

CARDIOVASCULAR SYSTEM

SUBJECT : Anatomy

LEC NO. : 4

DONE BY : H.S

وَقُلْ رَبِّ زِدْنِي عِلْمًا



SCAN ME!

Histology of the Cardiovascular System

(The Heart and Blood Vessels)

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→ Histology of the
Heart & blood vessels

Histology of the Heart

• The wall of the heart is formed of 3 layers, from the inside-out:

1. Endocardium
2. Myocardium → (cardiac muscle fiber) → Thick layer.
3. Epicardium (visceral pericardium)

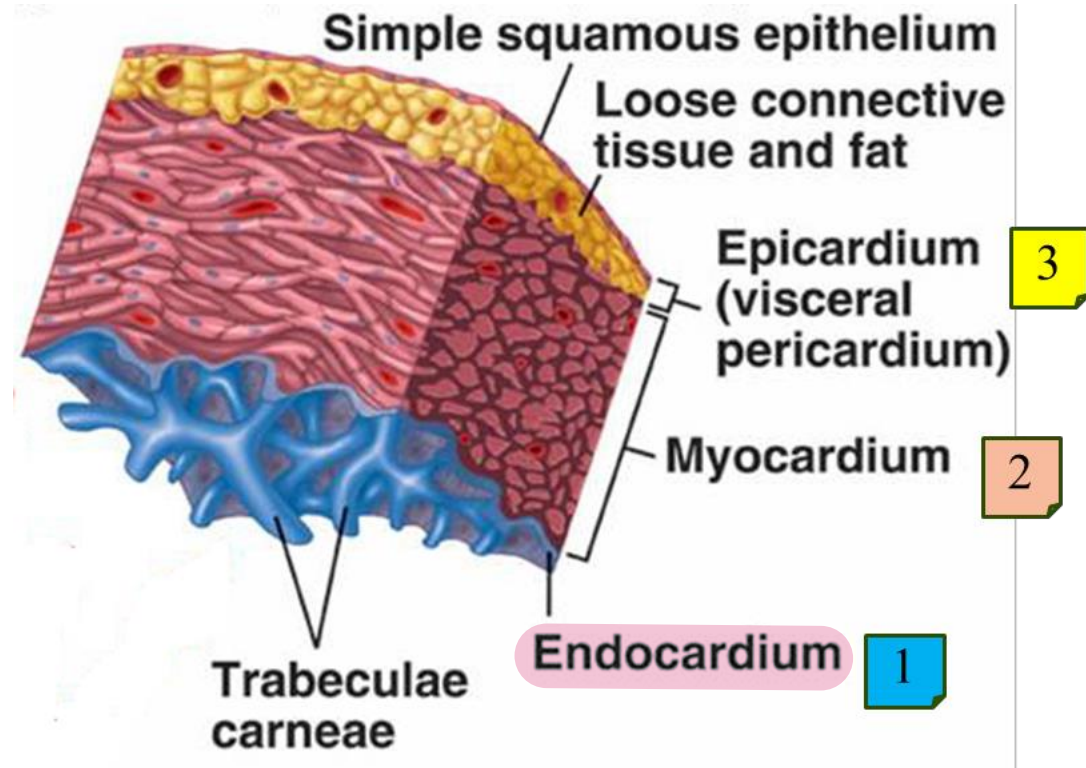


Fig.1: The layers of the heart wall.

The Endocardium:

- Formed of: The epithelium that lies the heart & blood vessels is simple squamous epithelium also known as endothelium.

① ○ Endothelium: simple squamous epithelium in contact with the blood.

② ○ Subendothelium: connective tissue with fibers and fibroblasts.

③ ○ Subendocardium: loose areolar connective tissue continuous with the connective tissue of the myocardium. Contains

* Purkinje fibers and blood vessels. → characteristic for endocardium.

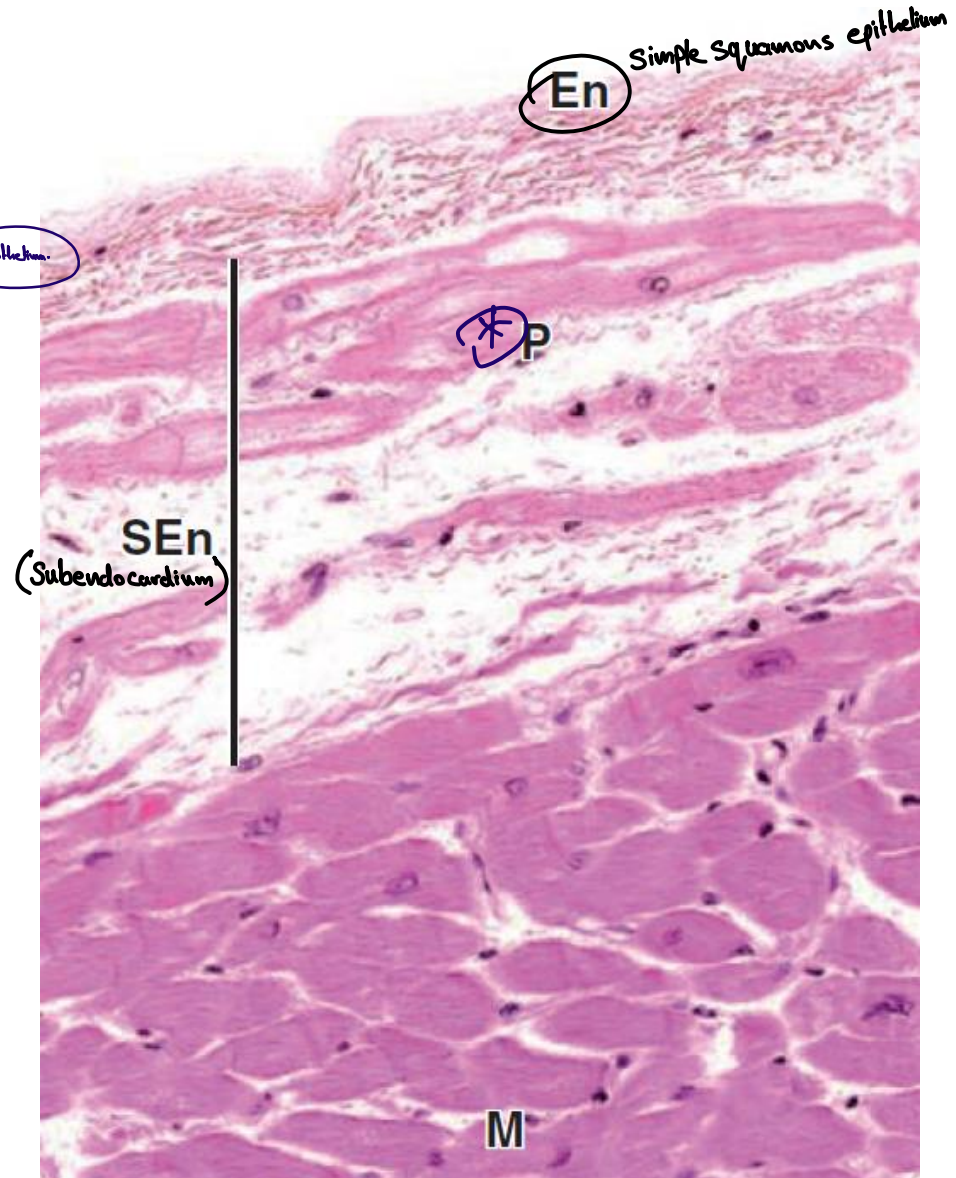


Fig.2: The endocardium. En, endothelium; SEn, subendocardium; P, Purkinje fibers; M, myocardium.

The Myocardium:

than atria
↑

- The thickest layer of the heart wall. It's thicker in the ventricles, and thickest in the left ventricle.
- Composed of cardiac muscle fibers that spiral around the heart chambers and that are attached to the (fibrous skeleton) of the heart.
↳ site of attachment of Cardiac Muscle fiber.
- Between the cardiac muscle fibers, we have loose areolar connective tissue (the endomysium).

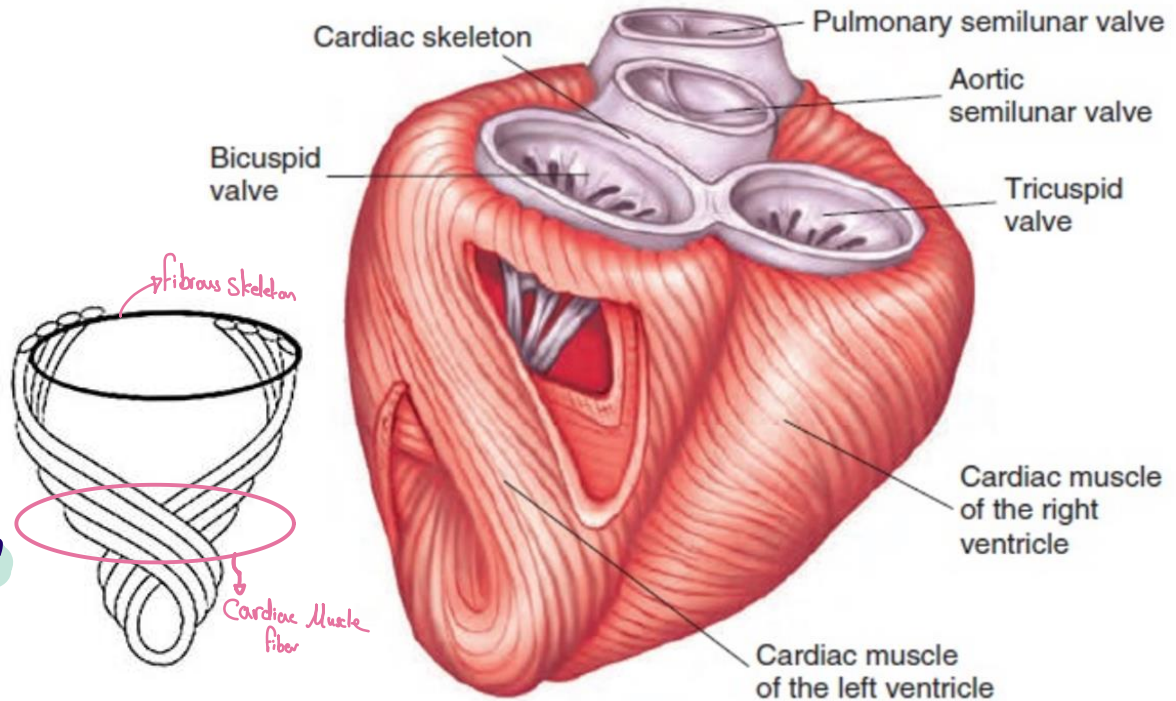


Fig.3: The spiral arrangement of the cardiac muscle fibers and their attachment to the fibrous skeleton.

Cardiac muscle fibers

- 1) Cells are branched.
- 2) Centrally located nucleus.
- 3) Cross-striation.
- 4) Branches are connected to each at the intercalated discs, where we have desmosomes and gap junctions.
- 5) Numerous mitochondria.
- 6) Lipofuscin and glycogen granules.

Intercalated discs: specialized junctions between cardiac muscle fibers (cardiomyocytes) that allow for rapid electric transmission.

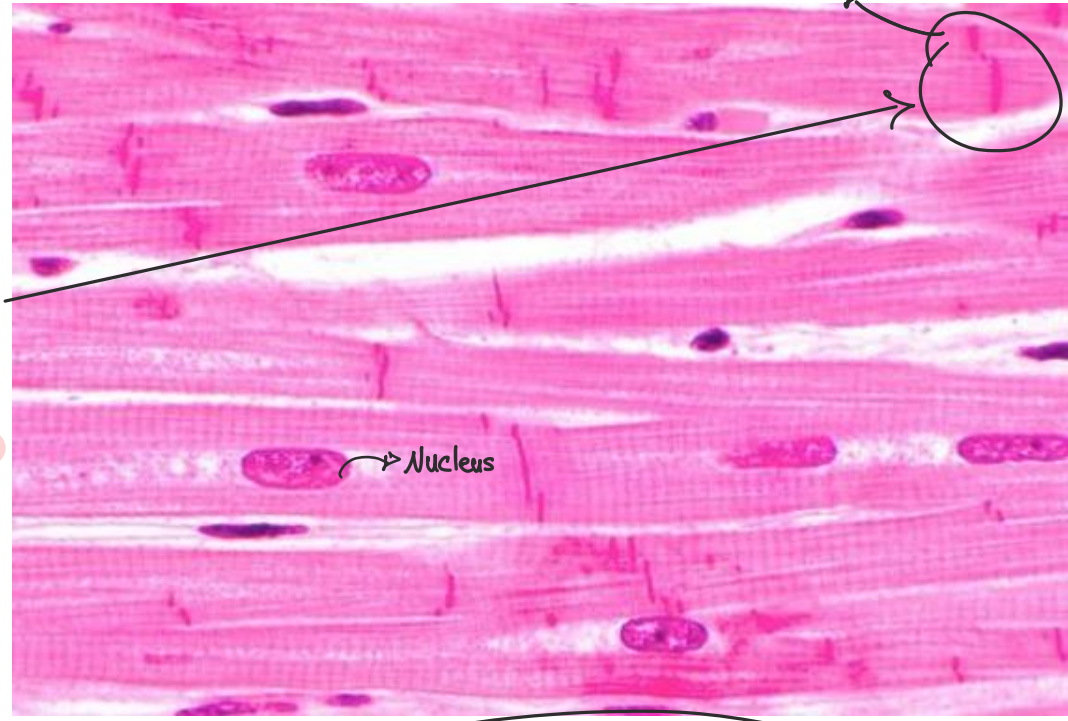


Fig.4: Cardiac muscle cells.

Critical adhesion Structures (with asterisk icon) → desmosomes

Allow transfer ions between adjacent cells (impulse conduction) (with asterisk icon) → gap junctions

Source of energy (with asterisk icon) → mitochondria

Yellow-brown pigment granules, old lysosomes. (with asterisk icon) → lipofuscin and glycogen granules

The Epicardium:

Simple squamous epithelium in serous membranes:

- Formed of an outer layer of simple squamous mesothelium, with an underlying connective tissue containing fat cells. * → a characteristic for epicardium.
- The mesothelial cells produce a lubricant fluid (the pericardial fluid) into the pericardial cavity to prevent friction. ^{منع الاحتكاك} The major vessels and nerves of the heart lie within the fatty connective tissue. ^{In epicardium}
- The epicardium correspond to the visceral pericardium and is continuous with the parietal pericardium.

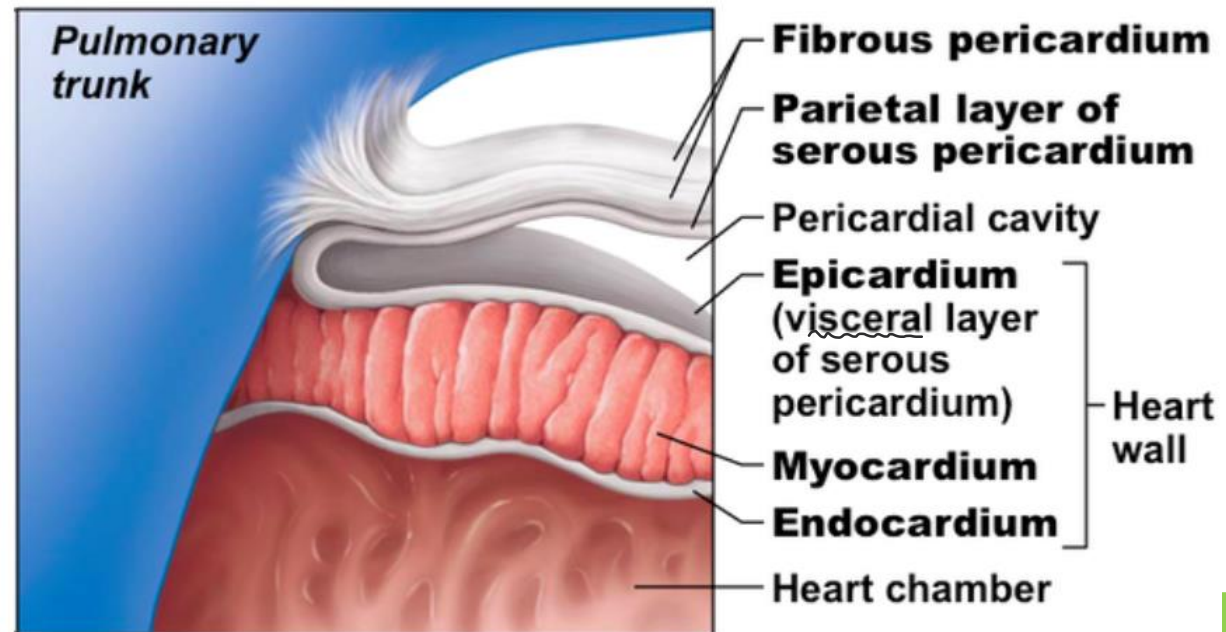


Fig.5: The various layers of the pericardium.

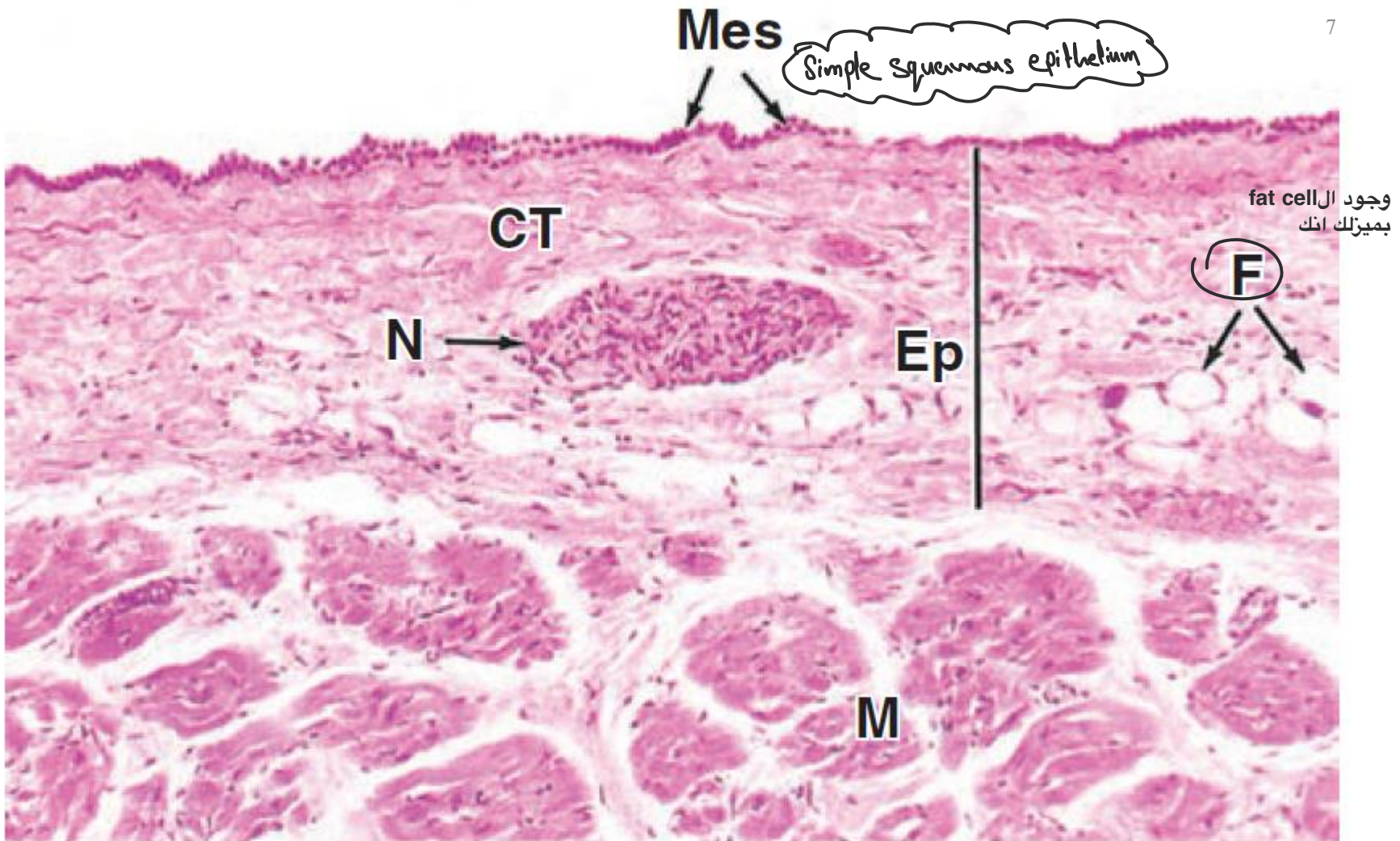


Fig.6: The epicardium. Ep, epicardium; Mes, mesothelium; CT, connective tissue; F, fat cells; N, nerve; M, myocardium.

Other structures in the heart

a) Purkinje fibers:

- Part of the conducting system of the heart. Found in the ventricles.
- Located in the subendocardial tissue.
- These are large, pale-staining cardiac muscle fibers with less myofibrils and more glycogen granules.

Purkinje fibers are modified cardiac muscles; less myofibrils & more glycogen

أفتح من الـ cardiac muscle يلي موجودة بال myocardium

b) Fibrous skeleton of the heart:

Located in endocardium between Atria & ventricles.

- Dense collagenous irregular connective tissue in the endocardium that serves as:
 - Base for the heart valves
 - Site for attachment of cardiac muscle fibers
 - Electrical insulator between atria and ventricle.

It stops the flow of electricity between the different chambers of the heart so that electrical impulses do not flow directly

It doesn't conduct impulse

c) Heart valves:

- Valve leaflets are formed of a fibrous core of connective tissue continuous with that of the fibrous skeleton, surrounded on both sides by endothelium.
- They are avascular. They obtain nutrients from the blood in the heart or blood vessels in the base of the valve.

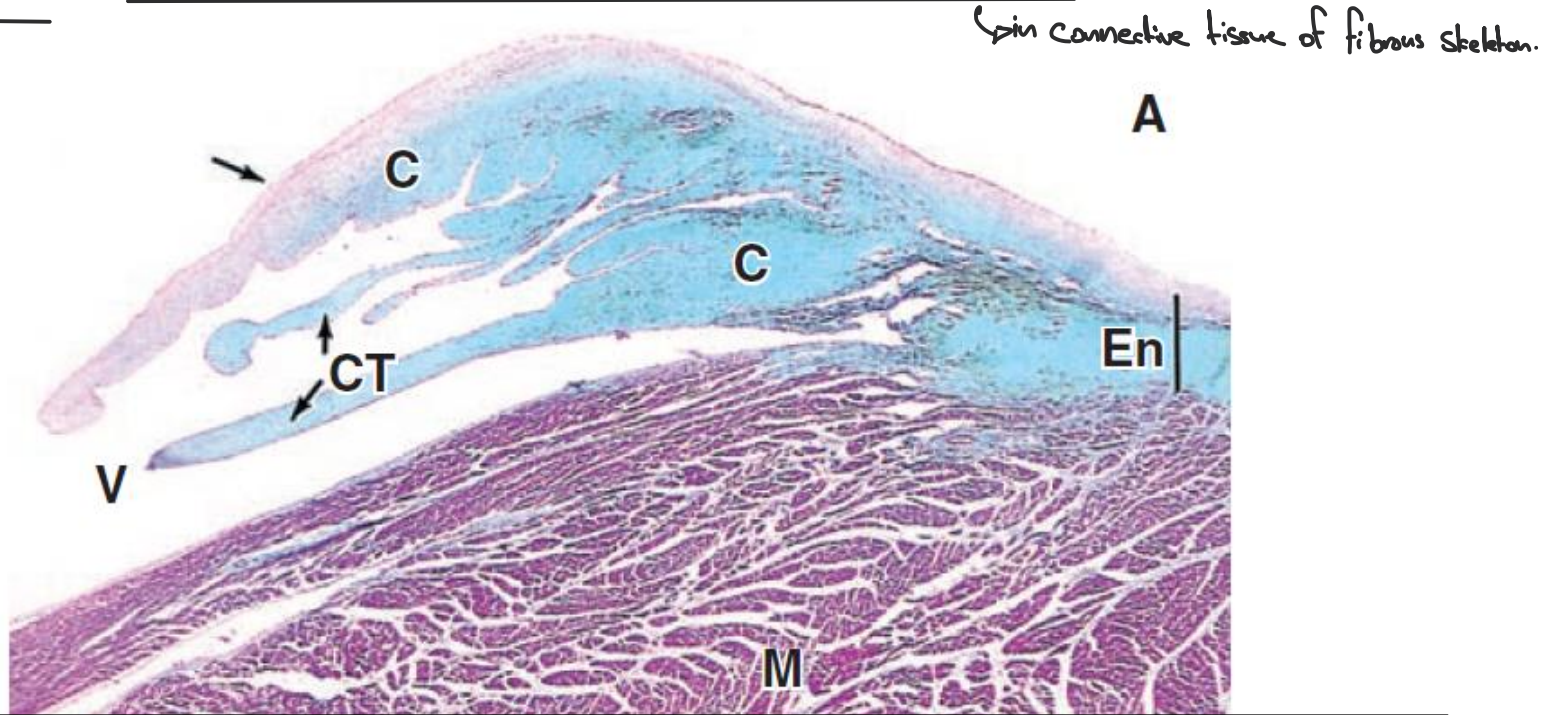


Fig.7: Atrioventricular valve (arrow) between atria (A) and ventricle (V). Note the core of fibrous connective tissue (C) which extends into the chordae tendinea (CT). En, endocardium; M, myocardium.

Histology of the Vessels

General layout of vessel wall

- All blood vessels (except capillaries) have the same general layout of their walls. From inside out:
 1. Tunica intima (interna) *in inside*
 2. Tunica media *in middle*
 3. Tunica adventitia (externa) *in outside*
- The difference between the vessels is in the relative composition and thickness of these layers.

①

Tunica intima (interna)

Direct contact with blood

- The *internal* layer of the vessel wall in *intimate* contact with blood.
- Formed of:
 - Endothelium (simple squamous epithelium)
 - Subendothelial loose connective tissue with some smooth muscle cells
 - Internal elastic lamina – a sheet of elastic fibers

②

Tunica media

Separates tunica intima from tunica media

- The middle layer of the wall.
- Formed of:
 - Smooth muscle cells with connective tissue
 - Elastic fibers
 - External elastic lamina

Separates tunica media from outermost layer (tunica adventitia)

3

Connective tissue of tunica adventitia
mixes with connective tissue of
surrounding tissue.

12

Tunica adventitia (externa)

يعني تساعد على تثبيت الvessle بالتissue surrounding
surrounding tissue

- The external layer. Usually bound to the surrounding connective tissue
- Formed of:
 - Dense irregular connective tissue adventitia
 - Vasa vasorum (vessels of the vessel). These supply nutrients and oxygen to the adventitia and outer media. The inner media and intima are supplied by direct diffusion from the blood inside the vessel. (The inner part of tunica Media.)
 - Nervi vasorum (nerves of the vessel). Control the diameter of the vessel by vasodilation or constriction.

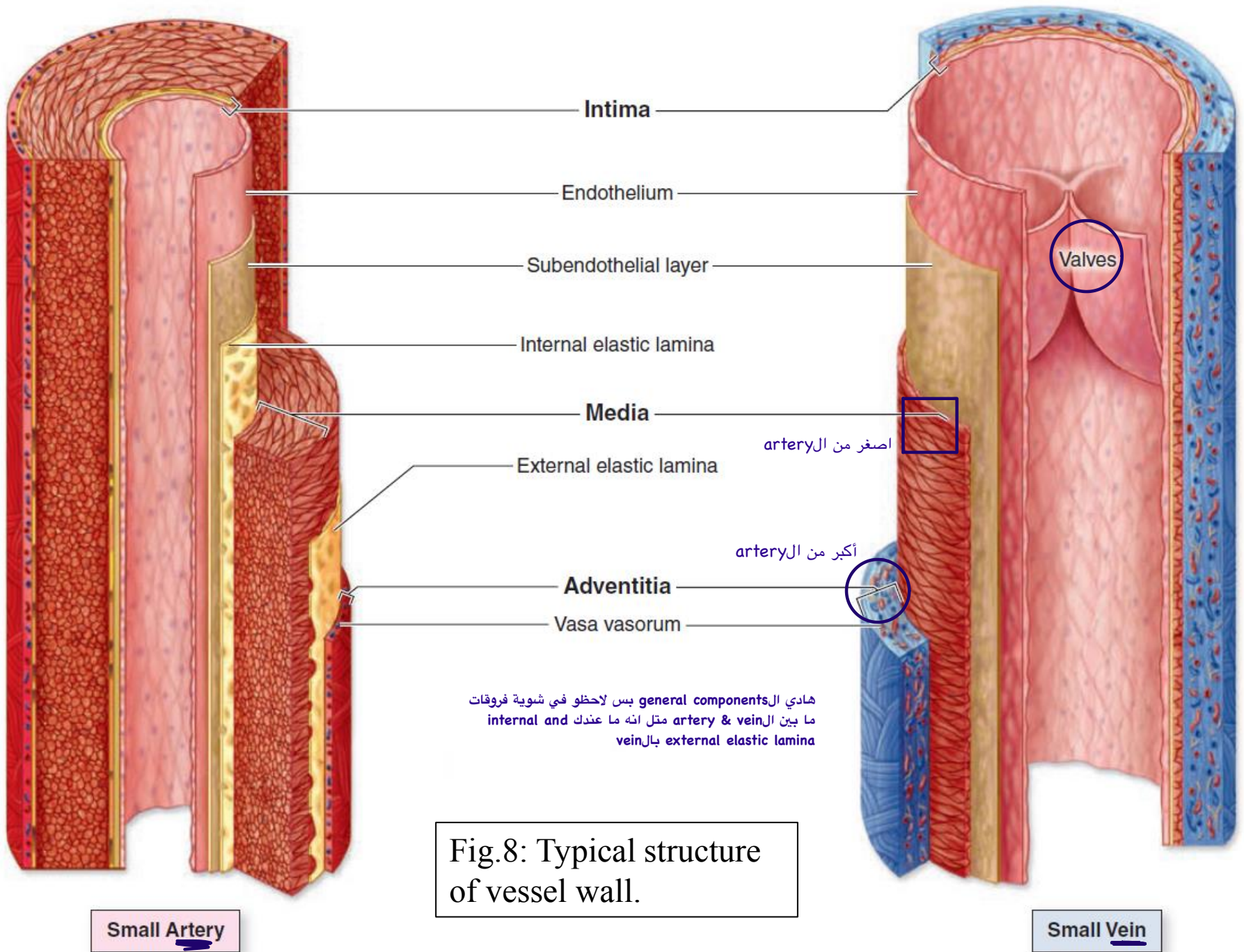


Fig.8: Typical structure of vessel wall.

Histology of the Vessels - Arteries

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The main components of blood vessels are : smooth muscle &



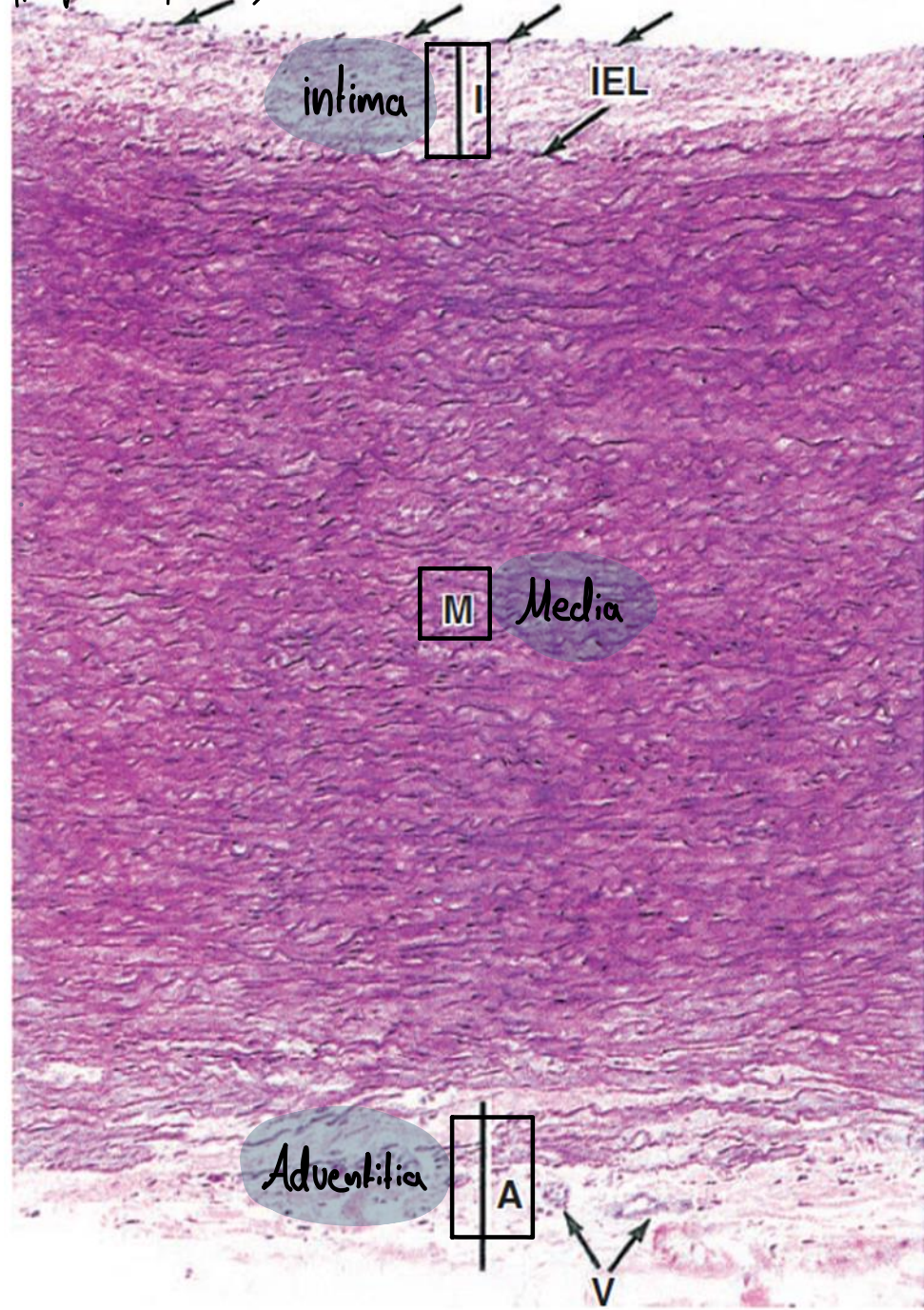
Very important to differentiate between smooth muscles and elastic fibers; the smooth muscles appear red under microscope the elastic fibers require a special stain and appear as thin dark wavy lines

The larger arteries

Elastic arteries

- These include the aorta and the pulmonary trunk and their main branches.
- They are ‘conducting arteries’ that carry blood to the smaller arteries. The compositions of the wall of elastic arteries :
 - **Tunica intima**: typical structure with smooth muscle cells.
 - ⊛ The internal elastic lamina may not be clearly recognized.
 - **Tunica media**: the thickest layer. Contains numerous fenestrated elastic laminae alternating with layers of smooth muscle fibers. The fenestrations allow nutrient to pass through. فيها ثقوب
Tunica media تحتوي الى الكثير من ال elastic lamia و عشان هيك سمينهاها .elastic artries
With few layers of smooth muscle cells
 - **Tunica adventitia**: typical structure with prominent vasa vasorum due to thick walls. ⊛

(Simple squamous epithelium)



→ Separates tunica intima from tunica media

Internal elastic lamina

Thin dark wavy line

⊗ And we have external elastic lamina , which separates tunica media from tunica adventitia, internal and external elastic laminae are not clearly recognizable due to difficulty of distinguishing between them and the tunica media layers.

#*The elastic arteries are dark in color due to the use of a special dye , to show the elastic laminae.

Fig.9: Elastic artery (aorta). Note the three layers of the wall: intima (I), media (M), and adventitia (A). Arrows at the top indicate the endothelium. The internal elastic lamina (IEL) can be seen in this image. V, vasa vasorum. Special stain was used to show the elastic fibers.

Muscular arteries

- These are 'distributing arteries' that distribute blood to the organs.
 - **Tunica intima**: thin with typical structure. (*) The internal elastic lamina is prominent.
 - **Tunica media**: the thickest layer. Contains numerous layers of smooth muscle fibers, with some elastic laminae. (*) The external elastic lamina is prominent.
 - **Tunica adventitia**: typical structure.

هنا قدرنا نشوف ال internal & external elastic laminae بوضوح
عكس ال elastic arteries بسبب انه هون طبقة ال tunica media فيها
smooth muscles more than elastic laminae ، سوو كثير
سهل علينا انه نميزهم ونشوفهم

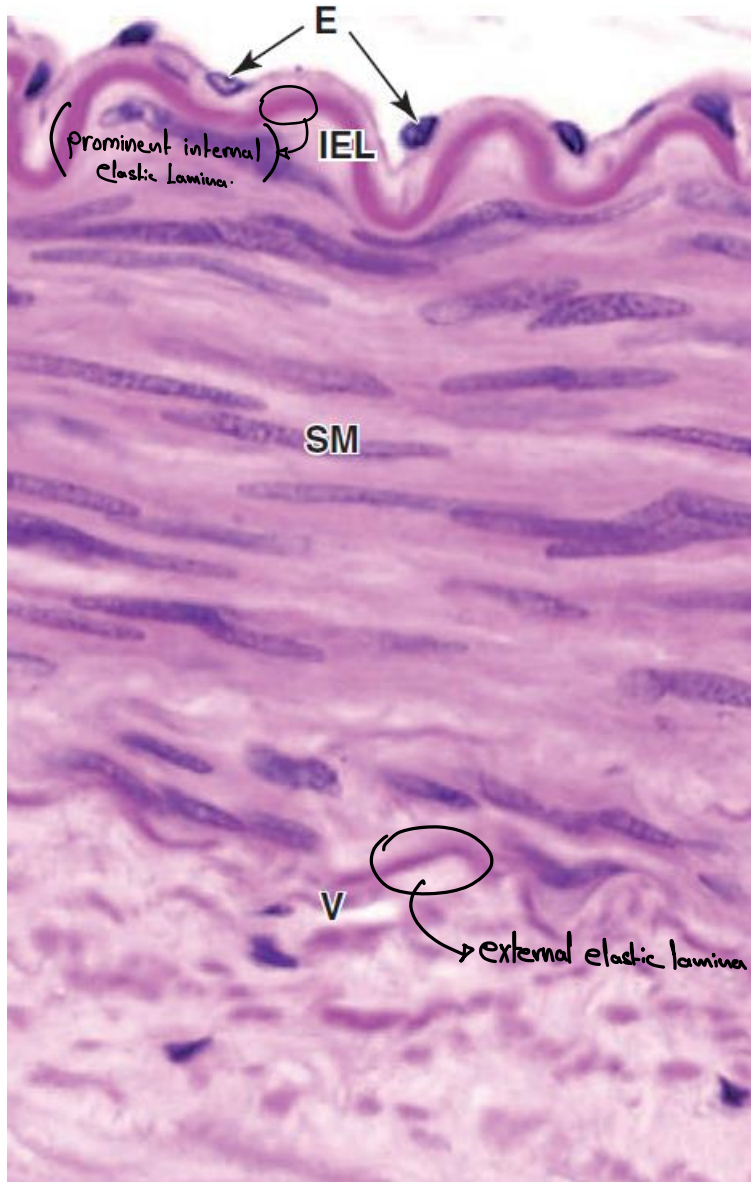


Fig.10: Muscular artery. Note the thin intima with the lining endothelium (E) and the prominent internal elastic lamina (IEL). The media is mostly smooth muscle fibers (SM). The adventitia is external with vasa vasorum (V).

Arterioles

- Arterial branches that are $<0.1\text{mm}$ in diameter. It's the beginning of the microvasculature of the organ.
 - Tunica intima: very thin with no elastic lamina. أهم ميزة الـ Arterioles إنه لا يحتوي على elastic lamina
 - Tunica media: formed of only 1-3 layers of smooth muscle fibers, with no elastic laminae.
 - Tunica adventitia: thin.

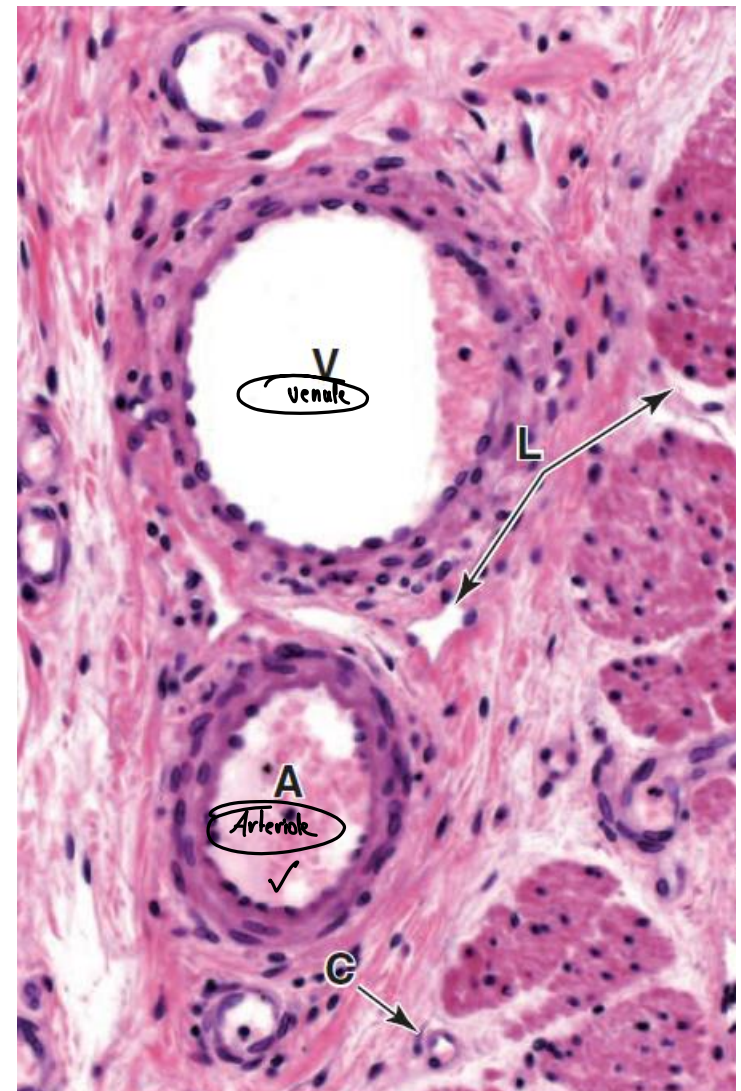
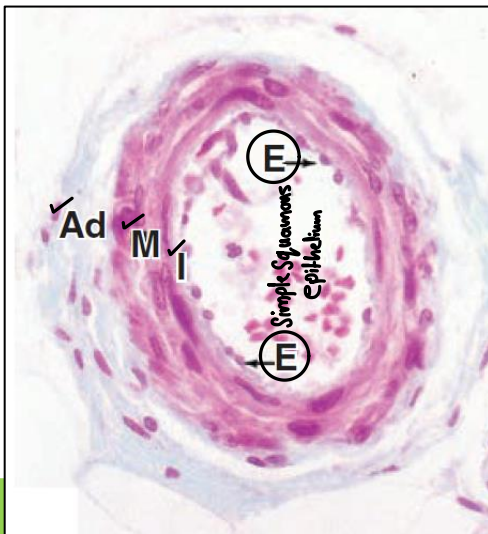


Fig.11: Microvasculature of an organ. A, arteriole. These give rise to capillaries (C), which then drain into a venule (V). Also shown are lymphatic vessels (L). To the left, wall of an arteriole: intima (I), media (M), and adventitia (Ad). E, endothelium.

- ⊗ Capillaries arise from arterioles. The smooth muscles of the arterioles act as sphincters to control the flow of blood into the capillaries.
- ⊗ Arterioles, also, give rise to *thoroughfare channels* that connect the arterioles to the *postcapillary venules*. Capillaries arise from the ^{from the proximal part} initial segment of these channels, which are called *metarterioles*. The flow of blood into the capillaries from the metarterioles is controlled by smooth muscle *precapillary sphincters*.

عبارة عن branch يربطلي الarteriole مباشرة مع الvenule
 At the begining of capillaries we have a rings of smooth muscles form the precapillary sphincters ;
- ⊗ Capillaries drain into the venous side of the thoroughfare channel ^{Into the capillaries.} which lacks smooth muscles.

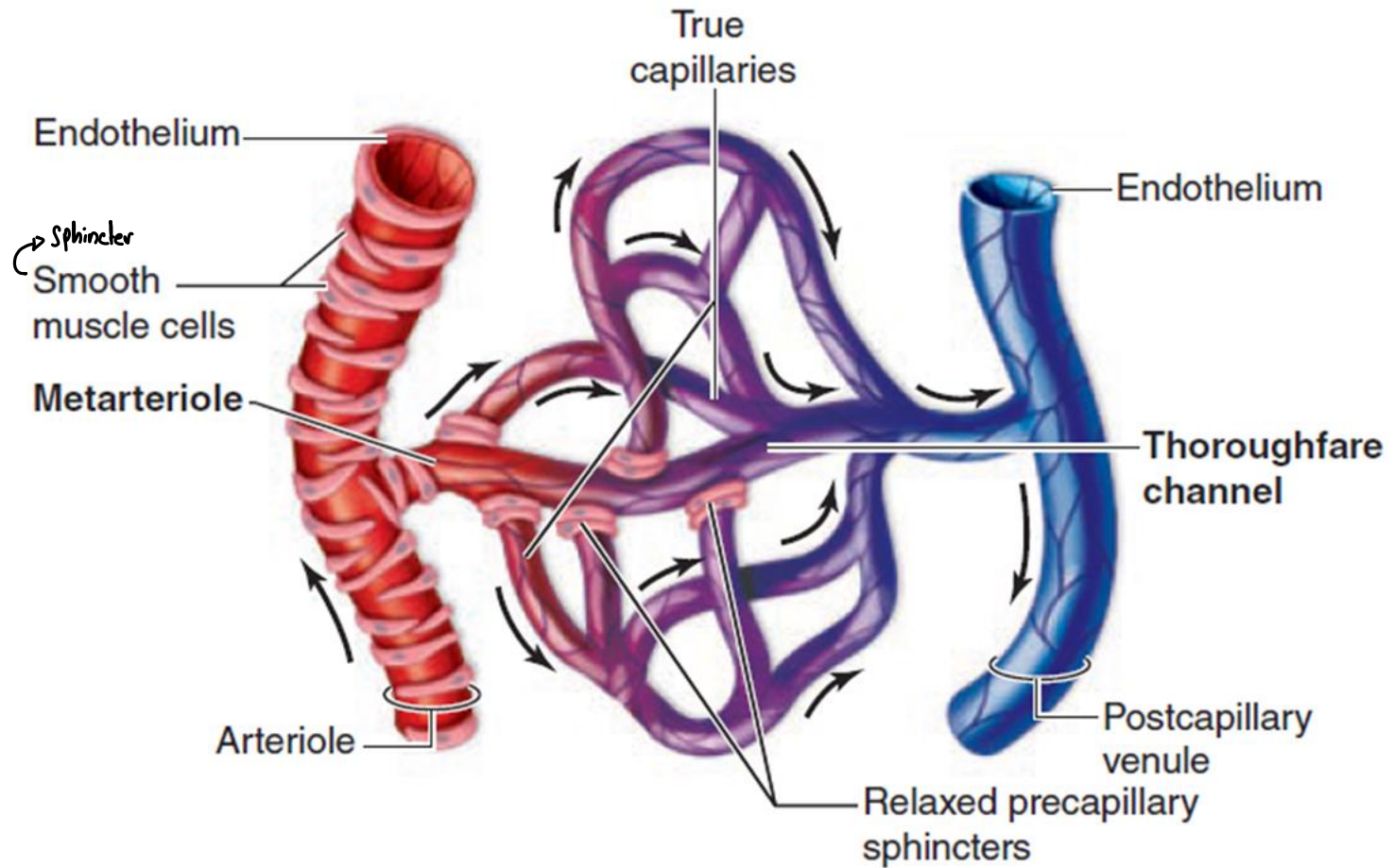
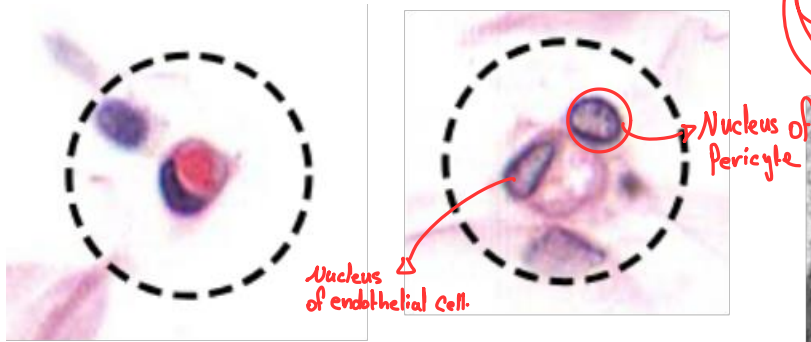


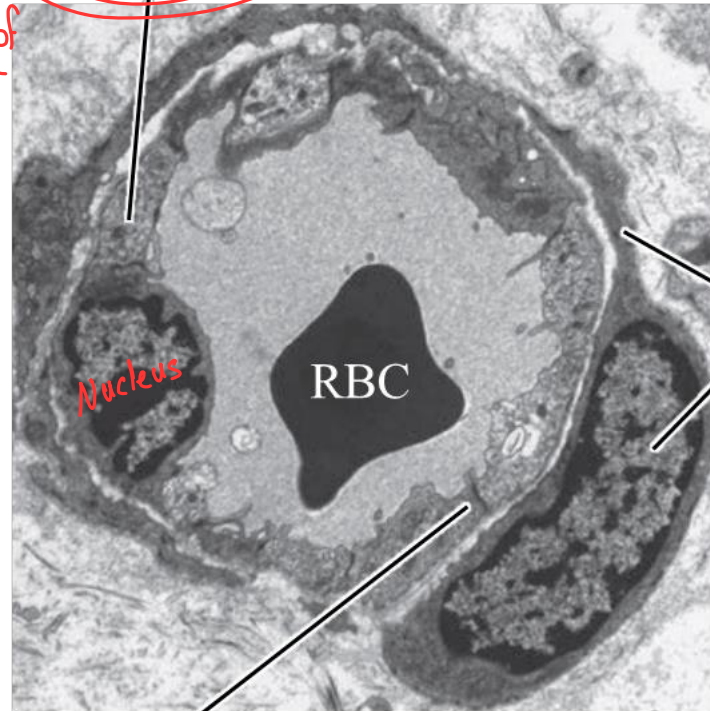
Fig.12: Microvasculature of an organ. The flow of blood through the capillaries is controlled by the contraction and relaxation of the precapillary sphincters.

Histology of the Vessels - Capillaries ²⁰

- Capillaries are the smallest vessels in the body. With a diameter of 4-10 μm , blood cells can pass only one at a time. وحدة وحدة يعني ما بتقدر اكثر من خلية دم واحدة تمرق من خلالها
- Exchange of gases and nutrients occur through the thin capillary walls. The density of the capillaries depends on the metabolic activity of the organ. كل ما كان active كل ما احتاج الى more capillaries
- They are formed of simple squamous endothelium rolled up in a tube surrounded by basal lamina and pericytes. The endothelial cells:
 - Are connected by tight junctions
 - Contain pinocytotic vesicles The cells that transport materials from one place to another (trans cytos)contain pinocytotic vesicles.
 - Release substance that prevent coagulation of blood, control passage of WBC into tissues, and affect vessels diameter



Endothelial cell



Pericyte and its process
Surround the capillary.

Fig.13: Capillaries. Above, light microscope images. In the top-left image, a red blood cell is filling the capillary. In the top-right image, the nucleus just outside the capillary belongs to a pericyte. To the right, electron microscope image of a capillary.

Tight junction

a) Continuous capillaries

- Many tight junctions between slightly overlapping endothelial cells. This allows ^{Highly regulated} well-regulated exchange across the cells.
- The most common type of capillary. Found in muscle, connective tissue, lungs, exocrine glands, and nervous tissue.

b) Fenestrated capillaries

- Have a sieve-like structure in which the endothelial cells are penetrated by numerous small circular fenestrations that allows more extensive exchange.
- ^{*} Some fenestrations are covered by very thin diaphragms of proteoglycans; ^{*} others may represent membrane invaginations that temporarily involve both sides of the very thin cells. The basement membrane however is continuous. شرح ال mechanism تبعها تحدي In areas that require passage of substances
- Fenestrated capillaries are found in some organs, such as the kidneys, intestine, choroid plexus, and endocrine glands.

Filtration of Blood. ↘

↳ Absorption of Nutrients.

↳ Formation of Cerebrospinal fluid.

↳ Secrete Hormones

مبدأ ال pinocytotic visceles انه بصير عندي invagination بمنطقة وحدة فقط من
الخلية وبعدها بتروح تمشي بالسيتوبلازم وتروح للجهة الثانية من الخلية وتتحد مع ال cell
membrane والمواد يلي موجدة داخل ال viscele بتنفرز للخارج
، لكن بال fenestrated capillaries وقت تتكون هادي ال viscele ويصير invagination
of ceell membrane بيروح يمتد للجهة الثانية من الخلية ف بيصير عندي مثل ممر او قناة
من خلالها بتمر المواد

c) Discontinuous capillaries (sinusoids) ^(ثقوب كبيرة)

- The endothelium has large perforations without diaphragms and irregular intercellular clefts. In addition, the basement membranes is highly discontinuous.
- These features and larger diameter of these capillaries permit maximal exchange of macromolecules as well as allow easier movement of cells between tissues and blood.
- Sinusoidal capillaries of this type are found in the liver, spleen, and bone marrow.

موسيس molecule حتى الخاايا بتقدر تمرق بسبب انه الثقوب كبيرة
 موجودة بالاماكن يلي بتكون جزيئات كبيرة مثل البروتينات ؛ لانها
 تحتاج الى ثقوب كبيرة تقدر تمر من خلالها

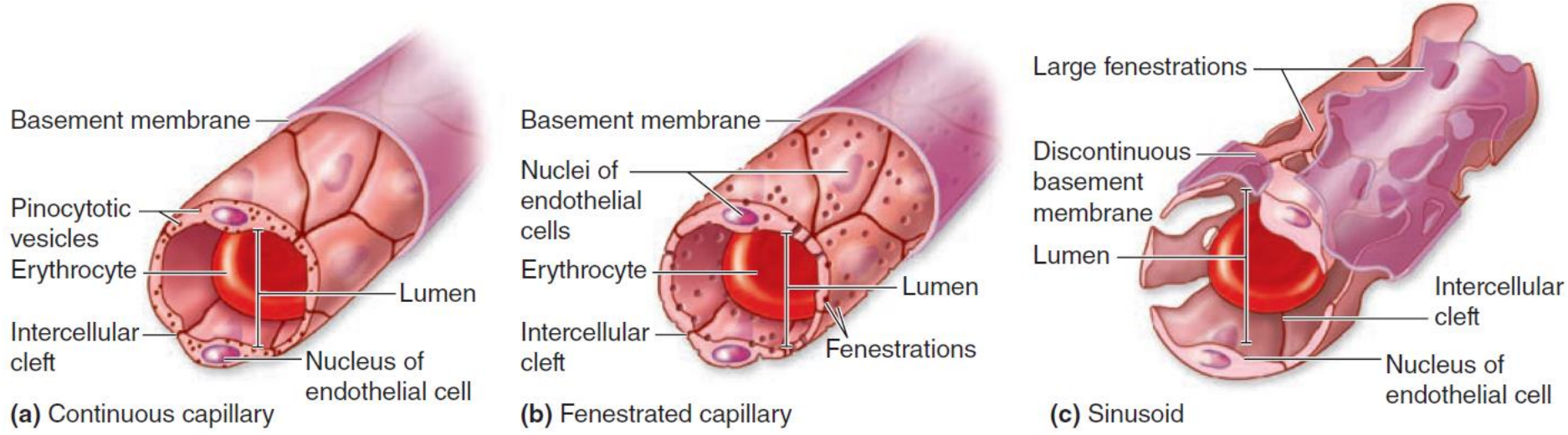


Fig.14: Types of capillaries.

Pericytes

وجود هادي ال pericytes يعيق عملية تبادل المواد

علشان هيك هو موجود بمنطقة ما يبصير فيها تبادل
(continuous capillaries) علشان هيك ما بتلاقي pericytes موجودة بال
fenestrated & discontinuous capillaries لانه محتاجهم لتبادل المواد.

Connective tissue cells

- Mesenchymal cells with long cytoplasmic processes that surround continuous capillaries and post-capillary venules.
- They are surrounded by a basal lamina that merges with the basal lamina of the capillary. These cells can contract & change the diameter of capillaries to regulate blood flow
- They have well-developed networks of myosin, actin, and tropomyosin indicating that pericytes dilate or constrict capillaries, helping to regulate blood flow.
- They help form new capillaries after injury.

Processes of pericytes surrounding the

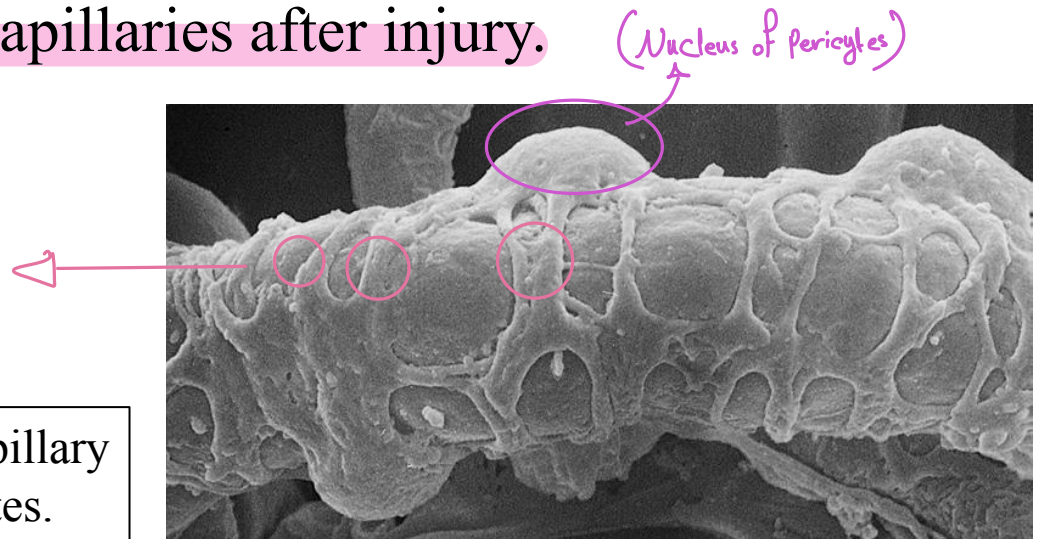


Fig.15: SEM of a capillary surrounded by pericytes.

Types of circulations

①

Typical circulation

Simple pathway: Arteriole → Capillary bed → Venule --- **Most common**

Direct connection between arterioles & venules without passing through capillaries

②

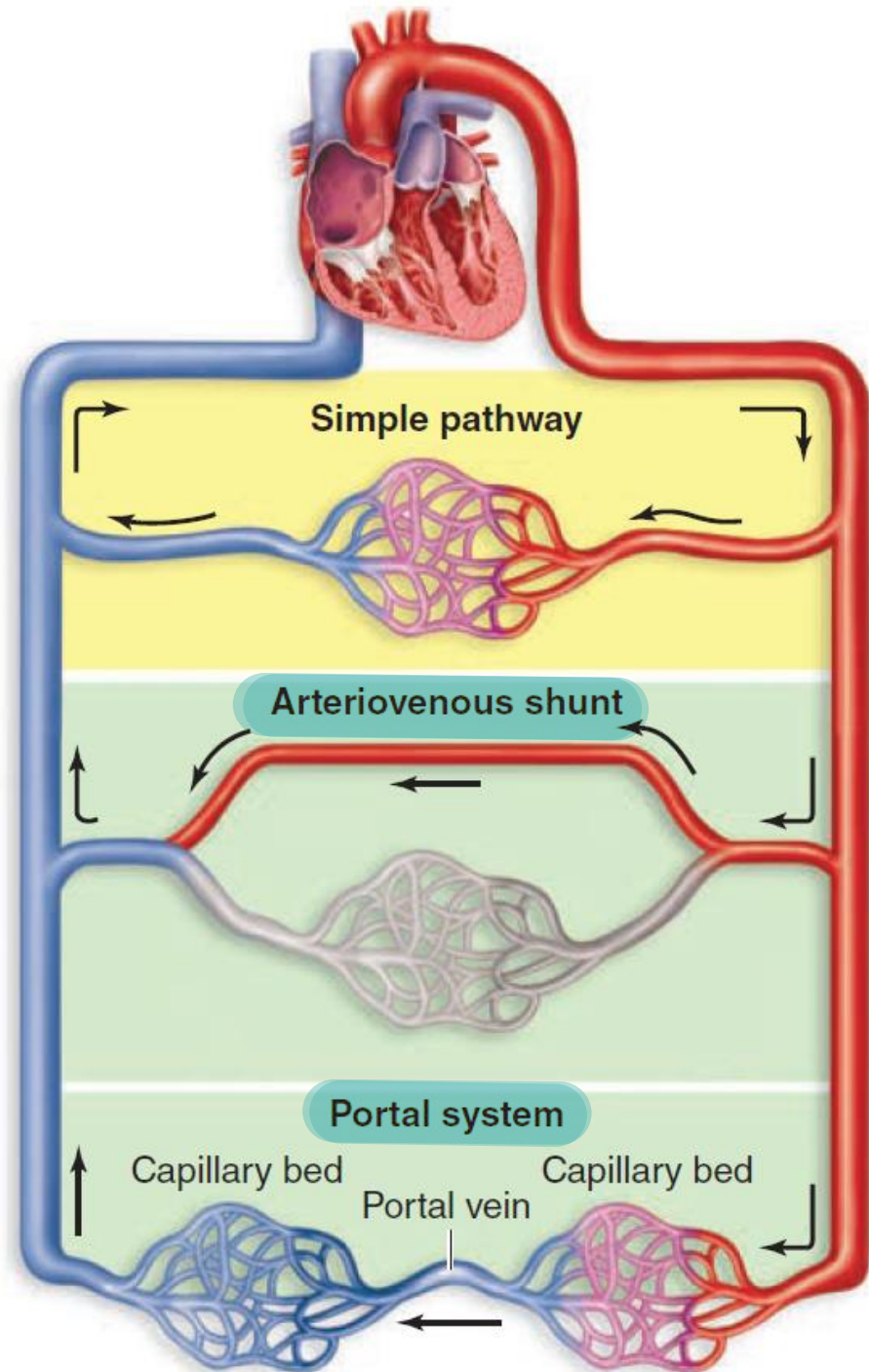
Arteriovenous shunts: blood is shunted directly from arterial to venous side bypassing capillaries ---

Skin

③

Portal systems: capillary bed 1 → portal vein → capillary bed 2 ---

Hepatic portal systems ♡ (in liver)



Histology of the Vessels - Veins

Venules

- *Postcapillary venules*
 - Similar to capillaries (endothelium and basal lamina) surrounded by pericytes. Larger diameter.
 - Site where white blood cells leave the circulation to enter inflamed tissue.

These are venules that accompany the arterioles

- *Collecting and muscular venules*
 - Have distinct tunica media with only 2-3 layers of smooth muscles.

→ Intima, Media, Adventitia.

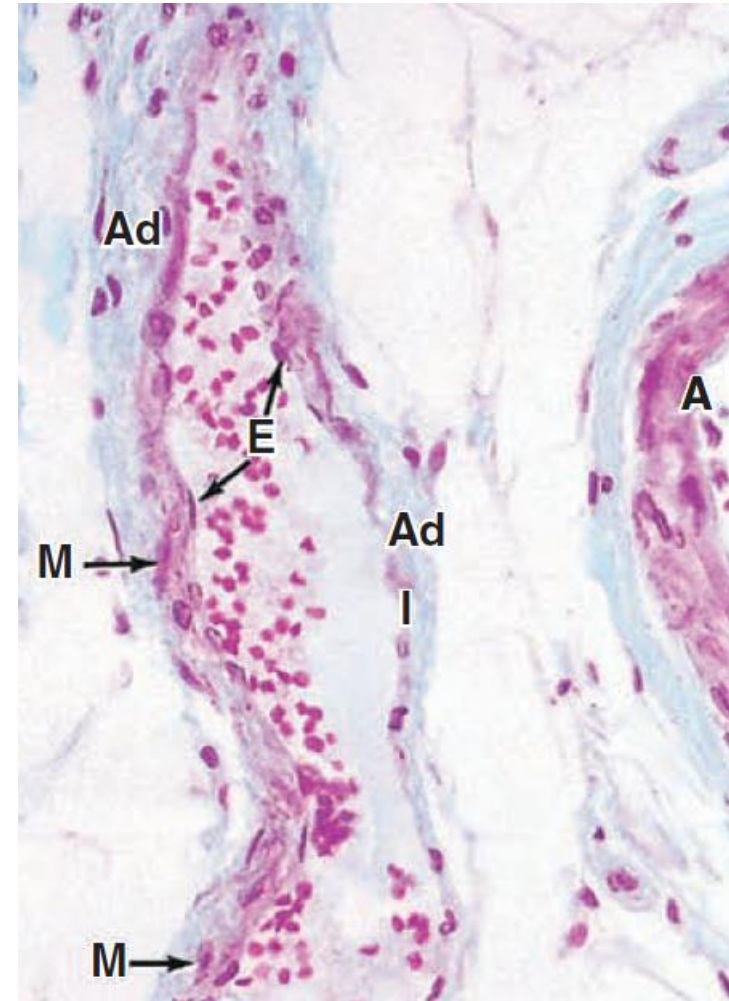


Fig. 16: Muscular venule. I, intima. E, endothelium. M, media. Ad, adventitia. Note the large lumen and the thin wall (compare with the arteriole A).

Small and medium veins

- Accompany the muscular arteries.
- The tunica intima is usually thin. The media has small bundles of smooth muscle cells (3-5 layers) mixed with a network of reticular fibers and delicate elastic fibers. The adventitia is thick and well developed with several collagen fibers.
- Medium veins possess valves.

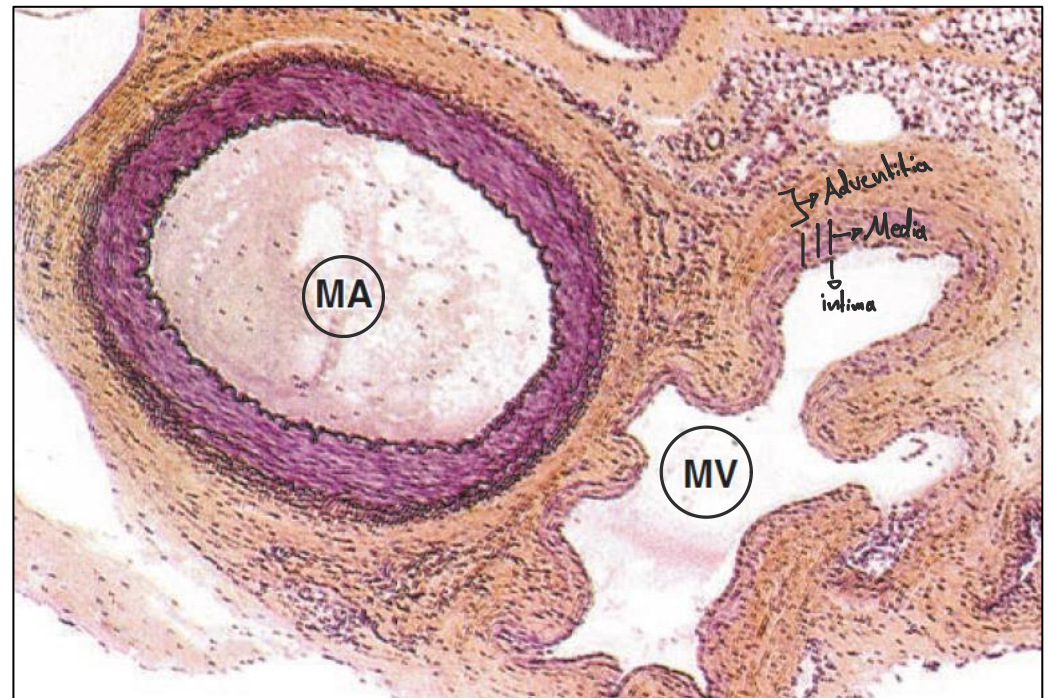


Fig.17: Medium vein (MV) accompanying a muscular artery (MA).

Large venous trunks → Superior & inferior vena cava.

- Accompany the large elastic arteries.
- Intima is well-developed. Media has alternating layers of smooth muscle (>5) and connective tissue. The tunica
 - ⊗ adventitia is thicker than the media in large veins and frequently contains longitudinal bundles of smooth muscle. Both the media and adventitia contain elastic fibers, and an internal elastic lamina may be present.
- ✓ • Possess valves which are folds of the tunica intima that prevent backflow of blood. They are most numerous in the veins of the leg.
- **Prominent** Vasa vasorum are numerous in the large veins because blood in the lumen is deoxygenated.

مثل ما بتعرفو انه الدم يلي موجود بال veins هو deoxygenated blood
 It is not enough to supply the wall of the vein sooo we need
 a vasa vasorum

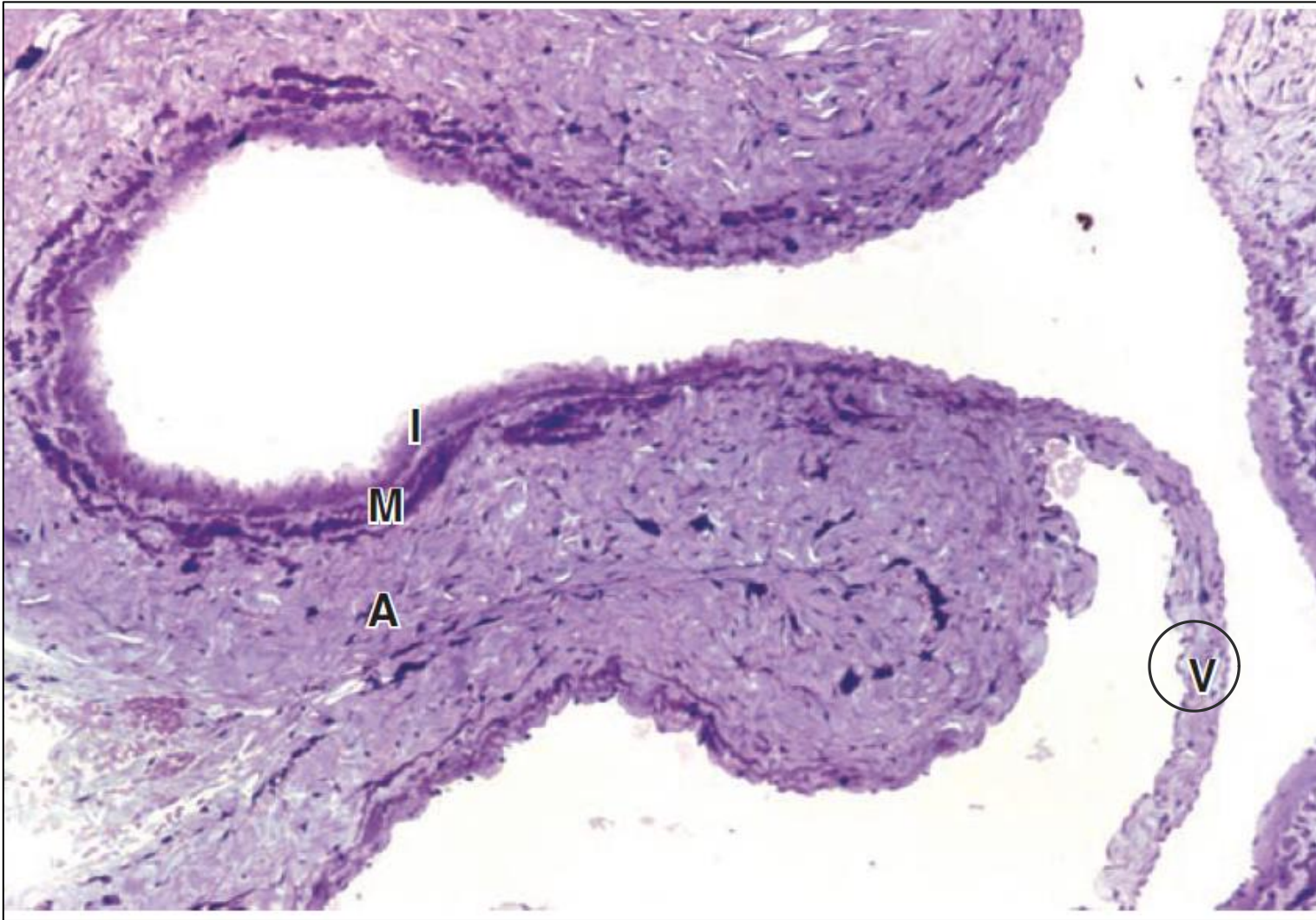


Fig.18: Large vein with distinct intima (I), media (M), and adventitia (A). Note the valve (V).

بالتوفيق يا حلوين ♥ ادعولي لو
سمحتوا 🙏

Thank You