TOPIC: RENAL PHYSIOLOGY STEP 2 - TUBULAR REABSORPTION

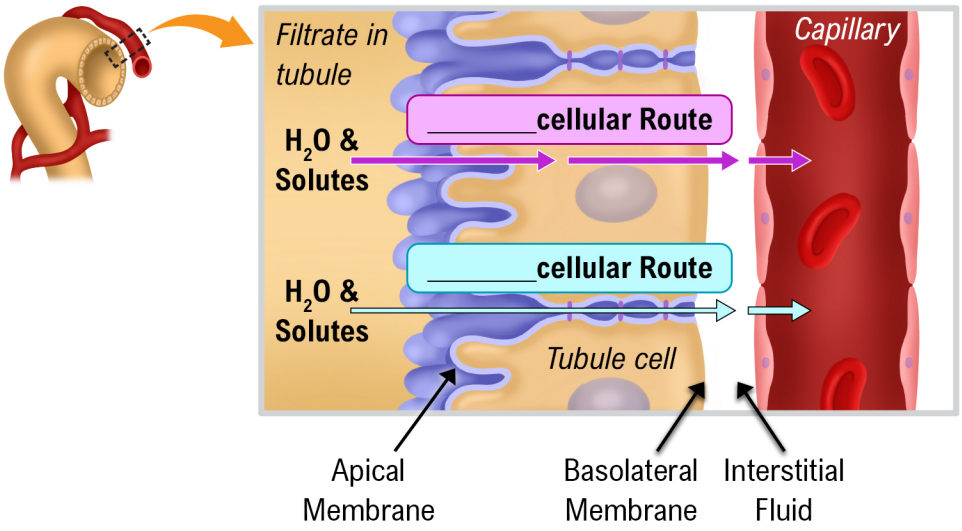
Introduction to Tubular Reabsorption

- **Tubular Reabsorption**: Moves water and other solutes out of the filtrate, _____ into the bloodstream.
  - Filtrate is formed at a *high rate*; ~_____% is reabsorbed back into the blood.
  - Reabsorption prevents the body from losing useful substances that entered the filtrate.

- There are ____ routes that substances can take when they're reabsorbed:
  1) **Transcellular Route**: Substances pass _____ tubule cells.
  2) **Paracellular Route**: Substances pass _____ tubule cells.

Recall **Membrane Transport**

This topic involves different types of membrane transport – consider refreshing your memory before diving in!



EXAMPLE

What is the route taken by substances being reabsorbed via the transcellular route?

a) Tubule lumen > basolateral membrane > tubule cell > apical membrane > interstitial fluid > capillary

b) Tubule lumen > gap between cells > tight junction > interstitial fluid > capillary

c) Tubule lumen > apical membrane > tubule cell > basolateral membrane > interstitial fluid > capillary

d) Tubule lumen > interstitial fluid > apical membrane > tubule cell > basolateral membrane > capillary

PRACTICE

Which of the following is **NOT** a purpose of tubular reabsorption?

a) To avoid losing important nutrients in urine such as glucose & amino acids.

b) To ensure urea is taken back up by the blood.

c) To maintain fluid balance in the body.

d) To avoid losing too much sodium.

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Map of the Lesson on Tubular Reabsorption

◆ Reabsorption looks slightly different in each part of the _____. Here is a map of the lesson on reabsorption:

Step 1:
Reabsorption in the **Proximal Tubule**

1a:
Reabsorption of Sodium and other Nutrients

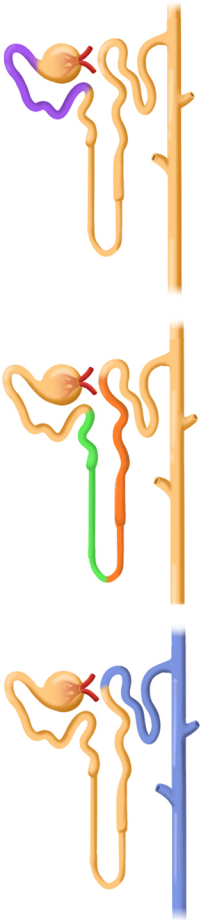
1b:
Reabsorption of Water

Step 2:
Reabsorption in the **Nephron Loop**

2a:
Reabsorption of Water in the **Descending Limb**

2b:
Reabsorption of Ions in the **Ascending Limb**

Step 3:
Hormone-Regulated Reabsorption in the **Distal Tubule**



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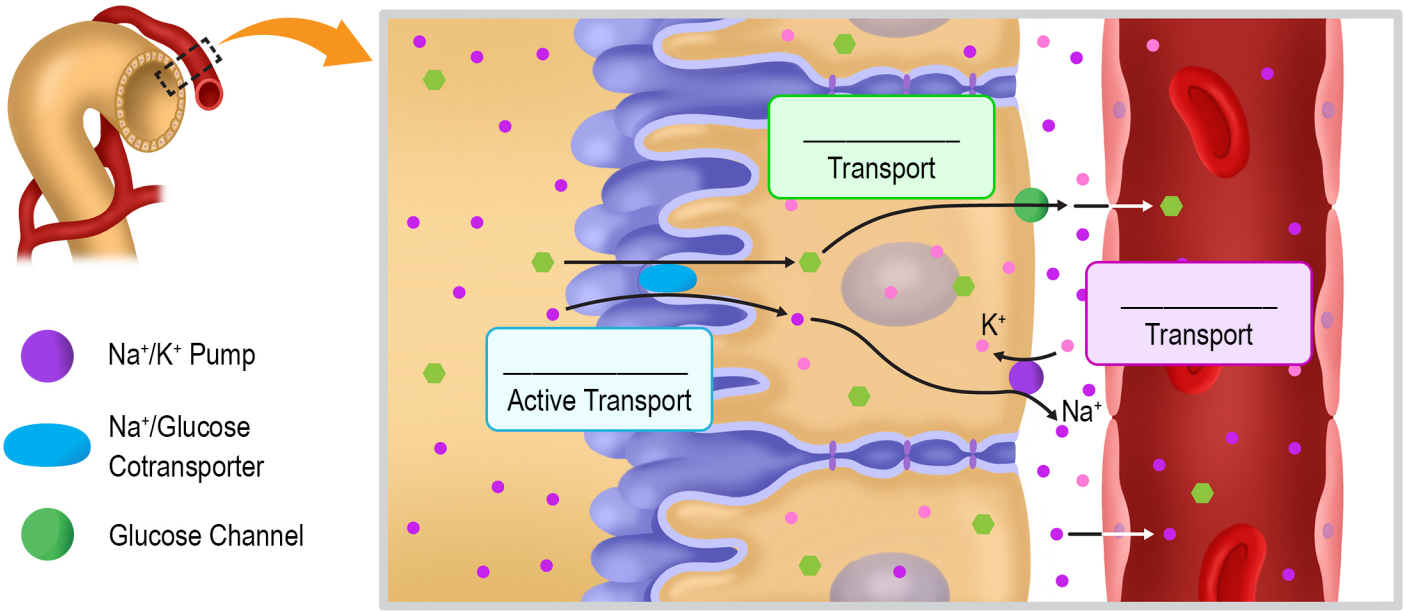
1a) Reabsorption of Sodium & Nutrients in the Proximal Tubule

- Reabsorption can be **active** (uses _____) or **passive** (doesn't use ATP).
- Na^+ reabsorption is driven *mainly* by _____ transport via the transcellular route.
- Na^+ and nutrients also travel via secondary active transport and passive transport.

Primary Active Transport	Secondary Active Transport	Passive Transport
Na^+/K^+ _____ in basolateral membrane of tubule cell *actively* transports sodium ions into interstitial space.	Na^+ ions from filtrate are "pulled in" via cotransporters that also carry a specific **nutrient** (e.g. glucose, amino acids) *against* its concentration gradient.	Solutes travel from tubule cell into the capillary *passively* via simple diffusion (lipid-soluble substances) & facilitated _____ (glucose & other nutrients).



EXAMPLE

Which of the following substances *primarily* utilizes secondary active transport at the apical membrane and facilitated diffusion at the basolateral membrane?

a) Water molecules.
b) Sodium ions.
c) Urea.
d) Glucose.

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PRACTICE

Which of the following solutes are primarily reabsorbed by *primary* active transport?

a) Potassium ions.

b) Sodium ions.

c) Urea.

d) Glucose.

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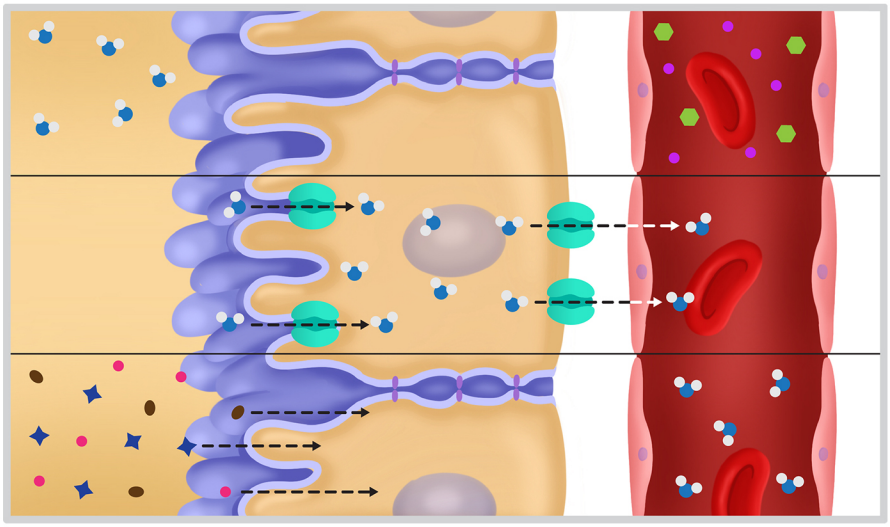
1b) Passive Reabsorption of Water & Solutes in the Proximal Tubule

◆ In the proximal tubule, water and solute reabsorption follows this pattern:

1. Movement of Na^+ & solutes out of filtrate establishes a strong _____ gradient.
2. This causes _____ molecules to be reabsorbed via aquaporins (_____ water reabsorption).
3. A steep concentration gradient for other solutes is established Solutes "_____" water.



EXAMPLE

What is the primary driving force that causes water to "follow" salt out of the tubule & into the capillary?

a) Osmotic gradient.
b) Active transport.
c) Presence of aquaporins.
d) None of the above.

PRACTICE

In the proximal tubule, _____ ions are pumped out of the tubule via _____ transport. This creates an _____ gradient, causing water to be reabsorbed through _____.

a) Potassium; active; osmotic; gaps between cells.
b) Sodium; passive; osmotic; aquaporins.
c) Potassium; active; ionic; gaps between cells.
d) Sodium; active; osmotic; aquaporins.

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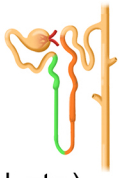
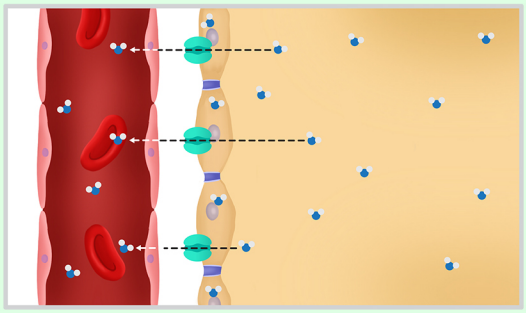
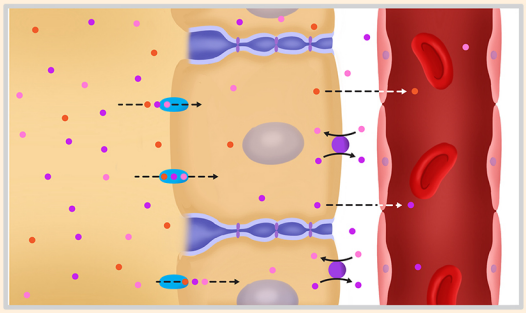
2) Reabsorption in the Nephron Loop



- Reabsorption in the nephron loop employs similar mechanisms to the proximal tubule.
  - However, permeability of the descending and ascending limbs _____.
- ~65% of filtrate is reabsorbed in the proximal tubule, including _____ organic solutes (glucose, amino acid, etc.).
  - Once filtrate reaches the nephron loop, it is mostly water and _____.

Substance	2a) Descending Limb	2b) Ascending Limb
Water	Contains _____porins - water reabsorbed via osmosis.	Aquaporins are _____- osmosis does **not** occur.
Ions (Na^+, Cl^-, K^+)	Impermeable to ions – _____ reabsorption.	Secondary Active Transport (apical) & Primary Active Transport (_____ lateral).
		

EXAMPLE

True or False (if false, choose the answer that best corrects the statement): The descending limb of the nephron loop is very permeable to water but impermeable to ions.

a) True.

b) False; it is permeable to both water and ions.

c) False; it is impermeable to both water and ions.

d) False; it is impermeable to water and permeable to ions.

PRACTICE

Predict what would happen if the tubule wall of the descending limb suddenly lost all its aquaporins.

a) More reabsorption would occur in the nephron loop.

b) Urine would be higher in volume & more dilute.

c) Urine would be lower in volume and more concentrated.

d) Urine would have the same volume but be more concentrated.

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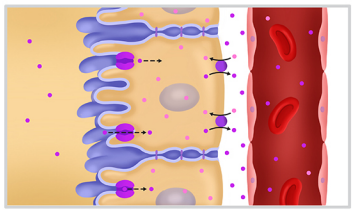
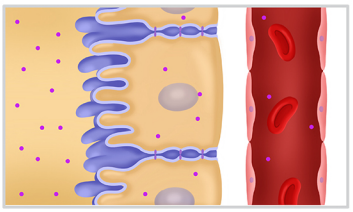
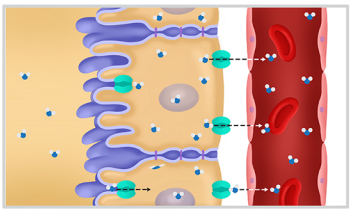
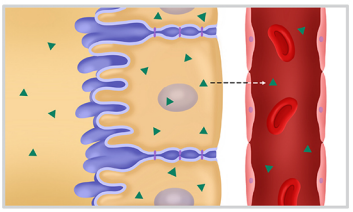
3) Reabsorption in the Distal Tubule and Collecting Duct

- Reabsorption in the proximal tubule and nephron loop tends to occur at a _____ rate.
- Reabsorption in the distal tubule and collecting duct _____ depending on the body's needs.
- There are _____ hormones that influence the rate at which various substances are reabsorbed:
  1. **Aldosterone:** "Salt-retaining hormone" – increases Na^+ reabsorption.
  2. **Atrial Natriuretic Peptide (ANP):** Opposite of aldosterone; reduces rate of _____ reabsorption.
  3. **Antidiuretic Hormone (ADH):** Reduces volume of urine by increasing rate of _____ reabsorption.
  4. **Parathyroid Hormone (PTH):** Stimulates Ca^{2+} reabsorption in the DT.

 1	 2	 3	 4
_____	_____ Natriuretic Peptide (ANP)	_____diuretic hormone (ADH)	_____thyroid hormone (PTH)

EXAMPLE

Which hormone causes aquaporins to be interested in the wall of the collecting duct?

a) Aldosterone.
b) Atrial Natriuretic Peptide.
c) Antidiuretic hormone.
d) Parathyroid hormone.

PRACTICE

Dr. Miller is a pediatric nutritionist working with a patient who has a low dietary calcium intake. Concerned about the possibility of hypocalcemia, she orders bloodwork. What hormone would you expect to be elevated in this patient's bloodwork?

a) Aldosterone.
b) Atrial Natriuretic Peptide.
c) Antidiuretic Hormone.
d) Parathyroid Hormone.

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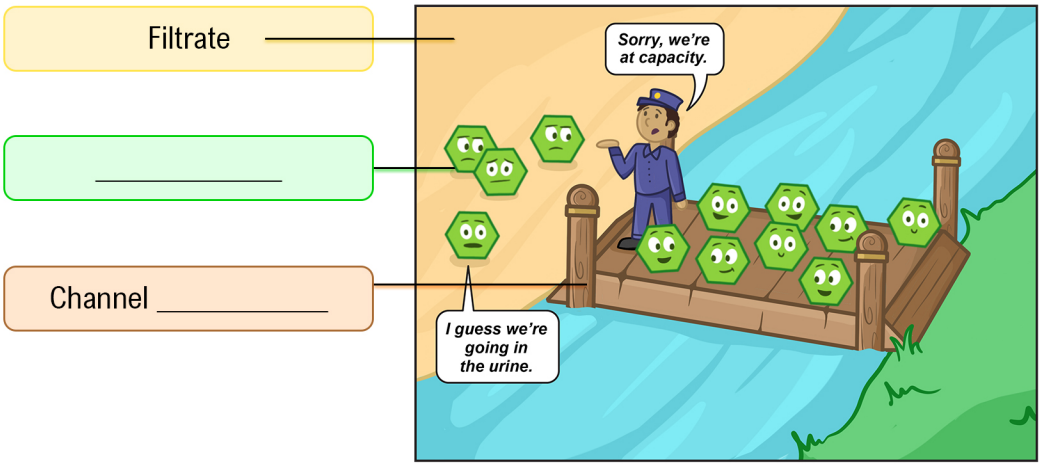
Transport Maximum (T_M) & Renal Threshold

- **Transport Maximum (T_M):** Maximum amount of a given substance that can be reabsorbed (in mg/min).
  - Reflects the number of _____ proteins in the renal tubule available to "ferry" the substance.
  - When all transport proteins are _____, nutrients will be excreted in urine.
- **Renal Threshold:** The blood concentration at which a given substance begins to appear in the _____ (in mg/dL).



EXAMPLE

In which of the following conditions would you expect to see high levels of glucose in the urine?

a) Hypercalcemia.

b) Lupus.

c) Hyperglycemia.

d) Hypoglycemia.

PRACTICE

Ryan just ate a very protein-rich meal. Because of this, the amino acid levels in his blood currently exceed the transport maximum and the renal threshold for amino acids (65 mg/dL). What will happen to the excess amino acids?

a) They will be reabsorbed.

b) They will bond to sodium ions.

c) They will end up in the urine.

d) They will build up in the nephron.

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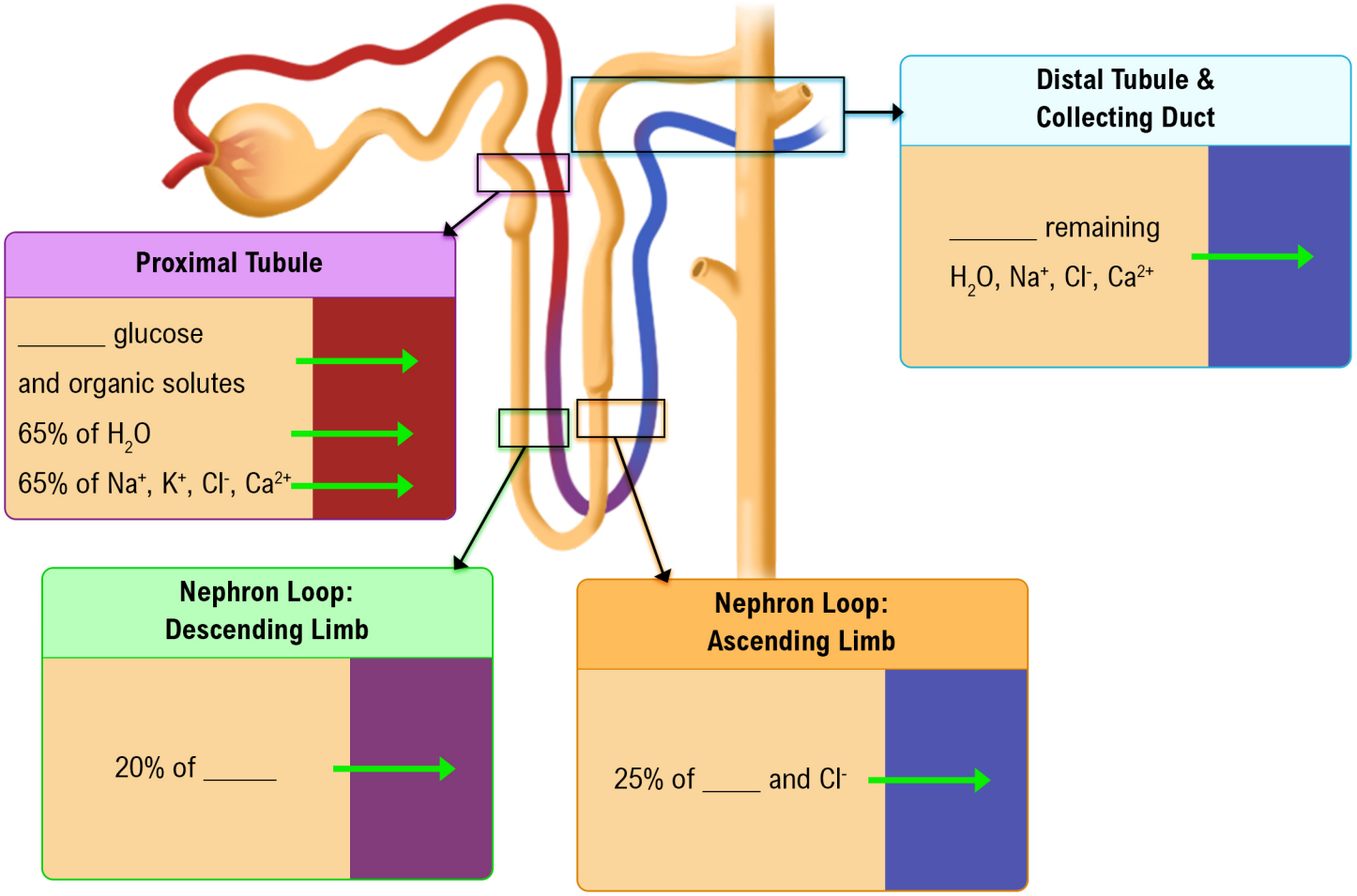
Review of Tubular Reabsorption

- Reabsorption allows our body to reclaim important solutes from _____.



EXAMPLE

How much of the water filtered through the glomerulus is normally reabsorbed in the proximal tubule?

a) 40%
b) 25%
c) 65%
d) 99%

PRACTICE

In which section of the nephron is the process of reabsorption influenced by hormones?

a) Proximal Tubule.
b) Descending limb of nephron loop.
c) Ascending limb of nephron loop.
d) Distal tubule & collecting duct.