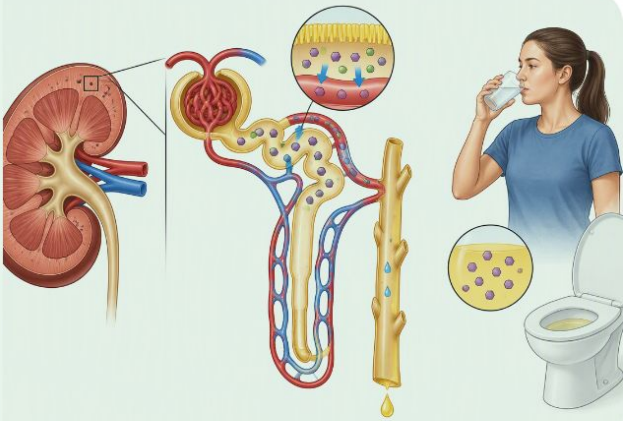
BIOLOGY · ~38 MIN · 4 SECTIONS · 8 QUESTIONS

Tubular Reabsorption and the Renal Threshold v4



In this lesson

Explain how tubular reabsorption returns most filtrate and useful solutes to the blood, and use the renal-threshold and osmotic-diuresis strategies to interpret glycosuria, polyuria and polydipsia.

Core idea

Recognise whether a question requires a capacity comparison, a volume calculation, route tracing or causal ordering, then apply only that branch.

1. The Renal-Threshold Decision Rule
2. Daily Reabsorption and PCT Volume
3. The Brush-Border Route to Blood
4. The Glycosuria-to-Polydipsia Chain

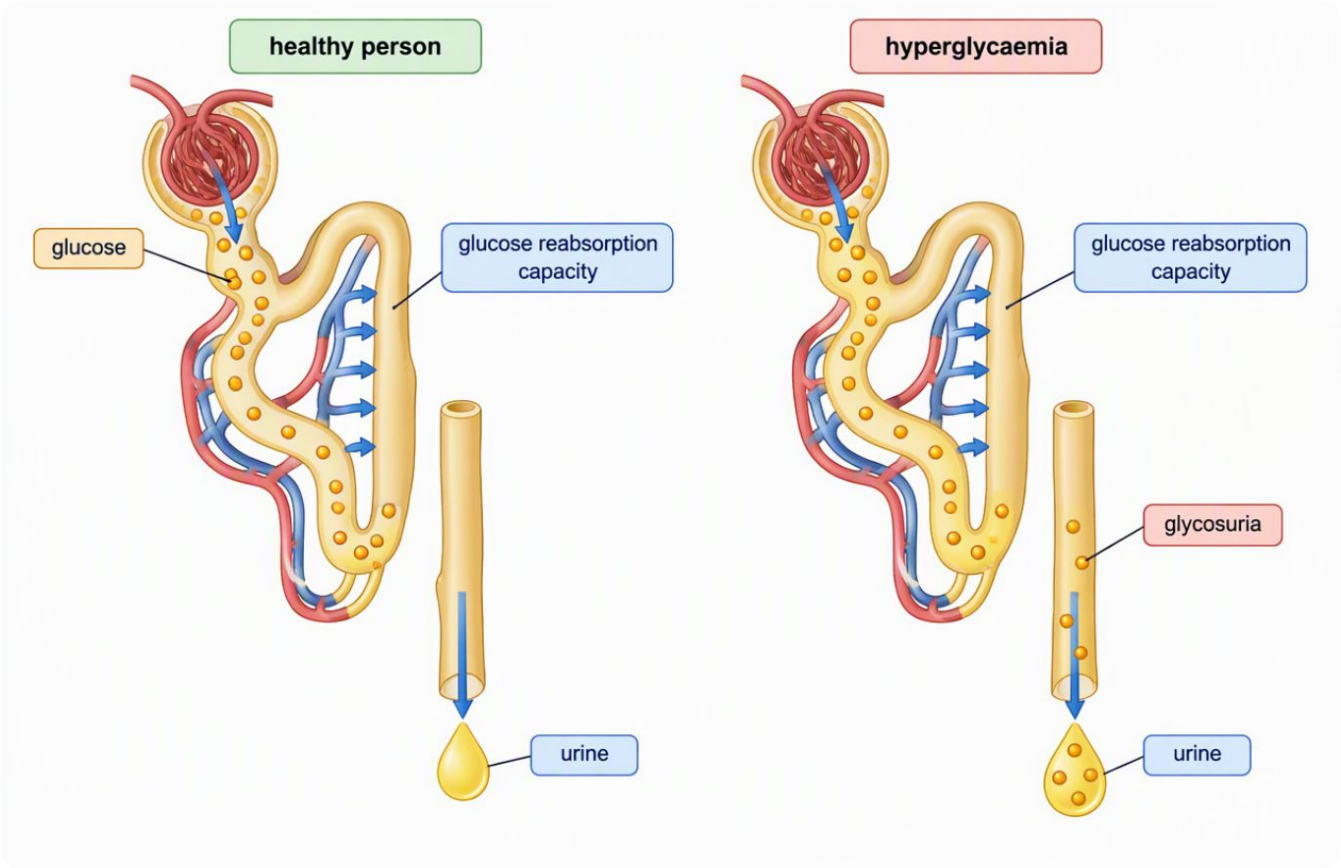
1 The Renal-Threshold Decision Rule

Key rule

The renal threshold is the point at which the tubules can no longer completely reabsorb a substance that is normally completely reabsorbed. Below this capacity the substance is absent from urine; above it, the excess remains in urine.

FOR EXAMPLE

A healthy person has no glucose in urine, whereas hyperglycaemia that exceeds glucose reabsorption capacity causes glycosuria.



Below glucose reabsorption capacity no glucose appears in urine, but excess filtered glucose remains in urine as glycosuria.

Renal threshold

For a normally completely reabsorbed compound, filtered load within tubular capacity gives no urinary compound; filtered load above capacity gives excess compound in urine. Glycosuria means glucose in urine.

Apply this qualitative rule only to a substance described as normally completely reabsorbed; do not introduce a numerical cutoff or transport maximum.

FOR EXAMPLE

Normal glucose: completely reabsorbed, so none appears in urine; excessive blood glucose: capacity is exceeded, so glucose appears in urine.

A filtered nutrient is normally completely reabsorbed, and its filtered load remains below tubular capacity.

→ **The nutrient is absent from urine.**

Capacity is sufficient.

A person has a very high blood concentration of a filtered nutrient that is normally completely reabsorbed.

→ **The nutrient appears in urine.**

Filtered load exceeds capacity.

A filtered ion is only partly reabsorbed in the proximal tubule. →

The renal-threshold rule for complete reabsorption does not predict that the ion will be absent from urine.

The complete-reabsorption condition is missing.

Quick practice

Practice

Two cases involve filtered compound X, which is normally completely reabsorbed. In case 1 its filtered load is below tubular capacity; in case 2 its filtered load exceeds capacity. Compound Y is filtered but only partly reabsorbed in the proximal tubule. Which conclusion is justified?

A. X is absent from urine whenever it is normally completely reabsorbed, regardless of filtered load.

B. X is absent in case 1 and appears in case 2; the renal-threshold rule alone does not determine whether Y is absent from urine.

C. X appears when its filtered load is below capacity and is absent when the load exceeds capacity.

D. The renal-threshold rule applies to Y in the same way because Y is filtered.

E. Y is definitely absent from urine because some Y is reabsorbed in the proximal tubule.

Answer

B) X is absent in case 1 and appears in case 2; the renal-threshold rule alone does not determine whether Y is absent from urine.

1. X is normally completely reabsorbed, so check whether each filtered load is below or above capacity before predicting urinary content.
2. Below capacity leaves no X in urine; therefore A ignores capacity and C reverses the two load conditions.
3. For Y, partial reabsorption does not satisfy the rule's complete-reabsorption premise, so D and E overgeneralise it.
4. Thus X is absent in case 1, appears in case 2, and Y is undecidable by this rule. So the answer is B.

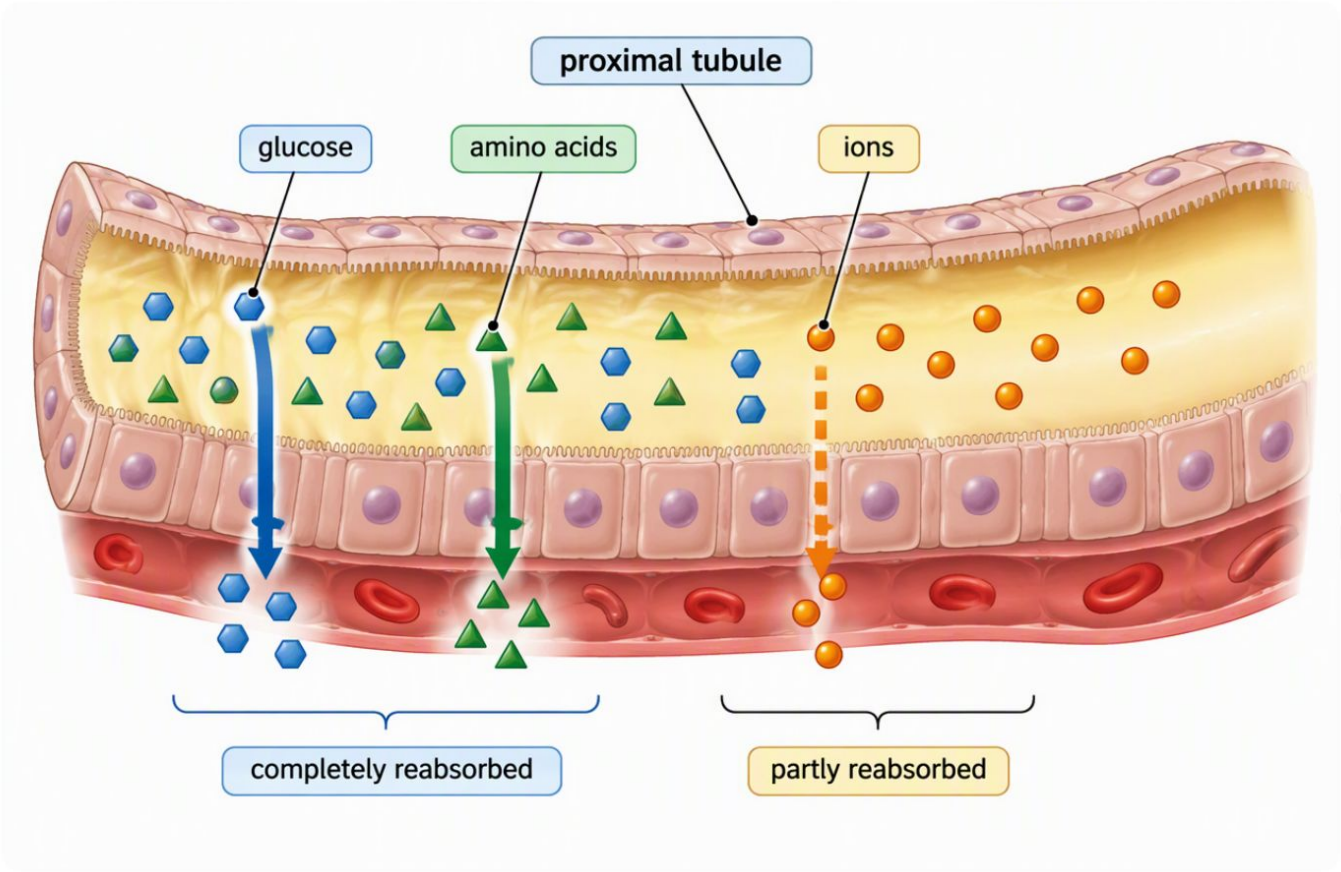
2 Daily Reabsorption and PCT Volume

Key rule

Filtrate reabsorption and proximal-tubule volume

$$f_{\text{reabsorbed}} = \frac{V_{\text{filtrate}} - V_{\text{urine}}}{V_{\text{filtrate}}}, \qquad \%\ \text{reabsorbed} = \frac{V_{\text{filtrate}} - V_{\text{urine}}}{V_{\text{filtrate}}} \cdot 100\%,$$

- Use daily adult volumes as approximate rounded values, not exact mutually matching constants.
- About 99% of filtrate is reabsorbed, leaving about 1.5 L of urine per day; precise regulation helps control body-water volume and blood composition.
- In the proximal convoluted tubule, about 65% of filtrate volume is reabsorbed. The remaining fluid volume falls but stays isotonic with plasma.
- Glucose and amino acids are completely reabsorbed in the proximal tubule under ordinary conditions, whereas ions are only partly reabsorbed there.



In the proximal tubule, glucose and amino acids are completely reabsorbed under ordinary conditions, while ions are only partly reabsorbed.

A person produces 2.0 L of urine from 200 L of filtrate in one day. Calculate the reabsorbed fraction and percentage.

→ $f = (200 - 2.0)/200 = 0.990$**, so** 99.0% **is reabsorbed.**

Direct daily-volume calculation.

A filtrate volume of 160 L/day enters the proximal tubule. Estimate the volume reabsorbed there and the volume leaving it.

→

$0.65 \cdot 160 = 104$ **L/day is reabsorbed and** 56 **L/day remains; the remaining fluid is isotonic with plasma.**

PCT percentage followed by the complementary volume.

Special case	What happens	Example
Rounded daily figures	The direct calculation may give about 99.2%, while the textbook description says about 99%.	$[(180 - 1.5)/180] \cdot 100\% \approx 99.2\%$, reported as about 99%.
PCT volume reduction	Tubular-fluid volume decreases but its concentration remains isotonic with plasma.	For 140 L/day, 65% reabsorbed leaves 49 L/day, still isotonic with plasma.

Quick practice

Practice

On one day, the urine volume is 2.5 L/day and is exactly 1/80 of the day's filtrate volume. Assuming approximately 65% of the filtrate is reabsorbed in the proximal convoluted tubule, what volume remains after the proximal tubule? The remaining fluid stays isotonic with plasma.

A. 2.5 L/day, isotonic with plasma

B. 70 L/day, isotonic with plasma

C. 130 L/day, isotonic with plasma

D. 197.5 L/day, isotonic with plasma

E. 200 L/day, isotonic with plasma

Answer

B) 70 L/day, isotonic with plasma

1. Because urine is 1/80 of filtrate, reverse the ratio rather than subtracting volumes.
   $V_{\text{filtrate}} = \frac{V_{\text{urine}}}{1/80} = 2.5 \times 80 = 200\ \text{L/day}$
2. The reversed ratio gives 200 L/day; A uses urine as the starting volume and E stops before the PCT calculation.
3. Applying 65% gives 130 L/day reabsorbed; C reports that amount, whereas D reports overall reabsorption, $200 - 2.5$.
   $V_{\text{PCT,reabsorbed}} = 0.65 \times 200 = 130\ \text{L/day}$
4. Subtracting the proximal reabsorbed volume leaves 70 L/day, and the fluid remains isotonic. So the answer is B.
   $V_{\text{PCT,remaining}} = 200 - 130 = 70\ \text{L/day}$

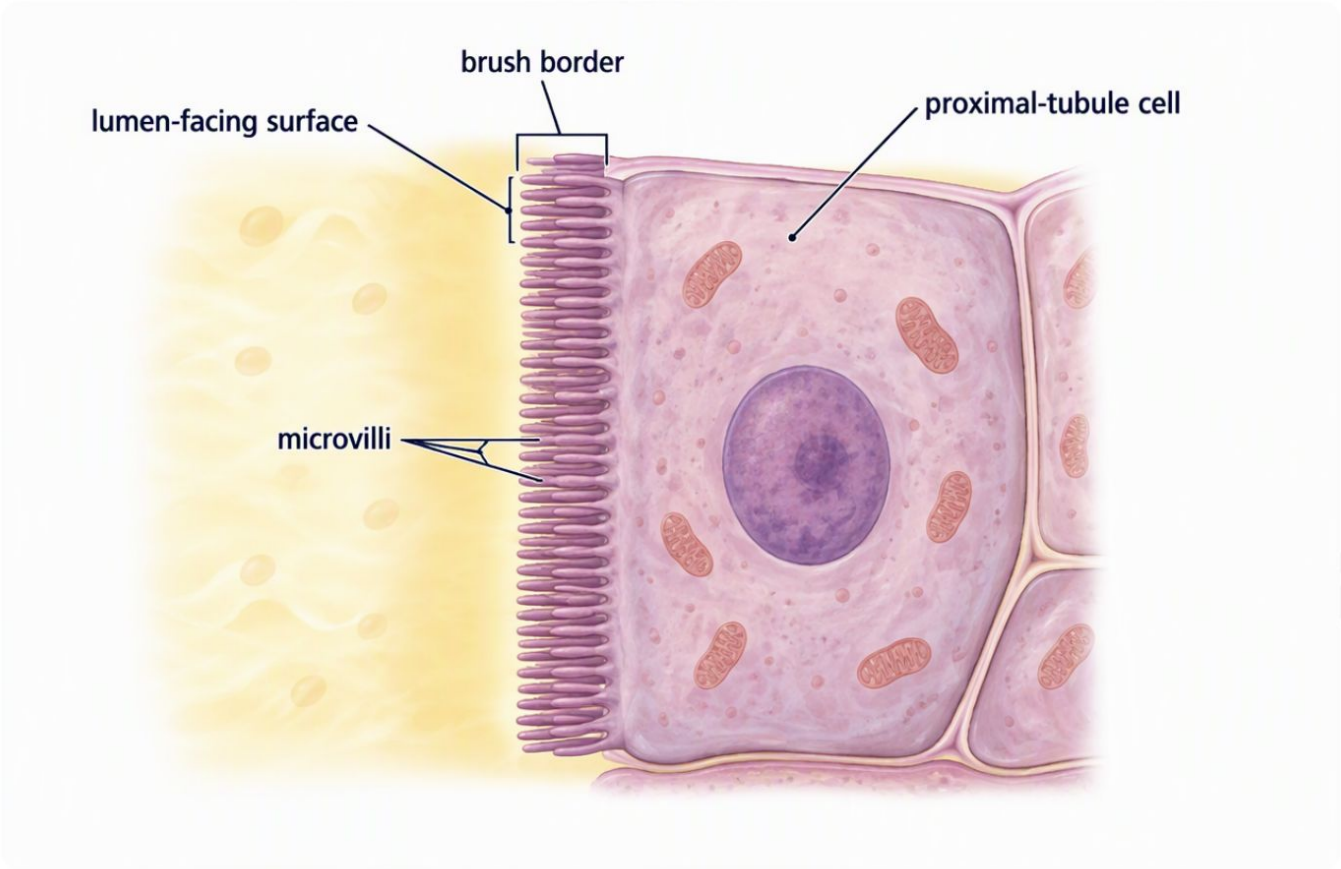
3 The Brush-Border Route to Blood

Key rule

A brush border is a layer of microvilli on the luminal surface of tubule cells. It greatly increases the surface available for tubular reabsorption.

FOR EXAMPLE

Microvilli on the lumen-facing surface of a proximal-tubule cell form the brush border.

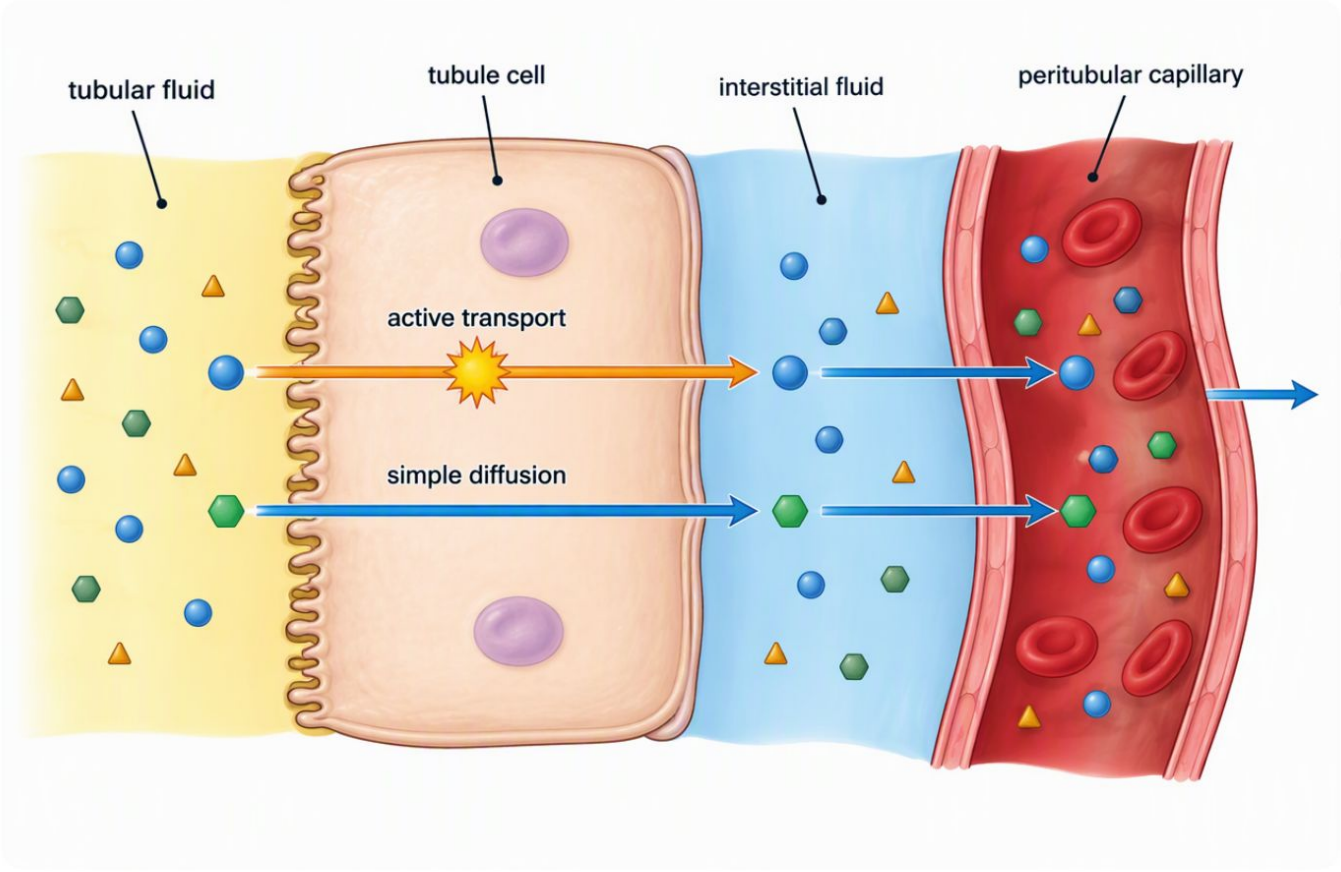


The brush border is made of microvilli on the lumen-facing surface of a proximal-tubule cell, greatly increasing the surface available for tubular reabsorption.

- Reabsorbed water and solutes leave the tubular fluid through the tubule cell, then enter the interstitial fluid and peritubular capillaries before returning to the blood.
- Some substances cross by active transport, which requires energy; others cross by simple diffusion.
- The route is not a direct jump from the tubule to a renal vein.

How To

1. **Leave the lumen** A substance moves from tubular fluid across the lumen-facing surface of a tubule cell.
2. **Cross the cell** It passes through the tubule cell; the mechanism may be active transport using energy or simple diffusion.
3. **Enter interstitial fluid** The substance leaves the cell and enters the fluid surrounding the tubule.
4. **Enter the capillary** It moves from interstitial fluid into a peritubular capillary and thereby returns to the blood.



Reabsorbed water and solutes pass from tubular fluid through a tubule cell and interstitial fluid into a peritubular capillary, by active transport or simple diffusion.

A water-soluble solute is reabsorbed from tubular fluid by a cell process requiring energy. Which route is correct?

→

Tubular fluid → tubule cell by active transport → interstitial fluid → peritubular capillary → blood.

Energy-dependent route.

A small solute moves down its concentration gradient across the tubule lining without energy expenditure.

→ **It can use simple diffusion, then enter interstitial fluid and a peritubular capillary.**

Energy-independent route.

Quick practice

Practice

A solute X is reabsorbed from tubular fluid by a process requiring energy. A second solute Y crosses the tubule lining by simple diffusion without energy expenditure. Which comparison correctly describes their route back to the blood?

A. Both X and Y use simple diffusion across the brush border, then enter the peritubular capillary directly.

B. X uses active transport and Y uses simple diffusion; both cross the lumen-facing brush border into a tubule cell, then pass through interstitial fluid to a peritubular capillary and the blood.

C. Both X and Y use active transport because all tubular reabsorption requires energy.

D. X crosses directly from tubular fluid into a peritubular capillary, whereas Y crosses the tubule cell and interstitial fluid.

E. The brush border is on the interstitial-facing surface, so both solutes enter interstitial fluid before crossing a tubule cell.

Answer

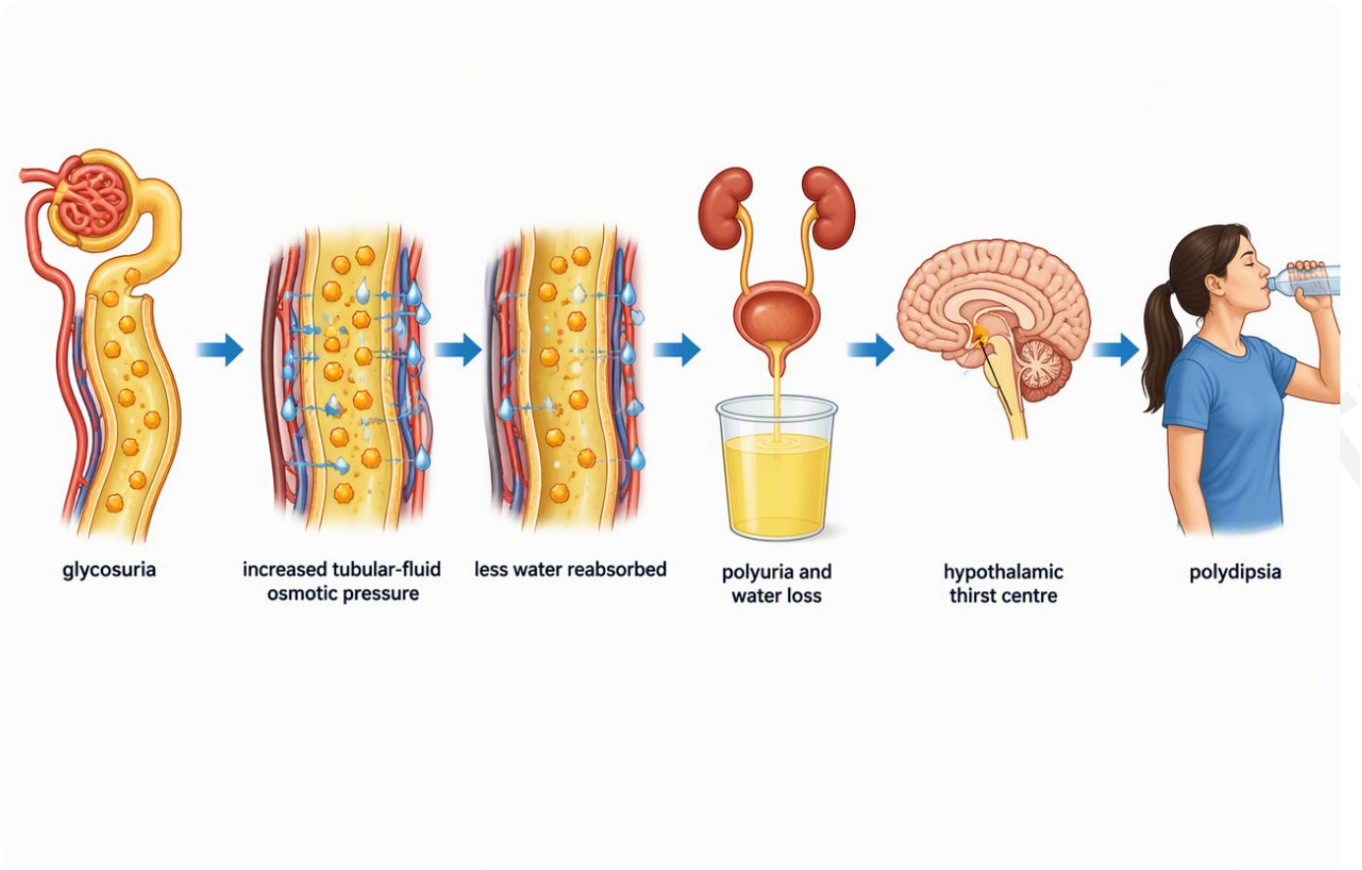
B) X uses active transport and Y uses simple diffusion; both cross the lumen-facing brush border into a tubule cell, then pass through interstitial fluid to a peritubular capillary and the blood.

1. Energy requirement identifies X as active transport; absence of energy identifies Y as simple diffusion.
2. The brush border is the luminal microvillus surface, so both solutes first enter a tubule cell from tubular fluid there.
3. After crossing cells, both pass through interstitial fluid to peritubular capillaries; A and C confuse mechanisms, D and E break the route.
4. Therefore the comparison and route in B are the only consistent ones. So the answer is B.

4 The Glycosuria-to-Polydipsia Chain

Key rule

- Glycosuria is glucose in urine; glucose raises the osmotic pressure of tubular fluid, so less water is reabsorbed.
- Polyuria is production of an abnormally large volume of urine. It follows reduced water reabsorption and water loss.
- Polydipsia is excessive thirst and drinking. Water loss stimulates the hypothalamic thirst centre, producing thirst and subsequent drinking.
- The causal order is glycosuria → increased tubular-fluid osmotic pressure → less water reabsorbed → polyuria and water loss → thirst → polydipsia.



Glycosuria increases tubular-fluid osmotic pressure, so less water is reabsorbed and polyuria with water loss precedes thirst and polydipsia.

How To

1. **Start with glycosuria** Hyperglycaemia exceeds glucose reabsorption capacity, leaving glucose in the tubular fluid and urine.
2. **Increase osmotic pressure** The glucose raises the osmotic pressure of tubular fluid.
3. **Reduce water reabsorption** The higher osmotic pressure means less water is reabsorbed from the tubules.
4. **Produce polyuria** More water remains in the tubular fluid, so urine volume increases and water is lost.
5. **Trigger polydipsia** Water loss stimulates the hypothalamic thirst centre, causing intense thirst and drinking.

A patient has glycosuria but no information about altered filtration. Which immediate tubular change explains increased urine volume?

→ **Glucose raises tubular-fluid osmotic pressure, so less water is reabsorbed.**

First consequence after glucose enters urine.

A patient with uncontrolled diabetes is passing unusually large volumes of urine and then drinking intensely.

→ **Polyuria and water loss precede thirst and polydipsia.**

Correct direction of causation.

PREPTEST PREPT

Quick practice

Practice

An uncontrolled-diabetes patient is found to have glucose in the urine. Later, urine volume becomes unusually large, followed by intense drinking. Which sequence explains these observations without treating drinking as the initial cause?

A. Glycosuria → lower tubular-fluid osmotic pressure → less water reabsorbed → polyuria and water loss → thirst → polydipsia

B. Glycosuria → higher tubular-fluid osmotic pressure → more water reabsorbed → polyuria and water loss → thirst → polydipsia

C. Glycosuria → higher tubular-fluid osmotic pressure → less water reabsorbed → polyuria and water loss → thirst centre → polydipsia

D. Polyuria and water loss → glycosuria → higher tubular-fluid osmotic pressure → less water reabsorbed → thirst → polydipsia

E. Glycosuria → higher tubular-fluid osmotic pressure → less water reabsorbed → thirst centre → polydipsia → polyuria and water loss

Answer

C) Glycosuria → higher tubular-fluid osmotic pressure → less water reabsorbed → polyuria and water loss → thirst centre → polydipsia

1. Excess filtered glucose remains in tubular fluid because reabsorption capacity is exceeded, producing glycosuria.
2. Glucose raises tubular-fluid osmotic pressure, reducing water reabsorption; A reverses the osmotic effect and B reverses water movement.
3. Retained water causes polyuria and water loss; only then does the thirst centre produce polydipsia, excluding D and E.
4. Thus the causal chain is the one in C. So the answer is C.

Worked Example

A person produces approximately 1.5 L of urine per day from approximately 180 L of glomerular filtrate. Which statement correctly combines the overall reabsorption calculation with proximal-tubule reabsorption?

A About 98.3% overall; 115 L/day reabsorbed in the PCT and 65 L/day remains hypertonic.

B About 99.2% overall, conventionally reported as about 99%; 117 L/day reabsorbed in the PCT and 63 L/day remains isotonic.

C Exactly 99.0% overall; 118 L/day reabsorbed in the PCT and 62 L/day remains concentrated.

D About 99.2% overall; 117 L/day reabsorbed in the PCT and 63 L/day becomes concentrated in the PCT.

E About 0.8% overall; 63 L/day reabsorbed in the PCT and 117 L/day remains isotonic.

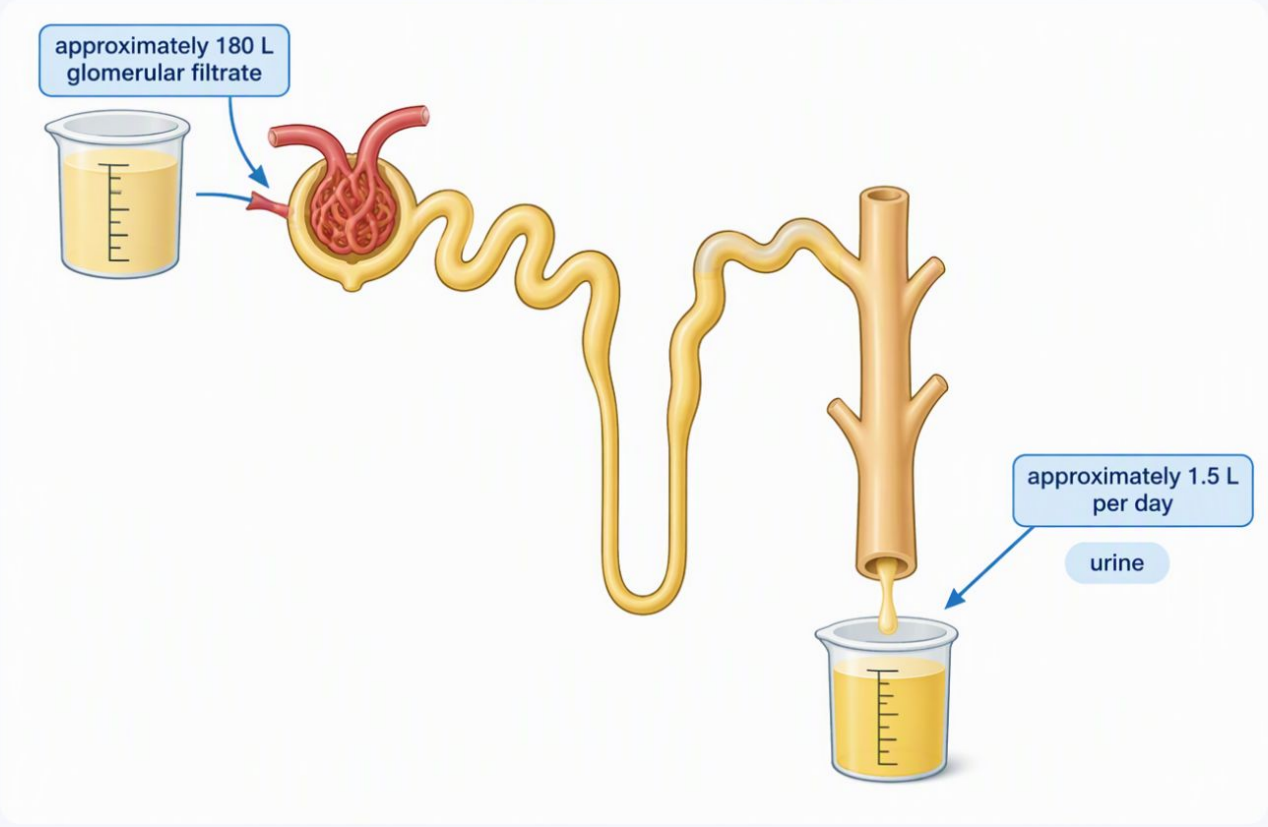
Calculate the overall fraction first, then apply the approximate 65% proximal-tubule fraction and interpret the remaining fluid.

Subtract daily urine volume from daily filtrate volume to find the volume reabsorbed overall.	$180 - 1.5 = 178.5\ \text{L/day}$
Divide the reabsorbed volume by filtrate volume and convert to a percentage.	$\frac{178.5}{180} \cdot 100\% = 99.166\ldots\% \approx 99.2\% \approx 99\%$
Calculate the approximate proximal-tubule volume reabsorbed.	$0.65 \cdot 180 = 117\ \text{L/day}$
Subtract the proximal-tubule reabsorbed volume from the starting volume; the remaining fluid is isotonic with plasma.	$180 - 117 = 63\ \text{L/day}$
The approximate inputs explain the rounded textbook figures, so option B is correct.	$99.2\% \approx 99\%$

Answer

B — About 99.2% overall, conventionally reported as about 99%; 117 L/day reabsorbed in the PCT and 63 L/day remains isotonic.

The percentages and volumes follow directly from subtraction, division and multiplication using the stated approximate daily values.



The worked problem gives approximately 180 L of glomerular filtrate and approximately 1.5 L of urine per day.

Worked Example 2 — Your Turn on the Marked Steps

Case Given glycosuria, increased urine osmotic pressure and excessive thirst, reconstruct the causal links and order the consequences.

A patient has glycosuria and increased tubular-fluid osmotic pressure. Which sequence correctly explains the subsequent symptoms?

A Less water reabsorbed → polyuria and water loss → thirst → polydipsia.

B Polydipsia → glycosuria → more water reabsorbed → polyuria.

C Polyuria → more water reabsorbed → reduced thirst → glycosuria.

D Thirst → glycosuria → less water reabsorbed → reduced urine volume.

E Glycosuria → more water reabsorbed → polyuria → water loss.

> The increased osmotic pressure reduces water reabsorption.
>
> Reduced water reabsorption leaves more water in the tubule, producing polyuria and water loss.
>
> Water loss stimulates thirst and drinking, so option A is correct.

Answer

A — Less water reabsorbed → polyuria and water loss → thirst → polydipsia.

The sequence follows the osmotic effect of glucose remaining in tubular fluid.

✎ Worked Example 3 — Try It First

Case Compare normal complete glucose reabsorption with hyperglycaemia that exceeds capacity.

In a healthy person, filtered glucose is within tubular reabsorption capacity; in another person, hyperglycaemia makes the filtered glucose load exceed capacity. What is expected?

A Glucose is absent from both urine samples.

B Glucose appears only in the healthy person's urine.

C Glucose appears only when hyperglycaemia exceeds reabsorption capacity.

D Glucose appears in both samples because filtration always causes glycosuria.

E Glucose appears only when blood glucose is below the capacity limit.

Answer

C — Glucose appears only when hyperglycaemia exceeds reabsorption capacity.

The two outcomes differ only in whether filtered load exceeds the qualitative renal threshold.

! Watch Out

Treating 180 L/day, 1.5 L/day, and 99% as exact mutually matching values.

The direct calculation gives about 99.2%, while exactly 99% of 180 L/day would leave 1.8 L/day rather than 1.5 L/day; the figures are rounded biological values.

Show the calculation with the given approximate volumes, report about 99.2% and then about 99%, and keep the proximal-tubule remainder isotonic rather than calling it concentrated.

Check Yourself

Medium

A person forms 210 L/day of filtrate and 1.8 L/day of urine. Approximately 65% of the filtrate volume is reabsorbed in the PCT. Which statement is correct?

A. About 98.1% overall; 136.5 L/day in the PCT; 73.5 L/day remains concentrated.

B. About 99.1% overall; 136.5 L/day in the PCT; 73.5 L/day remains isotonic.

C. Exactly 99.0% overall; 135.0 L/day in the PCT; 75.0 L/day becomes concentrated.

D. About 0.9% overall; 73.5 L/day in the PCT; 136.5 L/day remains isotonic.

E. About 99.1% overall; 73.5 L/day in the PCT; 136.5 L/day remains isotonic.

Answer

B — About 99.1% is reabsorbed overall; 136.5 L/day is reabsorbed in the PCT and 73.5 L/day remains isotonic.

Subtract urine from filtrate, divide by filtrate, multiply filtrate by 0.65, and retain isotonicity in the PCT.

Medium

A solute is reabsorbed from tubular fluid by an energy-requiring mechanism. Which sequence identifies its route back to the circulation?

A. Tubular fluid → renal vein → tubule cell → blood.

B. Tubular fluid → tubule cell → interstitial fluid → peritubular capillary → blood.

C. Tubular fluid → glomerulus → renal artery → blood.

D. Tubular fluid → tubule cell → renal vein, without an interstitial step.

E. Tubular fluid → peritubular capillary → tubule cell → interstitial fluid → blood.

Answer

B — Tubular fluid → tubule cell → interstitial fluid → peritubular capillary → blood.

Energy use identifies active transport, while the route still passes through the tubule cell, interstitium and peritubular capillary.

Medium

Master

A normally completely reabsorbed nutrient is present in urine in a patient with a very high blood concentration. Which explanation is correct?

A. The nutrient was not filtered, so it was added to urine by the glomerulus.

B. The filtered nutrient load exceeds tubular reabsorption capacity, so the excess remains in urine.

C. The tubules always excrete all filtered nutrients regardless of concentration.

D. The nutrient appears because all ions are completely reabsorbed in the PCT.

E. The nutrient is present because urine concentration mechanisms force nutrients into the tubule.

Answer

B — The filtered nutrient load exceeds tubular reabsorption capacity, so the excess remains in urine.

Apply the renal-threshold comparison to a substance that is normally completely reabsorbed.

A patient produces 2.2 L/day of urine from 220 L/day of filtrate, and glucose exceeds tubular reabsorption capacity. Which combined interpretation is correct?

A. 99.0% is reabsorbed overall; glycosuria increases water reabsorption and prevents thirst.

B. 99.0% is reabsorbed overall; glycosuria raises tubular-fluid osmotic pressure, causing less water reabsorption, polyuria, water loss and polydipsia.

C. 1.0% is reabsorbed overall; polyuria causes glycosuria, followed by increased water reabsorption.

D. 98.0% is reabsorbed overall; polydipsia causes glycosuria before polyuria.

E. 99.0% is reabsorbed overall; glucose is absent from urine because capacity is exceeded.

Answer

B — 99.0% is reabsorbed overall; glycosuria raises tubular-fluid osmotic pressure, causing less water reabsorption, polyuria, water loss and polydipsia.

Calculate $(220 - 2.2)/220 = 99.0\%$, then follow glycosuria through osmotic water retention, polyuria and thirst.

Summary

- Most filtrate is returned to blood, but daily figures are rounded approximations.
- Use the renal-threshold comparison only for substances normally completely reabsorbed.
- Trace reabsorbed material through tubule cell, interstitium and peritubular capillary.
- PCT volume falls while its fluid remains isotonic with plasma.
- Glycosuria comes before osmotic water loss, polyuria, thirst and polydipsia.