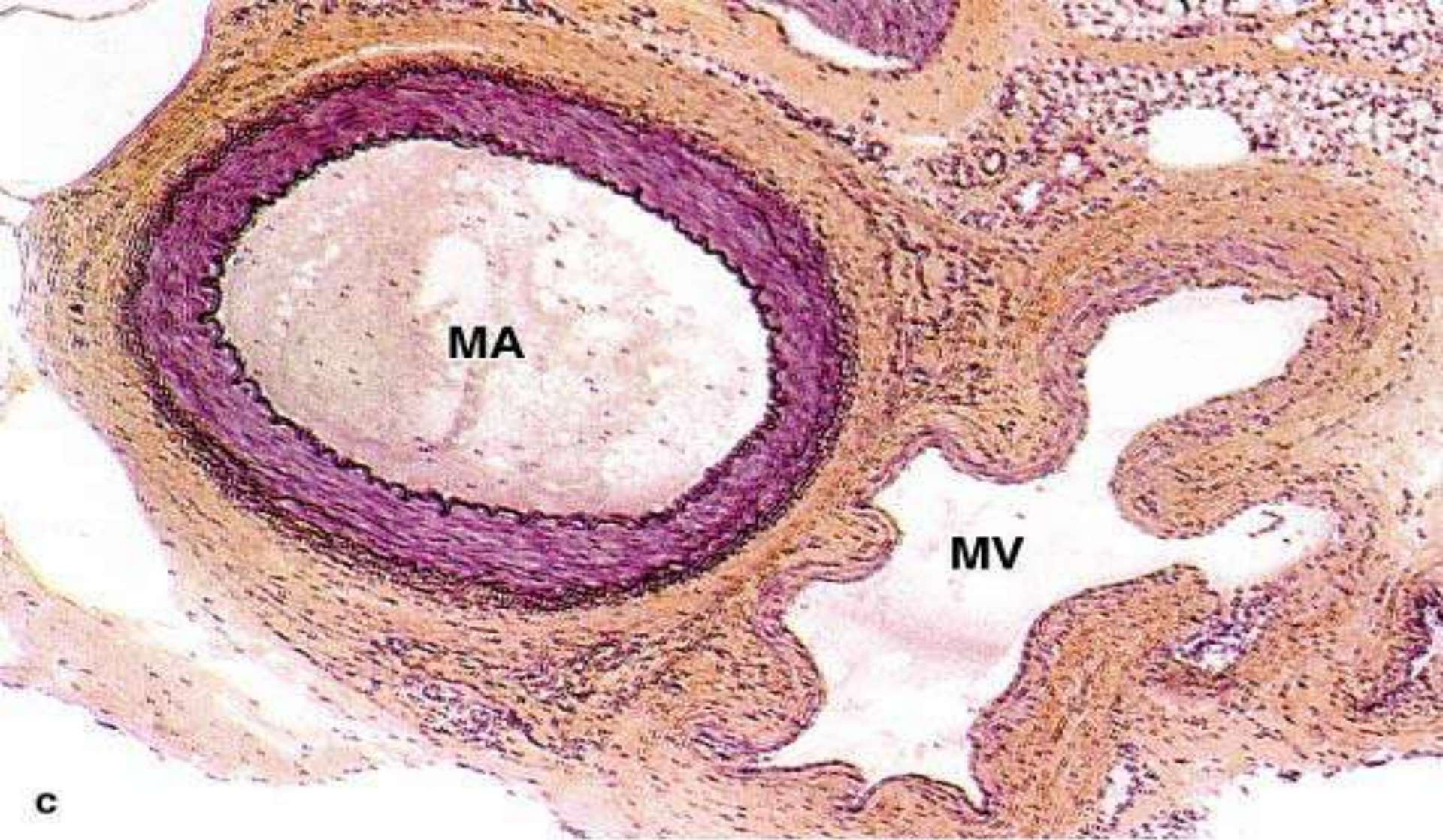
Small vein (V) shows a relatively large lumen compared to the small muscular artery (A) with its thick media (M) and adventitia (Ad). The wall of a small vein is very thin, containing only two or three layers of smooth muscle.



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition*: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

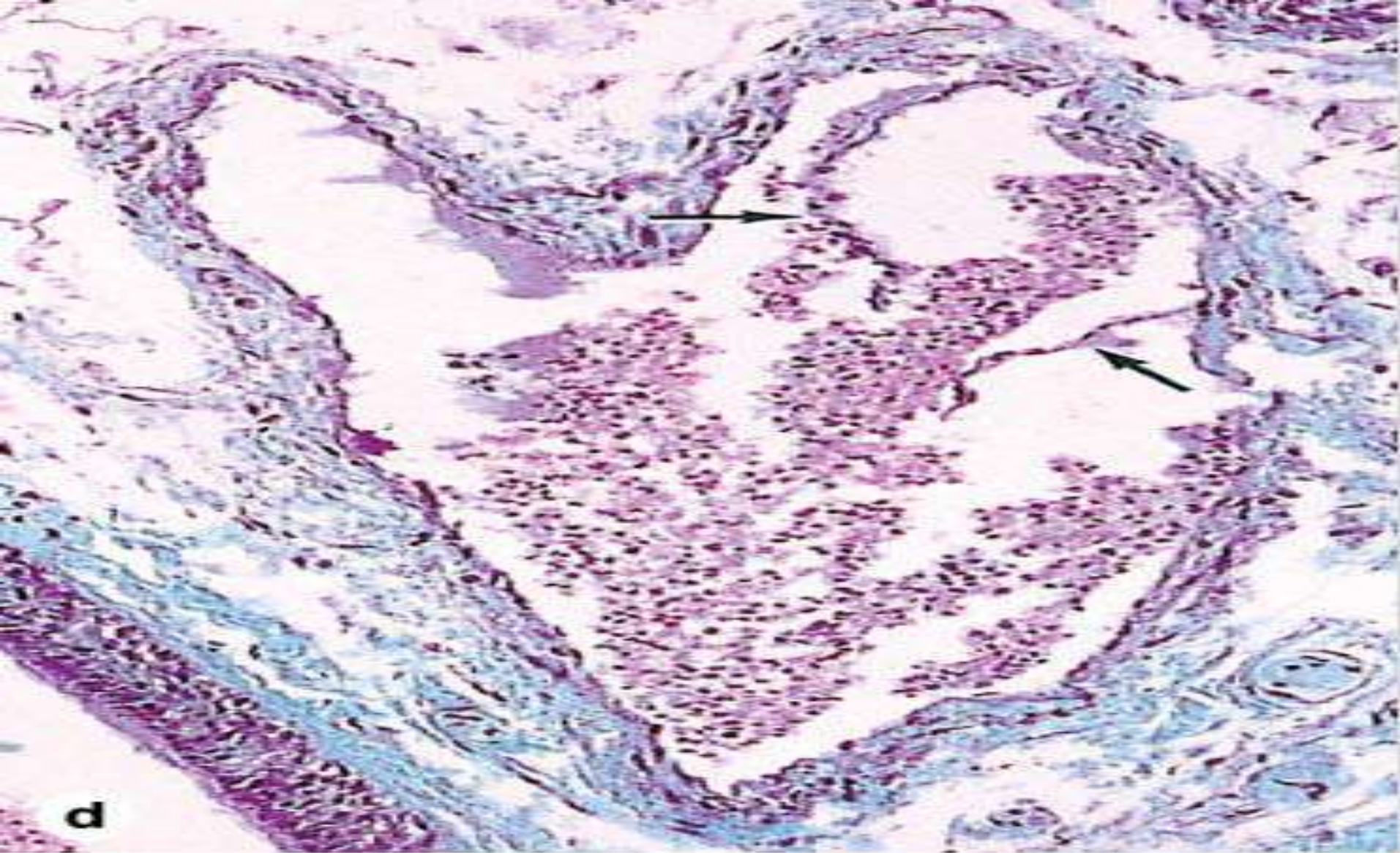
A convergence between two small veins showing valves (arrow). Valves are thin folds of tunica intima projecting well into the lumen which act to prevent backflow of blood.



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

A medium vein (MV) showing a thicker wall, but still less prominent than that of the accompanying muscular artery (MA). Both the media and adventitia are better developed, but the wall is often folded around the relatively large lumen.



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>
Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

A medium vein containing blood and showing valve folds (arrows). Masson trichrome.

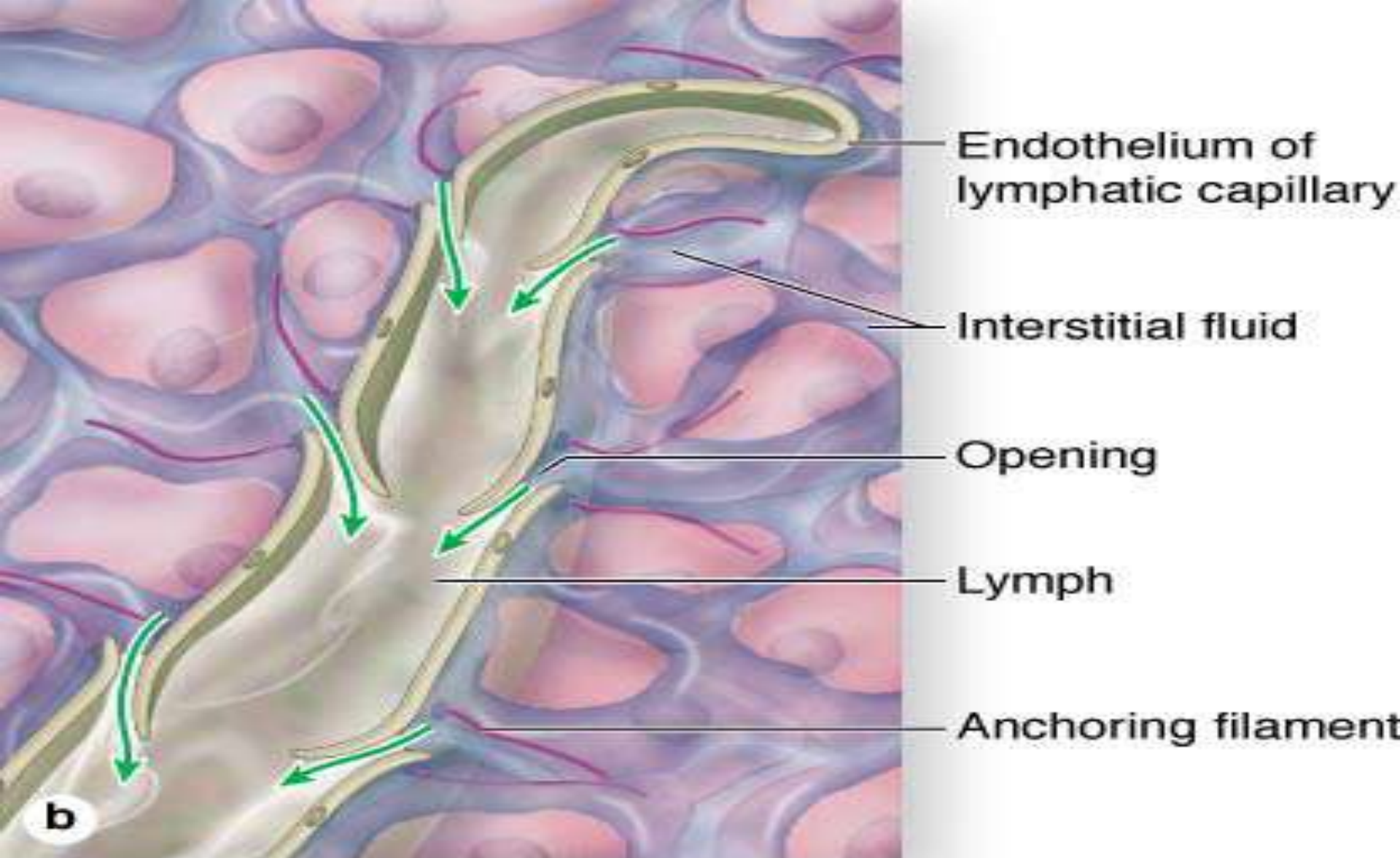
II-LYMPHATIC VASCULAR SYSTEM:

- 1-The body has a system of thin-walled endothelial channels that collect excess interstitial fluid from the tissue spaces and return it to the blood.
- 2-This fluid is called lymph; unlike the blood, it flows in only one direction, toward the heart.
- 3-The **lymphatic capillaries** originate in the various tissues as thin, closed-ended vessels that consist of a single layer of endothelium and an incomplete basal lamina. Lymphatic capillaries are held open by bundles of anchoring filaments of the elastic fiber system which also bind the vessels firmly to the surrounding connective tissue.

4-The thin lymphatic capillaries converge into larger lymphatic vessels. Interposed in the path of these lymphatics are lymph nodes.

5-The larger lymphatics have a structure similar to that of veins except that they have thinner walls and lack a clear-cut separation between tunics. They also have more numerous internal valves . The lymphatic vessels are often dilated and assume a nodular, or beaded, appearance between the valves.

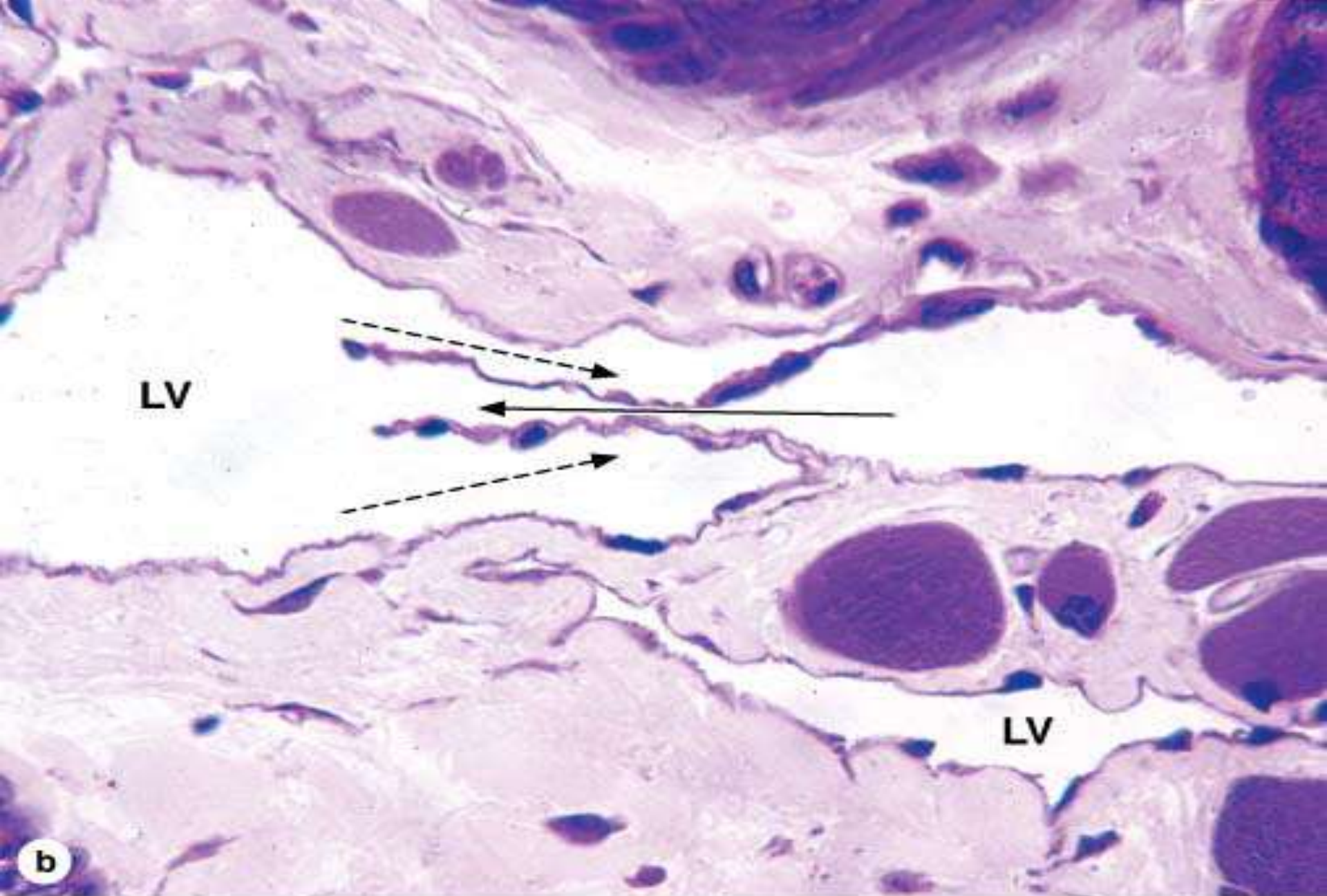
6-As in veins, lymphatic circulation is aided by external forces (eg, contraction of surrounding skeletal muscle) and unidirectional lymph flow is mainly a result of the many valves. Contraction of smooth muscle in the walls of larger lymphatic vessels also helps to propel lymph toward the heart.



Lymphatic capillary

Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition*: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.



b

Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas*, 12th Edition: <http://www.accessmedicine.com>

Copyright © The McGraw-Hill Companies, Inc. All rights reserved.