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UNIVERSITY · CANADA

Midterm #3 Review
Sections 09/010

TA: Greydon Gilmore
Physiology 2130
Feb 24th, 2020

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Courses > Phys 2130 > at bottom of page

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Your TA Reminding You….

- 3rd Midterm – Feb 28th @ 6pm (15%)
- 4th Assignment – Mar 27th (1.5%)
  - Post 2 MC questions: Mar 25th @ midnight
- 3rd Quiz – due Feb 25th @ 4pm (1%)
  - Opens: Feb 24th @ 4pm
  - Closes: Feb 25th @ 4pm
- 4th Quiz – due March 31st @ 4pm (1%)
  - Opens: March 30th @ 4pm
  - Closes: March 31st @ 4pm

Midterm Information

- When: Feb 28th from 6pm-7pm
- What: 35 multiple choice
  - Renal Physiology – 17 questions
  - Respiratory Physiology – 14 questions
  - GI physiology – 4 questions
- Where: TBD

Factors that minimize simple diffusion (p. 307)

$$Rate\ of\ dissusion = \frac{gradient\ * surface\ area}{thickness}$$

1. Huge surface area (300+ million alveoli
2. Blood flow velocity (slower flow = better reabsorption)
3. High pressure gradient
4. Thin membrane (BGB)
5. Rate of diffusion

Effects of Changing Ventilation (p. 324)

Changing ventilation affects arterial PO_2, PCO_2 and pH

A. Holding breath without changing metabolic activity
- ↓PO_2
- ↑PCO_2 (↑H^+ = ↓pH)

Less O_2 coming in at alveolar capillaries,
Less CO_2 leaving at alveolar capillaries (i.e. build up in blood)

B. Hyperventilating without changing metabolic activity
- ↑PO_2
- ↓PCO_2 (↓H^+ = ↑pH)

More O_2 coming in at alveolar capillaries,
More CO_2 leaving at alveolar capillaries (i.e. less in blood)

C. Increase metabolic activity without changing ventilation
- ↓PO_2
- ↑PCO_2 (↑H^+ = ↓pH)

More O_2 leaving at systemic capillaries (i.e. less in blood),
More CO_2 entering at systemic capillaries

Chapter 8: Renal
17 Questions on Exam

Professor: Dr. Woods

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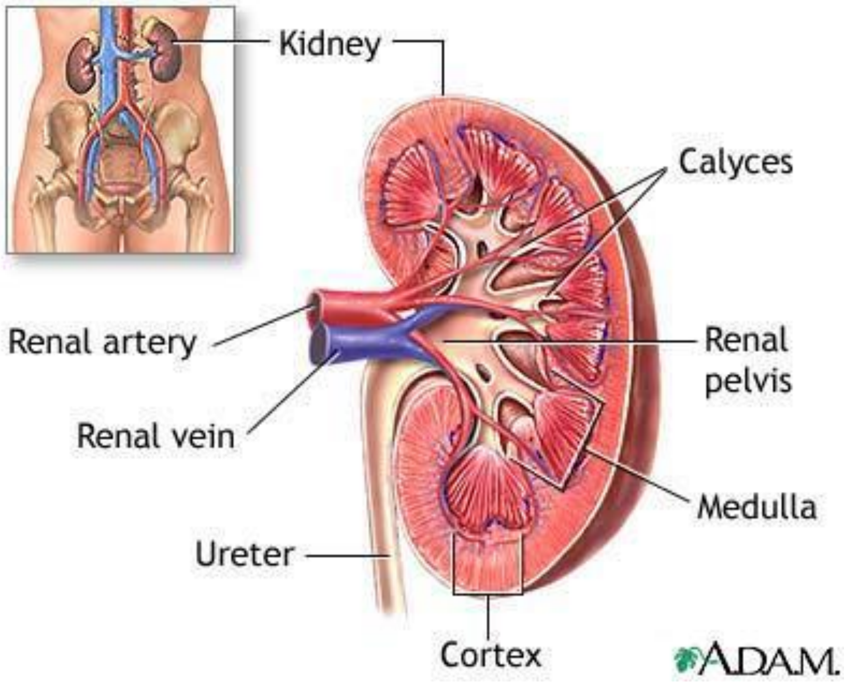
Overview of Chapter

1. Renal anatomy
2. Glomerular filtration
3. Transport mechanisms
4. Water and sodium handling
5. No Renin System
6. ANP

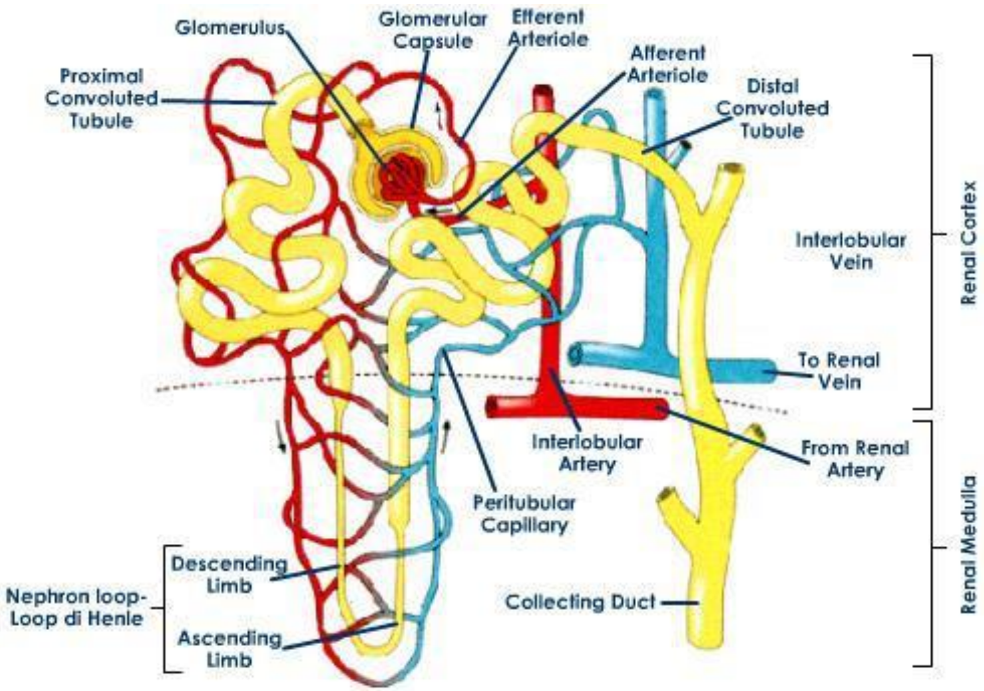
Kidney Anatomy

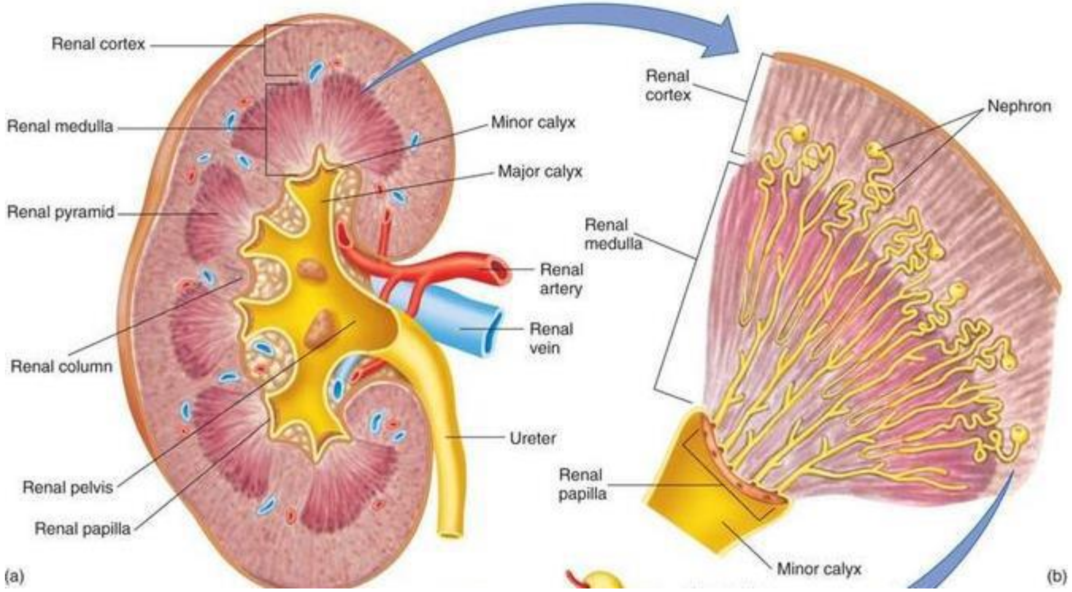
- Two kidneys that sit posterior and outside of abdominal cavity (i.e. retroperitoneal)
- Cortex = outer portion
- Medulla = inner portion
- Fluid collected into minor calyces → major calyces → renal pelvis → ureter
- Renal artery carries blood to kidneys
- Renal vein carries blood away from kidneys



Nephron Organization In The Kidney

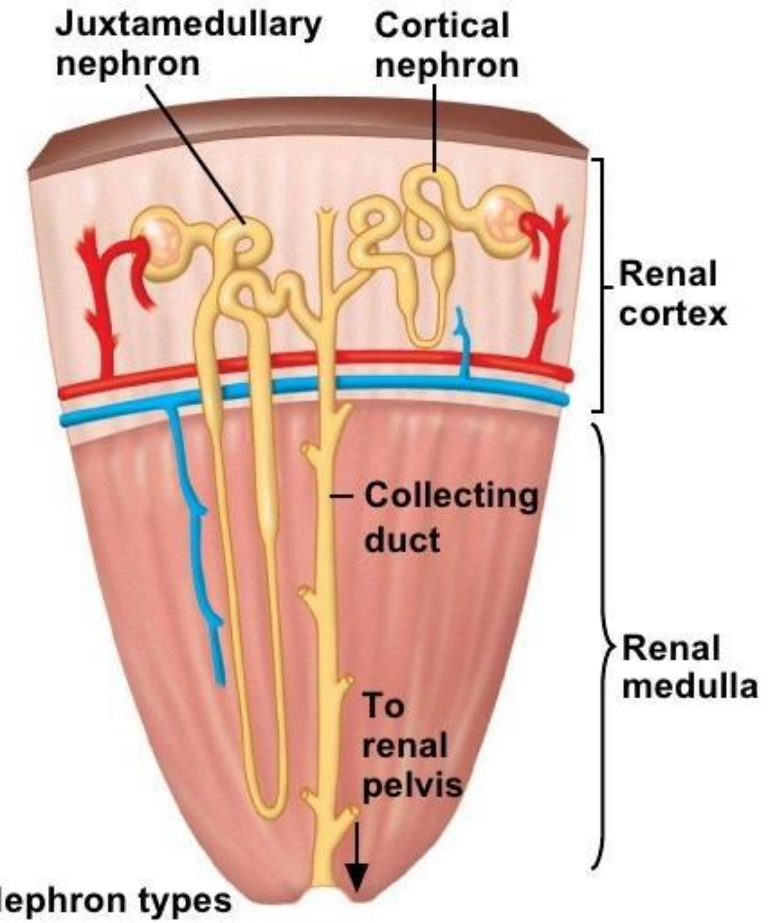
- Renal corpuscle located in cortex
- Loop of Henle projects into and out of renal medulla
- 4-5 nephrons share a collecting duct
- Collecting ducts drain into minor calyx
- In 3D, the ascending limb is found near the glomerulus





Types of Nephrons

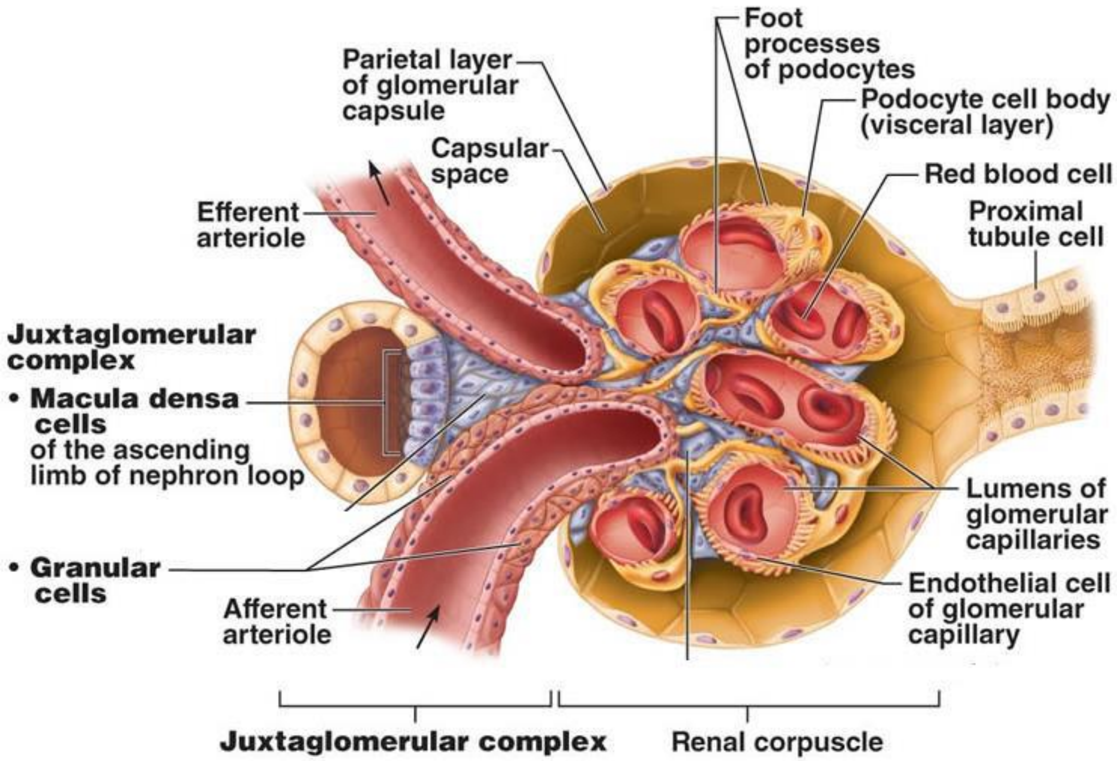
	Juxtamedullary Nephron	Cortical Nephron
# in Kidney	Few	Many
Ability to concentrate urine	Good	Bad
Ability to filter blood	Good	Good
Location of Corpuscle in Cortex	Low	High
Loop of Henle	Long	Short
Capillaries	Vasa recta	Peritubular



(c) Nephron types

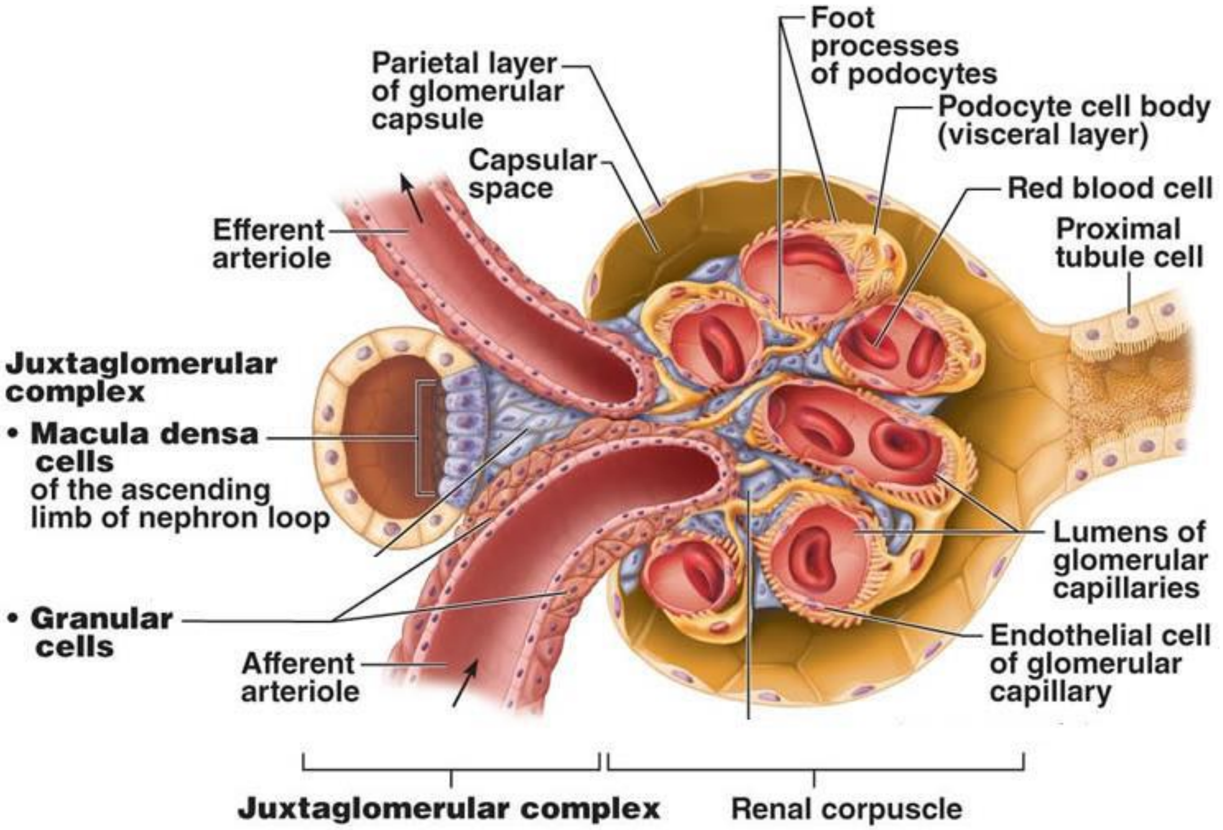
Renal Corpuscle

- Glomerulus: Group of fenestrated capillaries
- Fenestrations allow passage of many substances (ions, water, etc.) into Bowman's space (except red/white blood cells)
- Cells of Bowman's capsule (outer layer) are simple squamous epithelial cells
- Cells of Bowman's capsule (inner layer) are called podocytes
- Cells of glomerular capillaries are called endothelial cells
- Endothelial cells are fused with podocytes by basal lamina



Renal Corpuscle

- JGA: part of ascending Loop of Henle, containing macula densa
- Macula Densa: detect changes in Na^+ and Cl^- levels in filtrate, cause vasoconstriction of afferent arteriole.
- Granular Cells: release renin



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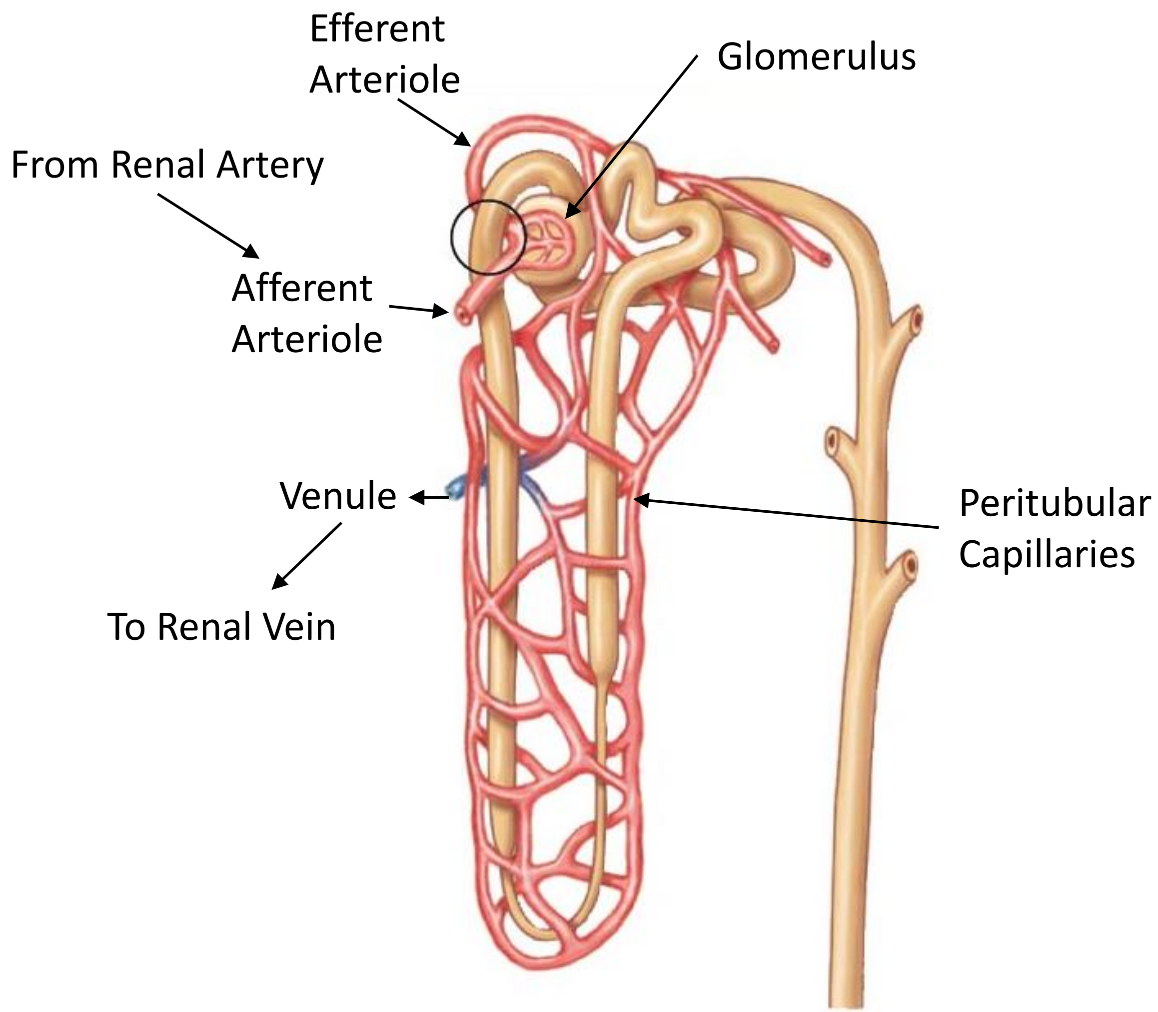
Blood Flow to the Kidneys

Blood flow to organs

Heart → Artery → Arteriole → Capillary → Venule → Vein → Heart

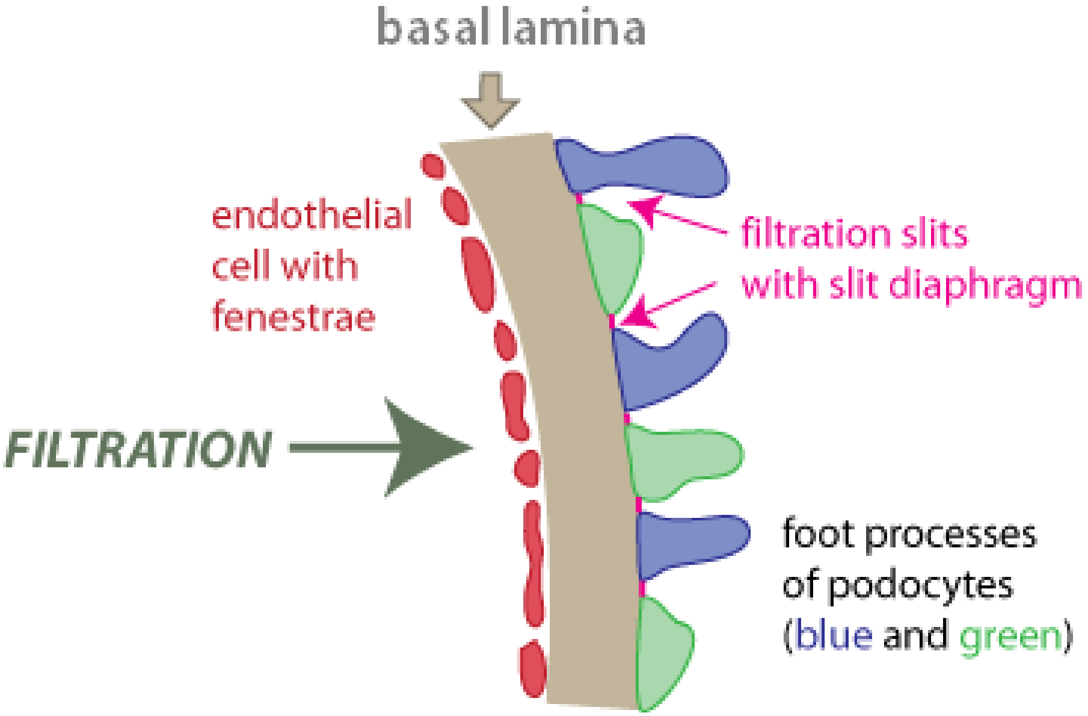
Blood flow to kidneys

Heart → Artery → Arteriole → Capillary → Arteriole → Capillary → Venule → Vein → Heart



Barriers to Filtration

1. Size of glomerular gaps/fenestrations
2. Gaps in basal lamina
3. Space between podocytes



Barriers to Filtration

- Of all the blood that arrives at kidney, only 20% is filtered
- Net filtration pressure (NFP): Sum of forces that affect filtration
  - NFP > 0 : filtration
  - NFP ≤ 0 : no filtration

	Hydrostatic Pressure of Glomerular Capillaries	Colloid Osmotic Pressure of Glomerular Capillaries	Hydrostatic Pressure of Bowman's Capsule	Colloid Osmotic Pressure of Bowman's Capsule
Abbreviation	P_{GC}	π_{GC}	P_{BC}	π_{BC}
Caused by	Blood flowing into glomerulus	Presence of proteins in glomerulus	Filtrate remaining in Bowman's space	Presence of proteins in Bowman's space
Filtration	Promotes	Inhibits	Inhibits	Promotes
mmHg	55	30	15	0

NFP Calculation

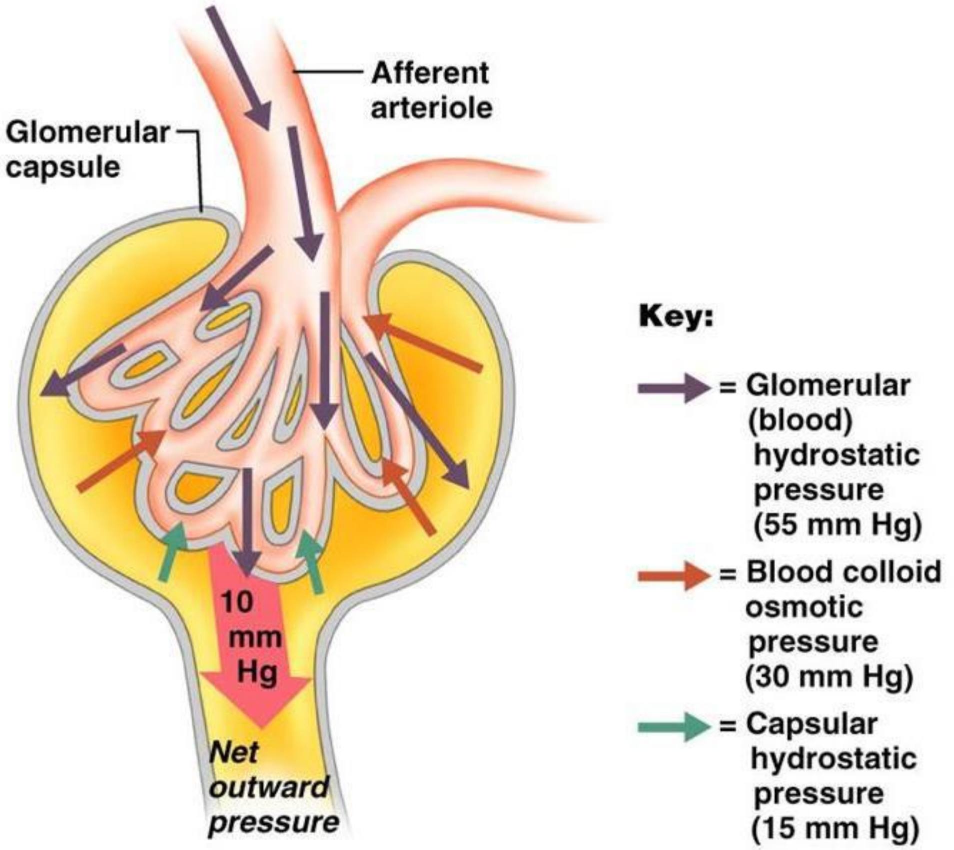
- NFP = Promotes Filtration – Inhibits Filtration

$= (P_{GC} + \pi_{BC}) - (P_{BC} + \pi_{GC})$

$= (55 + 0) - (15 + 30)$

$= 10$ mmHg

	P_{GC}	π_{GC}	P_{BC}	π_{BC}
Filtration	Promotes	Inhibits	Inhibits	Promotes
mmHg	55	30	15	0



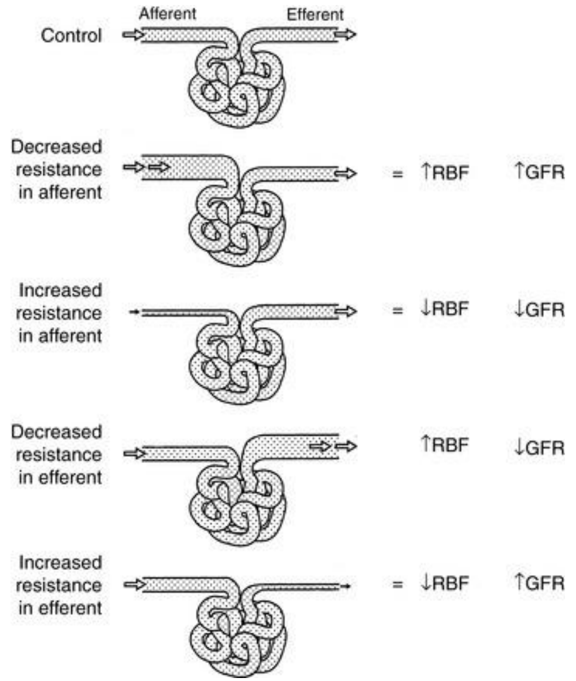
Glomerular Filtration Rate (GFR)

- Volume of fluid filtered per day by the kidneys
- Normal: 180 L/day (125 ml/min)
- Important to maintain a constant GFR throughout the day
- Affected by:
  1. Net Filtration Pressure (NFP)
     - Mostly affected by renal blood flow and pressure (P_{GC})
  2. Filtration Coefficient
     - Mostly affected by podocytes and basal lamina

GFR Regulation: Overview

- Both the myogenic response and tubuloglomerular response are used to increase and decrease GFR
- Their combined goal is to mediate a constant GFR throughout the day

	Afferent Arteriole		Efferent Arteriole	
Smooth Muscle	**Dilate**	**Constrict**	**Dilate**	**Constrict**
GFR	⬆	⬇	⬇	⬆



GFR Regulation: Myogenic Response

⬆ Arterial blood pressure

⬇

⬆ Afferent arteriolar blood pressure

⬇

⬆ Afferent arteriole stretches

⬇

⬆ Sensing by stretch sensitive ion channels (opening)

⬇

⬆ Depolarization of smooth muscle open voltage-gated Ca^{2+} channels

⬇

⬆ Smooth muscles of afferent arteriole contraction

⬇

⬆ Vasoconstriction

⬇

⬇ Blood flow in glomerulus

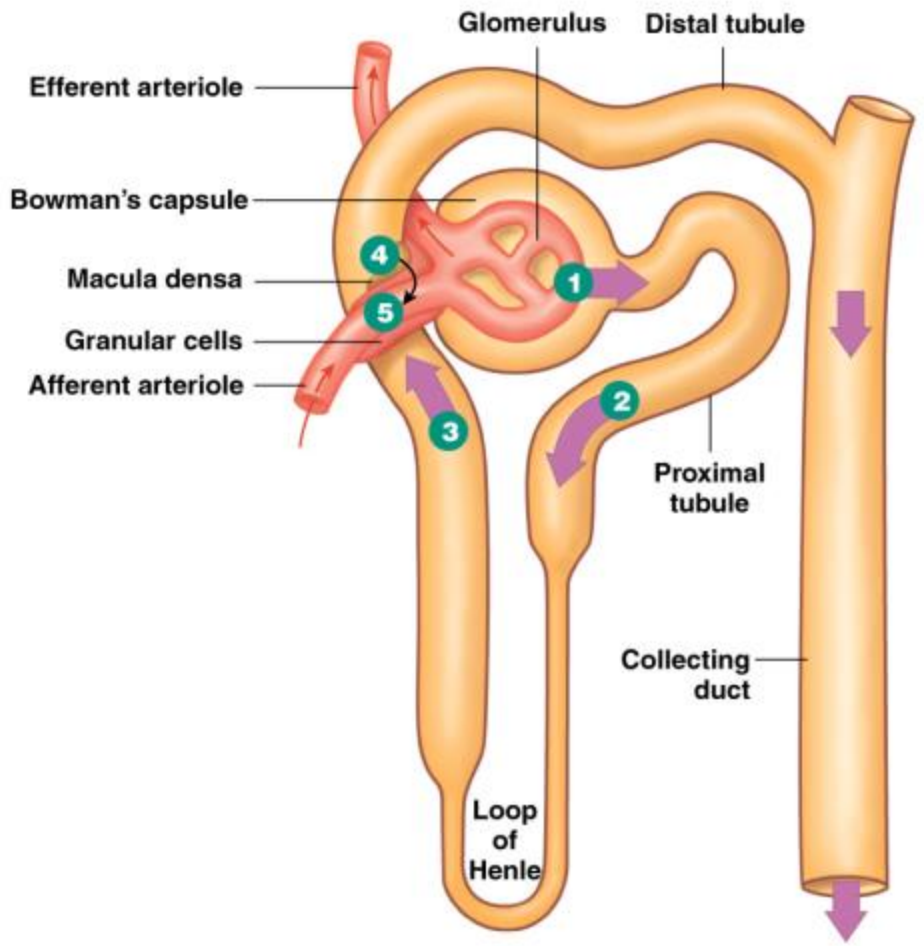
GFR Regulation: Tubuloglomerular feedback

1. GFR increases.
2. Flow through tubule increases.
3. Flow past macula densa increases.
4. Paracrine from macula densa to afferent arteriole
5. Afferent arteriole constricts.

Resistance in afferent arteriole increases.

Hydrostatic pressure in glomerulus decreases.

GFR decreases.



Measurement of GFR

- In order to measure GFR, you want to choose a substance that is excreted, but not reabsorbed
- Bad substances: glucose, ions, water
- Best substance: creatinine
- Rate of creatinine excretion from the body is equivalent to GFR
- GFR (L/day) = $([\text{Creatinine}]_{urine} \times \text{Urine/day}) / [\text{Creatinine}]_{plasma}$

$$= (90 \text{ mg/L} \times 2 \text{ L/day}) / (1 \text{ mg/L})$$

$$= 180 \text{ L/day}$$

Renal Handling

Example: Urea

Filtered Load of Urea = $[Urea]_{plasma}$ x GFR = 0.31 x 180 = 56 g/day

% Excreted = (Amount Excreted/Filtered Load) x 100% = (28/56) x 100% = 50 g/day

% Reabsorbed = 100 -% Excreted = 100 –50 = 50%

Substance	Concentration (in plasma)	Filtered Load	Amount Excreted	% Excreted	% Reabsorbed
Sodium	3.5 g/L	630 g/day	3.2 g	0.5%	99.5%
Glucose	1.0 g/L	180 g/day	0 g	0%	100%
Urea	0.31 g/l	56 g/day	28 g	50%	50%

What is true regarding reabsorption in the kidney?

a) all potassium is reabsorbed in the collecting duct
b) glucose is reabsorbed by a type of primary active transporter
c) all sodium is reabsorbed by a protein carrier transporter
d) water reabsorption can be both paracellular and transcellular in the proximal tubule

What is true regarding reabsorption in the kidney?

a) all potassium is reabsorbed in the collecting duct
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d) water reabsorption can be both paracellular and transcellular in the proximal tubule

What is true regarding the action of hormones on the nephron?

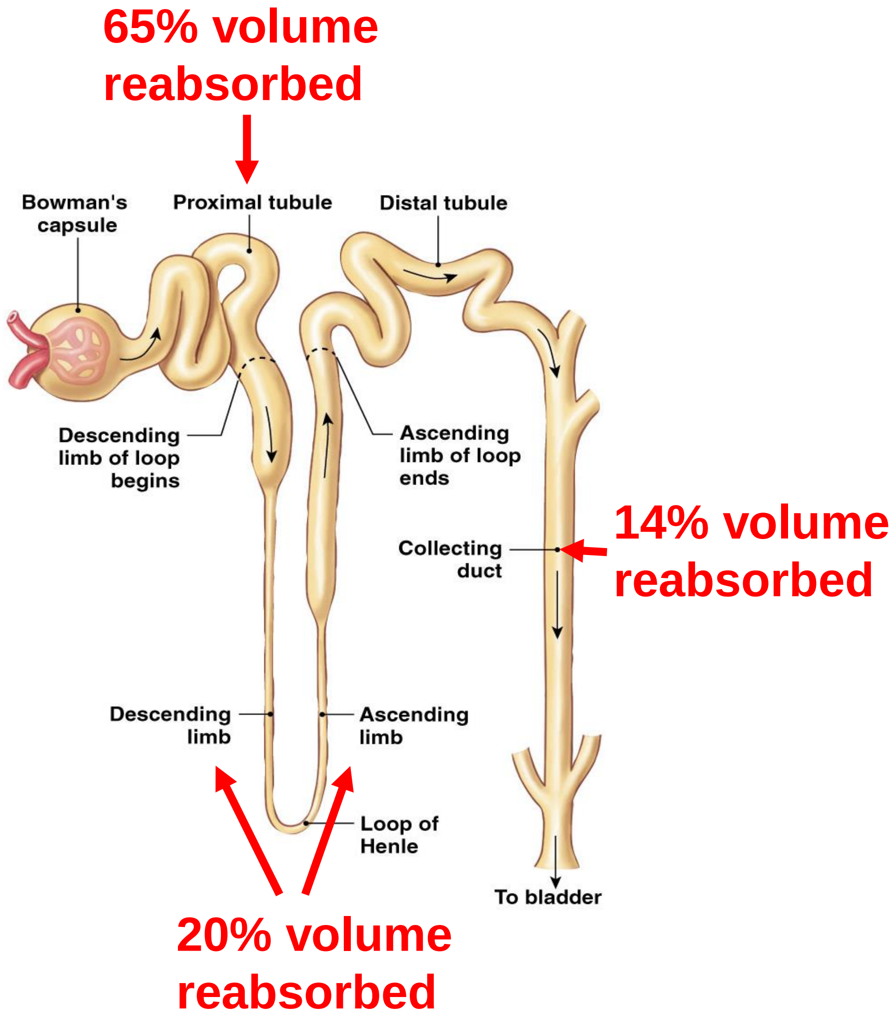
a) anti-diuretic hormone (ADH) increases sodium reabsorption in the proximal tubule
b) aldosterone increases sodium reabsorption in the collecting duct
c) angiotensinogen increases sodium reabsorption in the collecting duct
d) angiotensin II increases water reabsorption in the proximal tubule

What is true regarding the action of hormones on the nephron?

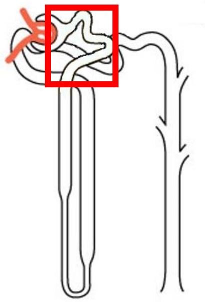
a) anti-diuretic hormone (ADH) increases sodium reabsorption in the proximal tubule
b) aldosterone increases sodium reabsorption in the collecting duct
c) angiotensinogen increases sodium reabsorption in the collecting duct
d) angiotensin II increases water reabsorption in the proximal tubule

Reabsorption Along The Tubule

Segment of Tubule	Substances	Hormone Regulation	Percent
Proximal Tubule	Glucose, H_2O, Na^+, K^+, Cl^-	Yes	65%
Descending Limb of LOH	H_2O and minimal Na^+	No	20 %
Ascending Limb of LOH	Na^+, K^+, Cl^-	No	
Distal Tubule	Na^+, K^+, Cl^- , Ca^{2+}	Yes	14%
Collecting Duct	H_2O, Na^+	Yes	



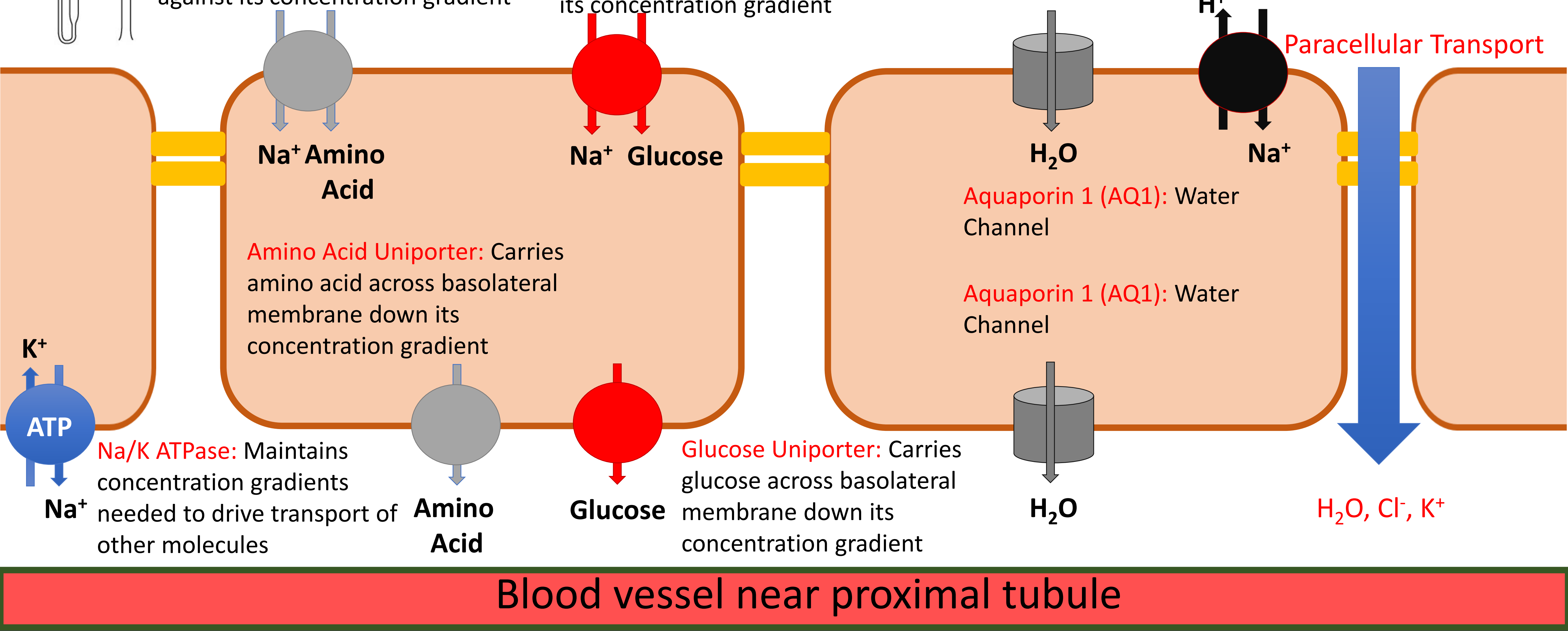
Proximal Tubule



Na+/Amino Acid Symporter: Uses Na^+ gradient to carry an amino acid across luminal membrane against its concentration gradient

Na+/Glucose Symporter: Uses Na^+ gradient to carry glucose across luminal membrane against its concentration gradient

Na/H+Antiporter/Exchanger: Uses Na gradient to carry H+ across luminal membrane into filtrate



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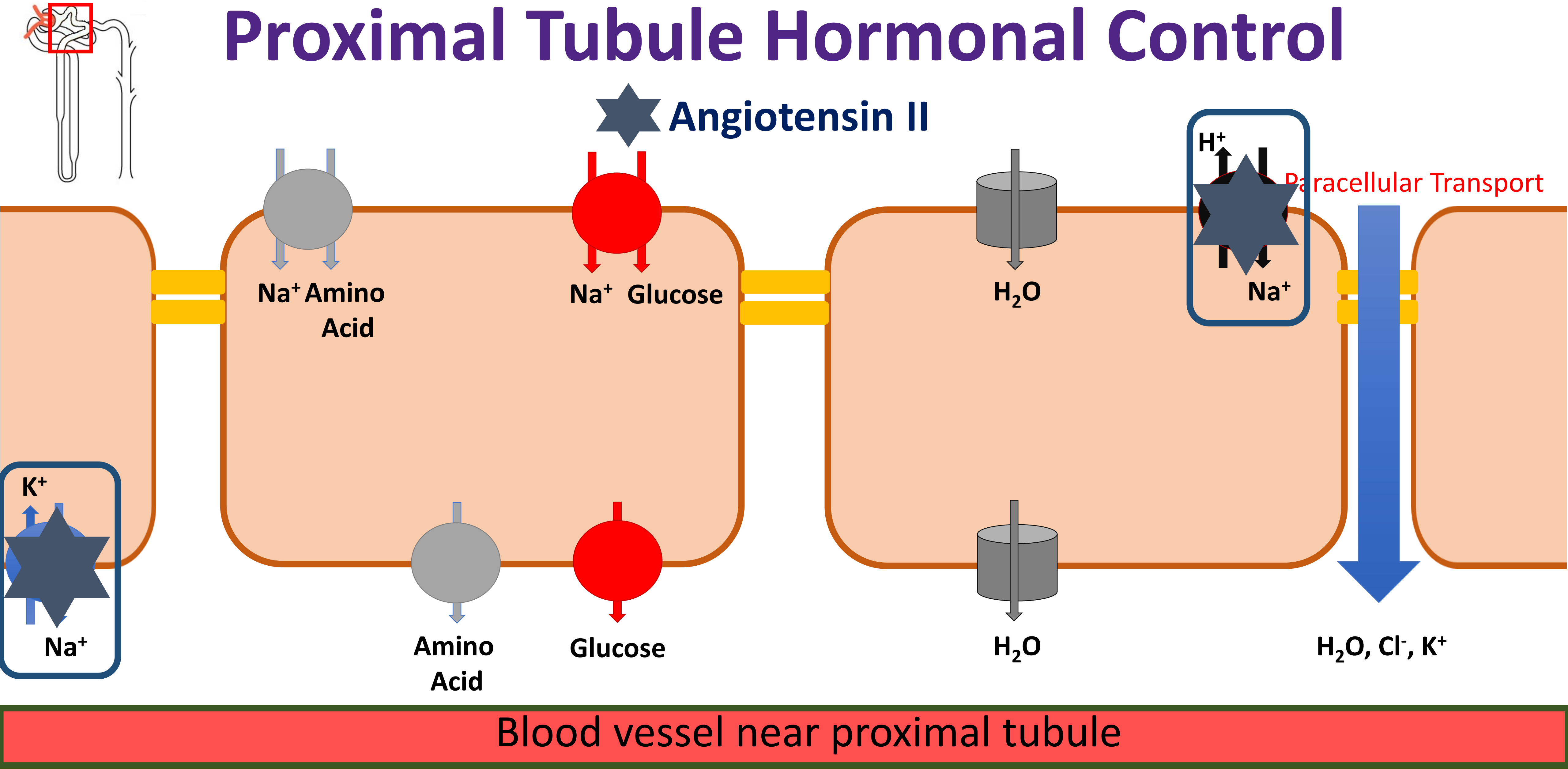
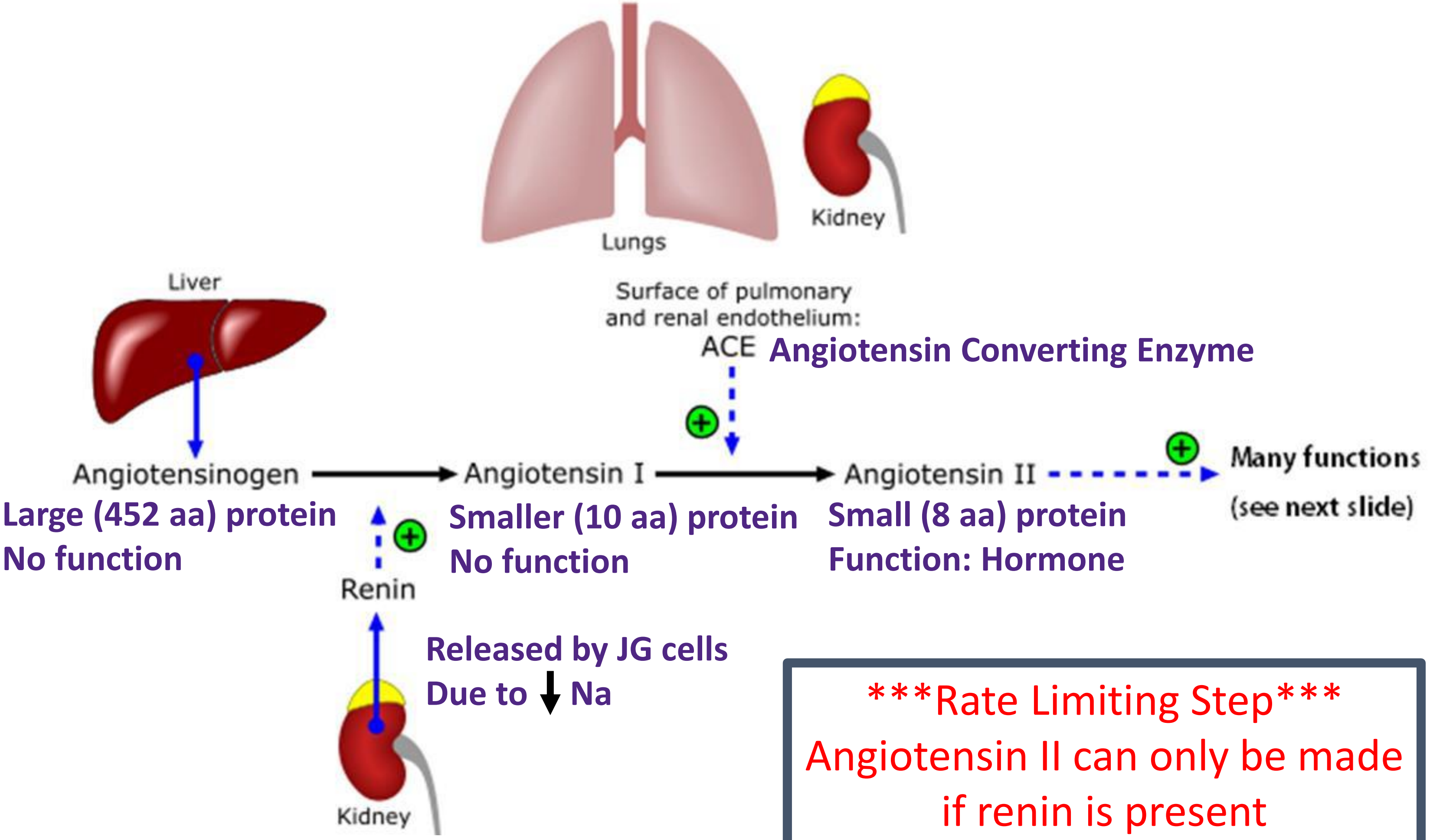
Proximal Tubule Hormonal Control



RAAS



Rate Limiting Step
Angiotensin II can only be made if renin is present

Angiotensin II

- Made by cleavage of:

  angiotensinogen ➡ angiotensin I ➡ angiotensin II
- Peptide hormone (= requires cell-surface receptor on luminal membrane)

Stimulus

- Release of renin by JG cells due to ↓ Na^+

Goal

- Increase Na^+ reabsorption in proximal tubule

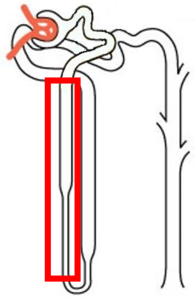
How

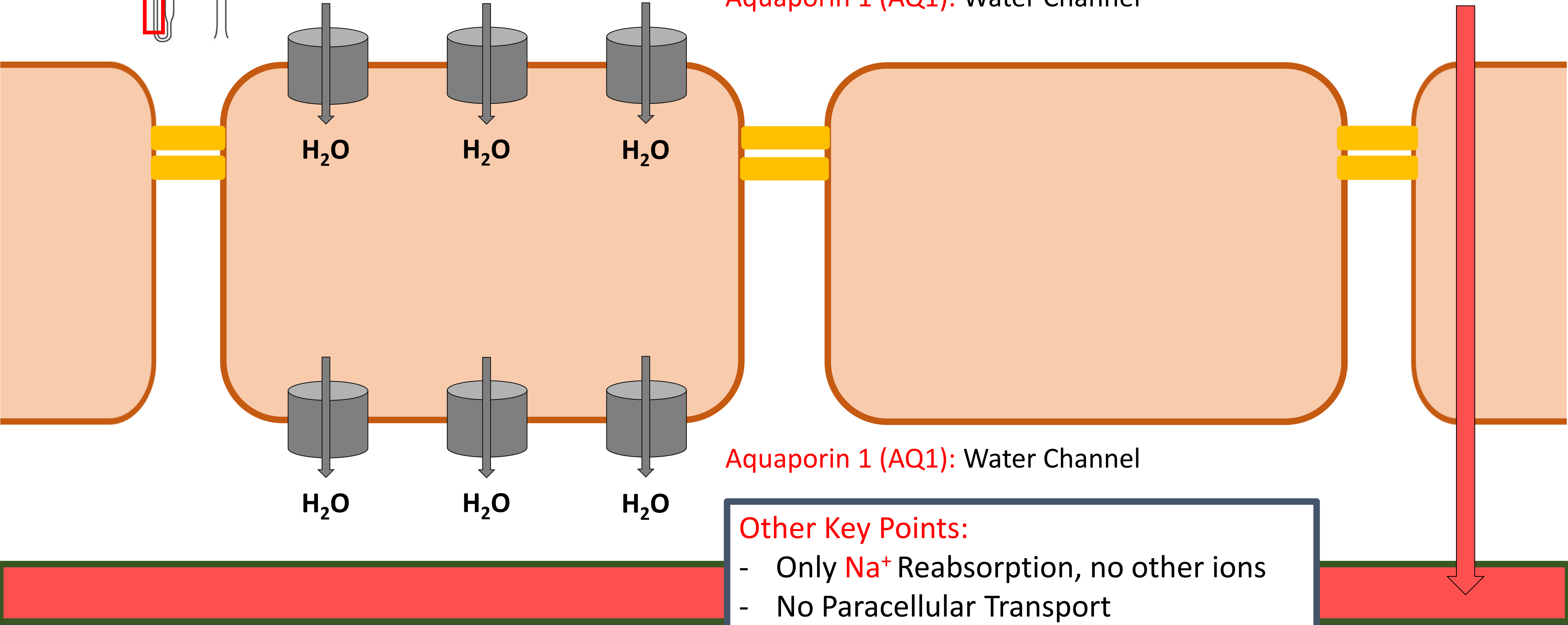
1. Increase activity of Na^+ /H^+ exchanger and Na^+ /K^+ ATPase in proximal tubule
2. Decrease GFR by constricting afferent arteriole

Renin

- Renin released due to low sodium levels

Descending LOH





Overall Goal: REABSORPTION

Other Key Points:
- Only Na^+ Reabsorption, no other ions
- No Paracellular Transport
- No Hormonal Regulation

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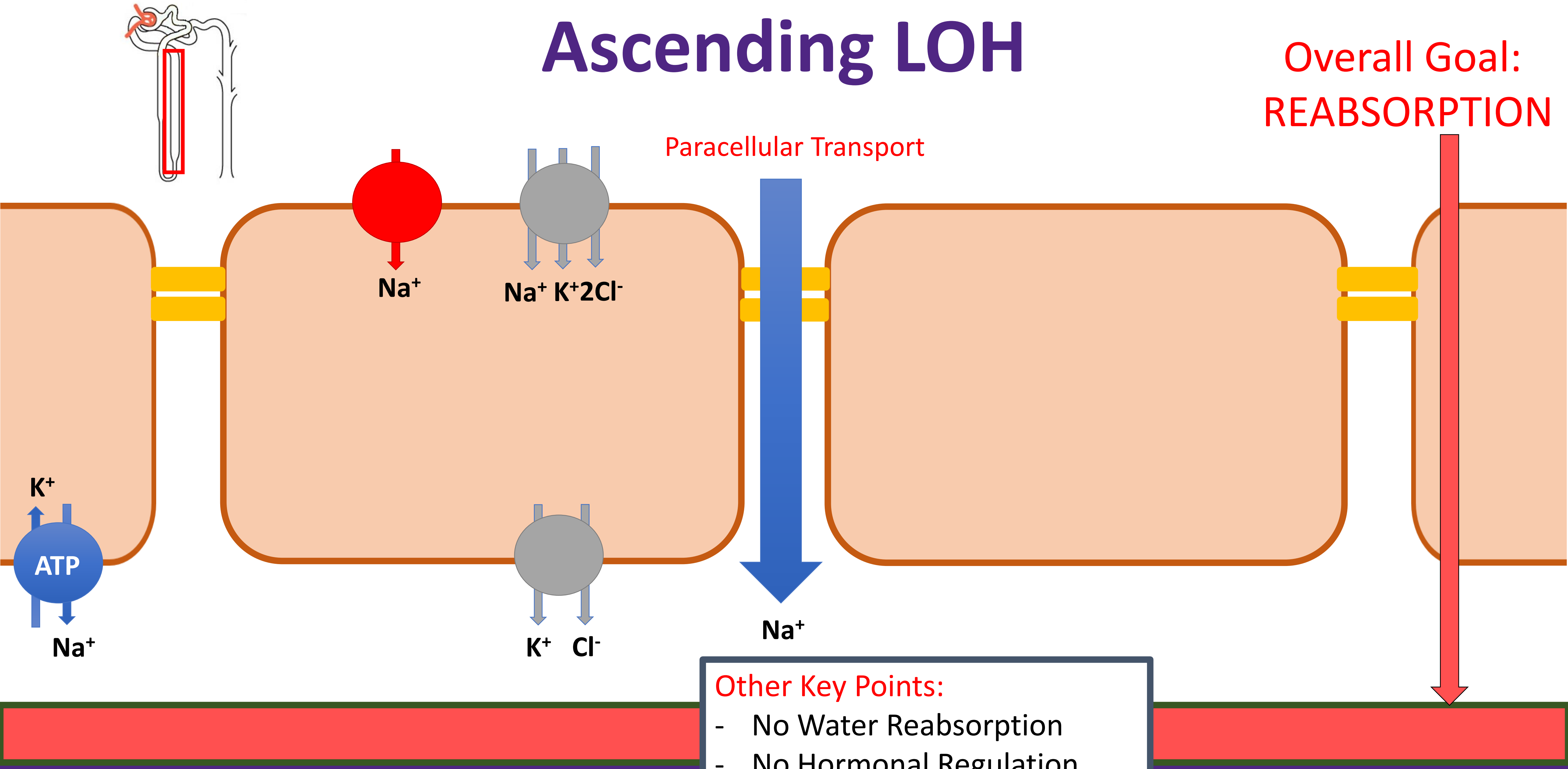
Ascending LOH

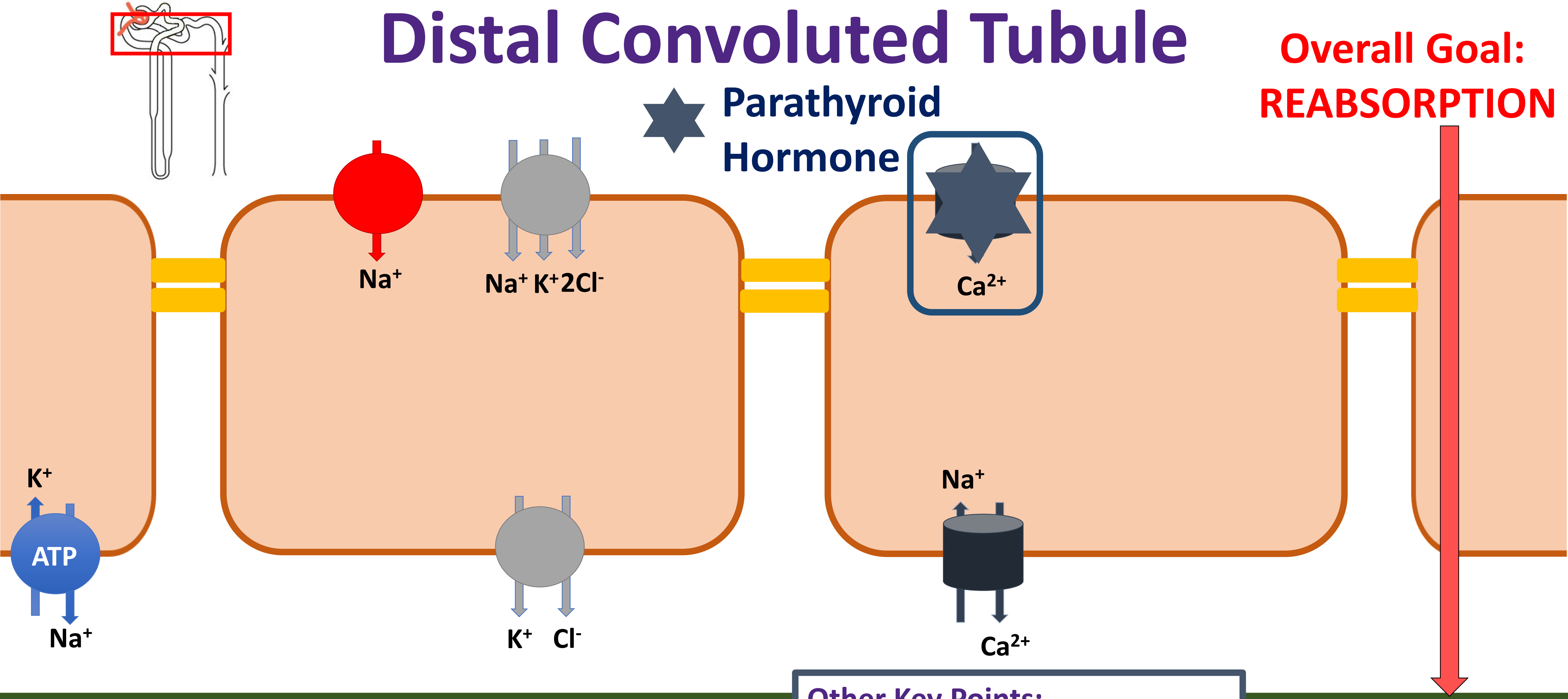
Overall Goal:
REABSORPTION



Other Key Points:
- No Water Reabsorption
- No Hormonal Regulation

Distal Convoluted Tubule

Overall Goal: REABSORPTION



Other Key Points:

- No Water Reabsorption
- No Paracellular Transport

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Which of the following is a transporter that increases activity in the presence of aldosterone?

a) sodium/potassium ATPase in the proximal tubule
b) sodium/potassium ATPase in the collecting duct
c) sodium/hydrogen exchanger in the proximal tubule
d) sodium/hydrogen exchanger in the collecting duct

Which of the following is a transporter that increases activity in the presence of aldosterone?

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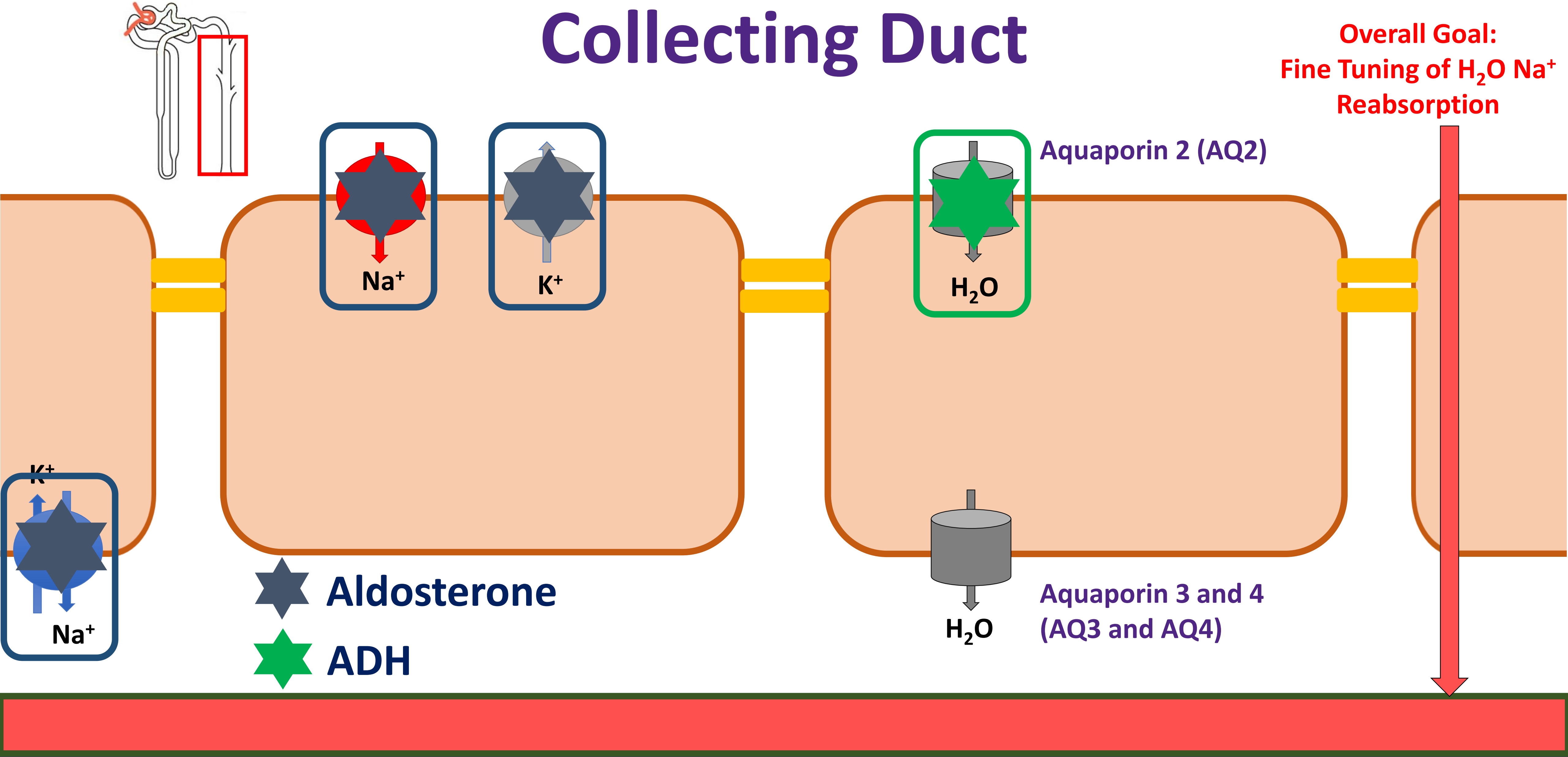
Collecting Duct



Aldosterone

- Made by adrenal gland
- Steroid hormone (= intracellular receptor)

Stimulus

- Angiotensin II, High K^+, ACTH

Goal

- Increase Na^+ reabsorption in collecting duct

How

1. ↑ Na^+ and K^+ channels in luminal membrane: by translocation and protein expression
2. ↑ Na^+ /K^+ ATPase activity and protein expression

Anti-Diuretic Hormone (aka Vasopressin)

- Made by hypothalamus (by neuroendocrine cells)
  - stored/released by posterior pituitary
- Peptide hormone (= requires cell-surface receptor on basolateral membrane)

Stimulus

High plasma osmolarity = Low ECF volume = Low BP

Goal

↑ water reabsorption = ↑ ECF volume = ↑ BP

Anti-Diuretic Hormone (aka Vasopressin)

↑ plasma osmolarity (fluid is hyperosmotic)

⬇

Osmoreceptors (in hypothalamus) shrink

⬇

ADH is released from posterior pituitary

⬇

Travels in blood to collecting duct

⬇

Binds to receptors on basolateral membrane

⬇

Increases # of AQ2 channels on luminal membrane

⬇

↑ water reabsorption

Anti-Diuretic Hormone (aka Vasopressin)

↓ BV = ↓BP

⬇

Baroreceptors (in aortic arch and carotid sinus) fire less AP to hypothalamus

⬇

ADH is released from posterior pituitary

⬇

Travels in blood to collecting duct

⬇

Binds to receptors on basolateral membrane

⬇

Increases # of AQ2 channels on luminal membrane

⬇

↑ water reabsorption = ↑BV = ↑BP

Atrial Natriuretic Peptide (ANP)

- Made by cardiac atrial cells
- Peptide hormone

Stimulus

- High blood pressure

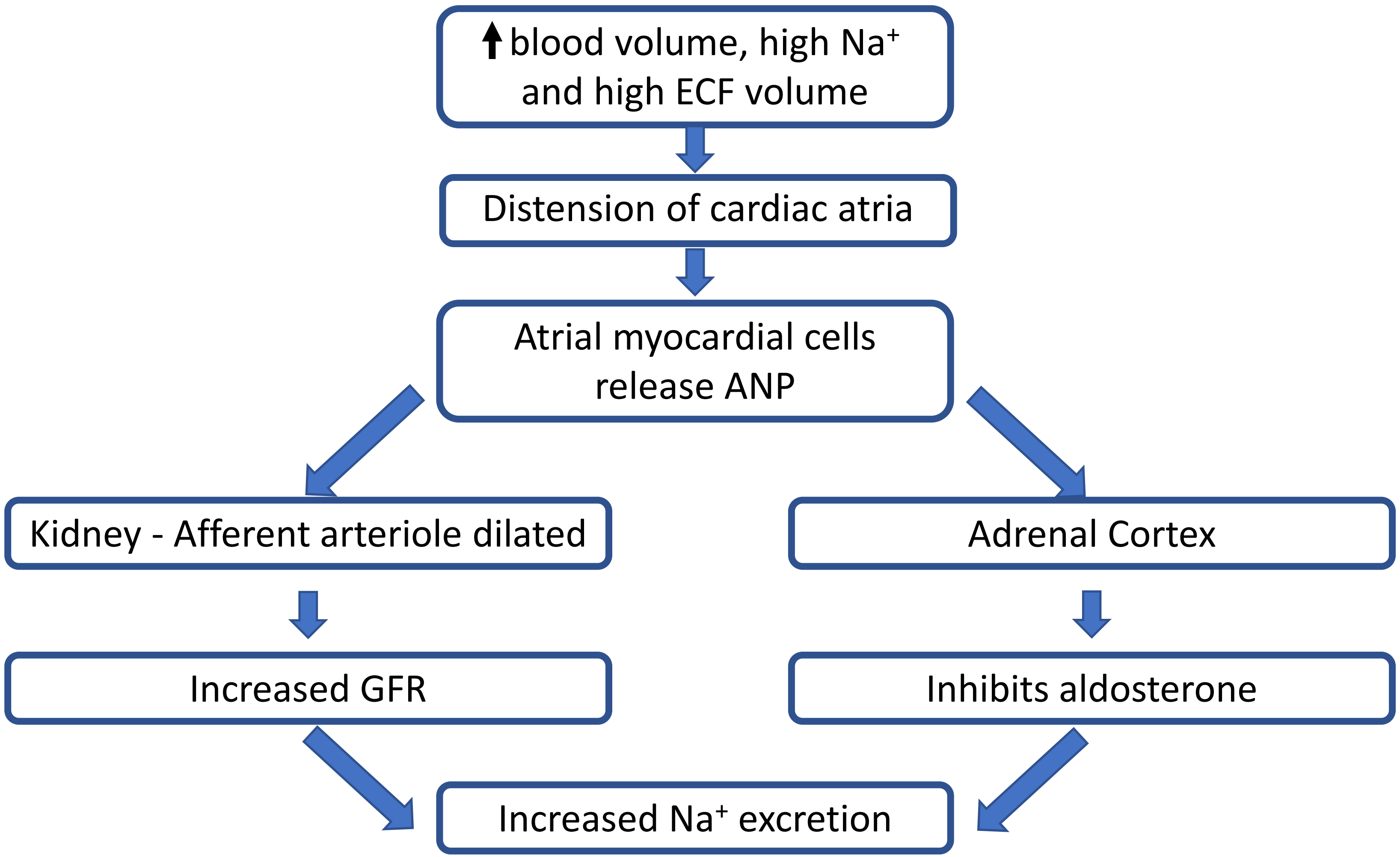
Goal

- Decrease Na^+ reabsorption

How

- Inhibits aldosterone secretion by adrenal glands
- Dilates afferent arterioles → increasing GFR
  - This increases flow of filtrate through tubule, leads to increase in Na^+ excretion

Atrial Natriuretic Peptide (ANP)



Based on the following information, what segment of the tubule is being described?

- Incapable of paracellular transport
- No water reabsorption
- Some hormonal control

A. Proximal tubule
B. Ascending limb of the loop of Henle
C. Distal convoluted tubule
D. Collecting duct

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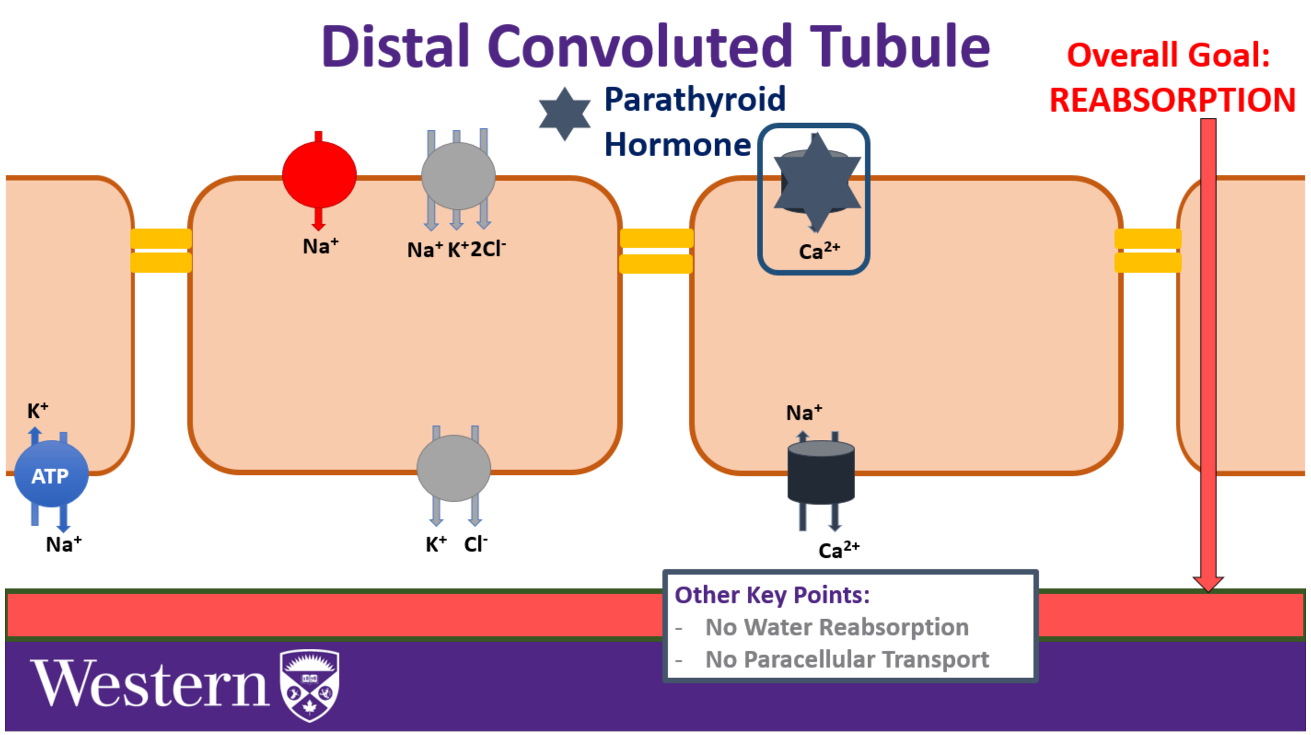

Summary of Transport

	Proximal Tubule	Descending Limb	Ascending Limb	Distal Tubule	Collecting Duct
Goal	Reabsorption of everything	Water reabsorption	Ion reabsorption	Ion reabsorption	Fine tuning (water and Na)
Water	Yes	Yes	No	No	Yes
Ions	Yes (Na^+, Cl^-, K^+)	Minimal (Na^+)	Yes (Na^+, Cl^-, K^+)	Yes (Na^+, Cl^-, K^+, Ca^{2+})	Yes (Na^+)
Paracellular Transport	Yes	No	Yes	No	No
Hormone Regulation	Angiotensin II	-	-	PTH	Aldosterone ADH

Summary of Hormonal Regulation

Hormone	Made By	Hormone Type	Stimulus	Response
Renin	Kidneys	N/A	Increased sodium	N/A
Angiotensin II	Angiotensin Converting Enzyme	Peptide	Renin – released due to low sodium	Increase sodium reabsorption in proximal tubule: 1. Increase activity of Na^+ /H^+ exchanger and Na^+ /K^+ ATPase 2. Constrict afferent arteriole (decreasing GFR)
Aldosterone	Adrenal Gland	Steroid	Angiotensin II and high K^+	Increase sodium reabsorption in collecting duct: 1. Increase Na^+ and K^+ channels in luminal membrane 2. Increase activity of Na^+ /K^+ ATPase
Atrial Natriuretic Peptide	Cardiac atrial cells	Peptide	High blood pressure	Decrease sodium reabsorption: 1. Inhibit aldosterone secretion from adrenal glands 2. Dilates afferent arteriole (increasing GFR)

Chapter 9: Respiratory
14 Questions on Exam

Professor: Dr. Beye

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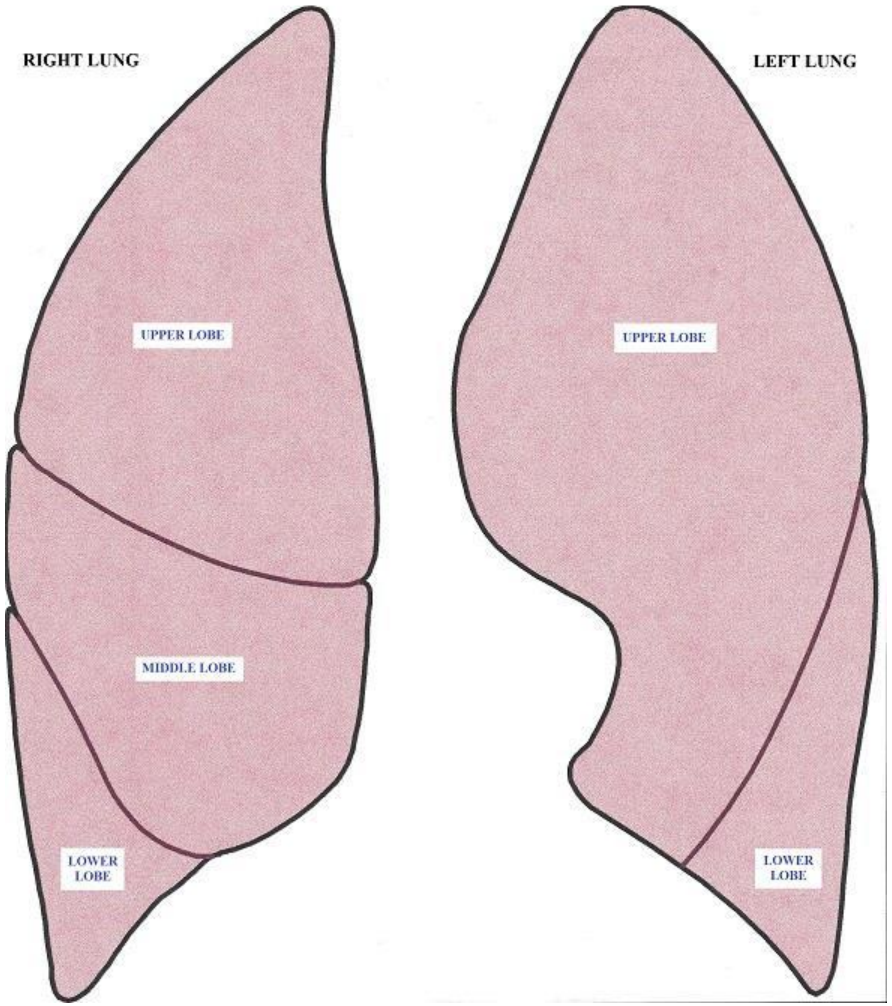
Overview of Chapter

1. Anatomy of respiratory system
2. Lung volume measurements
3. Partial pressures and gas exchange
4. Carbon dioxide transport

Lung Anatomy

Right Lung
3 Lobes



Left Lung
2 Lobes

Why? The heart sits on the left side of thoracic cavity

Lung Anatomy

Muscles

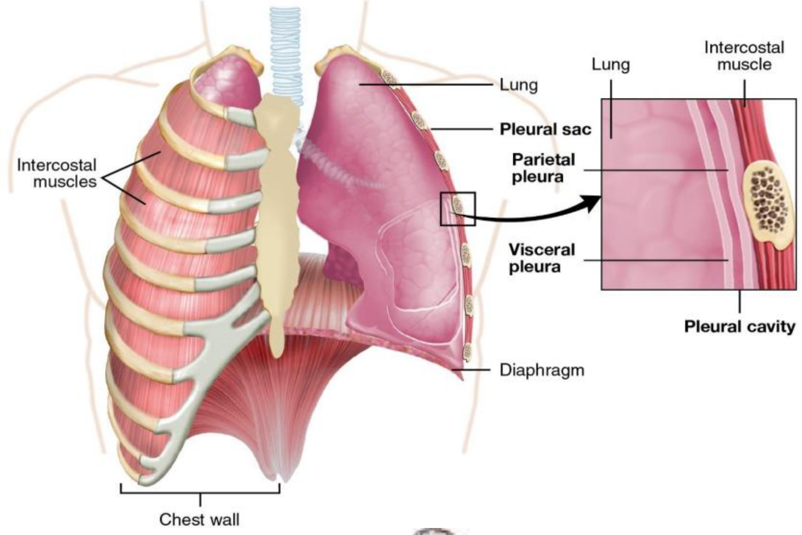
- Intercostal muscles (between ribs)
- Diaphragm (bottom)

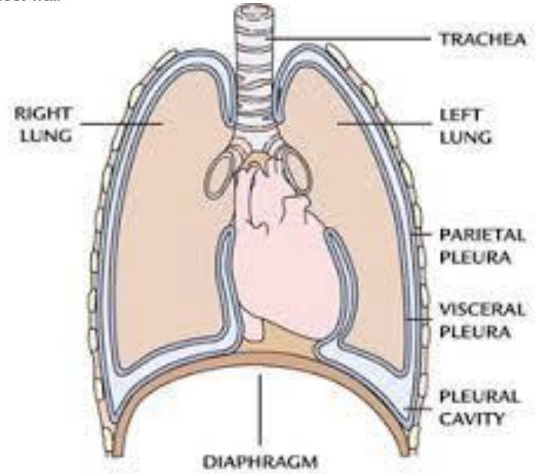
Pleural Layers

- Visceral pleura (against lungs)
- Intrapleural space/cavity
- Parietal pleura (against chest wall)

<u>V</u>isceral = <u>V</u>ery close

<u>P</u>arietal = <u>P</u>retty close

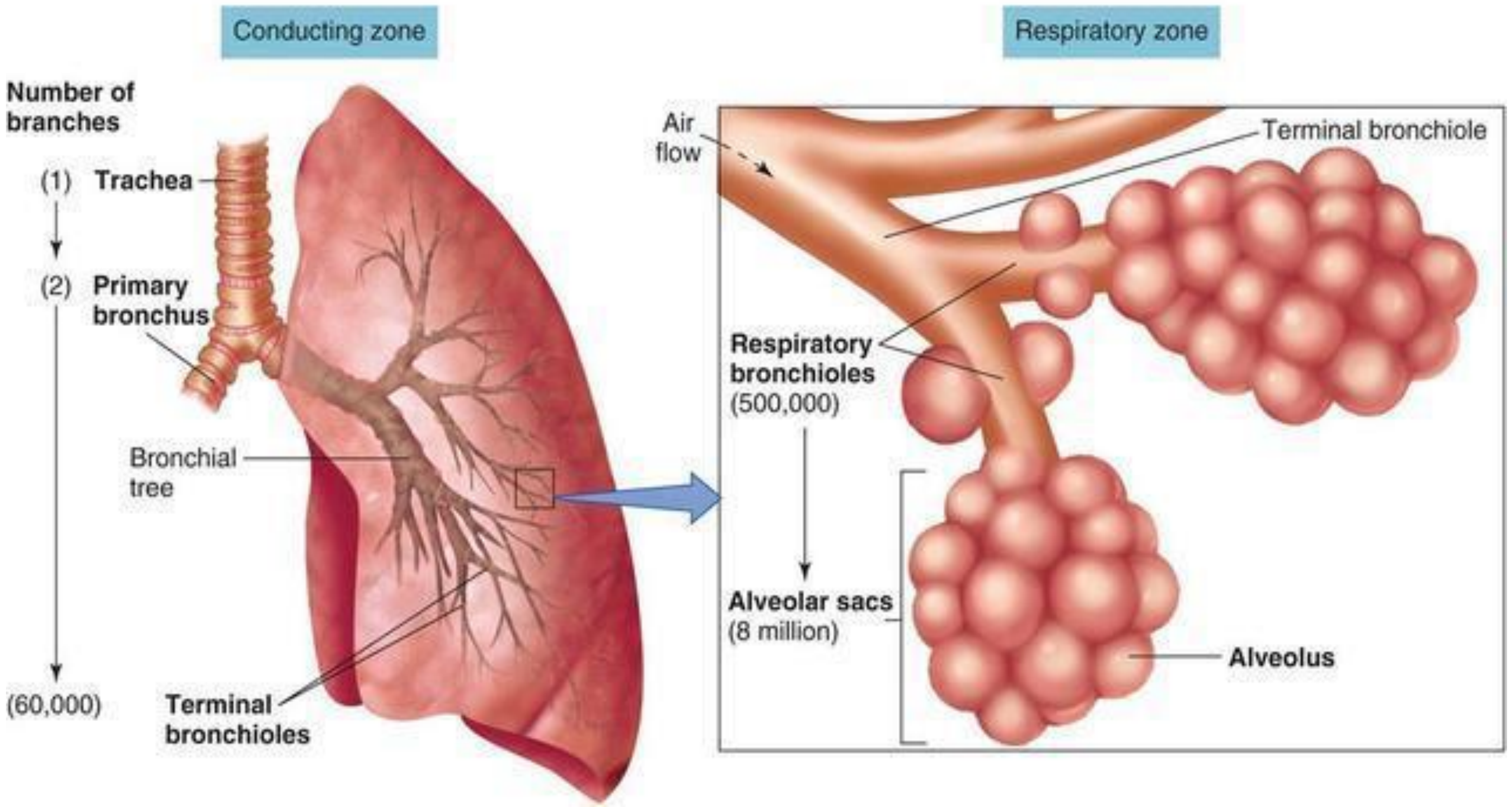




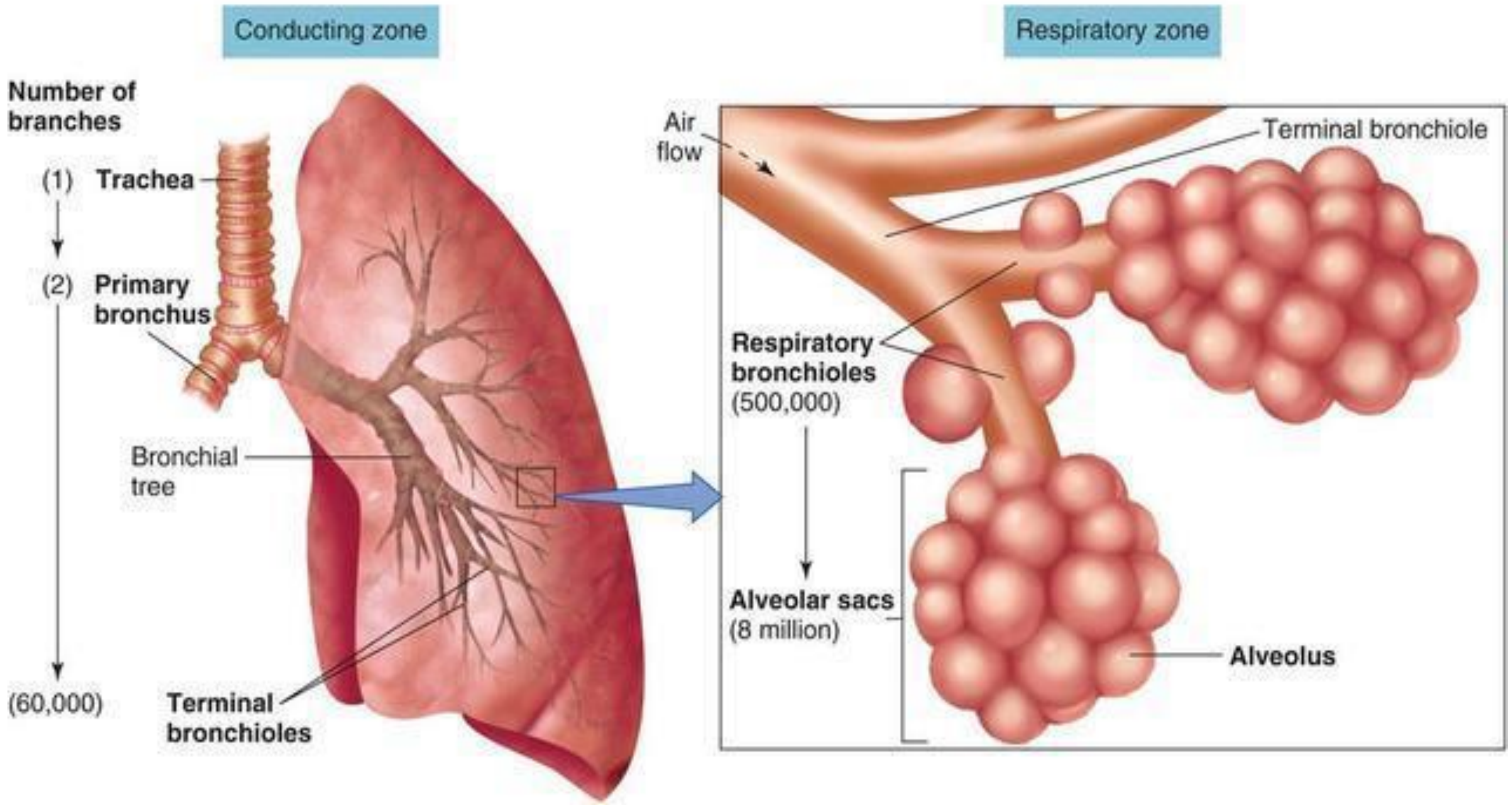
Lung Anatomy

Respiratory tract can be divided into two sections:

1. Conducting Zone
2. Respiratory Zone



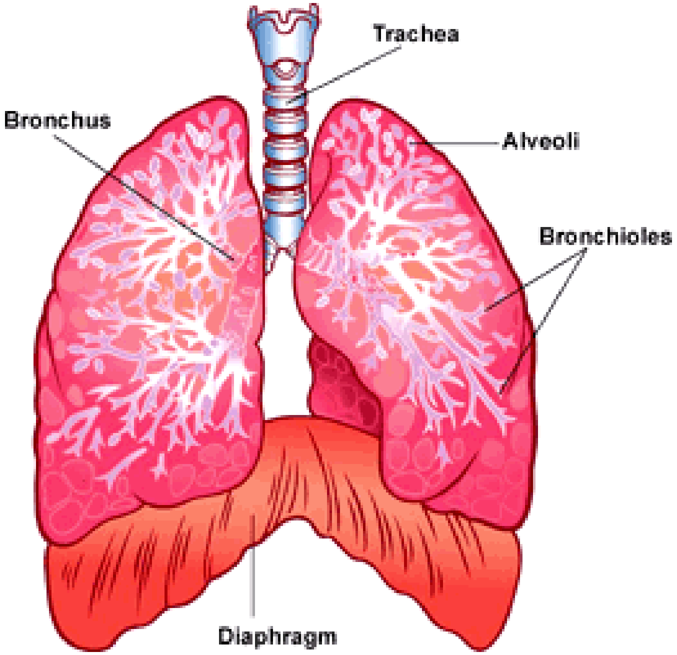
Zones of Respiratory Tract



Conducting Zone

Trachea → Primary Bronchus (Left and Right) → 2^0 Bronchi → 3^0 Bronchi → Bronchioles → Terminal Bronchioles

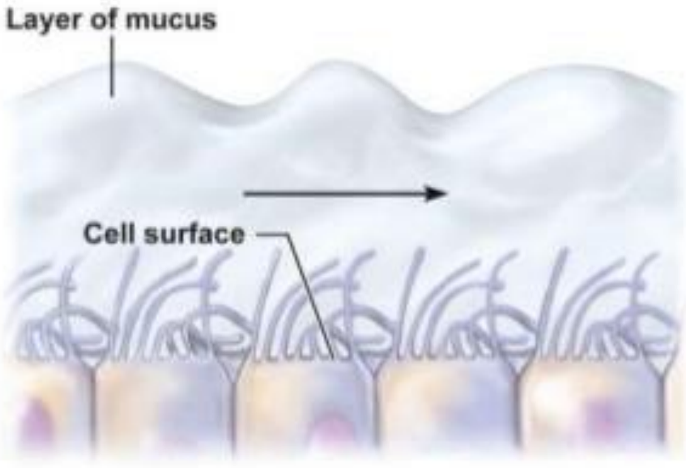
"Conducting zone terminates at terminal bronchioles"



Conducting Zone

Functions

- Transport air to lungs
- Filter, warm and moisten air
- Microbial defense:
  - Bronchial epithelial cells are ciliated
  - Cilia sweeps mucus with trapped micro-organisms towards the trachea
  - Smoking reduces function of cilia



(b) Traveling wave created by the activity of many cilia acting together propels mucus across cell surfaces.

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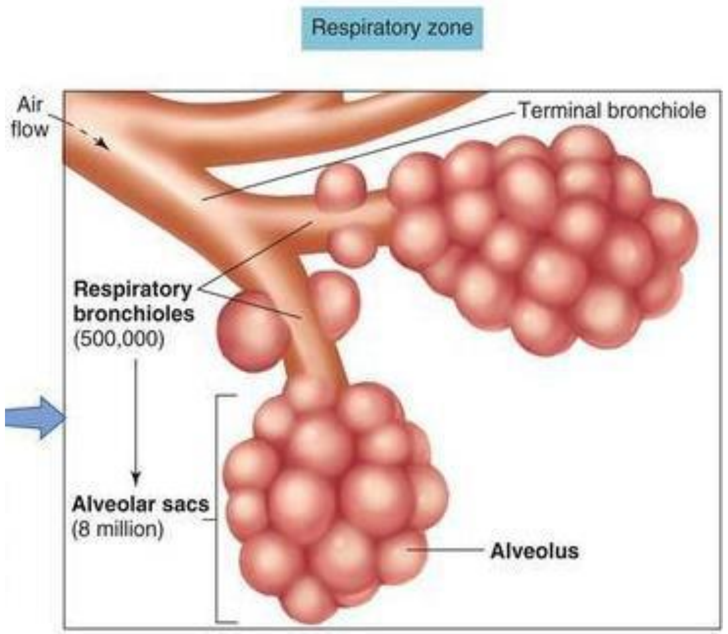
Respiratory Zone

Respiratory Bronchioles → Alveolar Ducts → Alveolar Sacs → Alveoli

"Respiratory zone begins at respiratory bronchioles"



The walls of the alveoli are composed of two types of cells, type I and II. The function of type II is to _______.

A. Secrete surfactant
B. Trap dust and other debris
C. Replace mucus in the alveoli
D. Protect the lungs from bacterial invasion

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A. Secrete surfactant
B. Trap dust and other debris
C. Replace mucus in the alveoli
D. Protect the lungs from bacterial invasion

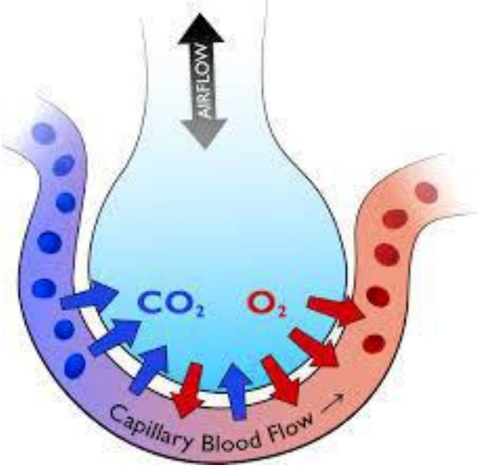
Respiratory Zone

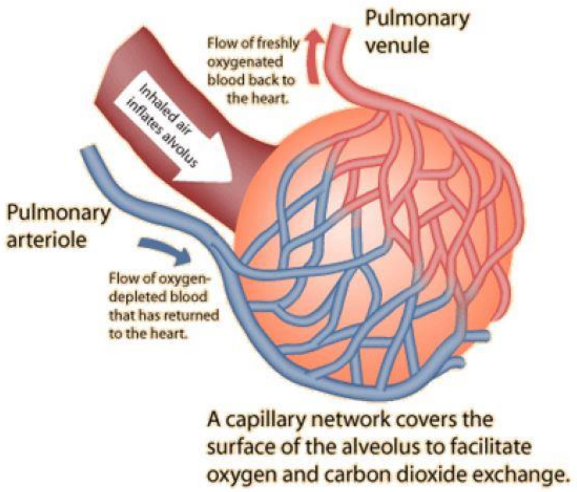
Function

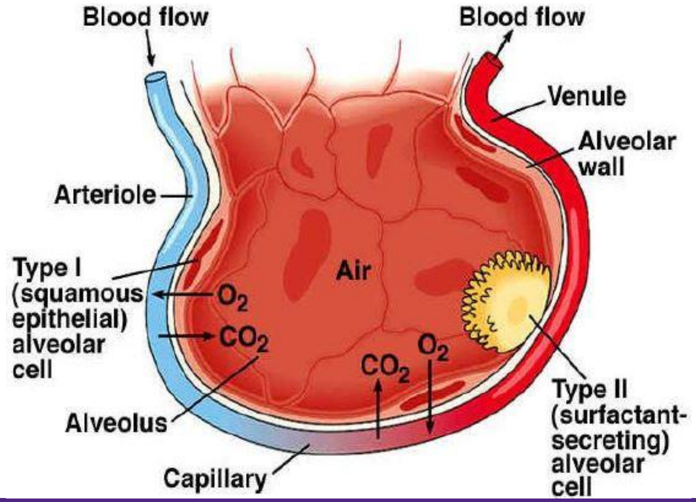
- Gas exchange in the alveoli at the blood gas barrier
    - CO^2 leaves blood supply into air
    - O^2 leaves air into blood supply

Cells

- Type 1 cell: flat and thin cells that form alveolar wall and allow for easy gas exchange between alveoli and capillary
- Type 2 cell: secrete surfactant
- Macrophages: destroy microorganisms







A 200 pound 20 year old man has a tidal volume of 500 mL and a respiratory rate of 10 breaths per minute. What is his anatomical dead space ventilation per minute?

A. 5 liters
B. 2 liters
C. 3000 Ml
D. 200 mL

V_D= Weight x Respiratory Rate

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A. 5 liters

B. 2 liters

C. 3000 Ml

D. 200 mL

V_D= Weight x Respiratory Rate

= 200 X 10

= 2000 mL → 2 Litres

Ventilation Calculations

- Tidal Volume: Amount of air entering lungs in one breath during normal inhalation
- Respiratory Rate: # of breaths per minute
- Pulmonary Ventilation (V_E): Amount of air entering lungs (both zones) per minute

$$V_E = \text{Tidal Volume x Respiratory Rate}$$

- Anatomical Dead Space Ventilation (V_D): Amount of air not involved in gas exchange (Anatomical dead space = 1 mL/pound)

$$V_D = \text{Weight x Respiratory Rate}$$

- Alveolar Ventilation (V_A): Amount of air entering only the respiratory zone per minute

$$V_A = V_E - V_D$$

Ventilation Calculations

Example: For a 150 lb individual with respiratory rate of 30 breaths/min and tidal volume of 200 mL/breath

V_E = Tidal Volume x Respiratory Rate

= 200 x 30

= 6000 mL/min

V_D = Weight x Respiratory Rate

= 150 x 30

= 4500 mL/min

$V_A = V_E - V_D$

= 6000 – 4500

= 1500 mL/min

By changing your pattern of breathing, you can alter how much air is actually available for gas exchange (V_A)

You head out for a run. About 5 minutes in, you notice you are breathing pretty hard. What is happening in your thoracic cavity?

a) your external intercostals are contracting during exhalation
b) your diaphragm is relaxing during inhalation
c) your intrapulmonary pressure will match the atmospheric pressure during exhalation
d) your internal intercostal muscles will pull your ribcage down and inwards during exhalation

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Inhalation

Diaphragm and external intercostal muscles contract (Diaphragm moves down and intercostals pull ribcage up and out)

⬇

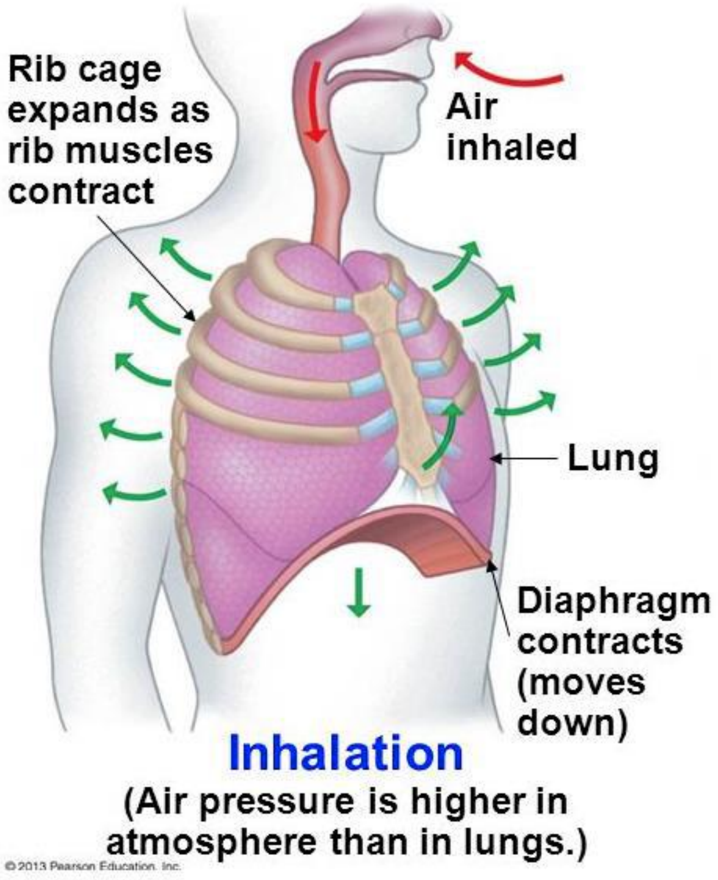
Thoracic cavity expands (Increase volume)

⬇

Decrease intrapulmonary pressure by Boyle's law (<760 mmHg)

⬇

Air moves in



Exhalation (Passive)

Diaphragm and external intercostal muscles relax (Diaphragm moves up and ribcage gets smaller)

⬇

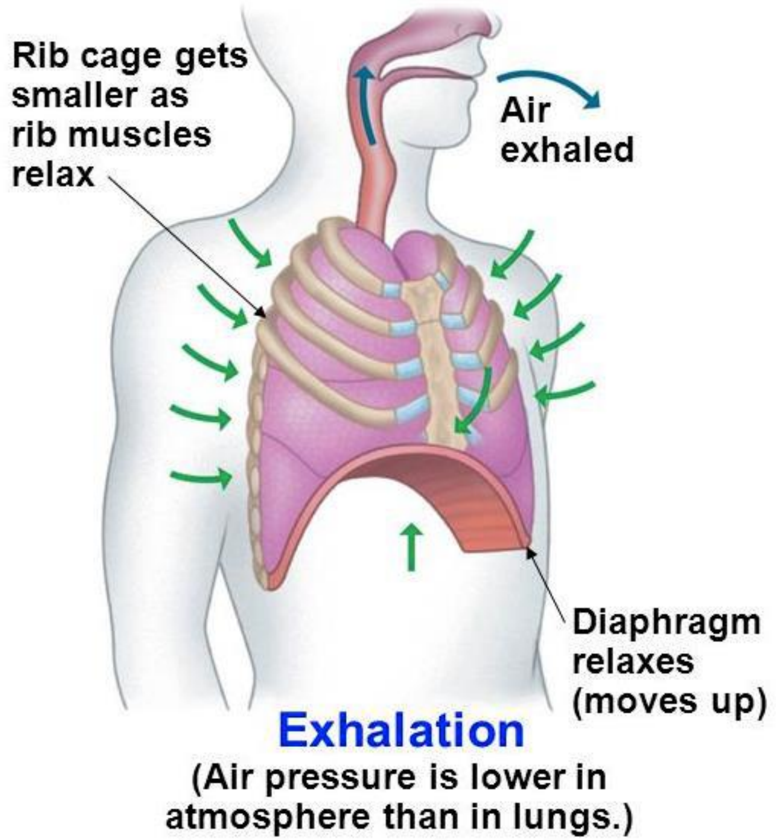
Thoracic cavity decreases in volume

⬇

Increase intrapulmonary pressure by Boyle's law (>760 mmHg)

⬇

Air moves out



Exhalation (Active - Exercise)

Diaphragm and external intercostal muscles relax

Internal intercostals, obliques and rectus abdominus contract

⬇

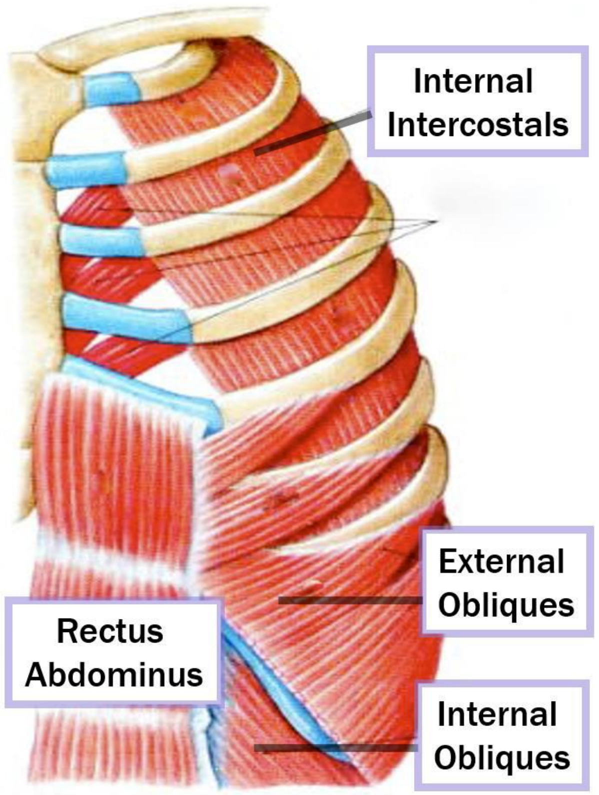
Thoracic cavity decreases in volume

⬇

Increase intrapulmonary pressure by Boyle's law (>760 mmHg)

⬇

Air moves out



During active exhalation (exercise), which of the following muscles are contracting?

1. Obliques
2. Diaphragm
3. Internal intercostals
4. External intercostals

A. 1, 2 and 3 are correct
B. 1 and 3 are correct
C. 2 and 4 are correct
D. Only 4 is correct
E. All are correct

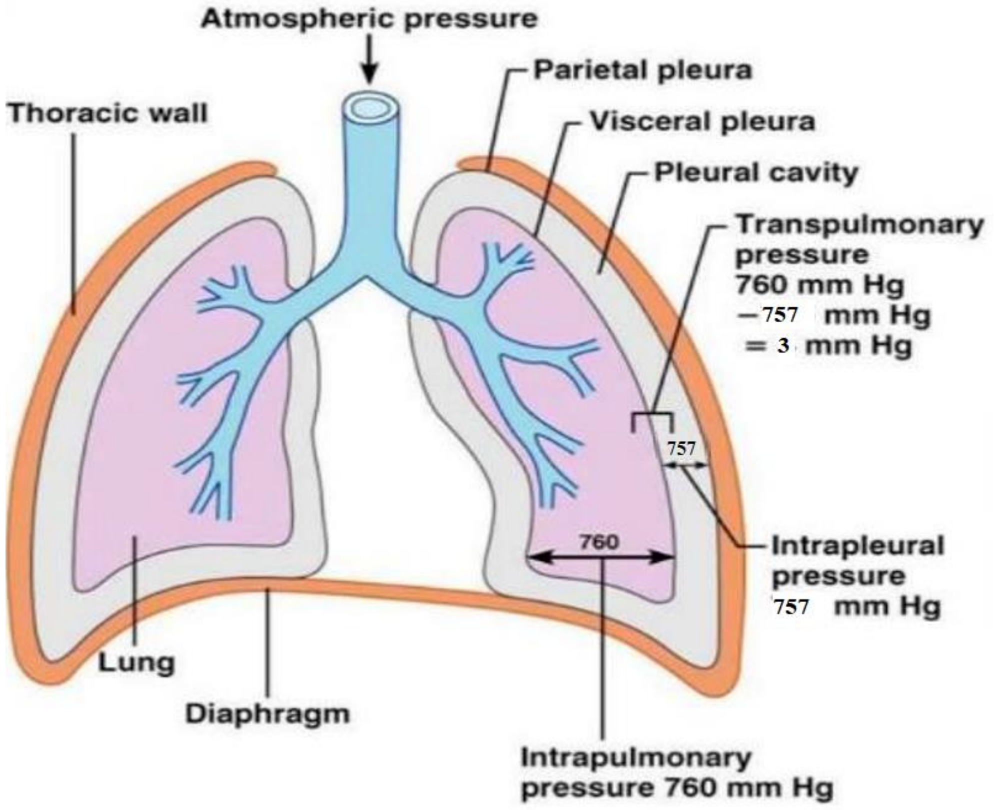
During active exhalation (exercise), which of the following muscles are contracting?

1. Obliques
2. Diaphragm
3. Internal intercostals
4. External intercostals

A. 1, 2 and 3 are correct
B. 1 and 3 are correct
C. 2 and 4 are correct
D. Only 4 is correct
E. All are correct

Intrapleural and Transpulmonary Pressure

- Intrapleural Pressure: Pressure in intrapleural space; 757 mmHg
  - Prevents lung from collapsing at the end of expiration
  - Allows for easy expansion of the lung
- Transpulmonary Pressure: Pressure across the lung; +3 mmHg
  - Intrapulmonary Pressure (760) – Intrapleural Pressure (757)

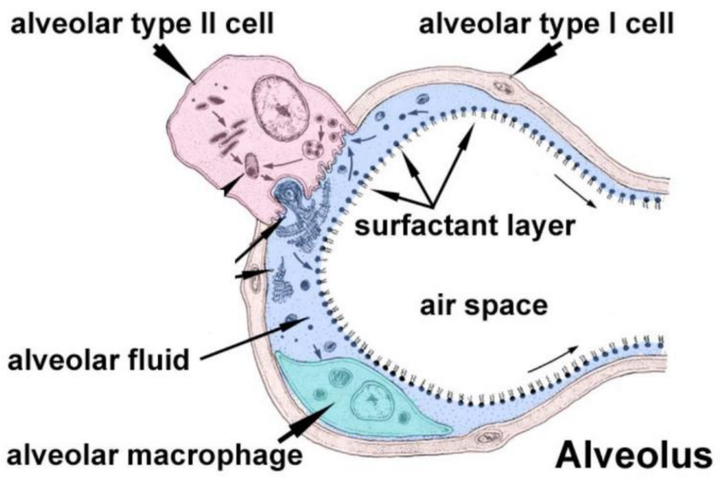


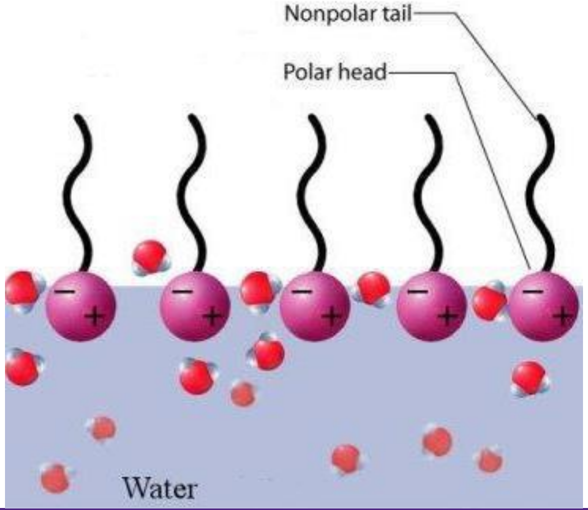
Lung Compliance

- Compliance is the "stretchability" of the lung
- Compliance = Change in volume / Change in pressure
- Affected by 2 factors:
  1. Elastic tissue of lungs (33%)
     - Caused by presence of elastin and collagen
  2. Surface tension in alveoli (66%)
     - Surfactant reduces surface tension
- An increase in these 2 factors decreases compliance and increases likelihood of lung collapse

Pulmonary Surfactant

- Released by type 2 cells
- Layer is spread across air-water interface in alveoli
- Surfactant = phospholipids + proteins
- Phospholipids: hydrophilic head towards water; hydrophobic head towards air
- Proteins: help with microbial defense
- Functions:
  1. Reduce surface tension
     - Improve compliance and prevent alveolar collapse
  2. Improves microbial defense function
     - Proteins help identify foreign particles for macrophages
- Neonatal respiratory distress syndrome (nRDS): premature infants lack mature surfactant system, which leads to poor lung function, alveolar collapse and hypoxemia (treatment = surfactant)





If in one breath a person takes in a larger tidal volume than they normally would, which one of the following statements would be correct?

a) they are likely be breathing in less than 500 mL (0.5 litres)
b) they would have a smaller IRV (inspiratory reserve volume)
c) they would have a larger total lung capacity
d) they would have a smaller FEV1

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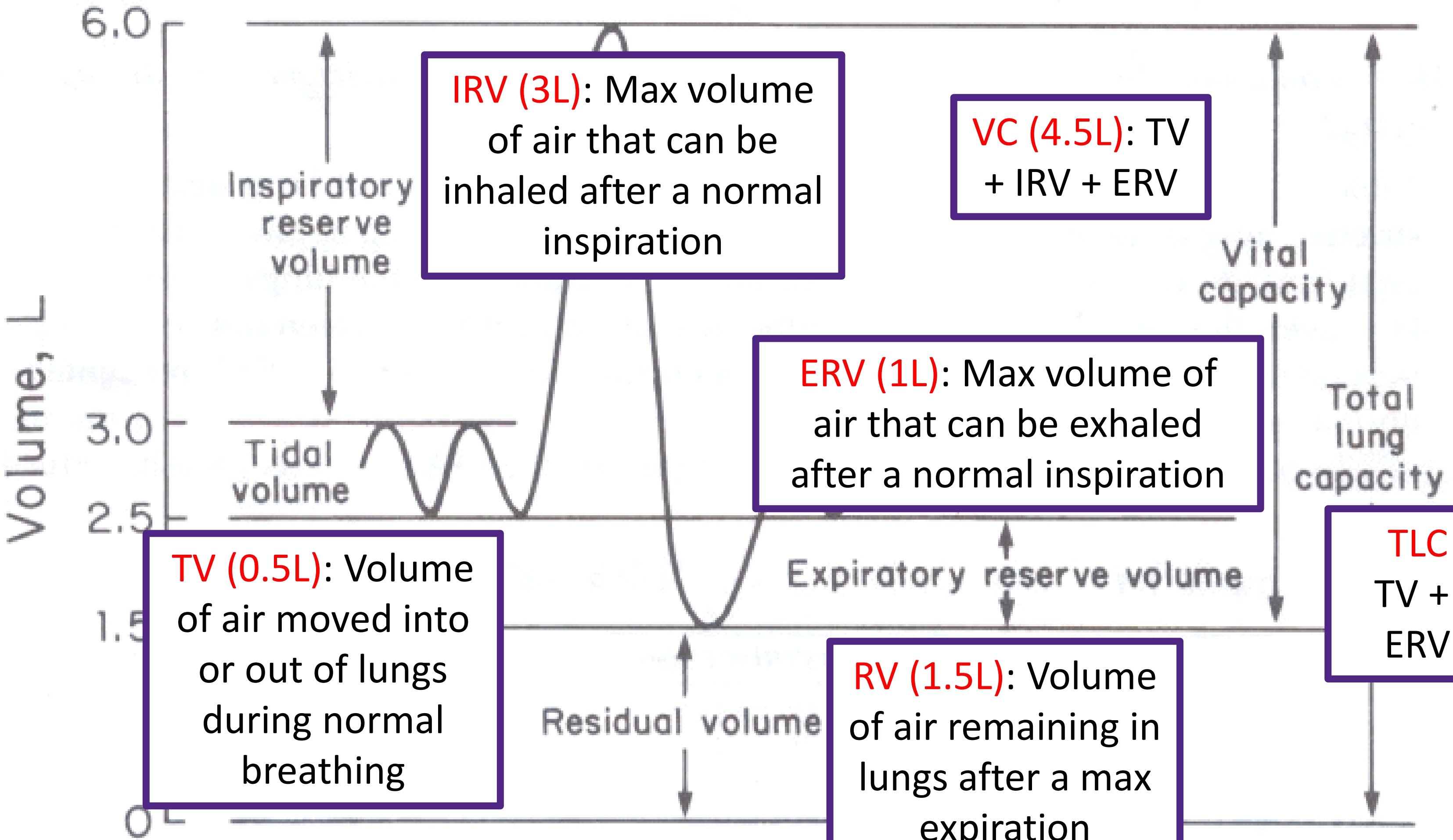
Spirometry



IRV (3L): Max volume of air that can be inhaled after a normal inspiration

VC (4.5L): TV + IRV + ERV

ERV (1L): Max volume of air that can be exhaled after a normal inspiration

TV (0.5L): Volume of air moved into or out of lungs during normal breathing

TLC (6L): TV + IRV + ERV + RV

RV (1.5L): Volume of air remaining in lungs after a max expiration

What is true of a restrictive lung disease?

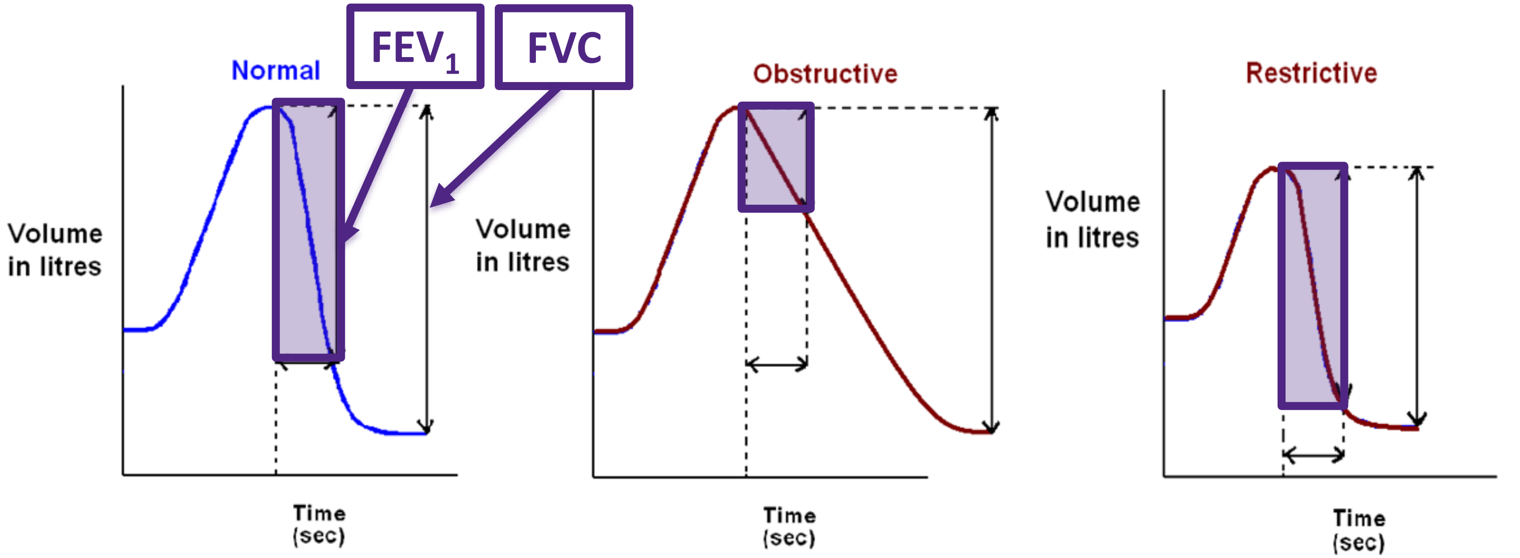
A. Emphysema is an example of a restrictive lung disease
B. Lungs can become floppy due to Loss of elastin
C. FEV1 decreases
D. FVC decreases

What is true of a restrictive lung disease?

A. Emphysema is an example of a restrictive lung disease
B. Lungs can become floppy due to Loss of elastin
C. FEV1 decreases
D. FVC decreases

Other Lung Measurements

- Forced vital capacity (FVC): how much air a person can exhale as fast as possible during a forced breath
- Forced expiratory volume (FEV_1): volume of exhalation over 1 second



Normal	Obstructive	Restrictive
FEV1	Decreases	No Change
FVC	No Change	Decreases
FEV1/FVC = 80 %	FEV1/FVC < 80%	FEV1/FVC > 80%

Lung Diseases: Obstructive

- Air flow obstruction during exhalation
- Diameter of bronchioles decreases (lumen constricted)

	Cause	Effect
Asthma	Spasms triggered by exercise, air pollution and allergies	• Airway inflammation and hyper-responsiveness
Chronic Bronchitis	Smoking	• Excessive mucus and inflammation
Emphysema	Smoking	• Alveolar wall break down creates large air sacs ($\downarrow$ surface area = poor gas exchange) • Loss of elastin reduces elastic recoil ($\uparrow$ compliance so lungs fill but can't empty)

Lung Diseases: Restrictive

- Air flow restriction during inhalation

	Cause	Effect
Pulmonary Fibrosis	Chronic inhalation of asbestos, coal, dust, pollution or sometimes unknown	• Fibrous scar tissue (thickened tissue) in alveoli and other lung tissue • Due to thick walls, poor gas exchange (similar to emphysema but different reason) • Lungs become stiff due to ↑in collagen = ↓compliance (opposite to emphysema)

In the pulmonary vein, what is the PO2 for a person at rest?

a) 40 mmHg
b) 46 mmHg
c) 100 mmHg
d) 159 mmHg

In the pulmonary vein, what is the PO2 for a person at rest?

a) 40 mmHg
b) 46 mmHg
c) 100 mmHg
d) 159 mmHg

Erthropoiesis

Process of producing new RBCs (2 million made and die each day)

- Occurs in bone marrow
- Regulated by the hormone, erythropoietin (EPO) from kidneys
- Normally, EPO levels are low for balanced RBC production to loss ratio
- When O_2 levels to kidney drop, EPO is released
- Drop in O_2 can be caused by:
    - ⬇ in # of RBCs (⬇carrying capacity)
    - ⬇ in cardiac output (⬇blood flow =⬇O_2)
    - lung disease
    - high altitude

Regulation of Ventilation

Stimulus: Altered PO_2 and PCO_2 levels

⬇

Sensors: Chemoreceptors sense change in P

⬇

Control centre: Info is sent to respiratory centre in medulla

⬇

Effector: Respiratory muscles change force of contraction and relaxation to alter pulmonary ventilation

⬇

Effect: PO_2 and PCO_2 levels return to normal

Chemoreceptors

	Central	Peripheral
Location	Medulla	Aortic arch and carotid body
Respond to changes in	pH only Note: H^+ cannot cross the blood brain barrier, but CO_2 can. So CO_2 is converted into bicarbonate and H^+ in CSF for detection	PO_2 PCO_2 pH

1. Gases move from high pressure to low pressure
2. Gases move until equilibrium
3. Gases only move at capillaries

Atmospheric PO_2 = 160 mmHg
Atmospheric PCO_2 = 0.3 mmHg

Alveolar PO_2 = 100 mmHg
Alveolar PCO_2 = 40 mmHg

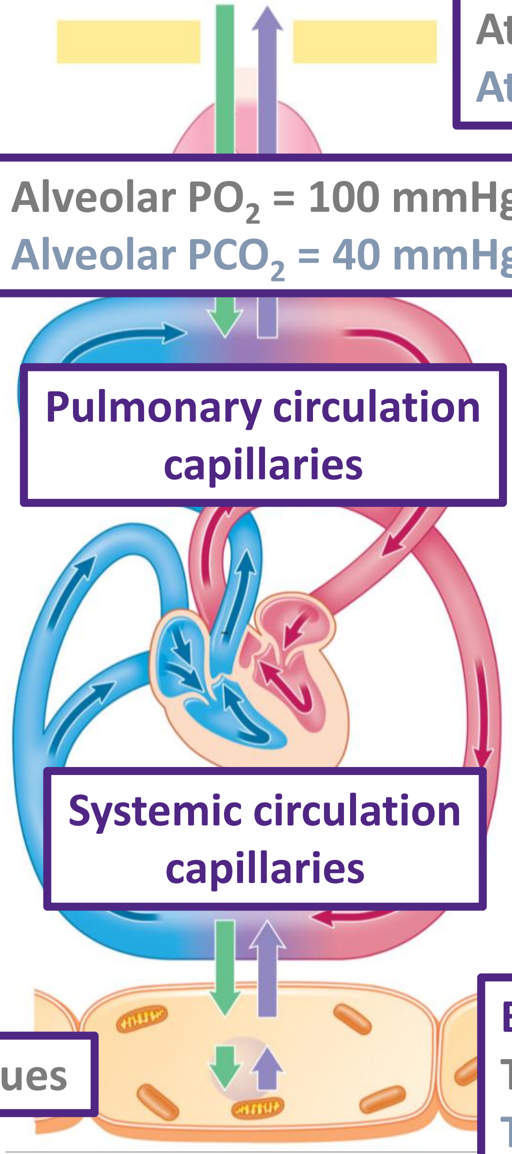
O_2 enters capillaries from alveoli

Pulmonary artery
PO_2 = 40 mmHg
PCO_2 = 46 mmHg

Pulmonary circulation capillaries

Pulmonary vein
PO_2 = 100 mmHg
PCO_2 = 40 mmHg

CO_2 enters alveoli from capillaries



Systemic veins
Venous PO_2 = 40 mmHg
Venous PCO_2 = 46 mmHg

Systemic circulation capillaries

Systemic arteries
Arterial PO_2 = 100 mmHg
Arterial PCO_2 = 40 mmHg

Body tissues
Tissue PO_2 = 40 mmHg (or less)
Tissue PCO_2 = 46 mmHg (or more)

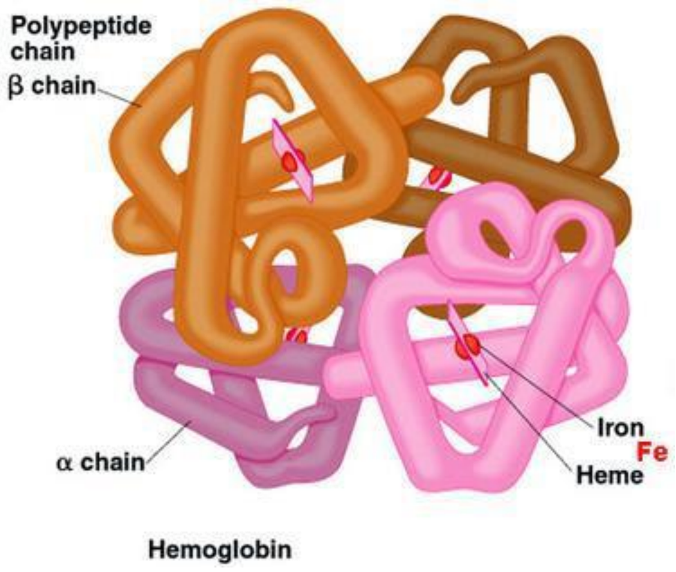
CO_2 enters capillaries from body tissues

O_2 leaves capillaries into body tissues

Oxygen Transport

Two Transport Mechanisms in Blood

1. Dissolved in plasma (1.5%)
   - Very inadequate
2. Carried by hemoglobin (98.5%)
   - O_2 + Hb ↔ HbO_2 (oxyhemoglobin)
   - Hb is found in RBCs
   - 4 heme groups (each Fe binds a O_2) + 4 globins (polypeptide chain)
   - Note: Hb transports BOTH O_2 and CO_2 (at different sites!)



Carbon Dioxide Transport

Three Transport Mechanisms in Blood

1. Dissolved in plasma (10%)
   - More soluble than O_2
2. Carried by hemoglobin (20%)
   - $CO_2 + Hb \leftrightarrow HbCO_2$ (carbamino hemoglobin)
   - Attached to "globin" not heme
3. Bicarbonate form (70%)

carbonic anhydrase

proton

$CO_2 + H_2O \leftrightarrow\leftrightarrow\leftrightarrow H_2CO_3 \leftrightarrow \leftrightarrow \leftrightarrow HCO_3^- + H^+$

carbonic acid

bicarbonate

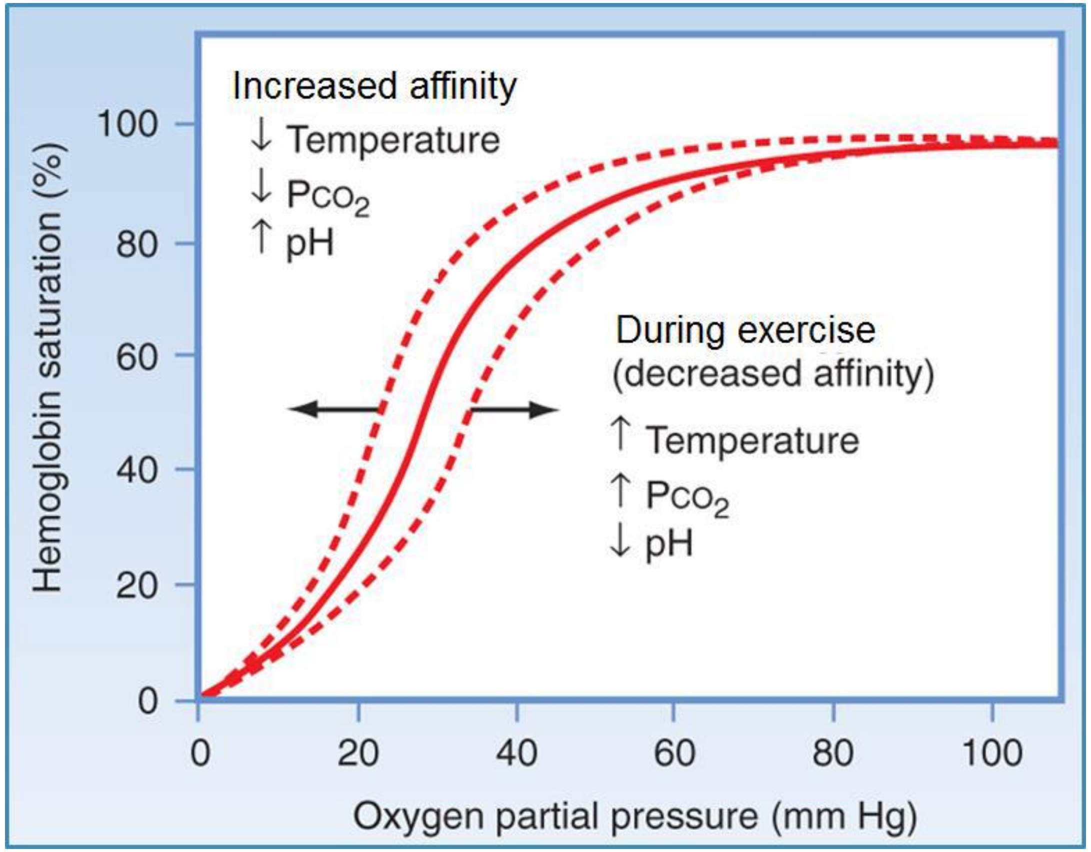
- Carbonic anhydrase is an enzyme found in RBCs

Oxyhemoglobin Dissociation Curve

How to read this graph:

- A resting cell (40 mmHg), Hb is 80% saturated with O_2
- An exercising cell (20 mmHg), Hb is 25% saturated with O_2
- At alveoli (100 mmHg), Hb is 98% saturated with O_2
- The steep slope means that a small change in PO_2 drastically effects Hb saturation

Thus, at lungs, Hb is highly saturated with O_2. At tissues, Hb is releasing O_2.

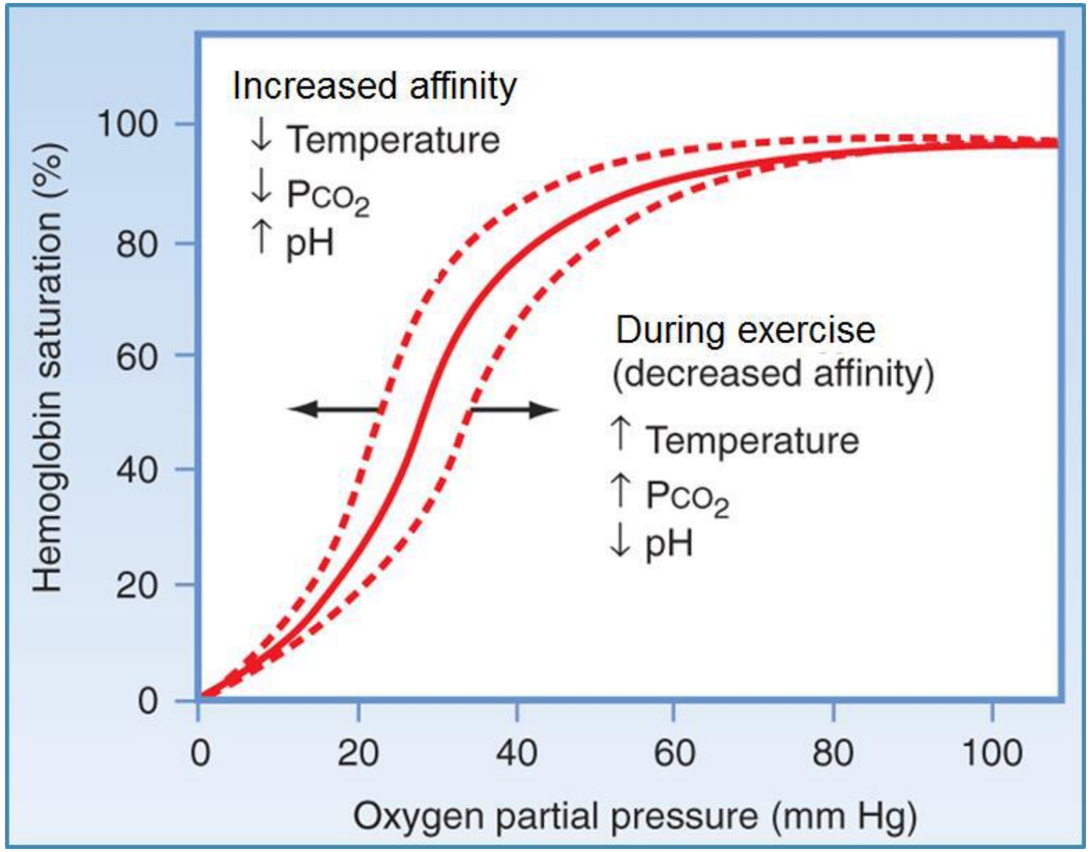


Oxyhemoglobin Dissociation Curve

Bohr Effect

- In the presence of CO_2 or protons, Hb has a decreased affinity for oxygen
- The curve shifts to the RIGHT
- Example: now at 40 mmHg, Hb is decreased from 80% to 60% saturation with O_2
- In other words, a right shift promotes O_2 offloading

Thus, during exercise (when temp, CO_2 and H^+ levels are high), more O_2 is delivered to tissues



Oxyhemoglobin Dissociation Curve

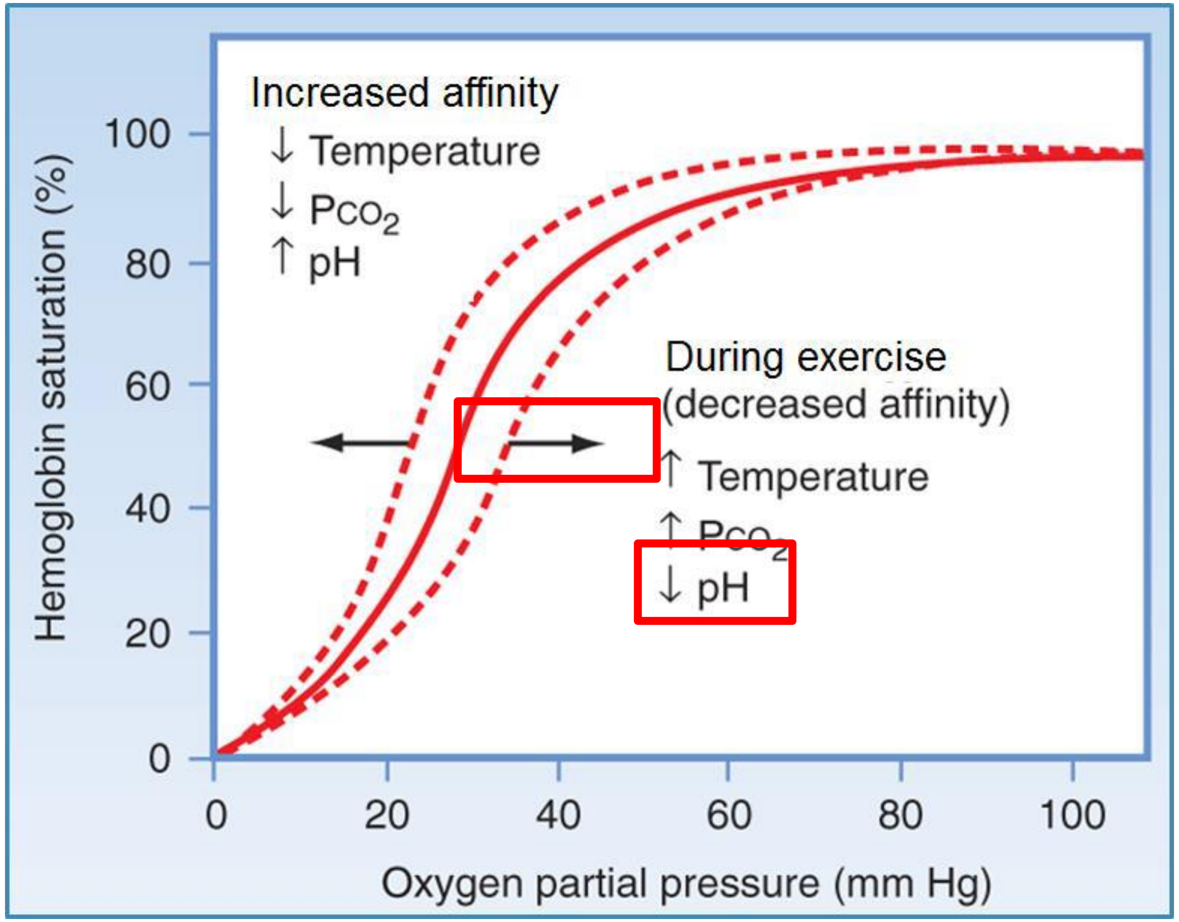
At Body tissues:

- CO^2 begins to bind & form bicarbonate and proton
- Curve shifts to right
- This enhances O_2 off loading at tissues

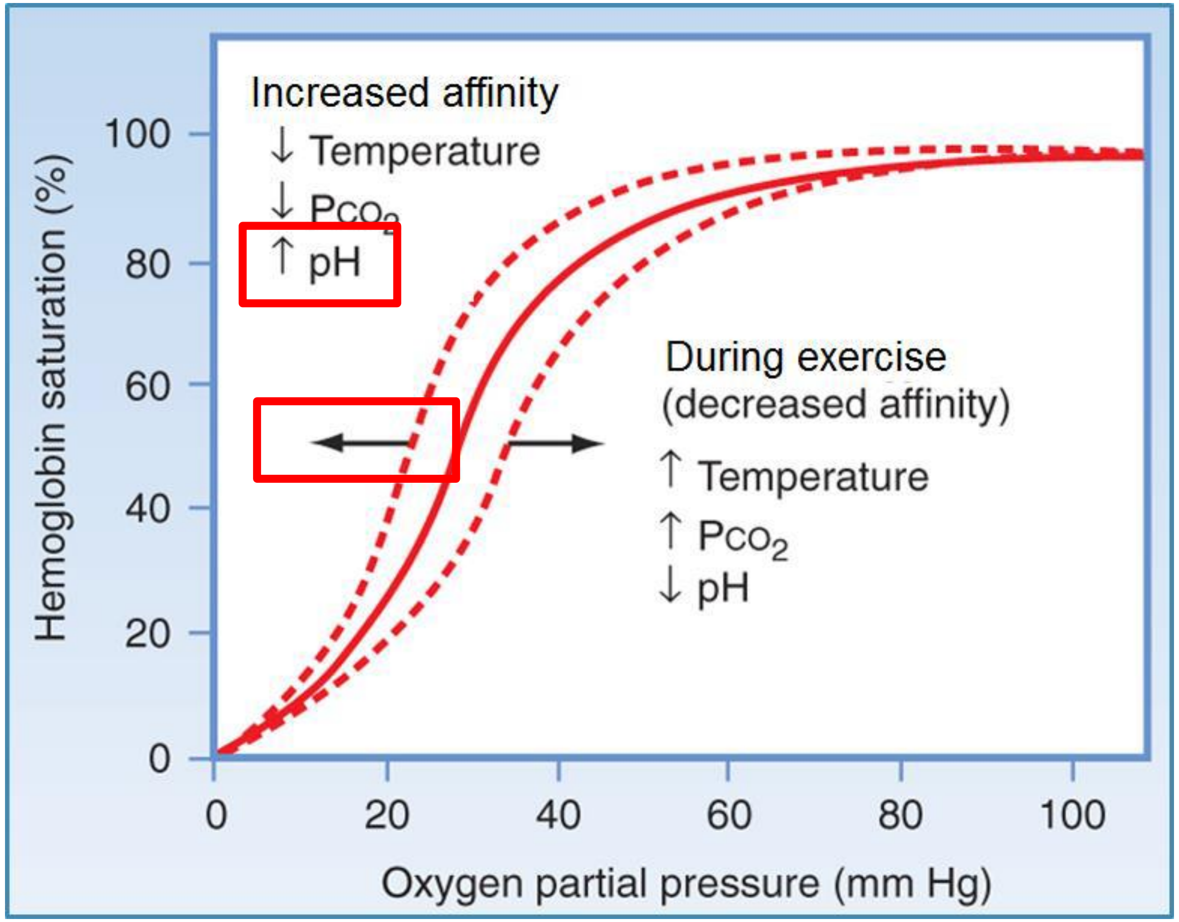
At Lungs:

- Blood passing through lungs gives up CO_2 & H^+ ions in the form of carbonic acid
- Bicarbonate will combine with the proton to form CO_2 and water and CO_2 will diffuse out of the blood stream at the lungs
- This shifts O_2 dissociation curve to left
- During this process the pH will increase and the affinity for oxygen by Hb will increase, allowing for binding of O_2

Shift Right = Decreased Affinity and increased off-loading



Shift Left = Increased Affinity



Bohr Effect

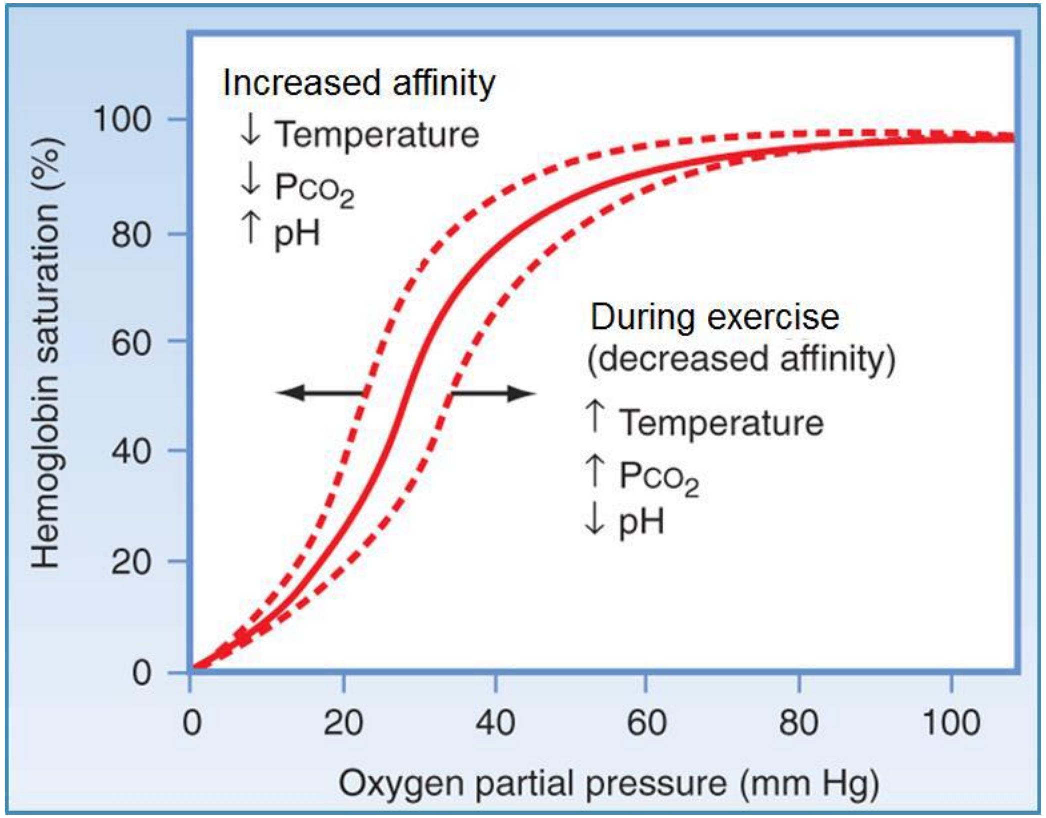
- In the presence of CO_2 or protons, Hb has a decreased affinity for oxygen

carbonic anhydrase

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow HCO_3^- + H^+$$

carbonic acid — bicarbonate — proton

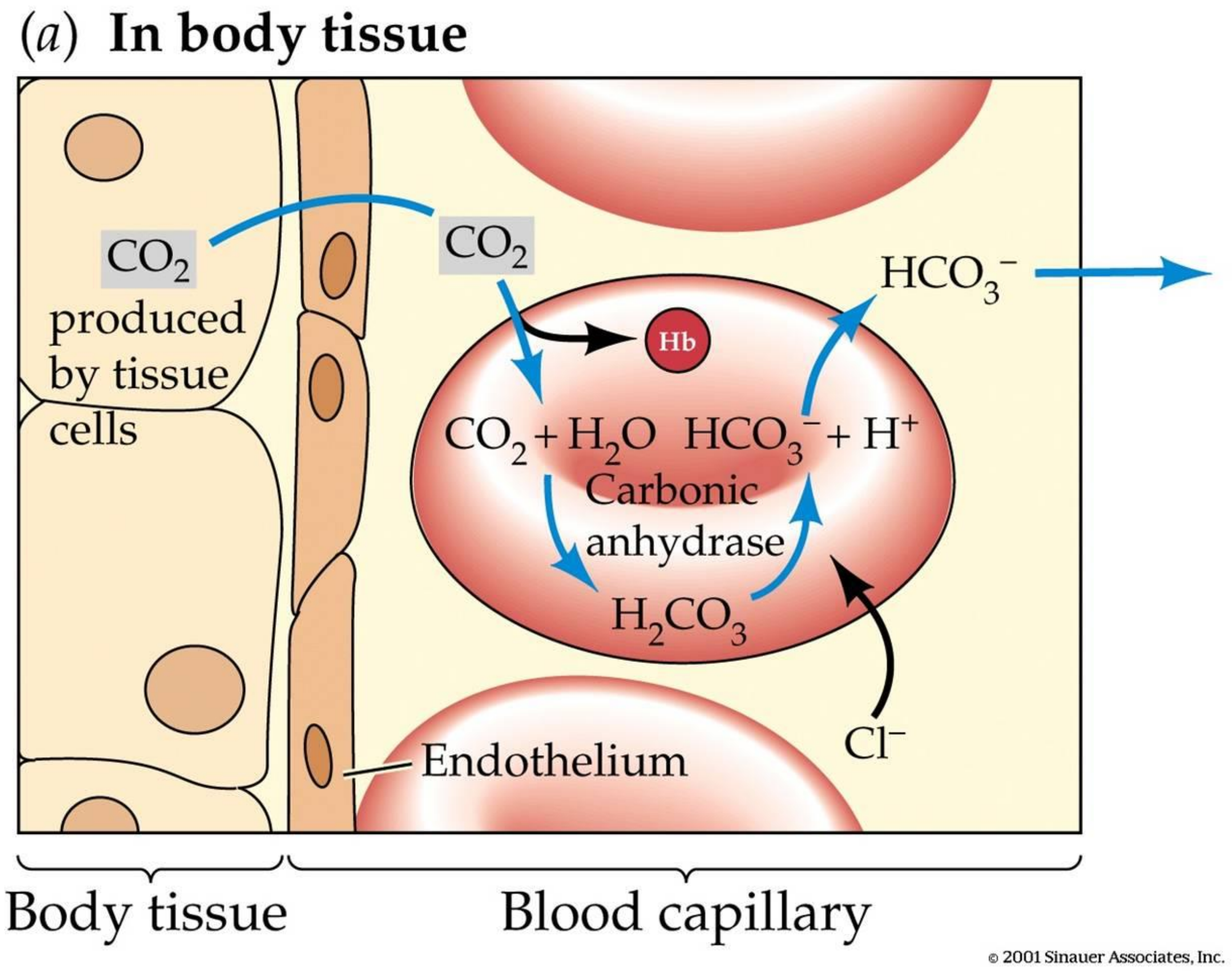
- Within the red blood cells CO_2 is converted to bicarbonate
- The pH of blood will change and cause the O_2 dissociation curve to shift right, causing more O_2 offloading at tissues



Chloride Shift

- As CO_2 leaves body tissue it enters the red blood cells
- CO_2 is converted into bicarbonate in the red blood cell and a proton is formed
- The pH will decrease and oxygen affinity of Hb will decrease, allowing off-loading into the tissues
- As bicarbonate exits the red blood cell a chloride molecule will enter to maintain the charge balance
  - To maintain an electrically neutral state

Chloride Shift: Body Tissues



Western

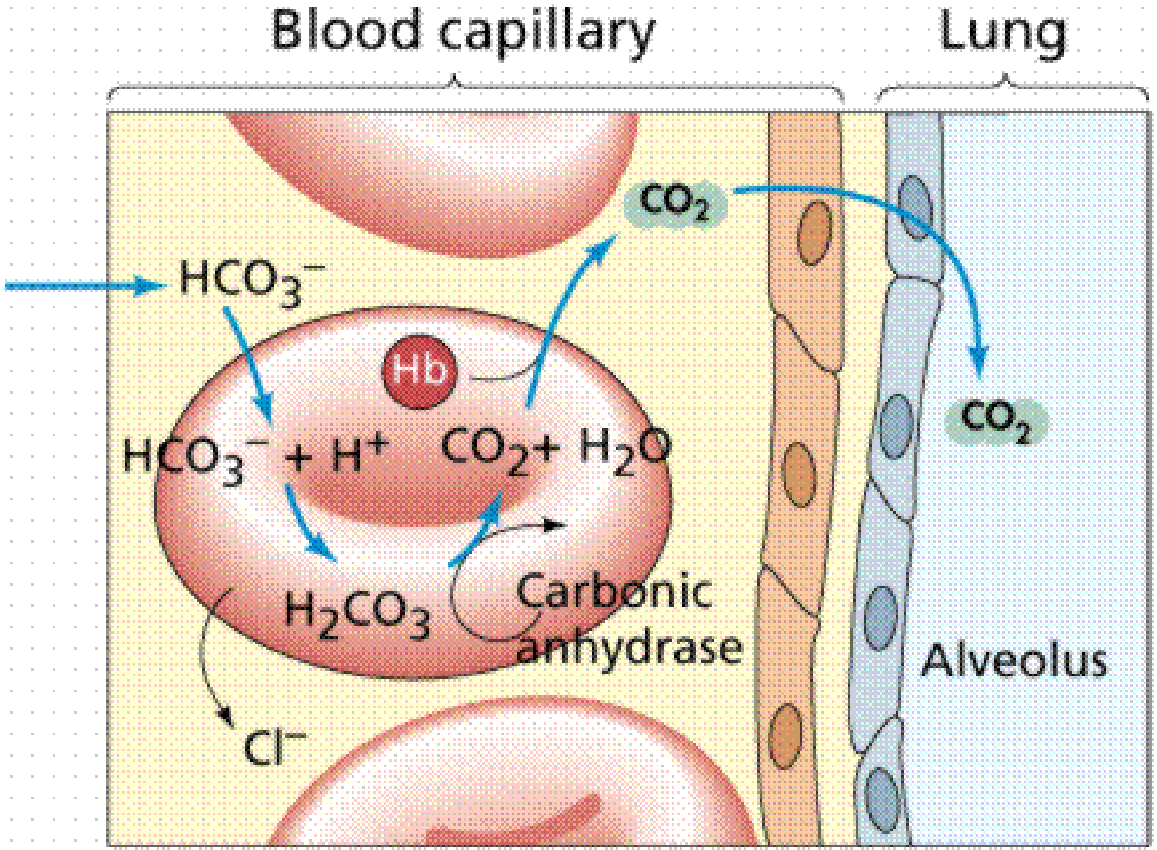
Chloride Shift: At Lungs

- Takes place in reverse

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow HCO_3^- + H^+$$

- At pulmonary capillaries, the bicarbonate ion will enter the red blood cell and a chloride will leave the red blood cell
- Bicarbonate will combine with the proton to form CO_2 and water and CO_2 will diffuse out of the blood stream at the lungs
- During this process the pH will increase and the affinity for oxygen by Hb will increase, allowing for binding of O_2

Chloride Shift: At Lungs



Intro to Gastrointestinal Physiology

Chapter 10: Dr. Woods

Western

Four Processes of Digestive System

1. **Secretion**
   - Exocrine into lumen of GI tract
   - Endocrine into blood
2. **Digestion**
   - Chemical (enzymes)
   - Mechanical
3. **Motility**
   - Propels food through each segment of GI tract
   - Can participate in mechanical digestion
4. **Absorption**
   - Movement of macronutrients into cells of GI tract and then into blood

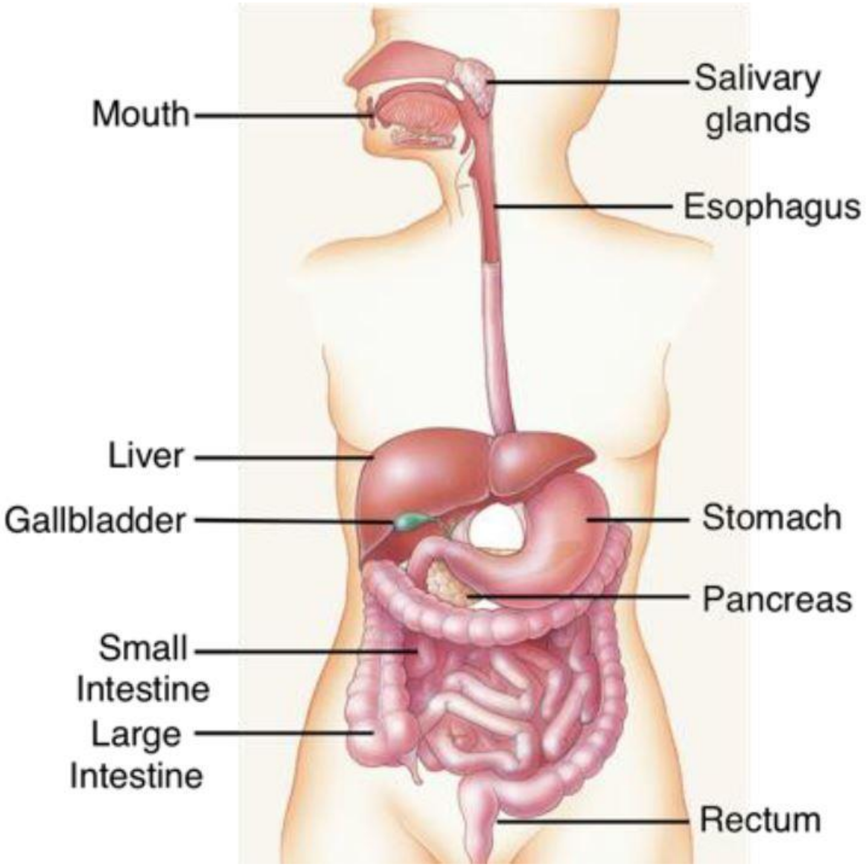
GI Tract

Main pathway

- Mouth and salivary glands
- Esophagus
- Stomach
- Small Intestine
- Large Intestine
- Rectum

Accessory Organs

- Liver (produces bile)
- Gall bladder (stores biles)
- Common bile duct
- Pancreas (endocrine and exocrine secretions)



Salivary Glands

Function

- Produce saliva (water, mucus, ions and salivary amylase; lipase in babies)

Parotid Gland

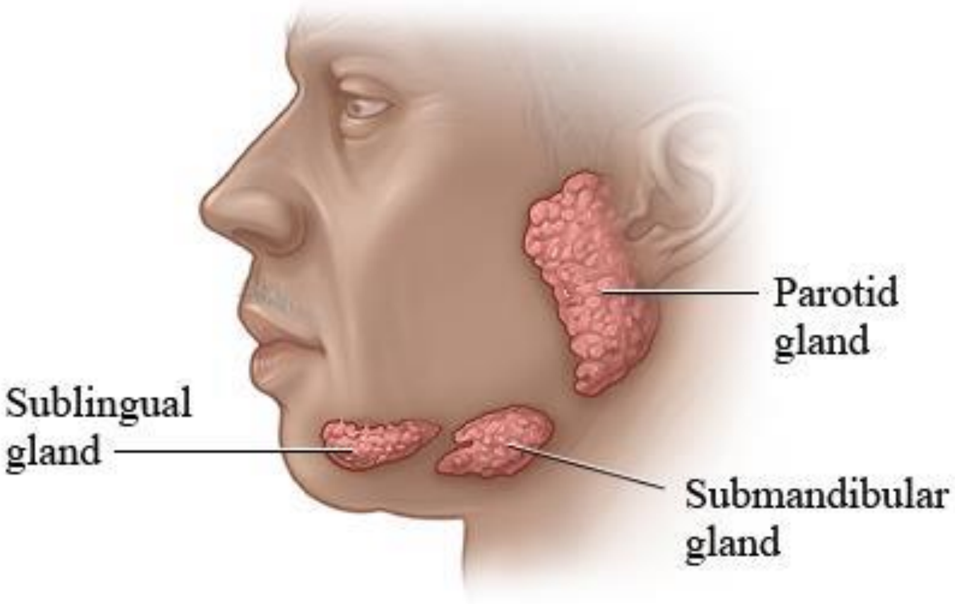
- Watery liquid that contains amylase and lingual lipase

Submandibular Gland

- Thicker liquid that contains mucus with less amylase and less lingual lipase

Sublingual Gland

- A lot of mucus and very little enzymes



Mastication, Swallowing and Peristalsis

Mastication

- Mechanical manipulation of food into a lump of food (bolus)

Swallowing → 3 Stages:

1. Voluntary stage
2. Pharyngeal stage (involuntary): propagation of food into pharynx; close trachea and nasal cavity
3. Esophageal (involuntary): propagation of food into esophagus

Peristalsis

- Movement of bolus down the esophagus by contraction of muscles
- Involuntary control by medulla
- Second peristaltic wave if food is still lodged

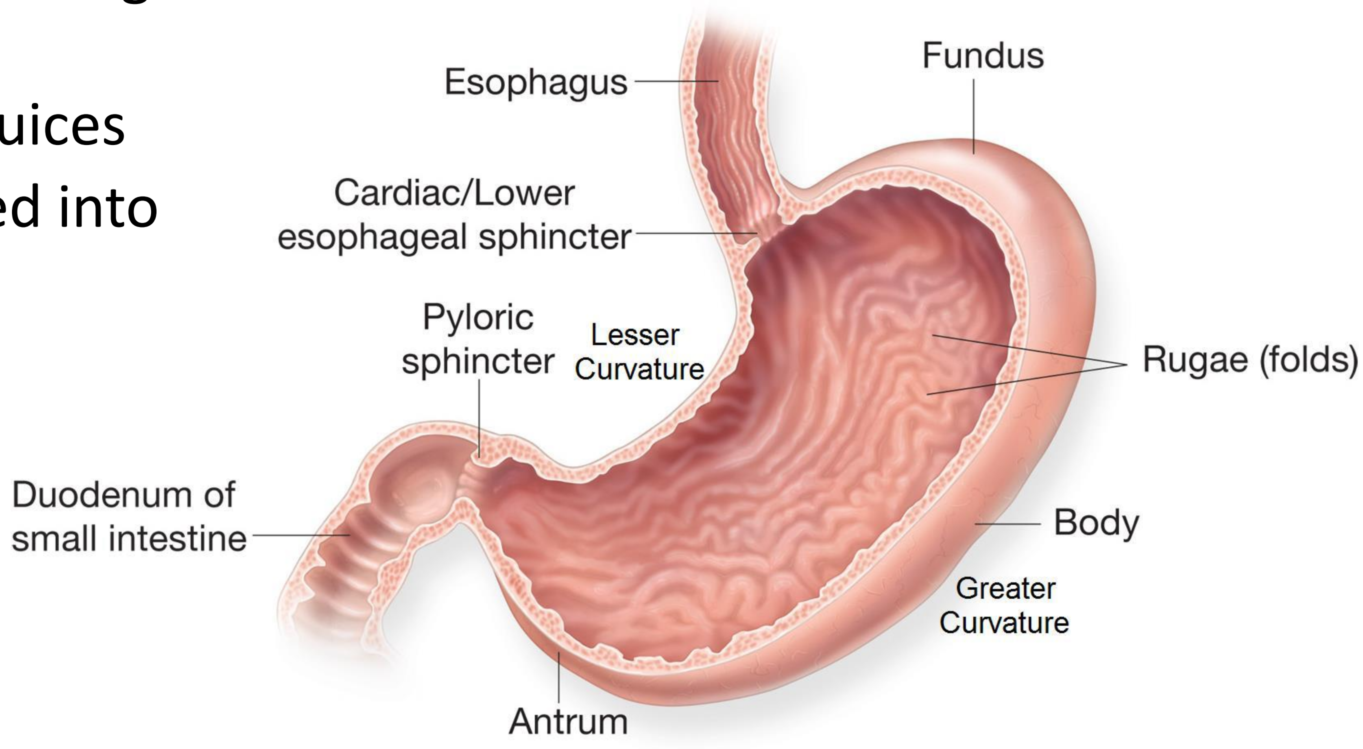
Mouth: Summary of Four Processes

1. **Secretion**
    - Saliva
2. **Digestion**
    - Chemical (amylase and lipase)
    - Mechanical (mastication)
3. **Motility**
    - Mastication in mouth
    - Peristalsis in esophagus
4. **Absorption**
    - None

Stomach

Function

- Reservoir for food before entering intestines for absorption
- Bolus is liquefied by gastric juices
- 2-3 L of gastric juices secreted into stomach per day



Layers of The Stomach

Mucosa

- Single layer of cells that can be endocrine or exocrine
- Large folds called rugae and invaginations called pits

Submucosa

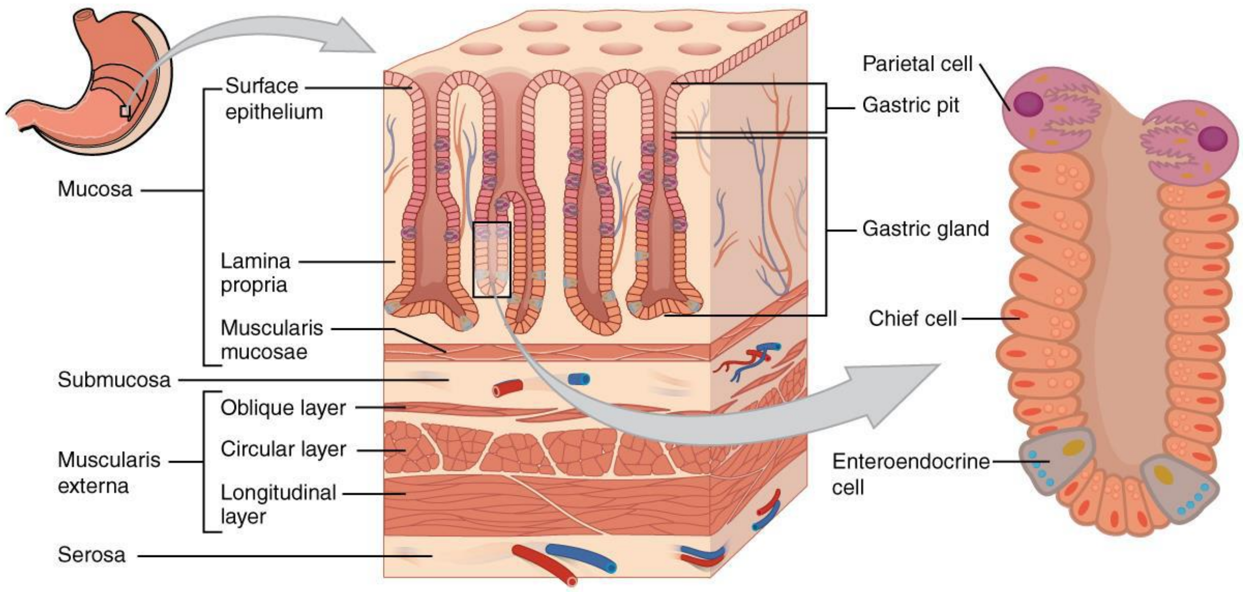
- Nervous plexus: submucosal plexus (detects food in stomach and sends signals to mucosa for response)
- Connective tissue to adhere mucosa to smooth muscle

Smooth muscle (Muscularis externa)

- Circular and longitudinal muscle to change shape of the stomach
- Nervous plexus: myenteric plexus (controls muscle)

Serosa

- External layer of dense connective tissue



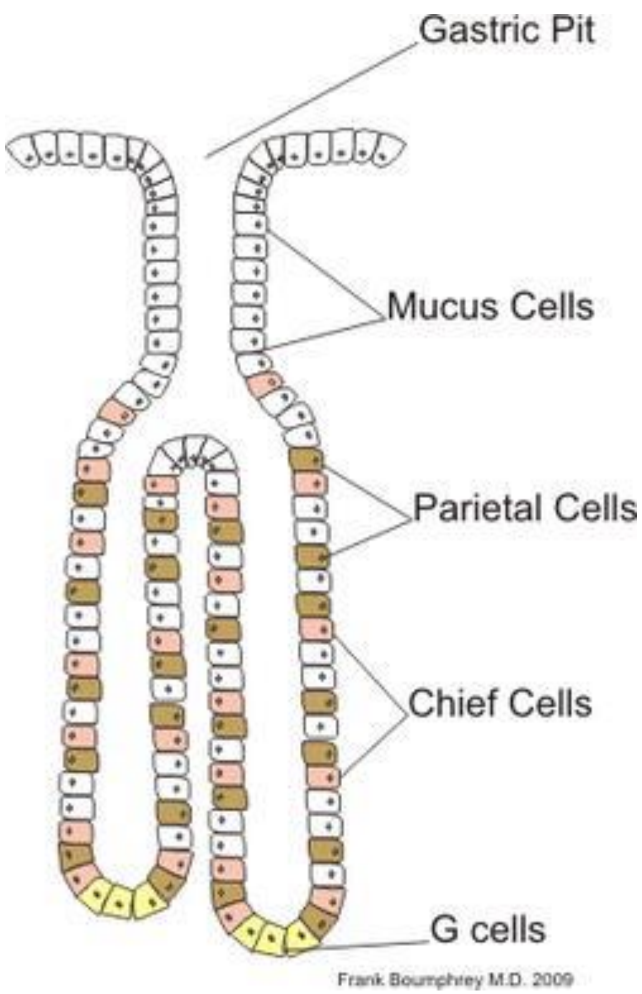
Secretions In The Stomach

Exocrine

Cell	Secretion	Function
Mucus Neck Cells	Mucus	Protects stomach from acid
Chief Cells	Pepsinogen	Inactive enzyme
	Gastric Lipase	Breakdown fats
Parietal Cells	Intrinsic Factor	Allows absorption of vitamin B12
	HCL acid	See slide 10.

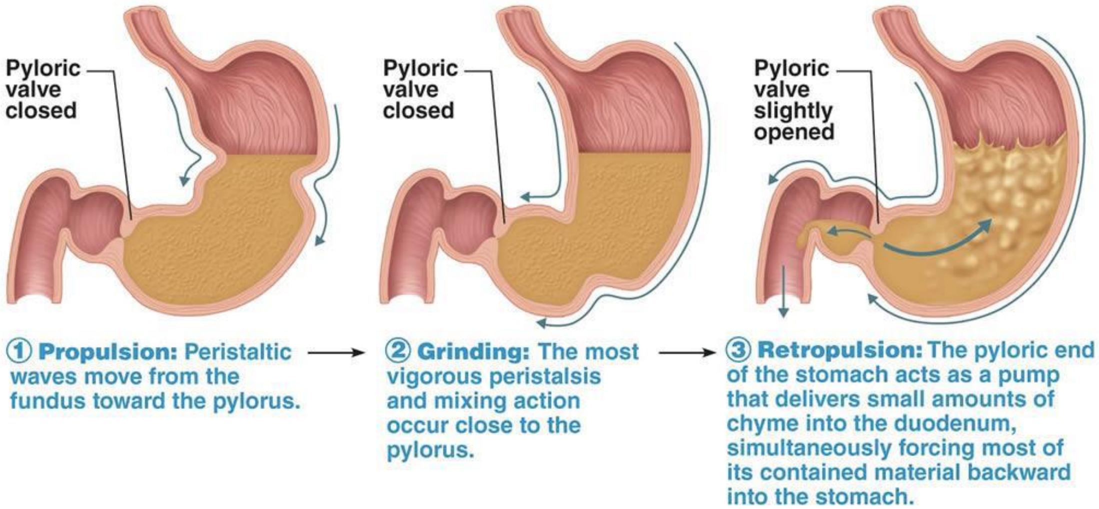
Endocrine

Cell	Secretion	Function
G Cell	Gastrin	Promotes gastric motility and function



Mechanical Digestion in the Stomach

- Gentle mixing waves(every 15-25 seconds), pyloric sphincter closed
- Vigorous mixing from body to pylorus
- Slight opening of pyloric sphincter, very small amount of chyme exits to the duodenum (retropulsion)
- Most chyme pushed back into stomach body for more mixing



Chemical Digestion in the Stomach

- HCl (parietal cells) cleaves pepsinogen (chief cells) to pepsin
- Pepsin: protein digestion
- Gastric lipase (chief cells; activated by HCl): lipid digestion
- Lingual lipase (activated by HCl): lipid digestion
- Salivary amylase (inactivated by HCl): carbohydrate digestion stops

HCl Acid in the Stomach

Functions:

- Activation of pepsin
- Activation of lingual and gastric lipase
- Inactivation of salivary amylase
- Kills microbes
- Denatures proteins
- Stimulates secretion of hormones

Anatomy of the Small Intestine

Duodenum

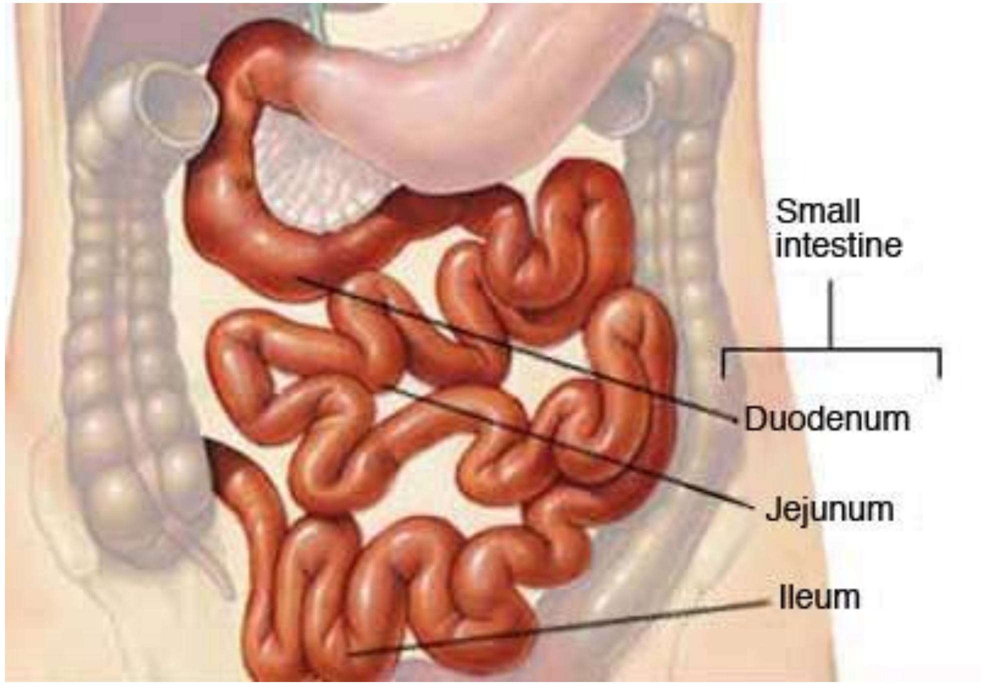
- Location of enzymes mixing with chyme, most digestion occurs here
- Can increase or decrease motility to optimize chemical digestion

Jejunum

- Many villi to increase surface area for optimal absorption
- Most absorption occurs here

Ileum

- Less villi but can still absorb nutrients if necessary

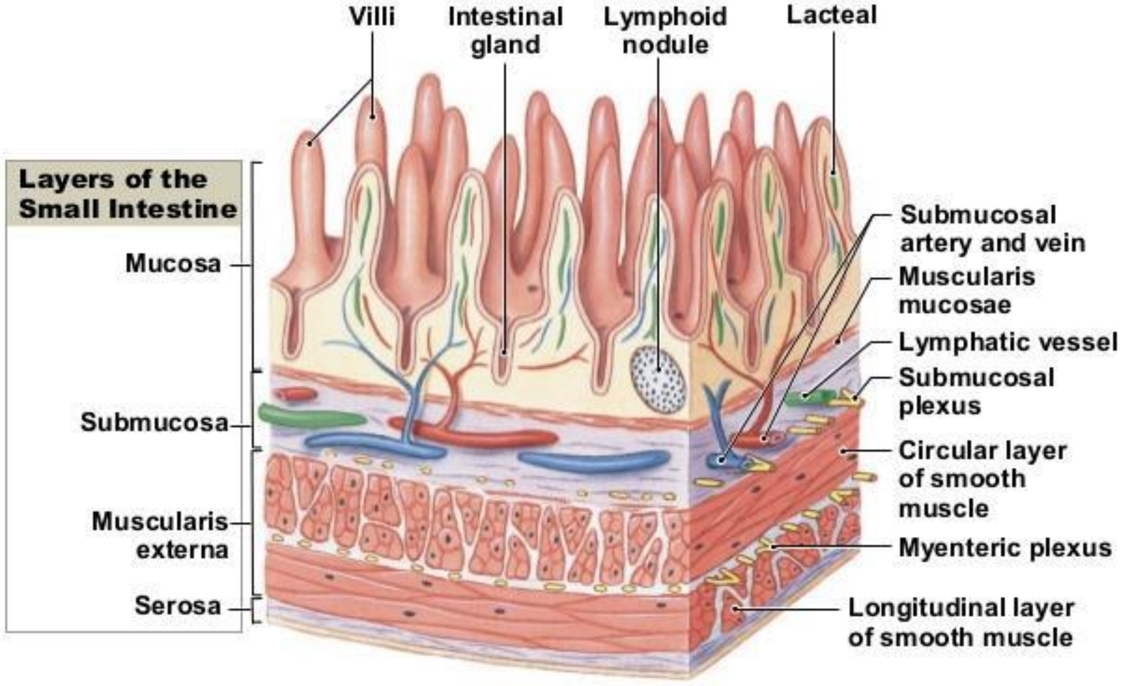


Layers of the Small Intestine

4 layers (similar to stomach)

- ➢Mucosa
- ➢Submucosa
  - ➢Submucosal plexus
- ➢Muscularis externa
  - ➢Myenteric plexus
- ➢Serosa

- SI has villi and microvilli that increases surface area for absorption
- Note: villi in SI ≠ rugae in stomach



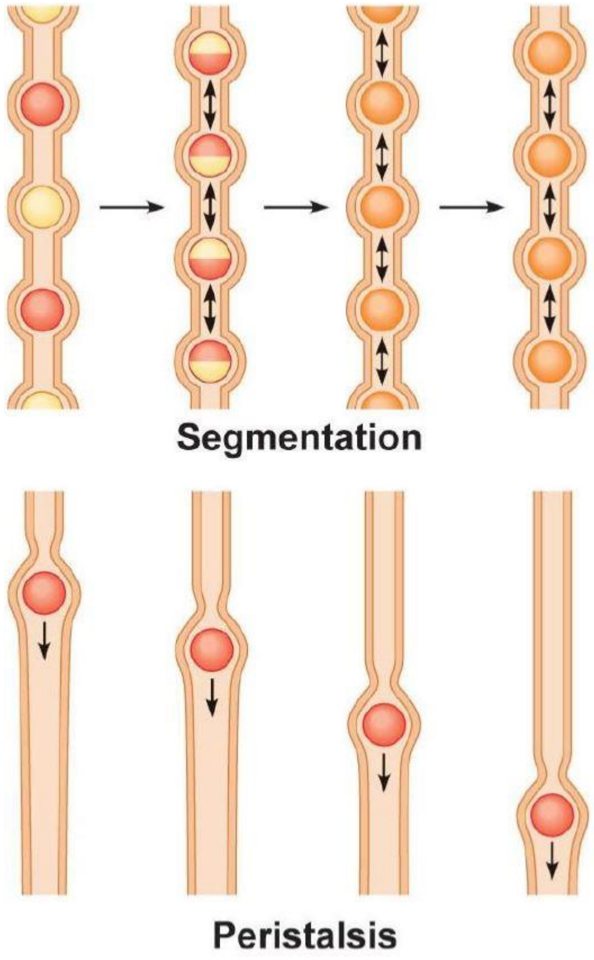
Motility of the Small Intestine

Segmentation

- Localized contractions for mixing chyme with digestive juices
- Increases the interactions of particles of food in chyme with absorptive cells of the mucosa layer

Peristalsis

- Propels chyme forward to next portion of SI (from pyloric sphincter to large intestine)



Cells in the Small Intestine

Exocrine

Cell	Secretion	Function
Goblet Cells	Mucus	Protects small intestine from acid
Intestinal Gland cells	Intestinal Juice (alkaline)	Neutralize acid from stomach
Paneth Cells	Lysozyme	Anti-bacterial enzyme

Endocrine

Cell	Secretion	Function
S Cell	Secretin	Stimulates release of bicarbonate from pancreas
CCK Cells	CCK: Cholecystokinin	Stimulates release of enzymes from pancreas and bile from gallbladder
K cells	GIP: Glucose Dependent Insulinotriphic peptide	Stimulates insulin release from the pancreas

What Questions Do You Have?

You can ask in the Owl forums as well!

Also anonymously ask questions in the online dropbox!!

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