

Date:
29/11/2023



لجان الرِّفعات



تفريغ فسيولوجي



موضوع المحاضرة: (2) Part (10) Lec

رقم المحاضرة: (13) Part (2)

إعداد الصيدلانية: سارة سميح السبع

ال reabsorption عبارة عن قسمين :
(١) لو صارت عن طريق الخلايا يكون اسمه transcellular من خلال المرور ب apical membrane ثم basolateral membrane بال diffusion

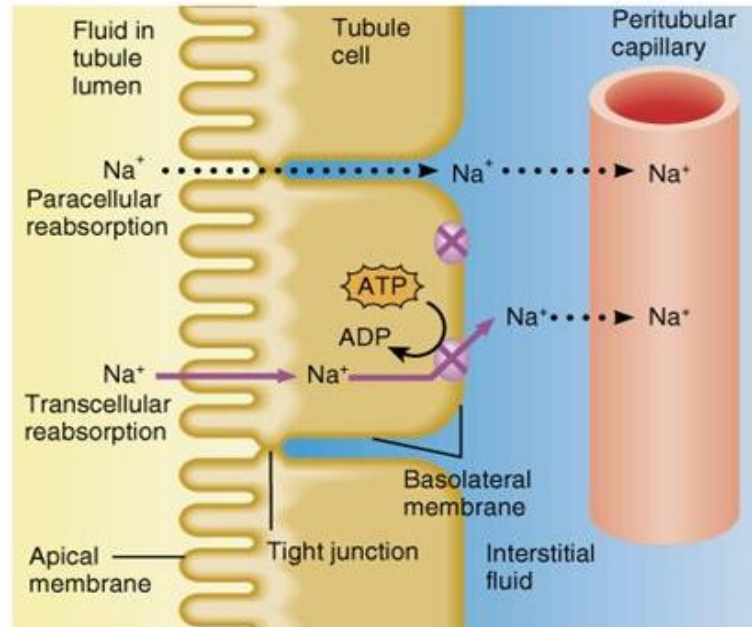
(٢) لو صار عن طريق ال gap junction كونها leaky وبتسمح للمواد تعبر من خلالها بصير اسمه paracellular هون المواد بتحتاج ال passive diffusion فال pumps+channels بتكون موجودة على ال basolateral membrane

REABSORPTION ROUTES

Reabsorption Routes ^{طرق}

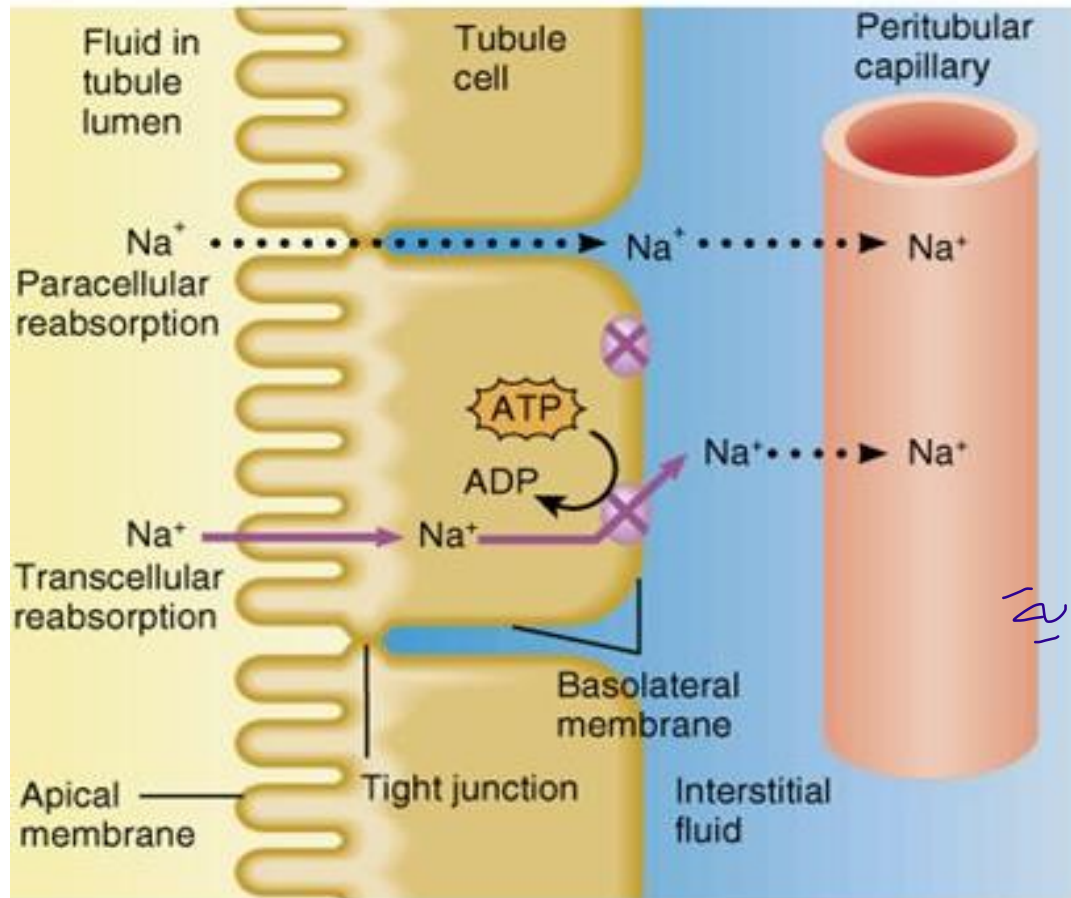
^{طرف الخلية}

- Paracellular reabsorption
 - 50% of reabsorbed material moves between cells by diffusion in some parts of tubule
- Transcellular reabsorption ^{في الخلية نفسها}
 - material moves through both the apical and basal membranes of the tubule cell by active transport



✓ In the renal system, **peritubular capillaries** ^{أوعية} are tiny blood vessels, supplied by the efferent arteriole, **that travel alongside nephrons** allowing reabsorption and secretion between blood and the inner lumen of the nephron.

REABSORPTION ROUTES



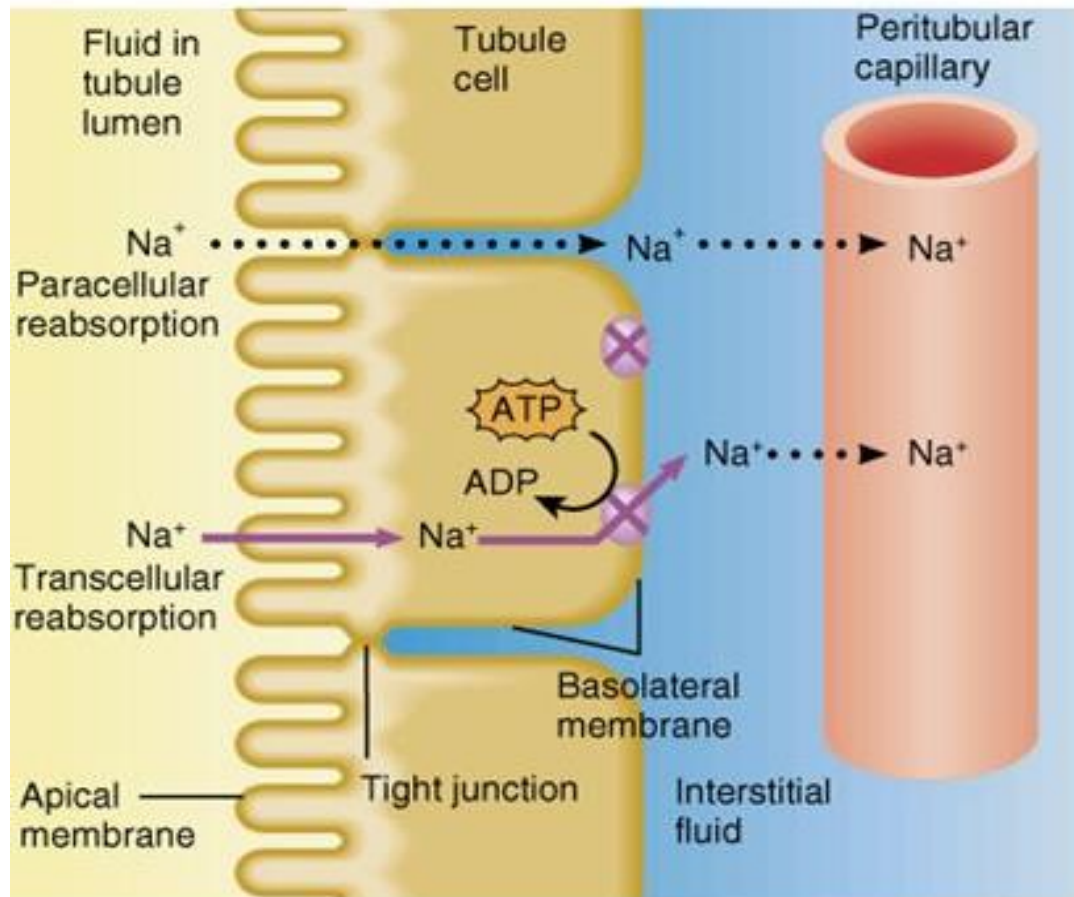
✓ The apical membrane contacts the tubular fluid, and the basolateral membrane contacts interstitial fluid at the base and sides of the cell.

✓ Even though the epithelial cells are connected by tight junctions, the tight junctions between cells in the proximal convoluted tubules are “leaky” and permit some reabsorbed substances to pass between cells into peritubular capillaries.

اقرب

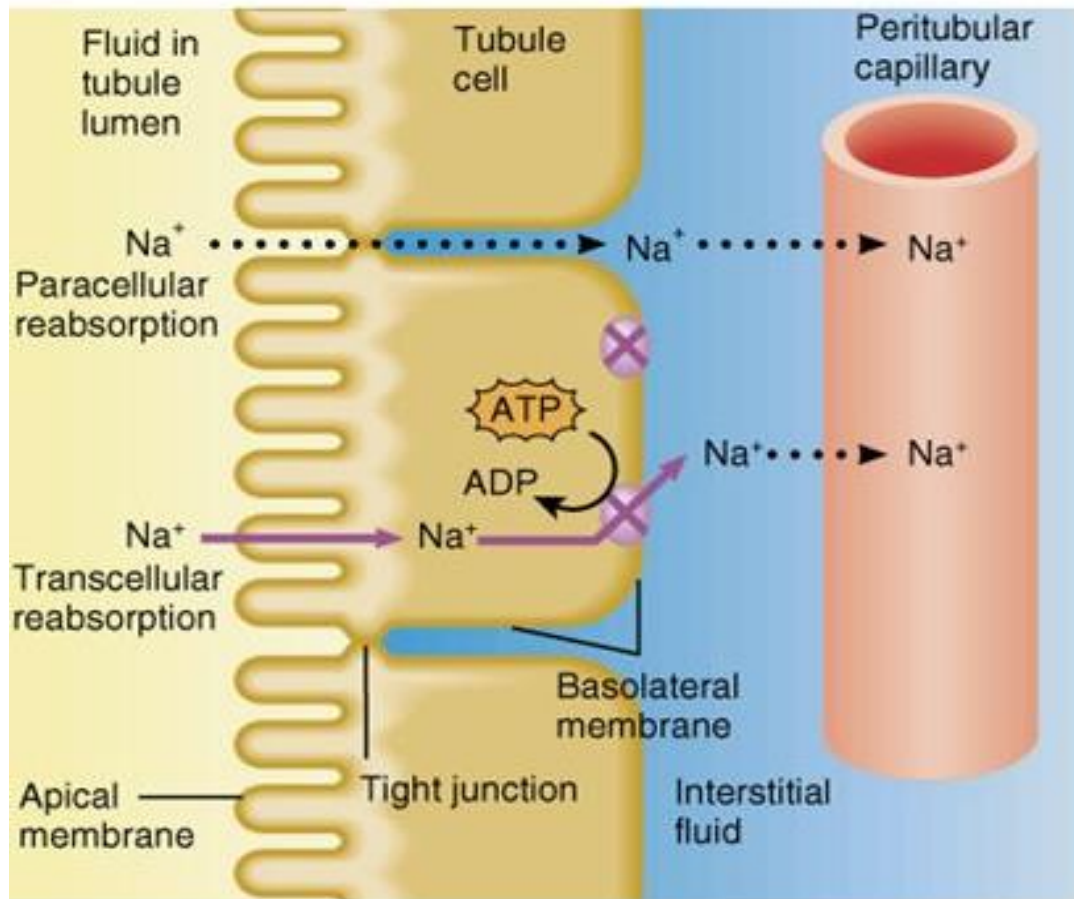
ملتوية

TRANSPORT MECHANISMS



- ✓ **In transcellular reabsorption**, a substance passes from the fluid in the tubular lumen through the apical membrane of a tubule cell, across the cytosol, and out into interstitial fluid through the basolateral membrane.
- ✓ When renal cells transport solutes out of or into tubular fluid, they move specific substances in one direction only. **Not surprisingly**, different types of transport proteins are present in the apical and basolateral membranes. The tight junctions form a barrier that prevents mixing of proteins in the apical and basolateral membrane compartments.

TRANSPORT MECHANISMS



- ✓ Each type of transporter has an upper limit on how fast it can work, just as an escalator has a limit on how many people it can carry from one level to another in a given period. This limit, called the transport maximum (T_m), is measured in mg/min.
- ✓ Cells lining the renal tubules, like other cells throughout the body, have a low concentration of sodium ions in their cytosol due to the activity of sodium-potassium pumps. These pumps are located in the basolateral membranes and eject sodium ions from the renal tubule cells. The absence of sodium-potassium pumps in the apical membrane ensures that reabsorption of sodium ions is a one-way process.

TUBULAR REABSORPTION

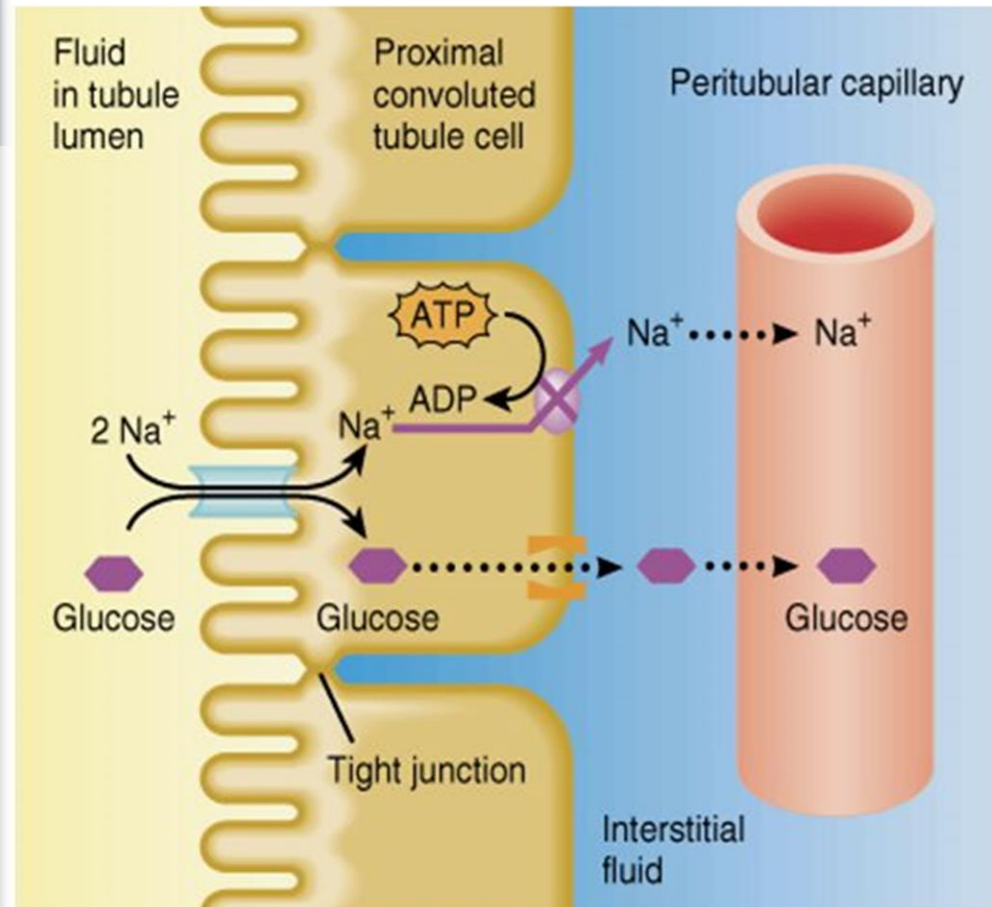
- ✓ Solute reabsorption drives water reabsorption **because all water reabsorption occurs via osmosis**. About **90% of the reabsorption of water** filtered by the kidneys occurs **along with the reabsorption of solutes such as sodium and chloride ions, and glucose**.
- ✓ Water reabsorbed with solutes in tubular fluid is termed obligatory water reabsorption **because the water is “obliged” to follow the solutes when they are reabsorbed**. **This type of water reabsorption occurs in the proximal convoluted tubule and the descending limb of the nephron loop**.
- ✓ Reabsorption of the final 10% of the water, a total of 10–20 liters per day, is termed facultative water reabsorption. Facultative water reabsorption is regulated by antidiuretic hormone and **occurs mainly in the collecting ducts**.

ADH

REABSORPTION AND SECRETION IN THE PROXIMAL CONVOLUTED TUBULE

- ✓ The largest amount of solute and water reabsorption from filtered fluid occurs in the proximal convoluted tubules.

Reabsorption of Glucose in PCT

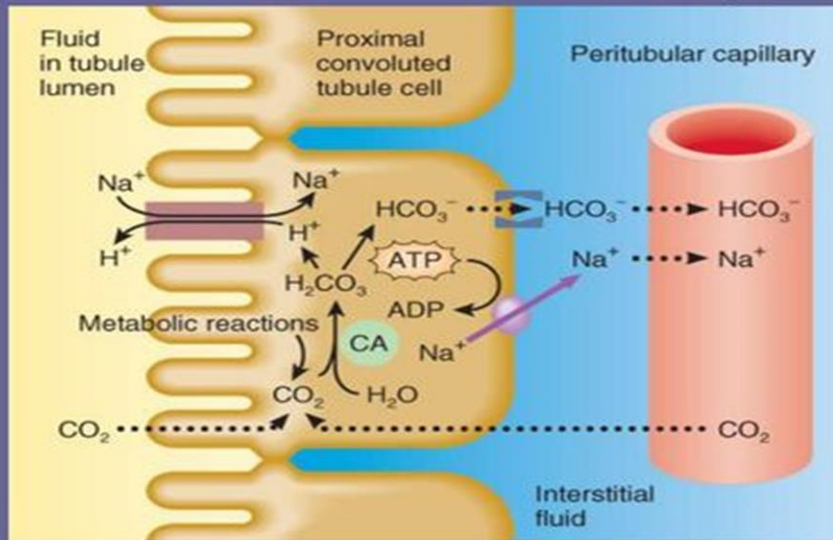


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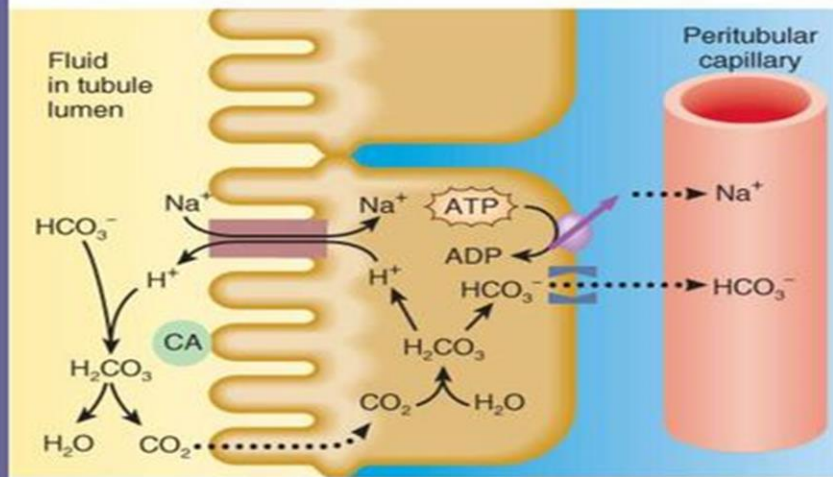
-  Na⁺-glucose symporter
-  Glucose facilitated diffusion transporter
-  Diffusion
-  Sodium-potassium pump

- Intracellular sodium levels are kept low due to Na⁺/K⁺ ATPase pump on basolateral membrane
- Low intracellular Na⁺ creates concentration gradient
 - high in filtrate – low in cell
- Na⁺ **symporters** on apical membrane use energy from gradient to bring in glucose
 - **Secondary active transport**
- 2 Na⁺ and 1 glucose attach to symporter and enter cell together
- Glucose then diffuses out of cell and into peritubular capillaries

Reabsorption of Bicarbonate, Na⁺ & H⁺ Ions



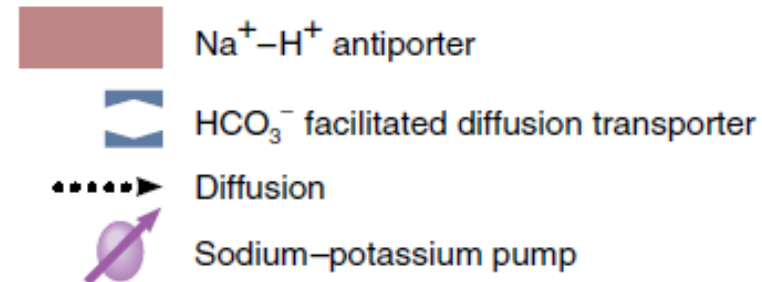
(a) Na⁺ reabsorption and H⁺ secretion



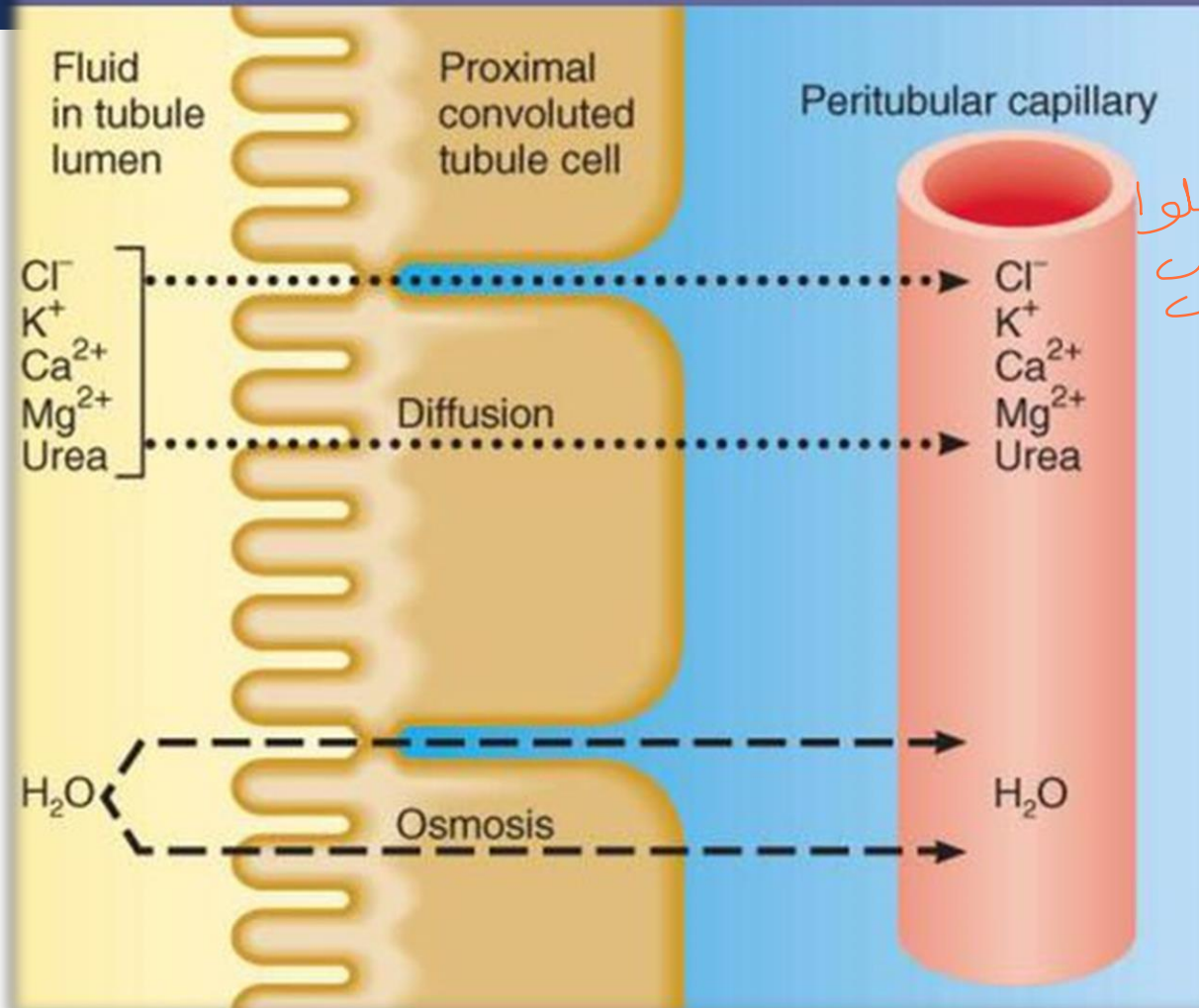
(b) HCO₃⁻ reabsorption

- Na⁺ antiporters reabsorb Na⁺ and secrete H⁺
 - PCT cells produce the H⁺ & release bicarbonate ion to the peritubular capillaries
 - important buffering system
- For every H⁺ secreted into the tubular fluid, one filtered bicarbonate eventually returns to the blood

Key:



Passive Reabsorption in the 2nd Half of PCT



ينتقلوا في نفس الاتجاه

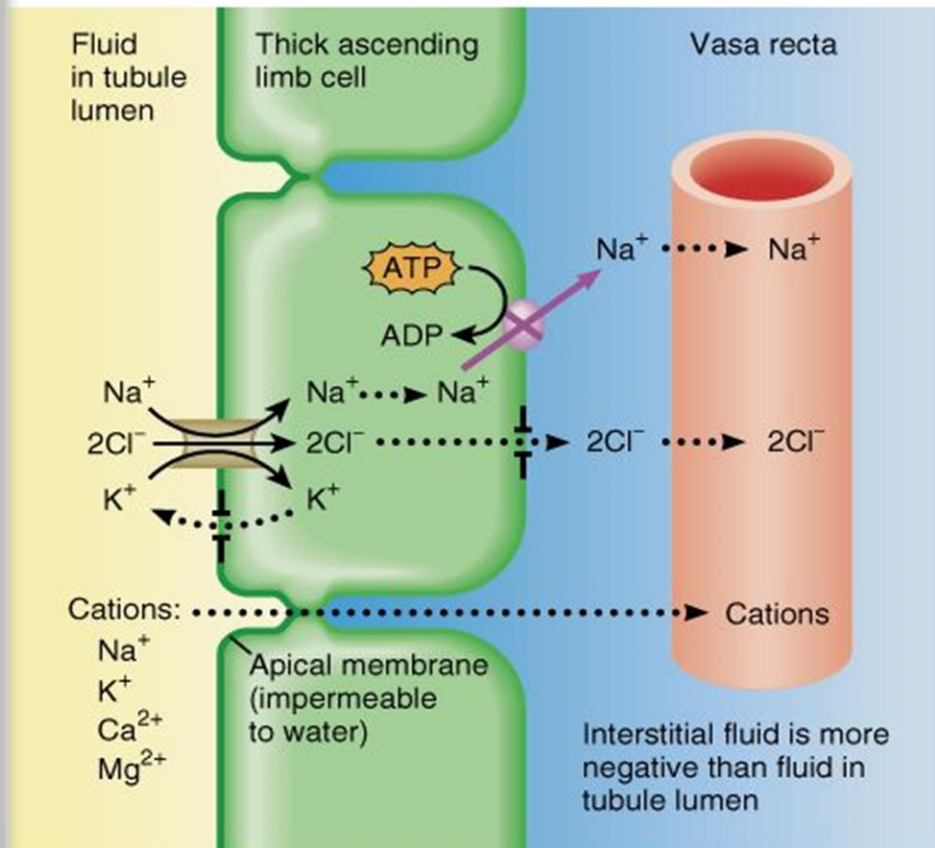
- Electrochemical gradients produced by symporters & antiporters causes passive reabsorption of other solutes
- Cl^- , K^+ , Ca^{2+} , Mg^{2+} and urea passively diffuse into the peritubular capillaries
- Promotes osmosis in PCT (especially permeable due to aquaporin-1 channels)

ينتقلوا
عكس
بعض

REABSORPTION IN THE NEPHRON LOOP

Because all of the proximal convoluted tubules reabsorb about 65% of the filtered water (about 80 mL/min), fluid enters the next part of the nephron, the nephron loop, at a rate of 40–45 mL/min.

Symporters in the Loop of Henle



- Thick limb of loop of Henle has Na^+ K^+ Cl^- symporters that reabsorb these ions
- K^+ leaks through K^+ channels back into the tubular fluid leaving the interstitial fluid and blood with a negative charge
- Cations passively move to the vasa recta

Key:



$\text{Na}^+-\text{K}^+-2\text{Cl}^-$ symporter



Leakage channels



Sodium-potassium pump



Diffusion

REABSORPTION IN THE EARLY DISTAL CONVOLUTED TUBULE

- Fluid enters the distal convoluted tubules at a rate of about 25 mL/ min because 80% of the filtered water has now been reabsorbed.
- The early or initial part of the distal convoluted tubule (DCT) reabsorbs about 10–15% of the filtered water, 5% of the filtered Na ions, and 5% of the filtered Cl ions.
- Reabsorption of Na and Cl ions occurs by means of Na–Cl ions symporters in the apical membranes.

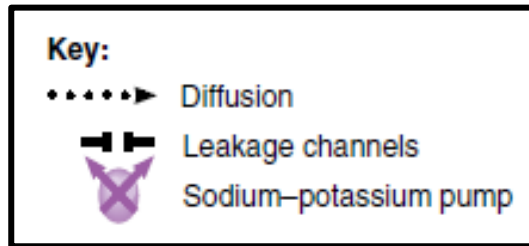
REABSORPTION IN THE EARLY DISTAL CONVOLUTED TUBULE

- Sodium–potassium pumps and Cl ions ^{تسرب} leakage channels in the basolateral **membranes** then permit reabsorption of Na ions and Cl ions into the peritubular capillaries.
- ^{جارات الدرقية تفرزه} The early DCT also is a major site where parathyroid hormone (PTH) **stimulates reabsorption of calcium ions**. The amount of calcium ions reabsorption in the early DCT ^{تختلف} varies depending on the body's needs.

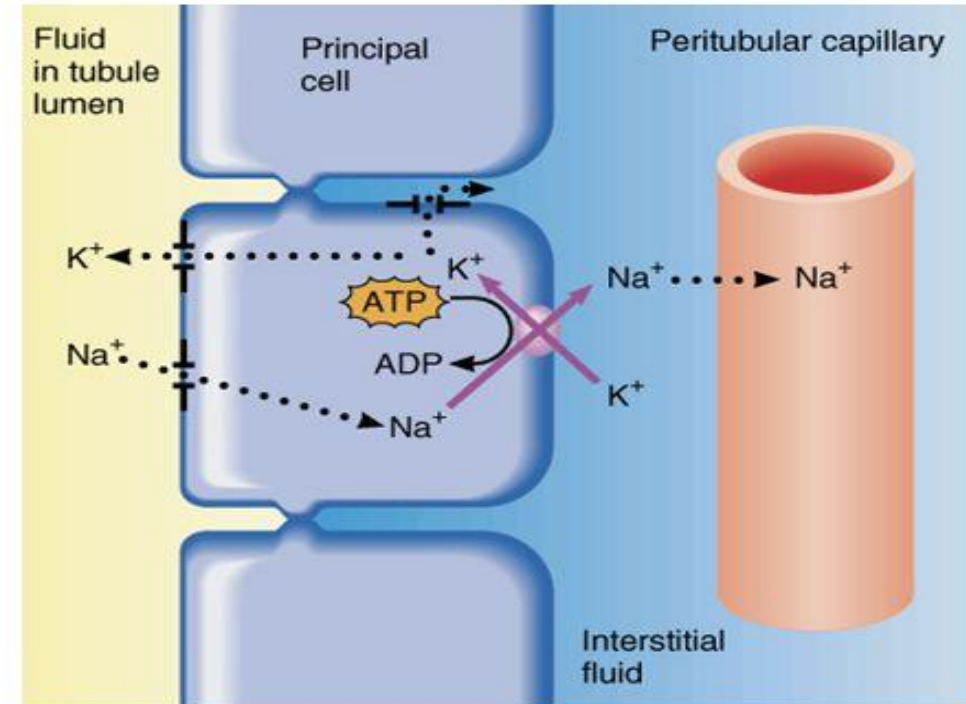
REABSORPTION AND SECRETION IN THE LATE DISTAL CONVOLUTED TUBULE AND COLLECTING DUCT

- ✓ **Two different types of cells—principal cells and intercalated cells**—are present at the late or terminal part of the distal convoluted tubule and throughout the collecting duct.
- ✓ **In contrast to earlier segments of the nephron**, sodium ions pass through the apical membrane of principal cells via sodium leakage channels rather than by means of symporters or antiporters.
- ✓ **In the apical membrane of principal cells**, sodium leakage channels allow entry of sodium ions while potassium ion leakage channels allow exit of potassium ions into the tubular fluid.

Actions of the Principal Cells



- Na^+ enters principal cells through leakage channels
- Na^+ pumps keep the concentration of Na^+ in the cytosol low
- Cells secrete variable amounts of K^+ , to adjust for dietary changes in K^+ intake
 - down concentration gradient due to Na^+/K^+ pump
- Aldosterone increases this Na^+ reabsorption (and passive water reabsorption) & K^+ secretion by principal cells by stimulating the synthesis of new pumps and channels.



HOMEOSTATIC REGULATION OF TUBULAR REABSORPTION AND TUBULAR SECRETION

- Five hormones تؤثر affect the extent of sodium, calcium and chloride ions, and water reabsorption as well as potassium ions secretion by the renal tubules. **These hormones include: angiotensin II, aldosterone, antidiuretic hormone, atrial natriuretic peptide, and parathyroid hormone.**

TABLE 26.4**Hormonal Regulation of Tubular Reabsorption and Tubular Secretion**

مهم جدا (لطفاً)

HORMONE	MAJOR STIMULI THAT TRIGGER RELEASE	MECHANISM AND SITE OF ACTION	EFFECTS
Angiotensin II	Low blood volume or low blood pressure stimulates renin-induced production of angiotensin II.	Stimulates activity of $\text{Na}^+ - \text{H}^+$ antiporters in proximal tubule cells.	Increases reabsorption of Na^+ , other solutes, and water, which increases blood volume and blood pressure.
Aldosterone	Increased angiotensin II level and increased level of plasma K^+ promote release of aldosterone by adrenal cortex.	Enhances activity of sodium–potassium pumps in basolateral membrane and Na^+ channels in apical membrane of principal cells in collecting duct.	Increases secretion of K^+ and reabsorption of Na^+ , Cl^- ; increases reabsorption of water, which increases blood volume and blood pressure.
Antidiuretic hormone (ADH)	Increased osmolarity of extracellular fluid or decreased blood volume promotes release of ADH from posterior pituitary gland.	Stimulates insertion of water channel proteins (aquaporin-2) into apical membranes of principal cells.	Increases facultative reabsorption of water, which decreases osmolarity of body fluids.
Atrial natriuretic peptide (ANP)	Stretching of atria of heart stimulates ANP secretion.	Suppresses reabsorption of Na^+ and water in proximal tubule and collecting duct; inhibits secretion of aldosterone and ADH.	Increases excretion of Na^+ in urine (natriuresis); increases urine output (diuresis) and thus decreases blood volume and blood pressure.
Parathyroid hormone (PTH)	Decreased level of plasma Ca^{2+} promotes release of PTH from parathyroid glands.	Stimulates opening of Ca^{2+} channels in apical membranes of early distal tubule cells.	Increases reabsorption of Ca^{2+} .

لما يكون عندي كمية قليلة من الماء في الجسم بصير ينعملها reabsorption عن طريق الـ peritubular capillaries وبترجع مرة ثانية للـ circulation فبنتج عندي concentrated urine

أما لو عندي كمية كبيرة من الماء في الجسم فبعد ما ينتهي امتصاص الـ ٧٠٪ وهي حاجة الجسم بطلع الباقي عن طريق الـ tubules وبتنتج diluted urine ، هون بتيجي وظيفة الـ osmoreceptor(sensory)

الـ tubules cells ما بتكون متلاصقة وإنما بينهم tight junction وفيها interstitial fluid اللي بتتأثر الـ osmolarity تاعته في عمليتي الـ reabsorption & secretion وحكينا عن طرق انتقال المواد قبل وبصير إما hypo/hypertonic هون بيجي دور الـ osmoreceptors اللي بصيرلها activation حتى تحافظ عليه isotonic

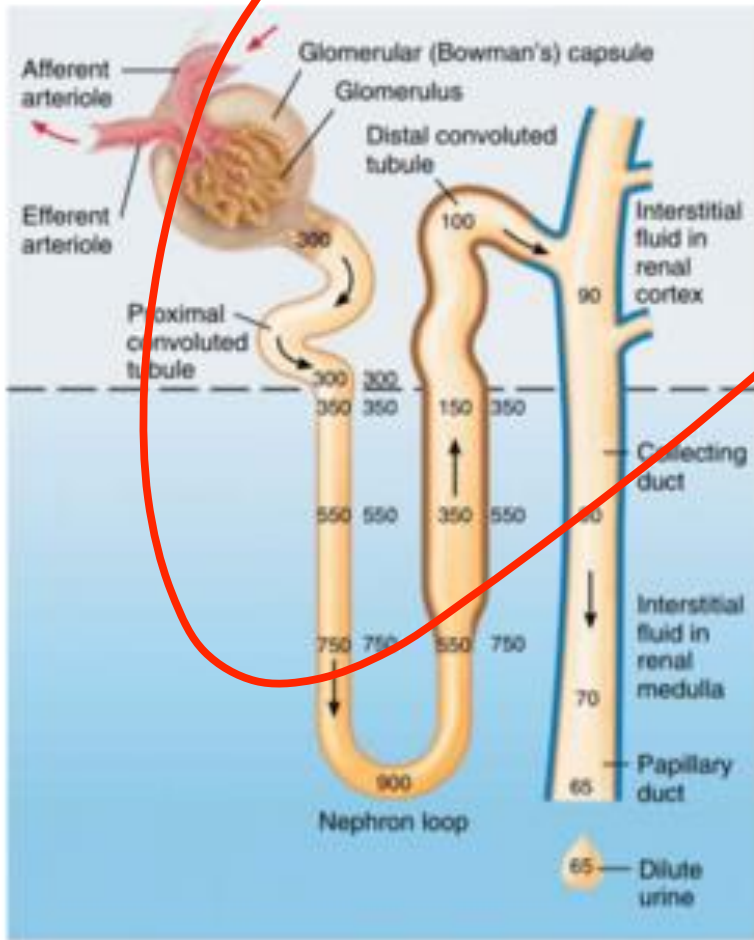
بتحكم بتنظيم الـ formation of diluted or concentrated urine هرمون (adh / antidiuretic) vassopressin

PRODUCTION OF DILUTE AND CONCENTRATED URINE

- Even though your fluid intake can be highly variable, the total volume of fluid in your body normally remains stable.
- Homeostasis of body fluid volume depends in large part on the ability of the kidneys to regulate the rate of water loss in urine.
- Normally functioning kidneys produce a large volume of dilute urine when fluid intake is high, and a small volume of concentrated urine when fluid intake is low or fluid loss is large.
- ADH controls whether dilute urine or concentrated urine is formed. In the absence of ADH, urine is very dilute. However, a high level of ADH stimulates reabsorption of more water into blood, producing a concentrated urine.

Figure 26.18 Formation of dilute urine. Numbers indicate osmolarity in milliosmoles per liter (mOsm/liter). Heavy brown lines in the ascending limb of the nephron loop and in the distal convoluted tubule indicate impermeability to water; heavy blue lines indicate the last part of the distal convoluted tubule and the collecting duct, which are impermeable to water in the absence of ADH; light blue areas around the nephron represent interstitial fluid.

When the ADH level is low, urine is dilute and has an osmolarity less than the osmolarity of blood.

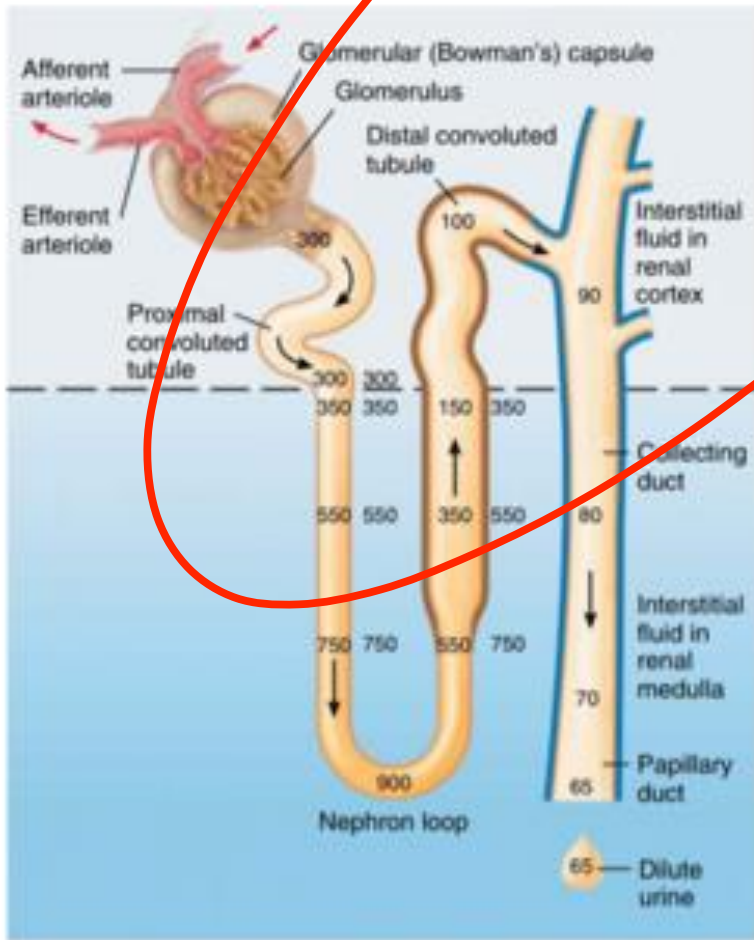


FORMATION OF DILUTE URINE

- Glomerular filtrate has the same ratio of water and solute particles as blood; its osmolarity is about 300 mOsm/liter.
- Fluid leaving the proximal convoluted tubule is still isotonic to plasma.
- When dilute urine is being formed, the osmolarity of the fluid in the tubular lumen increases as it flows down the descending limb of the nephron loop, decreases as it flows up the ascending limb, and decreases still more as it flows through the rest of the nephron and collecting duct.

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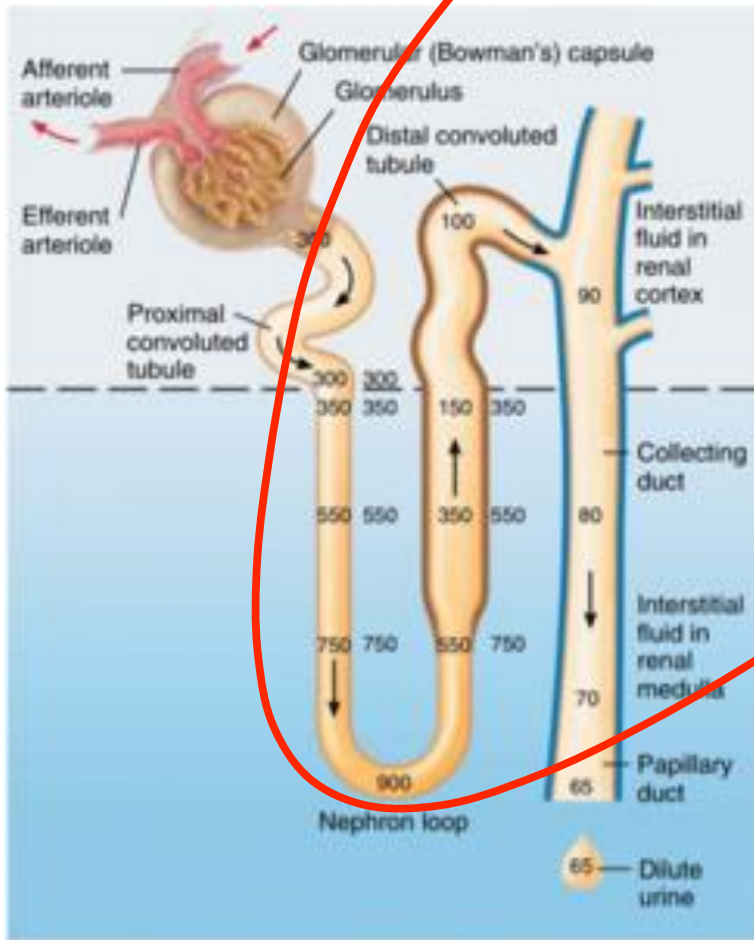


FORMATION OF DILUTE URINE

1. Because the osmolarity of the interstitial fluid of the renal medulla becomes progressively greater, more and more water is reabsorbed by osmosis as tubular fluid flows along the descending limb toward the tip of the nephron loop.
2. Cells lining the thick ascending limb of the loop have symporters that actively reabsorb sodium, potassium, and chloride ions from the tubular fluid.

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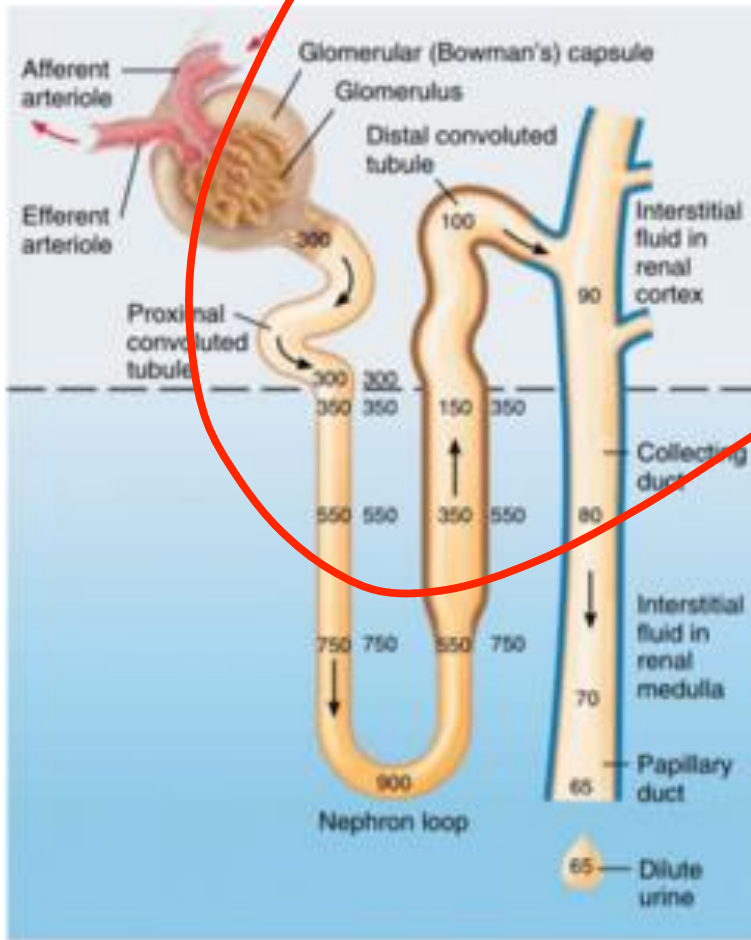


FORMATION OF DILUTE URINE

2. The ions pass from the tubular fluid into thick ascending limb cells, then into interstitial fluid, and finally some diffuse into the blood inside the vasa recta.
3. Although solutes are being reabsorbed in the thick ascending limb, the water permeability of this portion of the nephron is always quite low, so water cannot follow by osmosis. As solutes—but not water molecules—are leaving the tubular fluid, its osmolarity drops to about 150 mOsm/liter. The fluid entering the distal convoluted tubule is thus more dilute than plasma.

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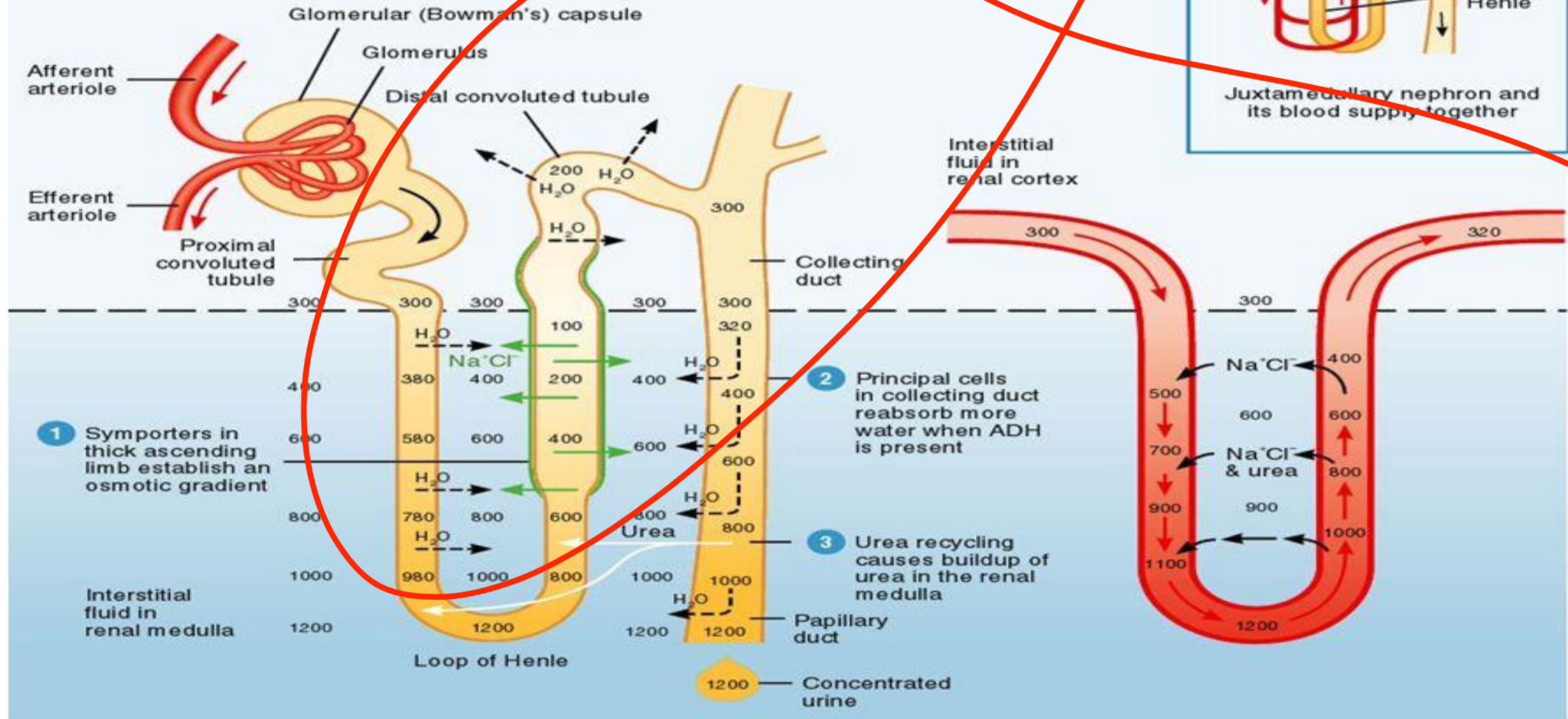
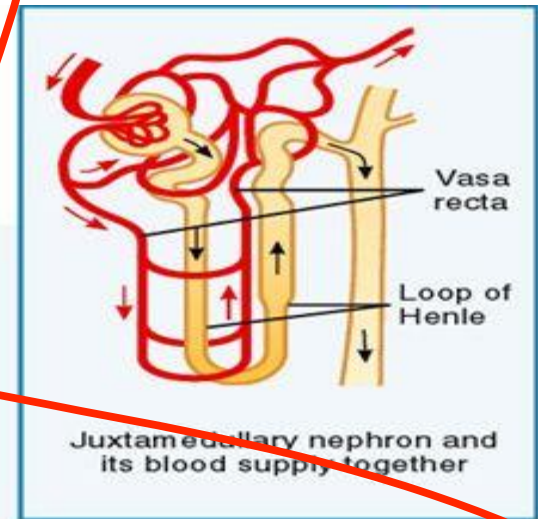
FORMATION OF DILUTE URINE

4. While the fluid continues flowing along the distal convoluted tubule, additional solutes but only a few water molecules are reabsorbed. The early distal convoluted tubule cells are not very permeable to water and are not regulated by ADH.
5. Finally, the principal cells of the late distal convoluted tubules and collecting ducts are impermeable to water when the ADH level is very low. Thus, tubular fluid becomes progressively more dilute as it flows onward. By the time the tubular fluid drains into the renal pelvis, its concentration can be as low as 65–70 mOsm/liter. This is four times more dilute than blood plasma or glomerular filtrate.

FORMATION OF CONCENTRATED URINE

- **When water intake is low or water loss is high** (such as during heavy sweating), **the kidneys must conserve water while still eliminating wastes and excess ions.** Under the influence of ADH, the kidneys produce a small volume of highly concentrated urine.
- Urine can be four times more concentrated (up to 1200 mOsm/liter) than blood plasma or glomerular filtrate (300 mOsm/liter).

Mechanism of urine concentration in long-loop juxtamedullary nephrons



(a) Reabsorption of Na^+ , Cl^- and water in a long-loop juxtamedullary nephron

(b) Recycling of salts and urea in the vasa recta

FORMATION OF CONCENTRATED URINE

- The ability of **ADH** to cause excretion of concentrated urine **depends on the presence of an osmotic gradient of solutes in the interstitial fluid of the renal medulla.**
- Two main factors contribute to building and maintaining this osmotic gradient: (1) **differences in solute and water permeability and reabsorption in different sections of the long nephron loops and the collecting ducts,** and (2) **the countercurrent flow of fluid through tube-shaped structures in the renal medulla.**

FORMATION OF CONCENTRATED URINE

- **Countercurrent flow refers to the flow of fluid in opposite directions.** This occurs when fluid flowing in one tube runs counter (opposite) to fluid flowing in a nearby parallel tube. Examples of countercurrent flow include the flow of tubular fluid through the descending and ascending limbs of the nephron loop and the flow of blood through the ascending and descending parts of the vasa recta.

FORMATION OF CONCENTRATED URINE

- Since countercurrent flow through the descending and ascending limbs of the long nephron loop **establishes the osmotic gradient in the renal medulla**, the long nephron loop is said to function as a countercurrent multiplier. **The kidneys use this osmotic gradient to excrete concentrated urine.**

FORMATION OF CONCENTRATED URINE

❑ **Production of concentrated urine by the kidneys occurs in the following way:**

1. **Symporters in thick ascending limb cells** of the nephron loop cause a buildup of Na and Cl ions in the renal medulla (water is not reabsorbed in this segment).
2. **Countercurrent flow through the descending and ascending limbs of the nephron loop** establishes an osmotic gradient in the renal medulla.

FORMATION OF CONCENTRATED URINE

2. Countercurrent flow: Since tubular fluid constantly moves from the descending limb to the thick ascending limb of the nephron loop, the thick ascending limb is constantly reabsorbing Na and Cl ions. Consequently, the reabsorbed Na and Cl ions become increasingly concentrated in the interstitial fluid of the medulla, which results in the formation of an osmotic gradient.

FORMATION OF CONCENTRATED URINE

- ❖ The descending limb of the nephron loop is very permeable to water but impermeable to solutes except urea.
- ❖ Because the osmolarity of the interstitial fluid outside the descending limb is higher than the tubular fluid within it, water moves out of the descending limb via osmosis.

FORMATION OF CONCENTRATED URINE

- ❖ The ascending limb of the loop is impermeable to water, but its symporters reabsorb Na and Cl ions from the tubular fluid into the interstitial fluid of the renal medulla, ~~so the osmolarity of the tubular fluid progressively decreases as it flows through the ascending limb.~~ Overall, tubular fluid becomes progressively more concentrated as it flows along the descending limb and progressively more dilute as it moves along the ascending limb.

FORMATION OF CONCENTRATED URINE

3. Cells in the collecting ducts reabsorb more water and urea. When ADH increases the water permeability of the principal cells, water quickly moves via osmosis out of the collecting duct tubular fluid, into the interstitial fluid of the inner medulla, and then into the vasa recta.

FORMATION OF CONCENTRATED URINE

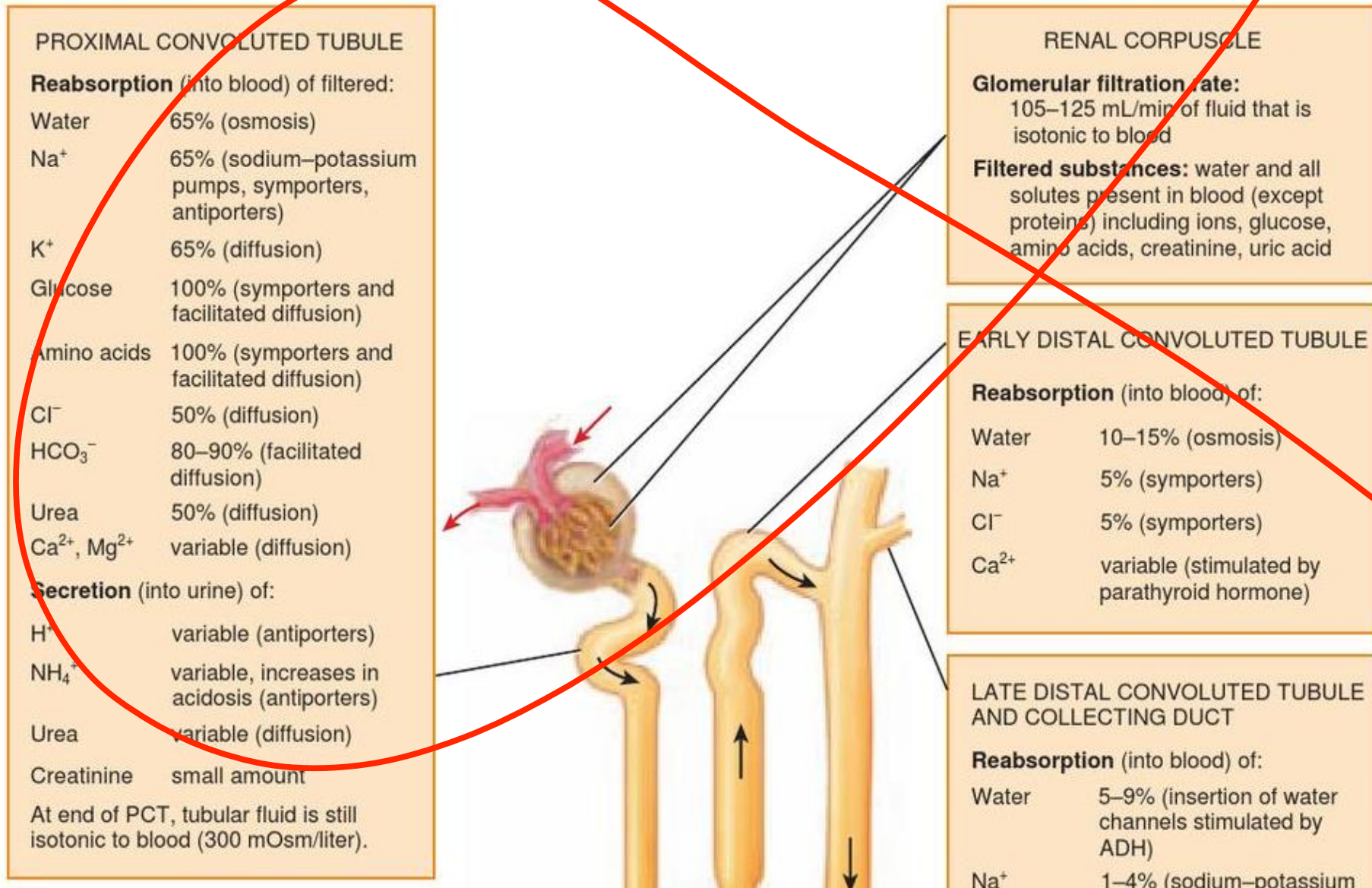
4. **Urea recycling** causes a **buildup of urea in the renal medulla**.

- As urea accumulates in the interstitial fluid, some of it diffuses into the tubular fluid in the **descending and thin ascending limbs of the long nephron loops**, which also are **permeable to urea**.
- However, while the fluid flows through the **thick ascending limb, distal convoluted tubule, and cortical portion of the collecting duct**, **urea remains in the lumen because cells in these segments are impermeable to it**.
- As fluid flows along the collecting ducts, water reabsorption continues via osmosis because ADH is present.

Figure 26.20 Summary of filtration, reabsorption, and secretion in the nephron and collecting duct.



Filtration occurs in the renal corpuscle; reabsorption occurs all along the renal tubule and collecting ducts.



isotonic to blood (300 mOsm/liter).

LOOP OF HENLE

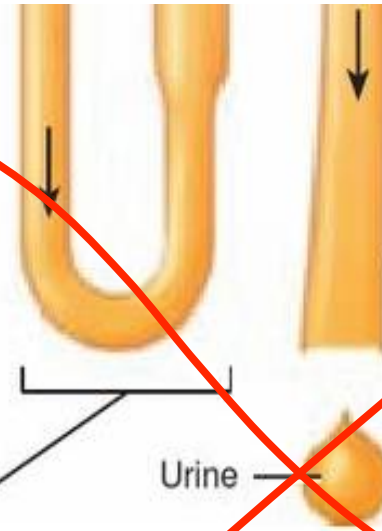
Reabsorption (into blood) of:

Water	15% (osmosis in descending limb)
Na^+	20–30% (symporters in ascending limb)
K^+	20–30% (symporters in ascending limb)
Cl^-	35% (symporters in ascending limb)
HCO_3^-	10–20% (facilitated diffusion)
Ca^{2+} , Mg^{2+}	variable (diffusion)

Secretion (into urine) of:

Urea	variable (recycling from collecting duct)
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At end of loop of Henle, tubular fluid is hypotonic (100–150 mOsm/liter).



Na^+	ADH) 1–4% (sodium–potassium pumps and sodium channels stimulated by aldosterone)
HCO_3^-	variable amount, depends on H^+ secretion (antiporters)
Urea	variable (recycling to loop of Henle)
Secretion (into urine) of:	
K^+	variable amount to adjust for dietary intake (leakage channels)
H^+	variable amounts to maintain acid–base homeostasis (H^+ pumps)
Tubular fluid leaving the collecting duct is dilute when ADH level is low and concentrated when ADH level is high.	

EVALUATION OF KIDNEY FUNCTION:

I - URINALYSIS

ما شرحنا
ما شرحنا

TABLE 26.5

Characteristics of Normal Urine

CHARACTERISTIC	DESCRIPTION
Volume	One to two liters in 24 hours; varies considerably.
Color	Yellow or amber; varies with urine concentration and diet. Color due to urochrome (pigment produced from breakdown of bile) and urobilin (from breakdown of hemoglobin). Concentrated urine is darker in color. Color affected by diet (reddish from beets), medications, and certain diseases. Kidney stones may produce blood in urine.
Turbidity	Transparent when freshly voided; becomes turbid (cloudy) on standing.
Odor رائحة	Mildly aromatic; becomes ammonia-like on standing. Some people inherit ability to form methylmercaptan from digested asparagus, which gives characteristic odor. Urine of diabetics has fruity odor due to presence of ketone bodies.
pH	Ranges between 4.6 and 8.0; average 6.0; varies considerably with diet. High-protein diets increase acidity; vegetarian diets increase alkalinity.
Specific gravity (density)	Specific gravity (density) is ratio of weight of volume of substance to weight of equal volume of distilled water. In urine, 1.001–1.035. The higher the concentration of solutes, the higher the specific gravity.

TABLE 26.6**Summary of Abnormal Constituents in Urine****ABNORMAL CONSTITUENT****COMMENTS****Albumin**

Normal constituent of plasma; usually appears in only very small amounts in urine because it is too large to pass through capillary fenestrations. Presence of excessive albumin in urine—**albuminuria** (al'-bū-mi-NOO-rē-a)—indicates increase in permeability of filtration membranes due to injury or disease, increased blood pressure, or irritation of kidney cells by substances such as bacterial toxins, ether, or heavy metals.

Glucose

Presence of glucose in urine—**glucosuria** (gloo-kō-SOO-rē-a)—usually indicates diabetes mellitus. Occasionally caused by stress, which can cause excessive epinephrine secretion. Epinephrine stimulates breakdown of glycogen and liberation of glucose from liver.

Red blood cells (erythrocytes)

Presence of red blood cells in urine—**hematuria** (hēm-a-TOO-rē-a)—generally indicates pathological condition. One cause is acute inflammation of urinary organs due to disease or irritation from kidney stones. Other causes: tumors, trauma, kidney disease, contamination of sample by menstrual blood.

Ketone bodies

High levels of ketone bodies in urine—**ketonuria** (kē-tō-NOO-rē-a)—may indicate diabetes mellitus, anorexia, starvation, or too little carbohydrate in diet.

TABLE 26.6**Summary of Abnormal Constituents in Urine**

ABNORMAL CONSTITUENT	COMMENTS
Bilirubin	When red blood cells are destroyed by macrophages, the globin portion of hemoglobin is split off and heme is converted to biliverdin. Most biliverdin is converted to bilirubin, which gives bile its major pigmentation. Above-normal level of bilirubin in urine is called bilirubinuria (bil'-ē-roo-bi-NOO-rē-a).
Urobilinogen	Presence of urobilinogen (breakdown product of hemoglobin) in urine is called urobilinogenuria (ū'-rō-bi-lin'-ō-je-NOO-rē-a). Trace amounts are normal, but elevated urobilinogen may be due to hemolytic or pernicious anemia, infectious hepatitis, biliary obstruction, jaundice, cirrhosis, congestive heart failure, or infectious mononucleosis.
Casts	Casts are tiny masses of material that have hardened and assumed shape of lumen of tubule in which they formed, from which they are flushed when filtrate builds up behind them. Casts are named after cells or substances that compose them or based on appearance (for example, white blood cell casts, red blood cell casts, and epithelial cell casts that contain cells from walls of tubules).
Microbes	Number and type of bacteria vary with specific urinary tract infections. One of the most common is <i>E. coli</i> . Most common fungus is yeast <i>Candida albicans</i> , cause of vaginitis. Most frequent protozoan is <i>Trichomonas vaginalis</i> , cause of vaginitis in females and urethritis in males.

EVALUATION OF KIDNEY FUNCTION:

2- BLOOD TESTS

❖ Two blood-^{cesi}screening tests can provide information about kidney function:-

1. Blood urea nitrogen (BUN) test.
2. Plasma creatinine.

BLOOD UREA NITROGEN (BUN) TEST

- ❖ It measures **the blood nitrogen that is part of the urea** resulting from catabolism and deamination of amino acids.
- ❖ **When glomerular filtration rate decreases severely**, as may occur with renal disease or obstruction of the urinary tract, **BUN rises steeply**.
انسداد *مستوى*
- ❖ **One strategy in treating such patients is to minimize their protein intake**, thereby reducing the rate of urea production.
تقليل

PLASMA CREATININE

- ❖ It results from catabolism of creatine phosphate in skeletal muscle.
- ❖ Normally, the blood creatinine level remains steady because the rate of creatinine excretion in the urine equals its discharge from muscle.
- ❖ A creatinine level above 1.5 mg/dL (135 mmol/liter) usually is an indication of poor renal function.

RENAL PLASMA CLEARANCE

- ❖ Renal plasma clearance is the volume of blood that is “cleaned” or cleared of a substance per unit of time, usually expressed in **units of milliliters per minute**.
- ❖ Low clearance ^{يشير} indicates inefficient excretion. For example, the clearance of glucose normally is zero because it is completely reabsorbed; therefore, glucose is not excreted at all.

RENAL PLASMA CLEARANCE

❖ Knowing a drug's clearance is essential for determining the correct dosage. If clearance is high (one example is penicillin), then the dosage must also be high, and the drug must be given several times a day to maintain an adequate therapeutic level in the blood.

The following equation is used to calculate clearance:

$$\text{Renal plasma clearance of substance S} = \left(\frac{U \times V}{P} \right)$$

where U and P are the concentrations of the substance in urine and plasma, respectively (both expressed in the same units, such as mg/mL), and V is the urine flow rate in mL/min.

RENAL PLASMA CLEARANCE

❖ **The clearance of a solute depends on the three basic processes of a nephron:**

1. **Glomerular filtration.**
2. **Tubular reabsorption.**
3. **Tubular secretion.**

TABLE 26.7**Summary of Urinary System Organs**

STRUCTURE	LOCATION	DESCRIPTION	FUNCTION
Kidneys	Posterior abdomen between last thoracic and third lumbar vertebrae posterior to peritoneum (retroperitoneal). Lie against ribs 11 and 12.	Solid, reddish, bean-shaped organs. Internal structure: three tubular systems (arteries, veins, urinary tubes).	Regulate blood volume and composition, help regulate blood pressure, synthesize glucose, release erythropoietin, participate in vitamin D synthesis, excrete wastes in urine.
Ureters	Posterior to peritoneum (retroperitoneal); descend from kidney to urinary bladder along anterior surface of psoas major muscle and cross back of pelvis to reach inferoposterior surface of urinary bladder anterior to sacrum.	Thick, muscular walled tubes with three structural layers: mucosa of transitional epithelium, muscularis with circular and longitudinal layers of smooth muscle, adventitia of areolar connective tissue.	Transport tubes that move urine from kidneys to urinary bladder.
Urinary bladder	In pelvic cavity anterior to sacrum and rectum in males and sacrum, rectum, and vagina in females and posterior to pubis in both sexes. In males, superior surface covered with parietal peritoneum; in females, uterus covers superior aspect.	Hollow, distensible, muscular organ with variable shape depending on how much urine it contains. Three basic layers: inner mucosa of transitional epithelium, middle smooth muscle coat (detrusor muscle), outer adventitia or serosa over superior aspect in males.	Storage organ that temporarily stores urine until convenient to discharge from body.
Urethra	Exits urinary bladder in both sexes. In females, runs through perineal floor of pelvis to exit between labia minora. In males, passes through prostate, then perineal floor of pelvis, and then penis to exit at its tip.	Thin-walled tubes with three structural layers: inner mucosa that consists of transitional, stratified columnar, and stratified squamous epithelium; thin middle layer of circular smooth muscle; thin connective tissue exterior.	Drainage tube that transports stored urine from body.



THANK YOU

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