Histology , lec1

(Vessel tunics)

Edited by : Rua'a Nader

Vessel tunics

Tunica intima:

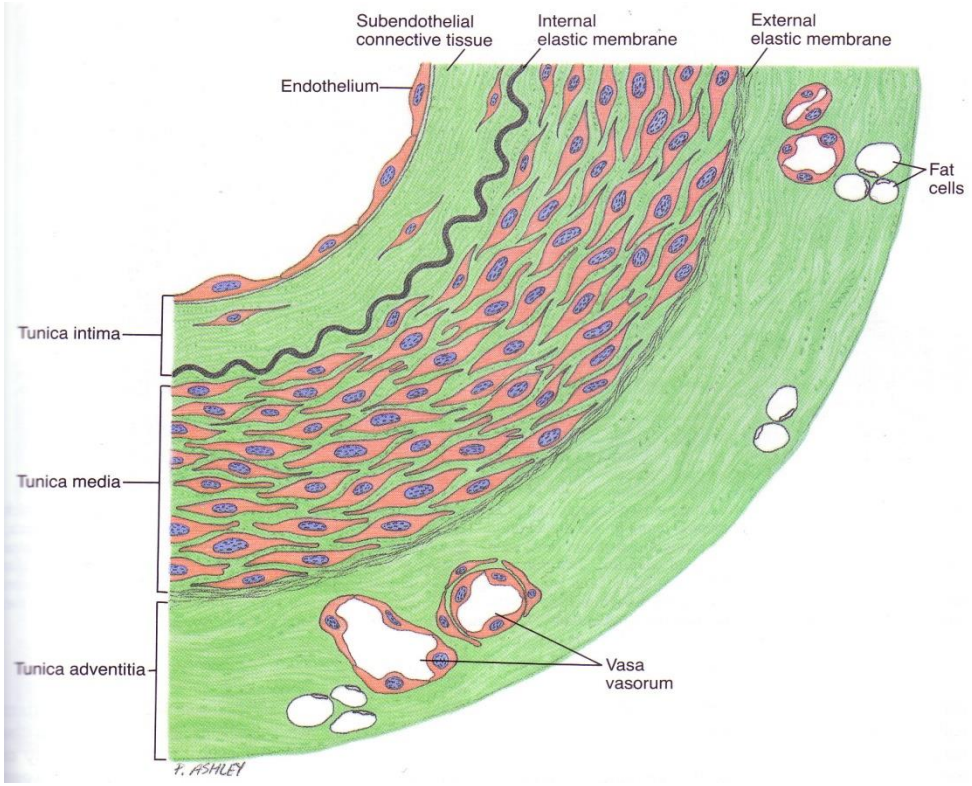
- Endothelium
- Subendothelial connective tissue
- Internal elastic lamina (membrane)

Tunica media

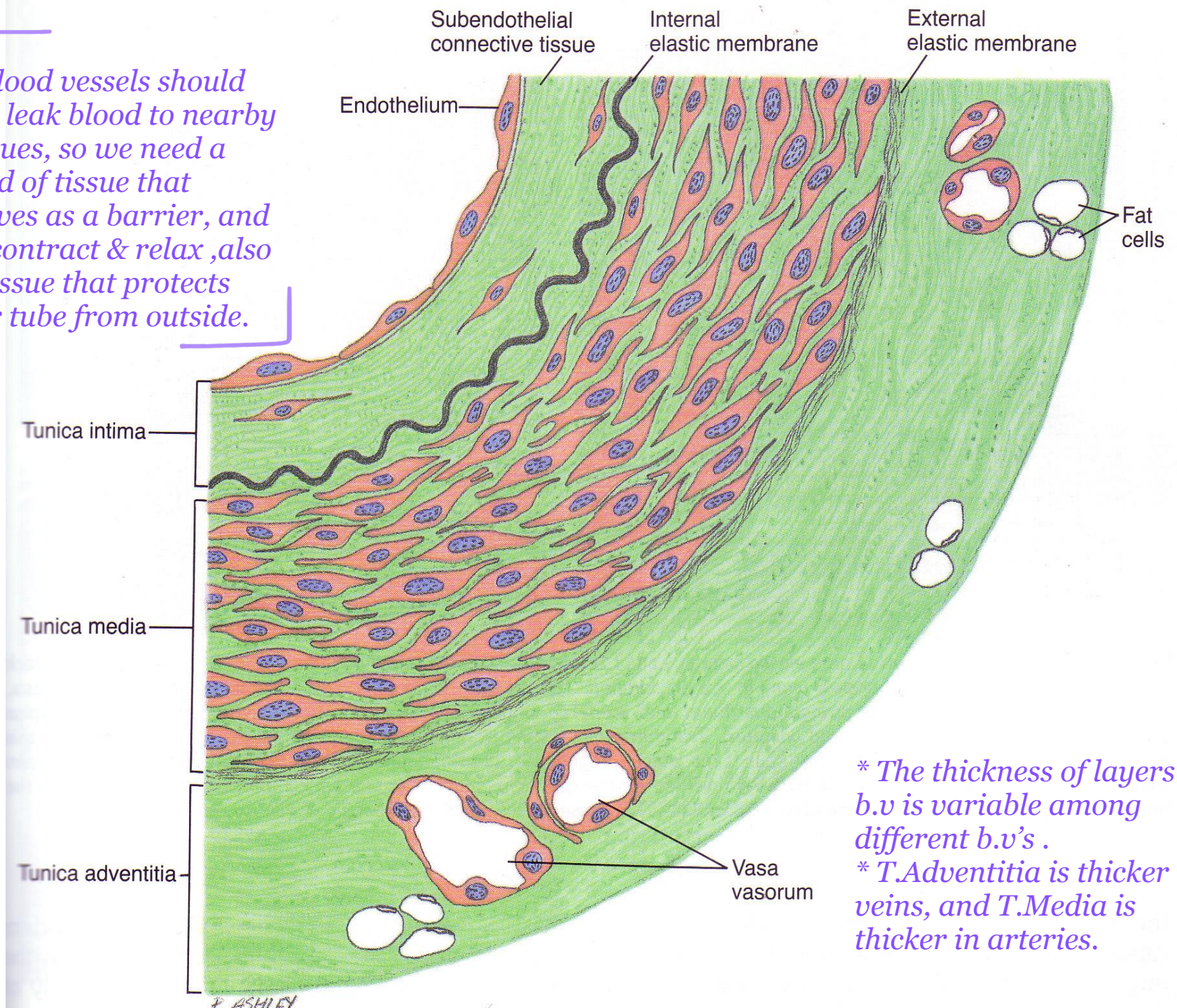
- Smooth muscle
- Elastic fibres
- External elastic lamina (membrane)

Tunica adventitia

- Connective tissue
- Vasa vasora



** Blood vessels have to accommodate themselves relative to the pressure that experienced all over the day.*



* Blood vessels should not leak blood to nearby tissues, so we need a kind of tissue that serves as a barrier, and to contract & relax ,also a tissue that protects our tube from outside.

* The thickness of layers of b.v is variable among different b.v's .
* T.Adventitia is thicker in veins, and T.Media is thicker in arteries.

Tunica Intima

The innermost layer of the vessel
consists of three components:

(A) Endothelium

(B) Basal lamina of the endothelial cells

(C) Subendothelial layer

The subendothelial layer of the intima in *arteries and arterioles* contains a sheet like layer or lamella of fenestrated elastic material called

The internal elastic membrane.

Endothelium

In the adult human body, a circulatory system consists of about
60,000 miles of different-sized vessels
that are lined by a simple squamous epithelium called **endothelium**

** It's very thin and adherent to each other tightly, so it functions as a barrier and allows diffusion to take place.*

The endothelium is formed by a continuous layer of flattened,elongated, and polygonally shaped endothelial cells

** Endotheliam is engaged in process of coagulation.*

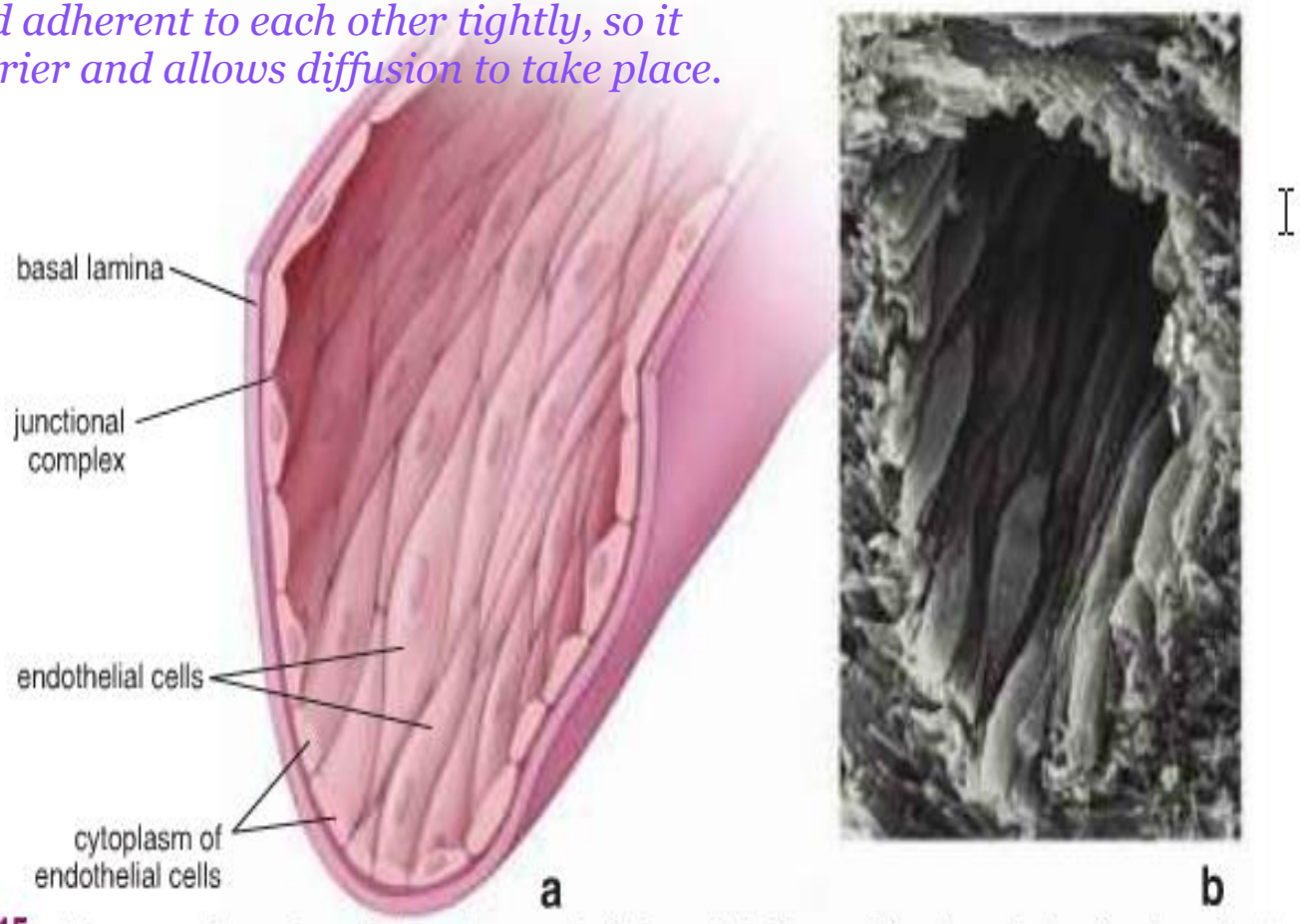
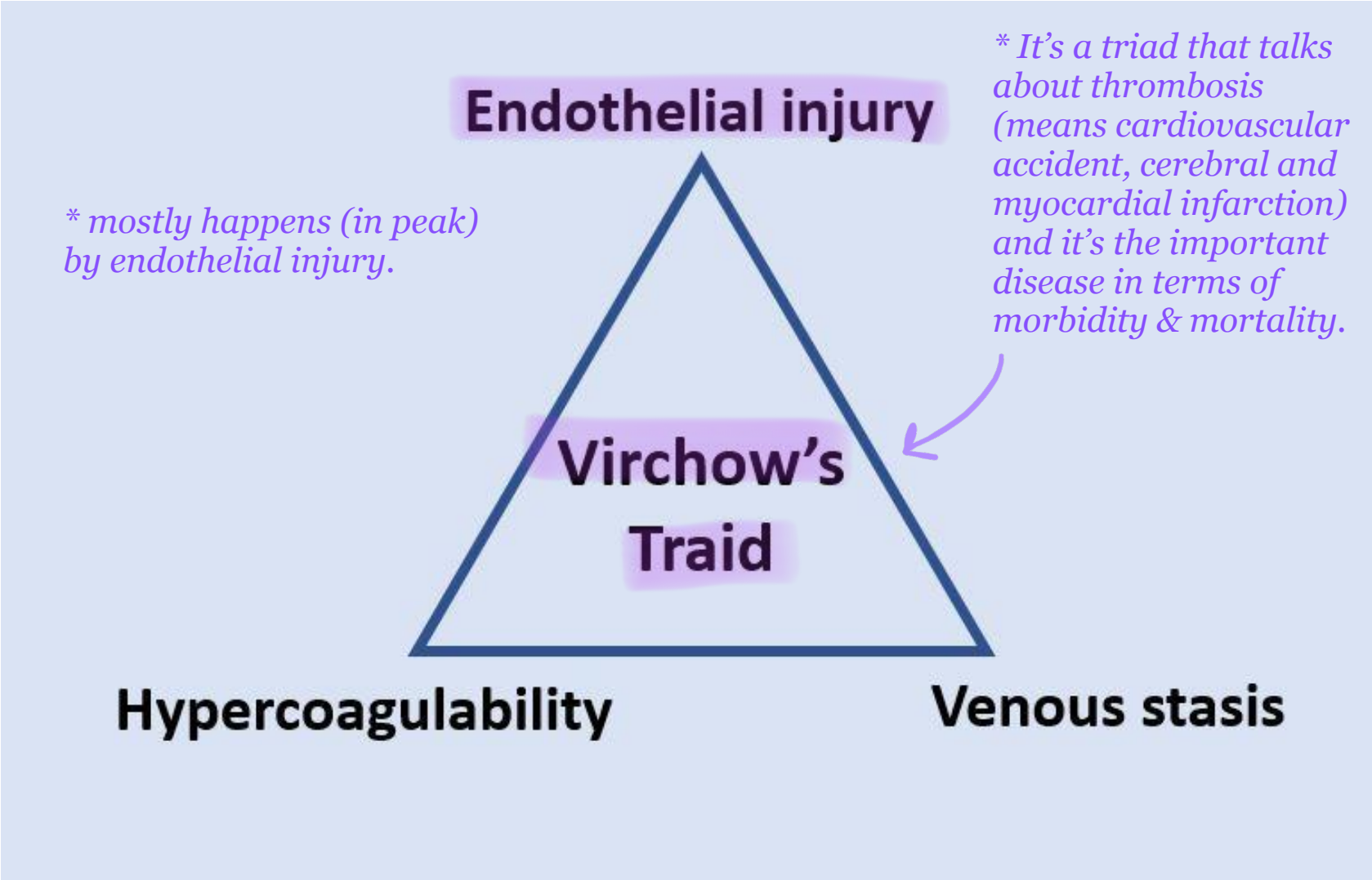
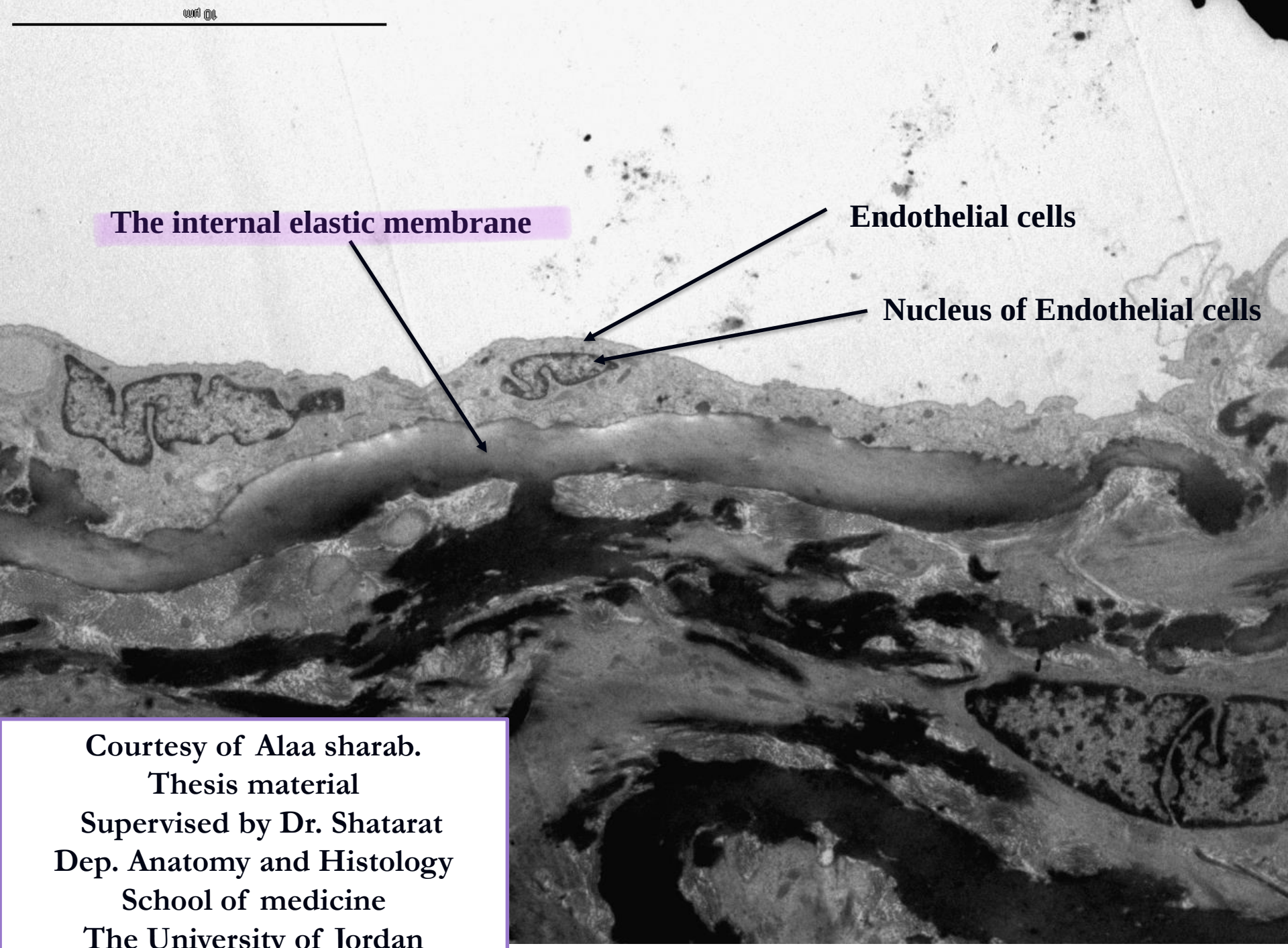


FIGURE 13.15 • Diagram and scanning electron micrograph of the endothelium. a. This schematic drawing shows the luminal surface of the endothelium. The cells are elongated with their long axis parallel to the direction of blood flow. Nuclei of endothelial cells are also elongated in the direction of blood flow. **b.** Scanning electron micrograph of a small vein, showing the cells of the endothelial lining. Note the spindle shape with the long axis of the cells running parallel to the vessel. ×1,100.



** so, endothelium is more than just a carpet .*



Courtesy of Alaa sharab.
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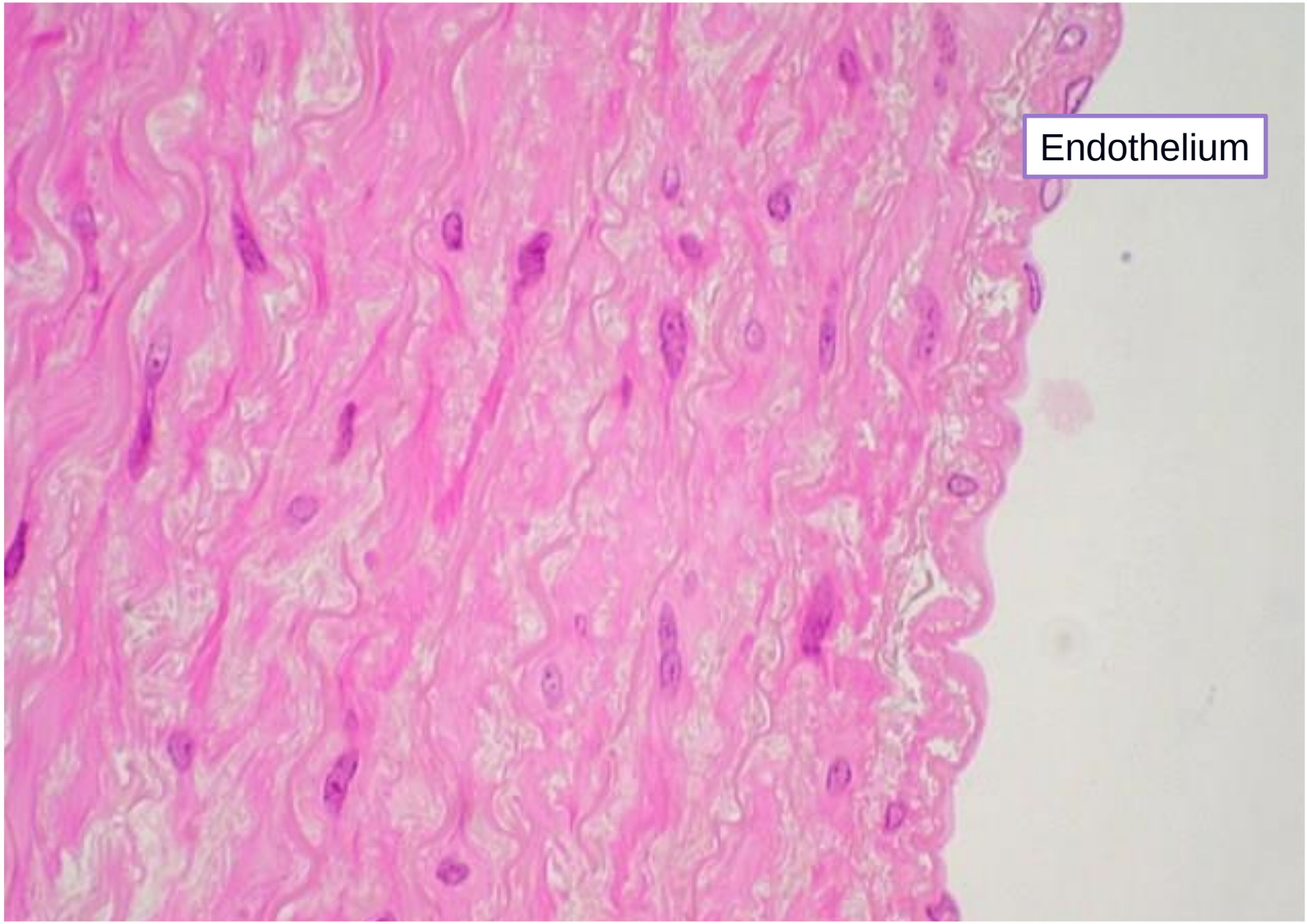

Endothelium

Endothelial cells possess rod like inclusions called **Weibel Palade bodies** that are present in the cytoplasm.

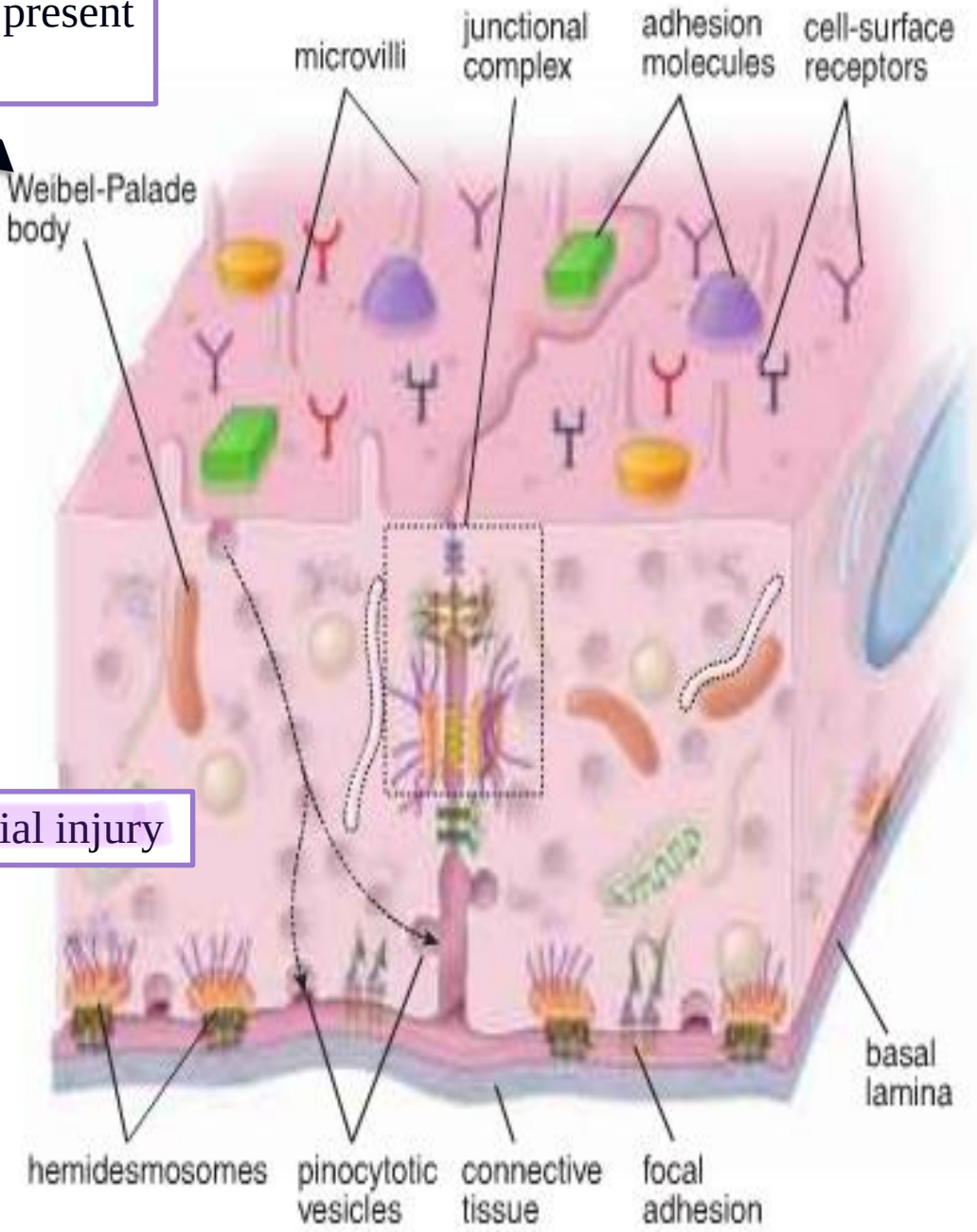
Contain von Willebrand factor
and
P-selectin

Von Willebrand factor is a glycoprotein synthesized by arterial endothelial cells

It binds coagulating factor VIII

Platelets adhesion to the site of endothelial injury

The antibody to **von Willebrand** factor is commonly used as an immunohistochemical ***marker*** for identification of **endothelium-derived tumors**



Functions of Endothelium (tunica intima…2)

Major Properties	Associated Functions	Active Molecules Involved
Maintenance of selective permeability barrier important it's a selective barrier	Simple diffusion Active transport Pinocytosis Receptor-mediated endocytosis	Oxygen, carbon dioxide Glucose, amino acids, electrolytes Water, small molecules, soluble proteins LDL, cholesterol, transferrin, growth factors, antibodies, MHC complexes
Maintenance of nonthrombogenic barrier	Secretion of anticoagulants Secretion of antithrombogenic agents Secretion of prothrombogenic agents	Thrombomodulin Prostacyclin (PGI_2), tissue plasminogen activator (TPA), antithrombin III, heparin Tissue thromboplastin, von Willebrand factor, plasminogen-activator inhibitor
Modulation of blood flow and vascular resistance important	Secretion of vasoconstrictors Secretion of vasodilators	Endothelin, angiotensin-converting enzyme (ACE) Endothelial-derived relaxation factor (EDRF)/nitric oxide (NO), prostacyclin
Regulation of cell growth	Secretion of growth-stimulating factors Secretion of growth-inhibiting factors	Platelet-derived growth factor (PDGF), hemopoietic colony-stimulating factors (GM-CSF, G-CSF, M-CSF) Heparin, transforming growth factor β (TGF-β)
Regulation of immune responses	Regulation of leukocyte migration by expression of adhesion molecules Regulation of immune functions	Selectins, integrins, CD marker molecules Interleukin molecules (IL-1, IL-6, IL-8), MHC molecules
Maintenance of extracellular matrix	Synthesis of basal lamina Synthesis of glycocalyx	Type IV collagen, laminin Proteoglycans
Involvement in lipoprotein, cholesterol, metabolism	Production of free radicals Oxidation of LDL	Reactive oxygen species (ROS), LDL, VLDL

Modified from Cotran S, Kumar V, Collins T, Robbins SL, eds. *Robbins Pathologic Basis of Disease*. Philadelphia: WB Saunders, 1999.

Shear stress (dragging force generated by the blood flow) produced between **erythrocytes** and **endothelial cells**

Activate eNOS

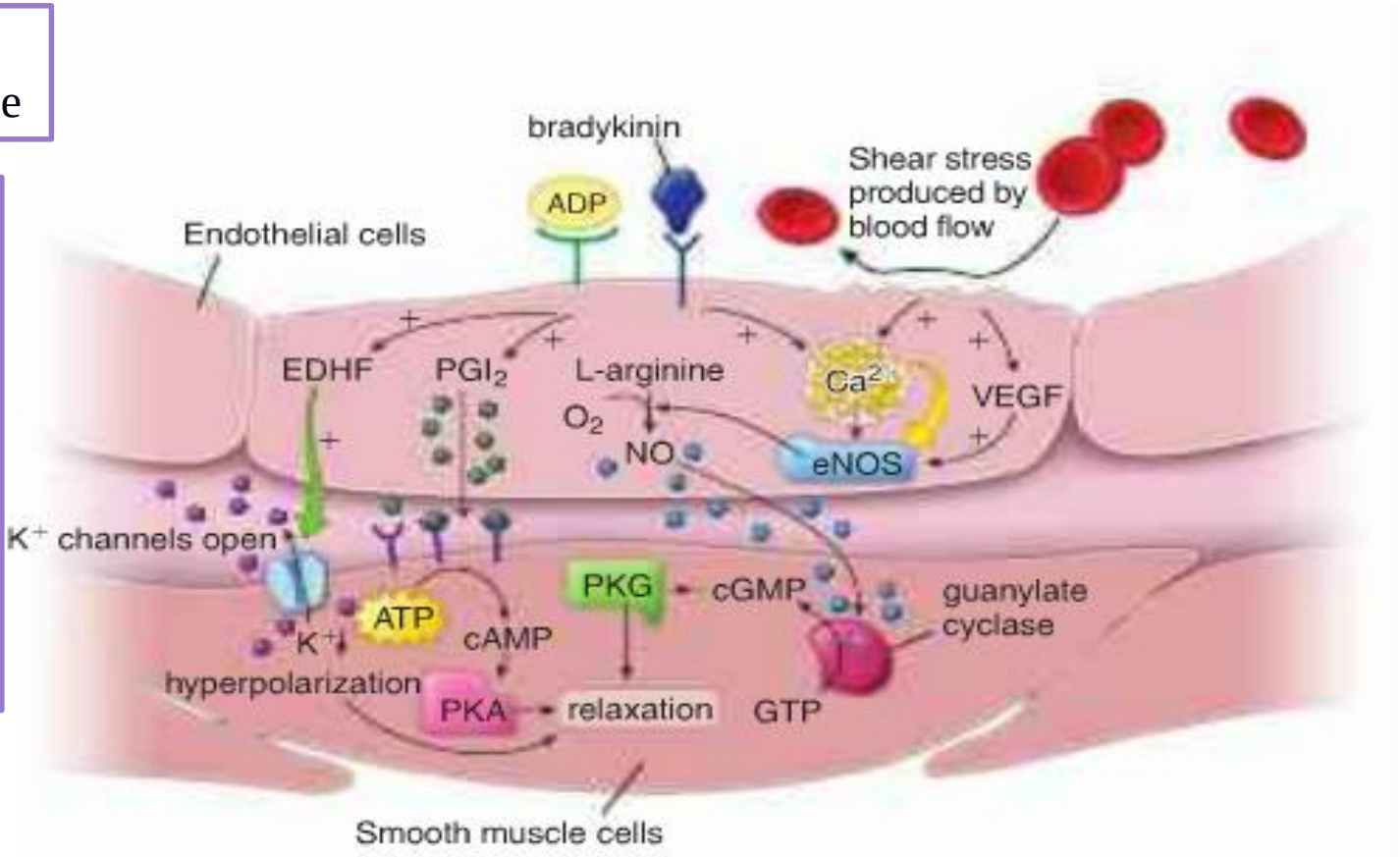
Increasing the production of NO

It diffuses to the underlying smooth muscles and activates **guanylatecyclase** production of **cGMP** which in turn activates

c GMP-dependent protein kinase G (PKG) metabolic pathways

Causing **Smooth Muscle relaxation.** *(Vasodilation)*

- (eNOS):endothelial nitric oxide synthase
- NO: is an endogenous vasodilatory gas continuously synthesized in endothelial cells by endothelial nitric oxide synthase (eNOS).



Subendothelial Connective Tissue

Composed of:

- Loose connective tissue.
- Few scattered longitudinally arranged smooth muscle cells

** It should be underlying connective tissue in order to give blood supply to endothelium.*

Internal Elastic Lamina

** Why do we need it?*

The size of whole arteries is changeable and endothelial cells need to be supported and not to detach from each other by internal elastic lamina (that surrounds them and gives them the ability and a bit of mobility during vasoconstriction & vasodilation of b.v) .

Well developed in muscular arteries.

Composed of fenestrated sheet of elastin.

Permits diffusion of substances into deeper layers.

Tunica Media

Tunica Media …1

(Smooth muscle cells are the most important cells in T.Media).

The largest layer in arteries.

Contains smooth muscle fibres, elastic fibres, collage type III and proteoglycans.

In capillaries and post capillary venules this layer is replace by pericytes.

The fibres and ground substance are secreted by smooth muscle cells.

There are ***NO*** fibroblasts in this layer.

** vascular smooth muscle cells function as contractile apparatus as well as production fibers, ground substance.*

Fibroblasts are not present in the tunica media
Smooth muscle cells synthesize
The collagen
Elastin
and other molecules of the extracellular matrix

** Endothelium can ask smooth muscle cells to come and migrate to adjacent intima .*

In addition, in response to growth factors
(i.e., PDGF, FGF) produced by endothelial cells

smooth muscle cells **may Proliferate and Migrate to the adjacent intima**.
This characteristic is important in normal *repair of the vascular wall* and in pathologic processes similar to those occurring in ***atherosclerosis***

** In pathological conditions that affect b.v , you need to remember that T.intima and its main cells (endothelium) & T.media with smooth muscle cells—> interact with each other. So, the intima itself will bulge and become bigger in response of inflammatory diseases such as; atherosclerosis.*

External Elastic Lamina (tunica media…2)

Present in large **muscular arteries.**

More delicate than the internal lamina.

It is also fenestrated.

Tunica Adventitia

Tunica Adventitia

(protective layer)

Thickest layer in veins.

Composed mainly of ***fibroblasts, type I collagen and few elastic fibres***.

It is continuous with the surrounding connective tissue.

** T.Adventitia is usually covered by perivascular fat.*

Contains **Vasa Vasorum**

They are small arteries.

Supply the wall of large vessels (more in veins than in arteries).

Branch profusely.

Contains Nerve supply to vessels

Vessels receive unmyelinated sympathetic vasomotor (vasoconstrictor) fibres.

** The main neurotransmitter released by sympathetic fibers and causes constriction of b.v*

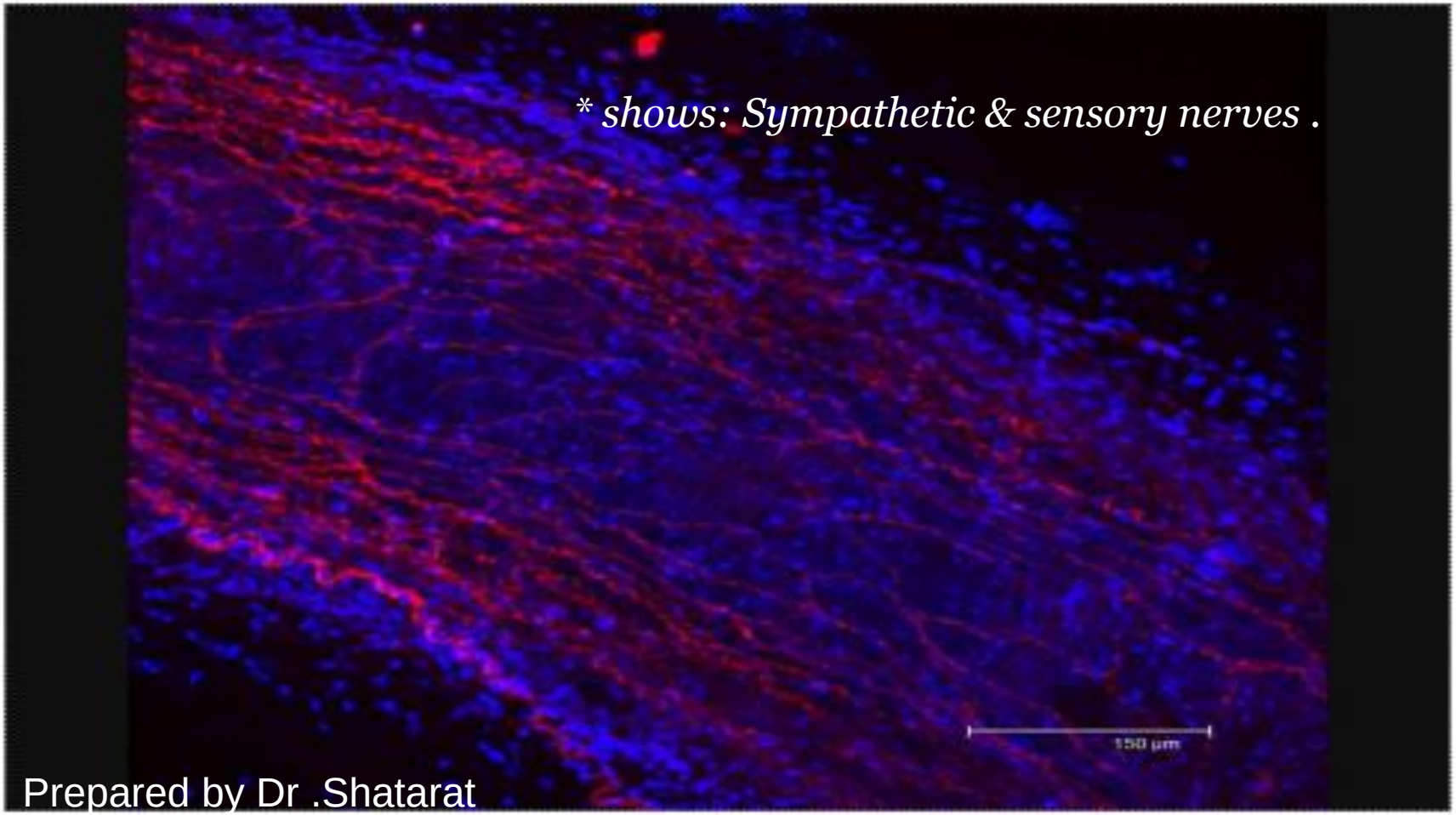
Neuoropeptide Y

Nerves enter the adventitia, release **Norepinephrine (NA)**, **ATP** and **NPY** as neurotransmitters which diffuse into the media, and stimulates smooth muscles.

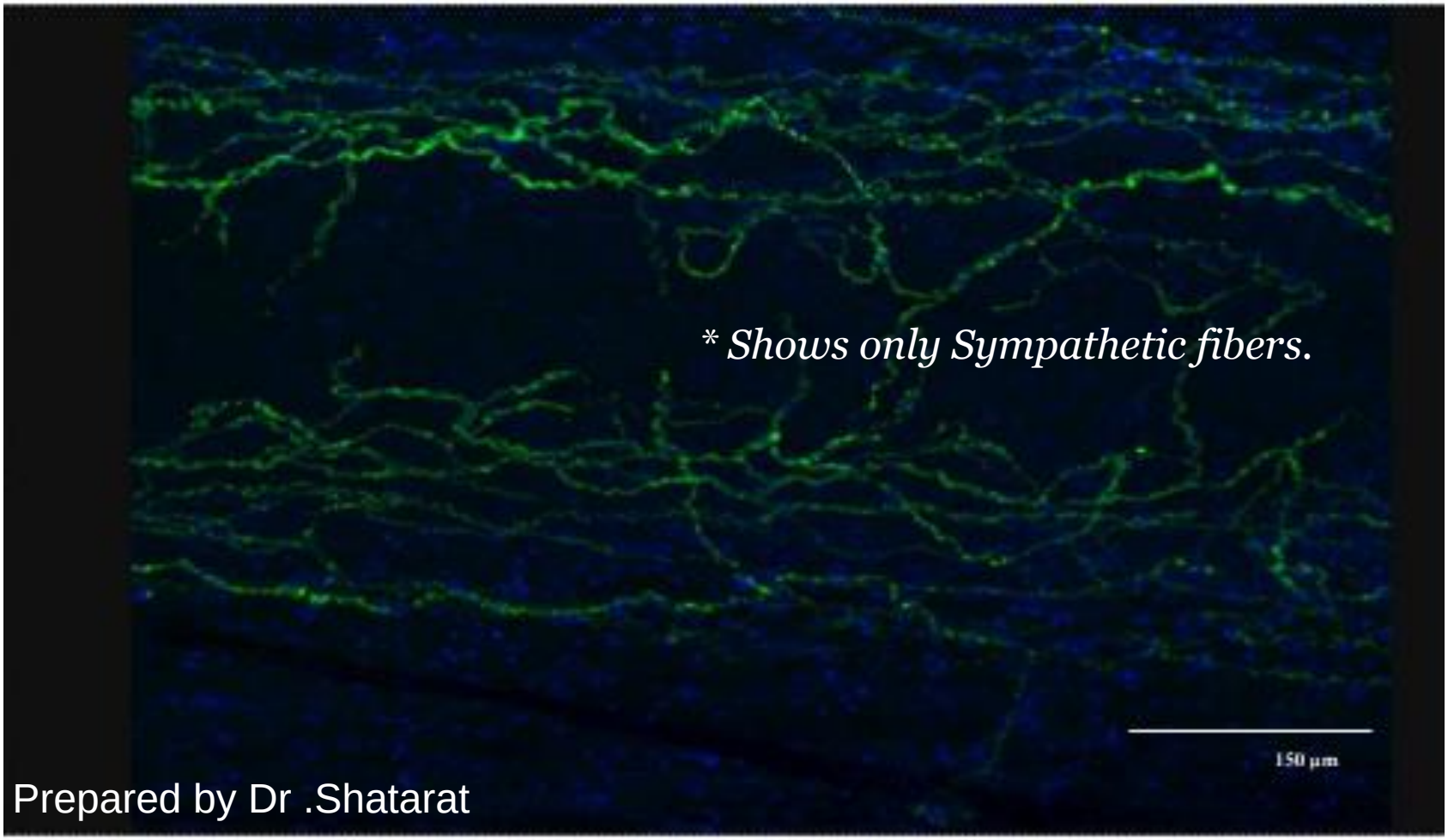
Read and enjoy

Raised tone reveals ATP as a sympathetic neurotransmitter in the porcine mesenteric arterial bed

Amjad shatarat, William Dunn, Vera Ralevic



A representative of maximum projection confocal images of whole-mount preparations of porcine mesenteric small arteries. A) Immunoreactive perivascular nerves stained for PGP9.5 (red) can be seen. Scale bar = 150 µm



A representative of maximum projection confocal images of whole-mount preparations of porcine mesenteric small arteries. A) Immunoreactive perivascular nerves stained for TH (green) can be seen. Scale bar = 150 μm.

!

Blood vessels Control

An increase in

sympathetic stimulation typically stimulates the smooth muscle to contract and narrowing the lumen. Such a decrease *in the diameter* of the lumen of a blood vessel is called

vasoconstriction

** vasoconstriction: in response of efficient O2 , so endothelium secrets endothelin —> contraction of b.v to control blood flow.*

** Vasodilation: if the tissue is hungry to O2 and needs more —> endothelium releases NO and cause relaxation of b.v*

In contrast, decreases, or in the presence of certain chemicals (such as nitric oxide) or in response to blood pressure, smooth muscle fibers relax. The resulting increase in lumen diameter is called

vasodilatation

** Endothelium picks up local signals in blood, perivascular nerves in T.Adventitia picks up body's signals(responses) , and under the effect of two regulators —> T.media either constrict or dilate.*

ROLE OF BLOOD VESSELS IN THE REGULATION OF SYSTEMIC BLOOD PRESSURE

Read and enjoy

Systemic blood pressure is the product of the cardiac output and systemic peripheral vascular resistance. The homeostatic systems that influence blood pressure are neural regulation, arterial baroreceptors and chemoreceptors, regulation of fluid volume, and humoral regulation (Guyton, 2005). Apart from the regulation of fluid volume, which is mainly controlled by the action of the kidneys, other factors that regulate systemic blood pressure mainly target blood vessels, with small arteries being crucial in the control of peripheral resistance and hence in regulating blood pressure. Blood vessels diameter is controlled by the three layers that compose the blood vessels. The innermost layer of blood vessels, which is called the endothelium, can actively contribute to the contractile status of blood vessels by releasing several biologically active substances including nitric oxide (NO) (Furchgott et al., 1984), prostacyclin (Moncada et al., 1979), as well as endothelium derived hyperpolarizing factor (EDHF) (Taylor and Weston, 1988).

Read and enjoy

The outermost layer of blood vessels, called the adventitia, contains perivascular nerves which are usually of two types; sympathetic and sensory (also called sensory-motor or capsaicin-sensitive sensory nerves). Both mediate their functions by releasing different neurotransmitters. Between the endothelial and adventitial layers is a layer of smooth muscle cells which responds to the different signals released from endothelium and perivascular nerves in the adventitia to enable the blood vessel to alter its diameter.

Thus the function of blood vessels is under a dual regulation of endothelium and perivascular nerves (Burnstock, 1990). Furthermore, blood vessels are also regulated by hormones within the blood and formed elements of blood such as red blood cells (RBC). RBC act as a sensor for hypoxia thus when O2 levels become low RBC release adenosine triphosphate (ATP) which stimulates vasodilatation (Dietrich et al., 2000). Therefore, blood vessel contractility is orchestrated by endothelium, blood borne factors and perivascular nerves. However, another mechanism which has been shown to be involved in the regulation of blood flow is the ability of small arteries, especially arterioles, to develop myogenic tone (MT) (Johnson, 1981). MT is the ability of small blood vessels to constrict in response to increases in intraluminal pressure or to relax in response to decreases in blood pressure regardless of the neuronal, hormonal and metabolic influences (Davis and Hill, 1999).

Written by Dr. shatarat