جامعة الملك سعود
King Saud University

MED438
KING SAUD UNIVERSITY

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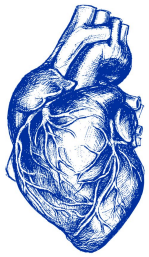
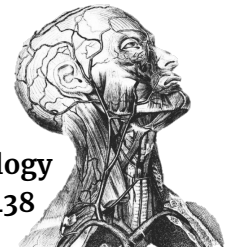
Lecture 13

Capillary circulation

- Red: important
- Black: in male / female slides
- Pink: in female slides only
- Blue: in male slides only
- Gray: extra information

Editing file





Physiology
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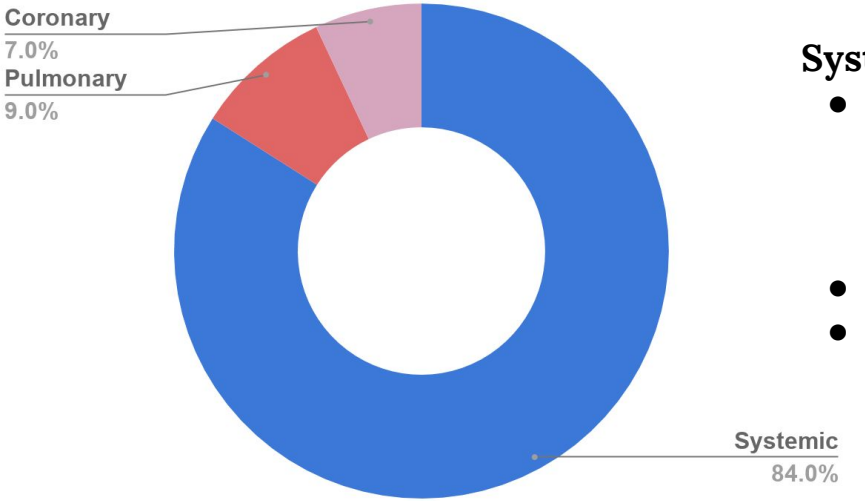
Objectives:

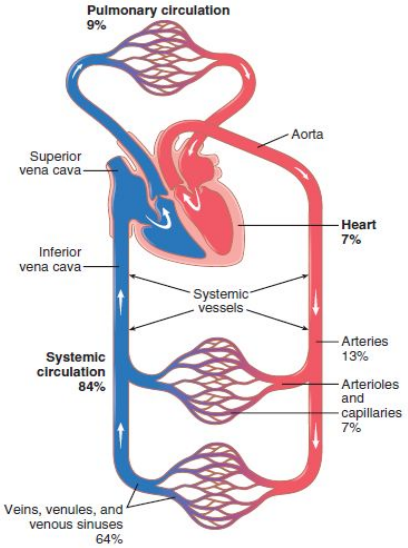
- Classification of The Vascular System
- Distribution of Blood Within the Circulatory System
- Structures of Capillary Wall
- Components of the microcirculation
- Types of blood capillaries
- Regulation of flow in the capillary beds.
- Diffusion and filtration. (Exchange of Fluid Between Capillaries & Tissues)
- Define edema, state its causes and discuss its mechanisms.
- The Lymphatic System

❑ Blood Distribution In Different Parts Of Circulatory System



Systemic circulation is split into:

- **Veins**, venules and venous sinuses = 64% (venous system serves as reservoirs for blood, particularly veins of abdominal organs and skin)
- **Arteries** = 13%
- **Capillaries,** arterioles, and heart = 7%



❑ Blood Vessels Comparison

Aorta	Arteries	Arterioles	Capillaries	Venules	Veins
Elastic recoil	Muscular, low resistance vessels	High resistance vessels	Exchange vessels	Capacitance vessels	Capacitance vessels

The Capillaries

- **Smallest** blood vessels, one endothelial cell thickness.
- Exchange vessels:
  - Provide direct **access** to cells.
  - Most **permeable**.
  - **Permits exchange** of nutrients & wastes.

Capillary Network

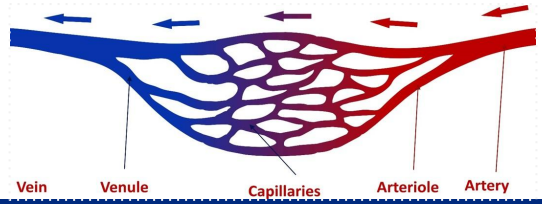
Female slides

- Blood flows from **arterioles** → **metarterioles** → **capillary** network (the shunt).
- **Venules drain** the network.
- **Smooth muscle** in arterioles, metarterioles, precapillary sphincters regulates blood flow (autoregulation).

Functions Of Capillaries

male slides

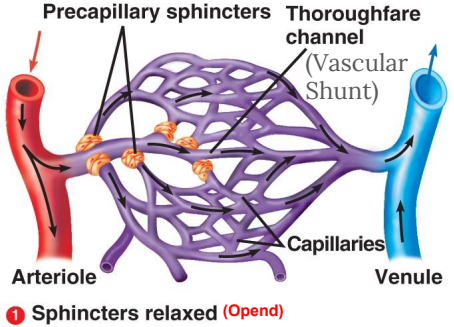
- They form a **selectively permeable** barrier between the circulatory system and the tissues supplied.
- Play a **metabolic role** produce prostacyclins, blood cell growth factors, fibroblast GF, platelet GF, and ACE in the lungs.
- **Inactivation** of intercellular messengers
- **Antithrombotic** function

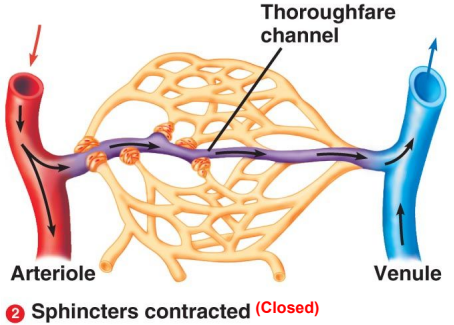


Capillary Bed

Capillary bed consist of **two types of vessels:**

Vascular shunt	True capillaries (exchange vessels)	
Directly connects an arteriole to a venule	Allow **O2 & nutrients** crossing <u>to cells</u>	Take up **CO2 & metabolic waste** products <u>from cells</u>





Components of Microcirculation

- **Arteriole = resistance**
- **Venule = capacitance**
- **Capillary = exchange of gas and water**

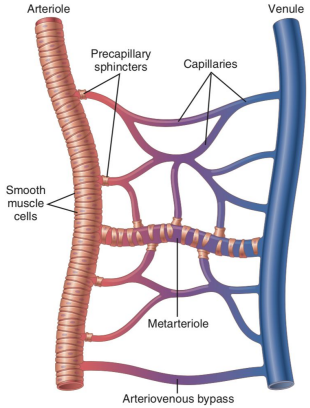


Figure 16-1. Components of the microcirculation.

Arterioles: highly muscular, and their diameters can change manyfold. The metarterioles (terminal arterioles) do not have a continuous muscular coat, but smooth muscle fibers encircle the vessel at intermittent points.
Venules: larger than the arterioles with a much weaker muscle coat. The pressure in the venules is much less than that in the arterioles, so the venules can still contract considerably despite the weak muscles.

Types Of Capillaries

Recall from histology lecture

Types based on diameter and or permeability:		
Continuous Capillaries	**Fenestrated Capillaries**	**Sinusoidal/discontinuous Capillaries**
- Do NOT have fenestrae (poers) - **Found in:** muscle, lung, and adipose tissue	- **Have fenestrae**: allow large substances to pass but NOT plasma proteins. - **Found in:** kidney glomeruli, small intestine, and endocrine glands.	- **Large diameter with large fenestrae.** (High permeability) - **Found in:** liver, spleen, bone marrow, lymphoid tissue, and some endocrine glands.

Female slides

What is the benefit of having sinusoidal capillaries between rows of hepatocytes?

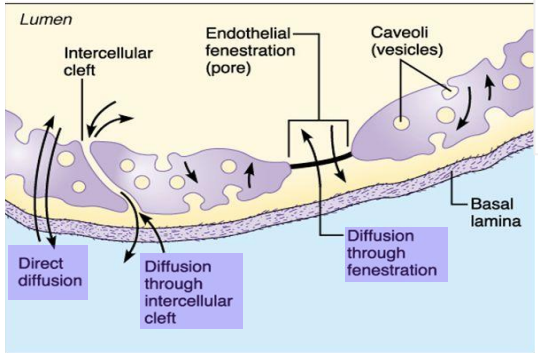
• Sinusoids are low pressure (to allow free exchange from blood into hepatocyte) vascular channels that receive blood from terminal branches of the hepatic artery and portal vein at the periphery of lobules and deliver it to central veins.

• They are lined with endothelial cells, highly porous, and can collect nutrient-rich blood coming from the small intestine. They also remove micro-debris.

Female slides

Diffusion in Capillary Walls

- **Direct** diffusion
- Diffusion through **intercellular cleft**
- Diffusion through **fenestration**

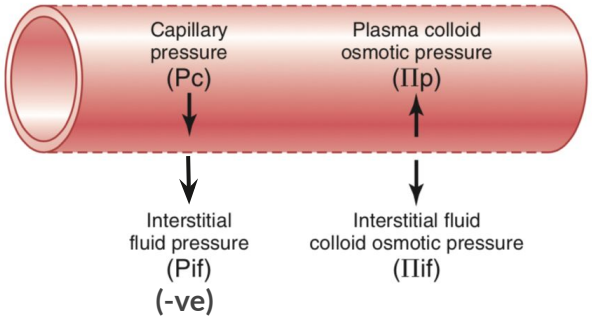


Fluid Exchange Between Capillaries and Tissues

- **Fluid pressure** and **colloid osmotic pressure** affect movement of fluid through capillaries.
- A net movement of fluid occurs from blood into tissues.
- Excess fluid gained by tissues is **removed by lymphatic system.**
- Fluid pressure and colloid osmotic pressure forces operate at the capillary membrane and tend to move fluid either **outward** or **inward** through the membrane pores.

Diffusion at Capillary Beds (Fluid Balance)

Outward Forces ↓			Inward Force ↑
Capillary hydrostatic pressure	Negative interstitial free fluid pressure	Interstitial fluid colloid osmotic pressure	Plasma colloid osmotic pressure
Arterial end: **30-40**mmHg **Venous** end: **10-15**mmHg	**3** mmHg	**8** mmHg	**25-28** mmHg



You can read more about it here

Analysis of the Forces ✦

Very important to know how to calculate the net force

At arterial end	
Forces Tending to Move Fluid Outward	**mm Hg**
Capillary pressure	30
Negative interstitial free fluid pressure	3
Interstitial fluid colloid osmotic pressure	8
TOTAL OUTWARD FORCE	41
Forces Tending to Move Fluid Inward	
Plasma colloid osmotic pressure	28
Summation of Forces	41-28=13
NET OUTWARD FORCE : cause filtration	13

At venous end	
Forces Tending to Move Fluid Outward	**mm Hg**
Capillary pressure	10
Negative interstitial free fluid pressure	3
Interstitial fluid colloid osmotic pressure	8
TOTAL OUTWARD FORCE	21
Forces Tending to Move Fluid Inward	
Plasma colloid osmotic pressure	28
Summation of Forces	28-21=7
NET INWARD FORCE : cause reabsorption	7

13 mmHg filtration pressure causes on average about 1/200 of the plasma in the flowing blood to filter out of the arterial ends of the capillaries into the interstitial spaces

Fluid Filtration & Reabsorption In Normal Microcirculation

At arterial end:

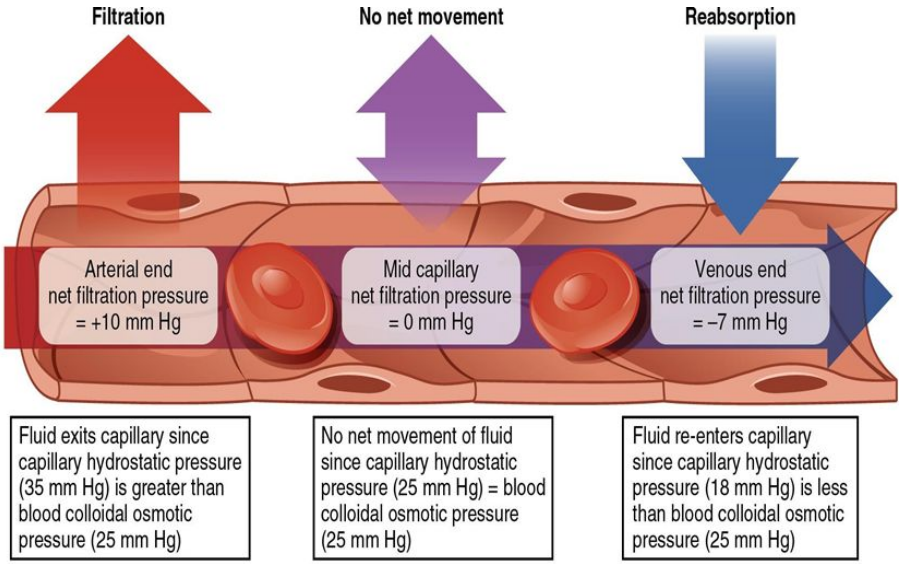
Water moves **out** of the capillary with a NFP of +5 to +10 mmHg.

Hydrostatic pressure dominates at the arterial end & net fluid flows out of the circulation.

At venous end:

Water moves **into** the capillary with a NFP of -5 to -7 mmHg.

Oncotic pressure dominates at the venous end & net fluid will flow into the circulation



Lymphatic capillaries

Lymphatic capillaries are small, thin-walled micro-vessels located in the **spaces between cells** EXCEPT CNS.

- Carries lymph into lymphatic vessels, connects to a lymph node to the venous circulation.
- Slightly **larger** in diameter than blood capillaries, allow interstitial fluid to flow into them but NOT out.

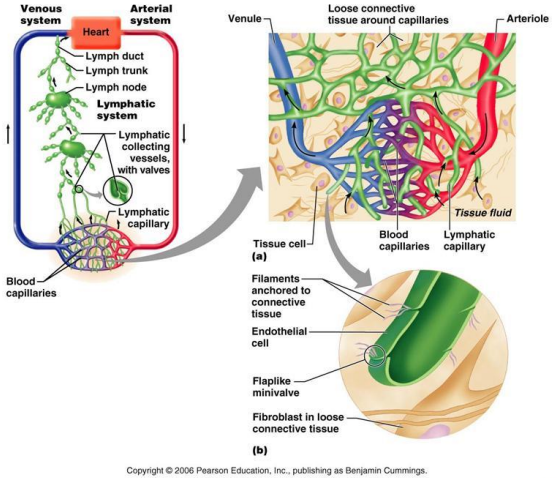


Figure 20.1

Functions:

- Drain excess interstitial (tissue) fluid back to the blood, in order to **maintain original blood volume.**
- **Transports absorbed fat** from small intestine to the blood
- Helps provide **immunological defenses** against pathogens.

Important notes :

- 90% reabsorbed at venous end of capillary, and the remain 10% absorbed by lymphatic system.
- If plasma protein oncotic pressure decreases ; this will cause **edema** and **lymphatic obstruction**

Clinical Significance Of Capillary Filtration

- **Blood loss:** Vasoconstriction of arterioles **lead to** decrease capillary hydrostatic pressure. Osmotic pressure of plasma proteins favours absorption of interstitial fluid **lead to increase** in blood volume

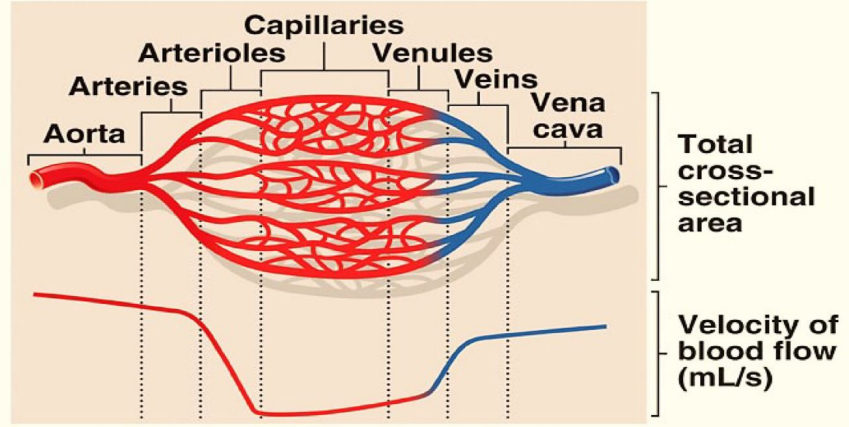
- **Congestive heart failure:** Venous pressure rises **lead to** build-up of blood in capillaries **lead to increase in** capillary hydrostatic pressure **lead to increase** in filtration **lead to** edema.

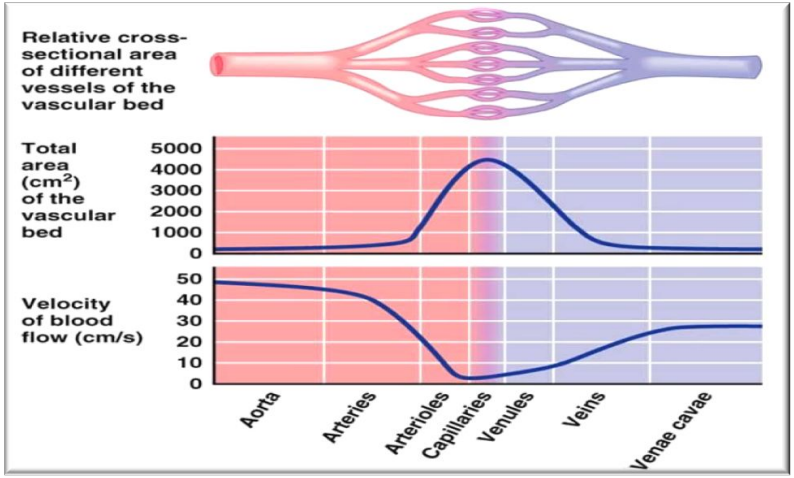
- **Hypoproteinemia** (Starvation, liver disease) **lead to decrease in** plasma protein colloid osmotic pressure **lead to** loss of fluid from capillaries **lead to** edema.

- **Inflammation:** The gaps between the endothelial cells increase because of the inflammatory mediators **lead to increase** in movement of proteins into the interstitium **lead to** edema.

Diameter and blood flow

The **velocity** of blood flow within each segment of the circulatory system is **inversely proportional** to the **total cross sectional area** of the segment. Because the aorta has the smallest total cross sectional area of all circulatory segments ,it has the **highest velocity** of blood flow





As diameter of vessels decrease, the total cross sectional area increase and velocity of blood flow decrease

Quiz

1. which of the following can occur if the plasma proteins decrease?

A. edema

B. clot

C. lymphatic obstruction

D. Both A & C

2. The True capillaries are:

A. Directly connects an arteriole to a venule

B. Exchange vessels

C. Has highest resistance

D. Has the highest capacitance

3. If the Hydrostatic pressure dominates at the arterial end , the net force will cause:

A.Filtration

B. reabsorption

C. edema

D. both A,B

4. which of the following is true about Sinusoidal Capillaries:

A. Have pores, allow large substances to pass but not plasma proteins

B. Do not have fenestrae

C. Large diameter with fenestrae

D. serves as reservoirs for blood

SAQ:

1. Describe the mechanism of how the edema occurs in congestive heart failure

Venous pressure rise→ build-up of blood in capillaries→ **increase in** capillary hydrostatic pressure→ **increase** in filtration **leading to** oedema.

2. If Forces Tending to Move Fluid Outward = 38 mmHg and the capillary pressure =28 mmHg . What is the net outward force at arterial end if the Plasma colloid osmotic pressure = 25 mmHg

=13 mmHg

Answers : D-B-A -C

Leaders

Sedra Elsirawani Abdulrahman Alhawas

Members

- Lama AlZamil
- **Arwa AlEmam**
- Noura AlTurki
- Ghada AlSadhan
- Nouf AlShammari
- Nouf AlHumaidhi
- Taibah AlZaid
- Ajeed AlRashoud
- Reem AlGarni
- Raghad AlKhashan
- Leen AlMazroa
- Sara Alarifi
- Maha AlNahdi
- Badr Almuhanna
- Abdulrahman Almezaini
- Omar Aldosari
- Omar Alghadir
- Ibrahim Alshaqrawi
- Abdullah Aldawood
- **Abdullah Shadid**
- Meshari Alzeer
- Mohammed Alhamad
- Abdullah Alassaf
- Khalid Alkhani
- Amjad Albaroudi
- Mohammed Alhuqbani