Date:
27/11/2023

لجان الدُّفعات

Soul Academy

تفريغ فسيولوجي

موضوع المحاضرة : lec (10) Part (1+2)

رقم المحاضرة : (13)

إعداد الصيدلانيه : سارة سميح السبع

THE URINARY SYSTEM

- The urinary system contributes (يساهم) to homeostasis by altering blood composition, pH, volume, and pressure; maintaining blood osmolarity; excreting wastes and foreign (غريبة) substances; and producing hormones.

- The urinary system consists of (1) two kidneys (كليتين), (2) two ureters (حالبين), (3) one urinary bladder (مثانة), and (4) one urethra.

3

*osmolarity ⇒ هي تركيز الـ (solute) في الماء (solvent) ومرتبطة بال solute أكثر من الماء

* مثال: اذا كانت تركيز الصوديوم مرتفع في الماء فإن الـosmolarity عالية

* Wastes ← ممكن اتكون ناتجة عن طعام أو أدوية أو فيتامينات

THE URINARY SYSTEM

- After the kidneys filter blood plasma (مجرى الدم), they return (المتبقي) most of the water and solutes to the bloodstream. The remaining water and solutes constitute urine, which passes through the ureters and is stored in the urinary bladder until it is excreted (تفرز) from the body through the urethra.

- Nephrology is the scientific study of the anatomy, physiology, and pathology of the kidneys.

- The branch of medicine that deals with the male and female urinary systems and the male reproductive system is called urology. A physician who specializes in this branch of medicine is called a urologist.

5

*يلي يصير بالصوديوم عكسه يصير بالبوتاسيوم

مثال: حدث للصوديوم اخراج (طلع في البول) فإن البوتاسيوم يزداد امتصاصه (يرجع الى الدم)

THE URINARY SYSTEM

- **Kidneys** regulate blood volume and composition; help regulate blood pressure, pH, and glucose levels; produce two hormones (calcitriol and erythropoietin); and excrete wastes in urine.
- **Ureters** transport urine from kidneys to urinary bladder.
- **Urinary bladder** stores urine and expels it into urethra.
- **Urethra** discharges urine from body.

6

OVERVIEW OF KIDNEY FUNCTIONS

1. **Regulation of blood ionic composition:** The kidneys help regulate the blood levels of several ions, most importantly sodium ions, potassium ions, calcium ions, chloride ions, and phosphate ions.
2. **Regulation of blood pH:** The kidneys excrete a variable amount of hydrogen ions into the urine and conserve bicarbonate ions, which are an important buffer of hydrogen ions in the blood. Both of these activities help regulate blood pH.

7

OVERVIEW OF KIDNEY FUNCTIONS

3. **Regulation of blood volume:** The kidneys adjust (ضبط) blood volume by conserving (حفظ) or eliminating (إزالة) water in the urine. An increase in blood volume increases blood pressure; a decrease in blood volume decreases blood pressure.

4. **Regulation of blood pressure:** The kidneys also help regulate blood pressure by secreting (إفراز) the enzyme renin, which activates (ينشط) the renin–angiotensin–aldosterone pathway. Increased renin causes an increase in blood pressure.

OVERVIEW OF KIDNEY FUNCTIONS

5. **Maintenance of blood osmolarity:** By separately (بشكل منفصل) regulating loss of water and loss of solutes in the urine, the kidneys maintain a relatively constant blood osmolarity close to 300 milliosmoles per liter (mOsm/liter).

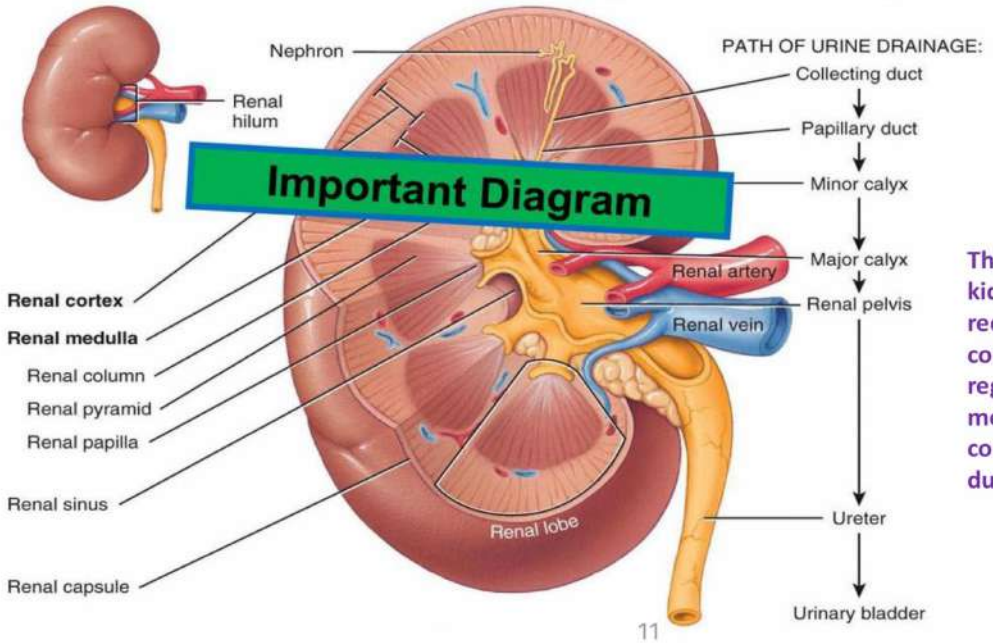
6. **Production of hormones:** The kidneys produce two hormones. **Calcitriol**, the active form of vitamin D, helps regulate calcium homeostasis, and **erythropoietin** stimulates the production of red blood cells.

OVERVIEW OF KIDNEY FUNCTIONS

7. **Regulation of blood glucose level:** Like the liver, the kidneys can use the amino acid glutamine in gluconeogenesis, the synthesis of new glucose molecules. They can then release glucose into the blood to help maintain a normal blood glucose level.

8. **Excretion of wastes and foreign substances.**

Figure 26.3 Internal Anatomy of the Kidneys



The two main regions of the kidney are the superficial, light red region called the renal cortex and the deep, dark red region called the renal medulla. Note that the collecting duct and papillary duct are not part of a nephron.

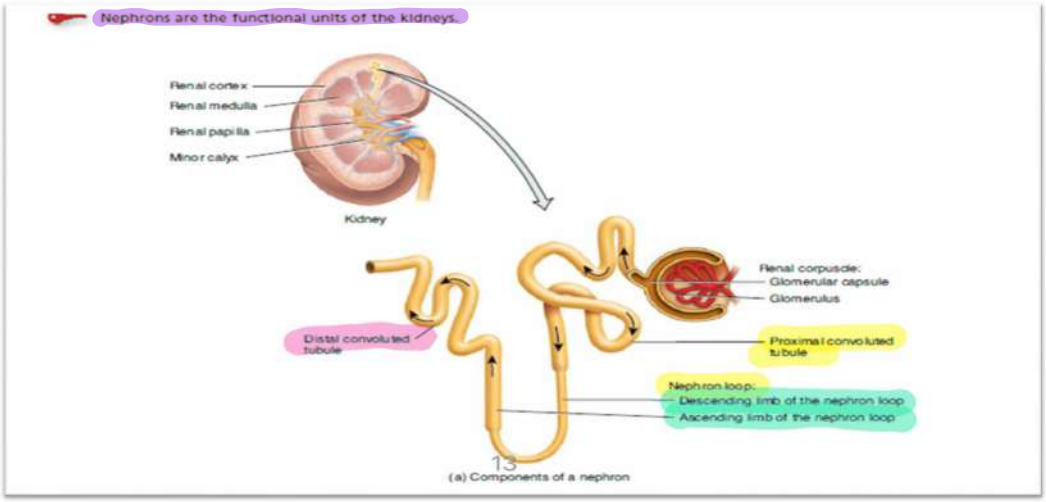
Renal artery (يتفرع فيعطي) → Renal arteriole (afferent arteriole) ← هو الذي يدخل الى الـ (kidneys)

Bowman's capsule (يتفرع داخل) → Capillaries (تتجمع مع بعض وتخرج من الجهة الأخرى) → efferent arteriole

→ peritubular capillaries (تكون حول الـ tubules) (تصب في)

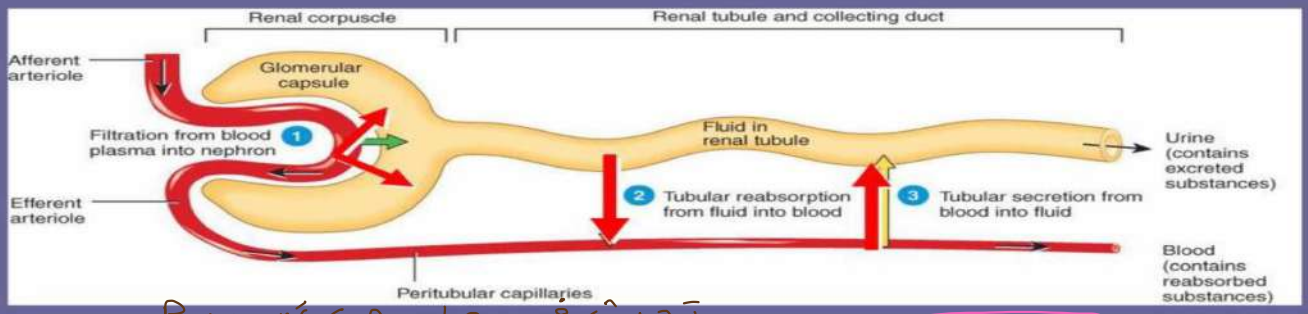
renal vein → inferior vena cava

THE STRUCTURE OF NEPHRONS AND ASSOCIATED BLOOD VESSELS



*excretion → يخرج من Kidneys الى ureters ثم الى bladder ثم الى urethra الى خارج الجسم عبر البول

Overview of Renal Physiology



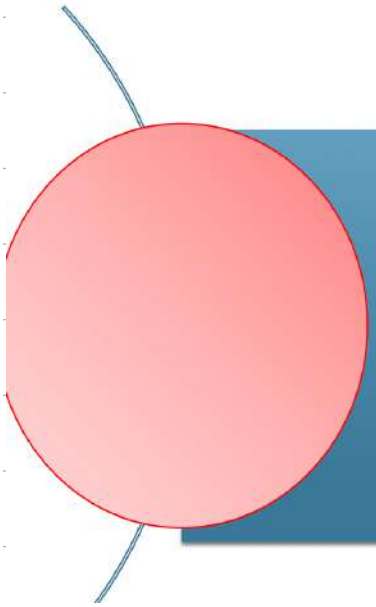
Bowman's capsule تحدث في

- Glomerular filtration of plasma
- Tubular reabsorption
- Tubular secretion

Glomerular filtration occurs in the renal corpuscle. Tubular reabsorption and tubular secretion occur all along the renal tubule and collecting duct.

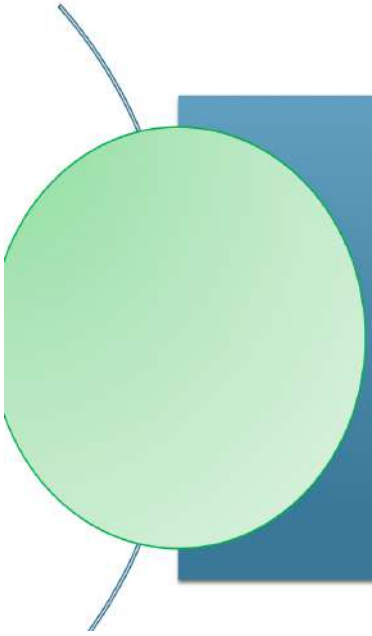
Blood circulation ترجع المواد التي تم اعادة امتصاصها الى

OVERVIEW OF RENAL PHYSIOLOGY



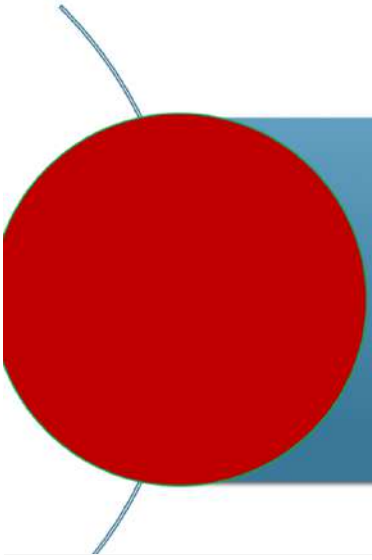
Glomerular filtration: In the **first step of urine production, water and most solutes in blood plasma move across the wall of glomerular capillaries**, where they are filtered and move into the **glomerular capsule** and **then into the renal tubule**.

OVERVIEW OF RENAL PHYSIOLOGY



Tubular reabsorption: As filtered fluid flows through the renal tubules and through the collecting ducts, **tubule cells reabsorb about 99% of the filtered water and many useful solutes. The water and solutes return to the blood as it flows through the peritubular capillaries and vasa recta.**

OVERVIEW OF RENAL PHYSIOLOGY



Tubular secretion: As filtered fluid flows through the renal tubules and collecting ducts, the renal tubule and duct cells secrete other materials, **such as wastes, drugs, and excess ions, into the fluid. Notice that tubular secretion removes a substance from the blood.**

GLOMERULAR FILTRATION

- The fluid that enters the capsular space is called the **glomerular filtrate**.
- The fraction of blood plasma in the afferent arterioles of the kidneys that becomes glomerular filtrate is the **filtration fraction**.
- On average, the **daily volume of glomerular filtrate in adults** is 150 liters in females and 180 liters in males.

* Bowman's capsule هي نفسها Glomerular capsule

* كمية الدم يلي ايتوصل من الـ afferent arterioles الى Capillaries (داخل كبسولة بولمان)

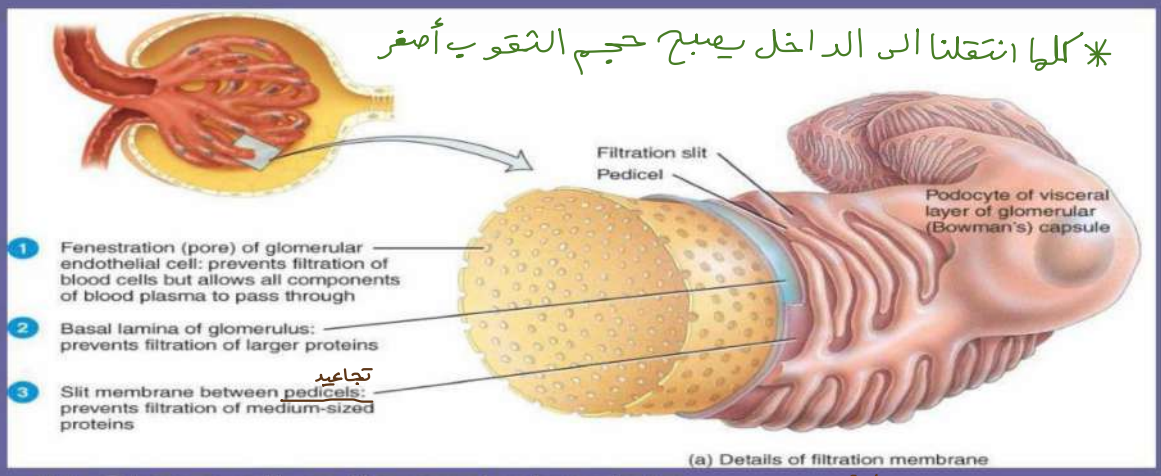
← يكون اسمها filtration fraction ← هو الجزء يلي مفروض يحدث له فلترة

* الجزء يلي من filtration fraction الذي حدث له فلترة يصبح اسمه (glomerular filtrate)

و تحدث الفلترة عن طريق (glomerular capsule) ← لانه موكل الـ filtration function بتفلتر في أشياء ابترجع للدم مثل (البلازما).

Filtration Membrane

*كلما انتقلنا الى الداخل يصبح حجم الثقوب أصغر



- #1 Stops all cells and platelets صفائح دموية
- #2 Stops large plasma proteins
- #3 Stops medium-sized proteins, not small ones

filtration membrane components :

1) endothelia cell → (red blood cells + (larger protein بعض) لا تعبر) البروتينات تعبر لا تعبر

2) Basal lamina → كامل الـ larger protein لا يعبر

3) Slit membrane between pedicels → تعبر (الفيتامينات + glucose) & medium protein الـ تمنع مرور

* large protein + medium protein + red blood cells لا يحدث لهم فلترة

له يعود دون عن طريق efferent arterioles الى general circulation

THE FILTRATION MEMBRANE

- Together, the glomerular capillaries and the podocytes form a leaky barrier known as **the filtration membrane**.
- **Substances filtered from the blood cross three filtration barriers**—a glomerular endothelial cell, the basal lamina, and a filtration slit formed by a podocyte.
- **Glomerular endothelial cells** are quite leaky because they have large fenestrations (pores) that measure [illegible] in diameter.

قطر

*glucose → totaly reabsorption
*glucose → zero excretion

*Creatinine → zero reabsorption
*Creatinine → totaly excretion
*Creatinine → Skeletal muscles هي مادة تخرج من العضلات التي تحدث في ال

THE FILTRATION MEMBRANE

- **The basal lamina**, a layer of a cellular material between the endothelium and the podocytes.

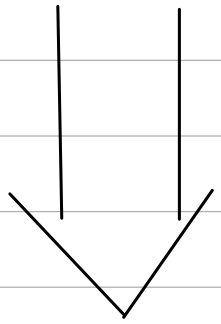
- Extending from each podocyte are thousands of footlike processes termed **pedicels** that wrap around glomerular capillaries. The spaces between pedicels are the **filtration slits. A thin membrane, the slit membrane, extends across each filtration slit;** it permits the passage of molecules having a diameter smaller than ~~0.006~~ 0.007 µm, including water, glucose, vitamins, amino acids, very small plasma proteins, ammonia, urea, and ions.

لا تحفظ قياسات الأقطار فقط معرفة أنه كل ما دخلنا لجوا بتصير أصغر

THE FILTRATION MEMBRANE

The principle of filtration—the use of pressure to force fluid and solutes through a membrane—is the same in glomerular capillaries as in blood capillaries elsewhere in the body. **However, the volume of fluid filtered by the renal corpuscle is much larger than in other blood capillaries of the body for three reasons:**

1. **Glomerular capillaries present a large surface area for filtration** because they are long and extensive.
2. **The filtration membrane is thin and porous.** Glomerular capillaries also are about 50 times leakier than blood capillaries in most other tissues, mainly because of their large fenestrations.
3. **Glomerular capillary blood pressure is high**. Because the efferent arteriole is smaller in diameter than the afferent arteriole, resistance to the outflow of blood from the glomerulus is high. As a result, blood pressure in glomerular capillaries is considerably higher than in blood capillaries elsewhere in the body.



lec (10) part (2) كمل

*Afferent arteriole (داخل بالكبسولة) ← اذا ضيقته يقل الضغط داخل الكبسولة

*Efferent arteriole (يخرج من الكبسولة) ← اذا حدث له تضييق يزداد الضغط داخل الكبسولة

NET FILTRATION PRESSURE

Figure 26.9 The pressures that drive glomerular filtration

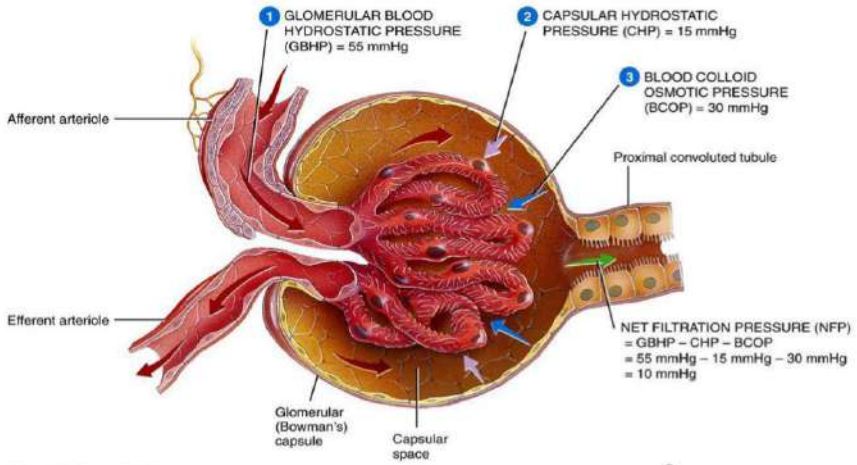


Figure 26.09 Tortora - PAP 12/e

Glomerular filtration depends on three main pressures. One pressure promotes filtration, and two pressures oppose filtration.

يعزز

Glomerular blood hydrostatic pressure promotes filtration, whereas capsular hydrostatic pressure and blood colloid osmotic pressure oppose filtration.

3

NET FILTRATION PRESSURE

- **Glomerular blood hydrostatic pressure (GBHP)** is the blood pressure in glomerular capillaries. Generally, GBHP is about 55 mmHg (millimetre of mercury). It promotes filtration by forcing water and solutes in blood plasma through the filtration membrane.

دفع

- **Capsular hydrostatic pressure (CHP)** is the hydrostatic pressure exerted against the filtration membrane by fluid already in the capsular space and renal tubule. CHP opposes filtration and represents a "back pressure" of about 15 mmHg.

ضد يمارس

يعارض

- **Blood colloid osmotic pressure (BCOP)**, which is due to the presence of proteins such as albumin, globulins, and fibrinogen in blood plasma, also opposes filtration. The average BCOP in glomerular capillaries is 30 mmHg.

يرجع الى

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NET FILTRATION PRESSURE

Net filtration pressure (NFP), the total pressure that promotes filtration, is determined as follows:

$$\text{Net filtration pressure (NFP)} = \text{GBHP} - \text{CHP} - \text{BCOP}$$

By substituting the values just given, normal NFP may be calculated:

$$\begin{aligned}\text{NFP} &= 55\ \text{mmHg} - 15\ \text{mmHg} - 30\ \text{mmHg} \\ &= 10\ \text{mmHg}\end{aligned}$$

Thus, a pressure of only 10 mmHg causes a normal amount of blood plasma (minus plasma proteins) to filter from the glomerulus into the capsular space.

GLOMERULAR FILTRATION RATE

- The amount of filtrate formed in all renal corpuscles of both kidneys each minute is the **glomerular filtration rate (GFR).**
- In adults, the **GFR averages** 125 mL/min in males and 105 mL/min in females.
- **Homeostasis of body fluids** requires that the kidneys maintain a relatively constant GFR.

GLOMERULAR FILTRATION RATE

- **If the GFR is too high**, needed substances may pass so quickly through the renal tubules that some are not reabsorbed and are lost in the urine.
- **If the GFR is too low**, nearly all the filtrate may be reabsorbed and certain waste products may not be adequately excreted.
- **GFR is directly related to the pressures that determine net filtration pressure**; any change in net filtration pressure will affect GFR.

GLOMERULAR FILTRATION RATE

- **The mechanisms that regulate glomerular filtration rate operate in two main ways**: ضبط — تعمل
- (1) **by adjusting blood flow into and out of the glomerulus**. GFR increases when blood flow into the glomerular capillaries increases.
- (2) **by altering the glomerular capillary surface area available for filtration**. Coordinated control of the diameter of both afferent and efferent arterioles regulates glomerular blood flow. Constriction of the afferent arteriole decreases blood flow into the glomerulus; dilation of the afferent arteriole increases it. تغيير — تمدد
- **Three mechanisms control GFR: renal autoregulation, neural regulation, and hormonal regulation.**

nonvoluntary

RENAL AUTOREGULATION OF GFR

- The kidneys themselves help **maintain a constant renal blood flow and GFR despite normal, everyday changes in blood pressure**, like those that occur during exercise. This capability is called **renal autoregulation**.

- It consists of two mechanisms—the **myogenic mechanism** and **tubuloglomerular feedback. Working together, they can maintain nearly constant GFR over a wide range of systemic blood pressures.**

RENAL AUTOREGULATION OF GFR

- The **myogenic mechanism** occurs when stretching triggers contraction of smooth muscle cells in the walls of afferent arterioles. As blood pressure rises, GFR also rises because renal blood flow increases. However, the elevated blood pressure stretches the walls of the afferent arterioles, which narrows the arteriole's lumen. As a result, renal blood flow decreases, thus reducing GFR to its previous level.

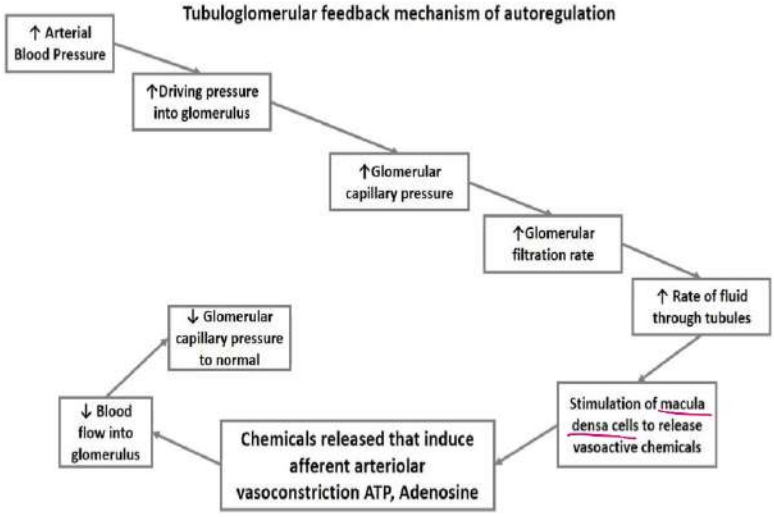
يرتفع

ينخفض

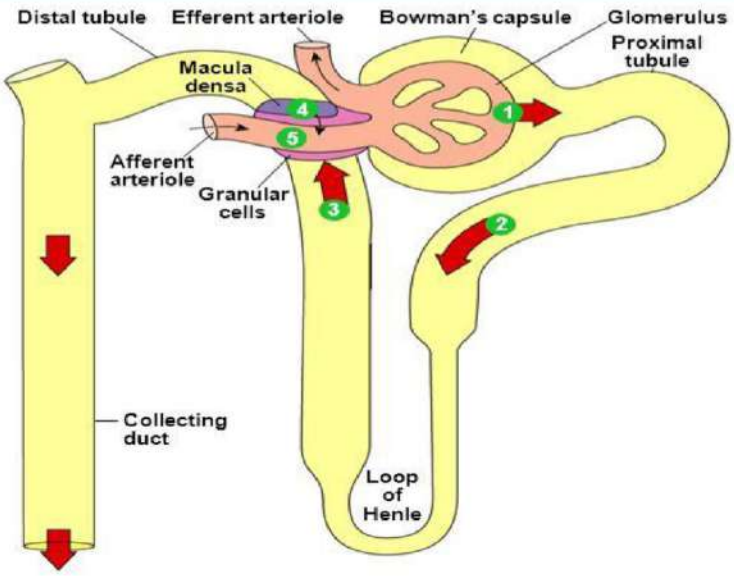
تجويف

RENAL AUTOREGULATION OF GFR

- The **second contributor to renal autoregulation**, **tubuloglomerular feedback**, is so named because part of the renal tubules—the macula densa (is an area of closely packed specialized cells lining the wall of the distal tubule, at the point where the thick ascending limb of the Loop of Henle meets the distal convoluted tubule.)—provides feedback to the glomerulus.



Tubuloglomerular Feedback



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

Resistance in afferent arteriole increases.

Hydrostatic pressure in glomerulus decreases.

GFR decreases.

NEURAL REGULATION OF GFR

- Like most blood vessels of the body, those of the kidneys are supplied by sympathetic ANS fibers that release norepinephrine.
- **At rest**, sympathetic stimulation is moderately low, the afferent and efferent arterioles are dilated, and renal autoregulation of GFR prevails.
- **With moderate sympathetic stimulation**, both afferent and efferent arterioles constrict to the same degree. Blood flow into and out of the glomerulus is restricted to the same extent, which decreases GFR only slightly.

NEURAL REGULATION OF GFR

- **With greater sympathetic stimulation**, however, as occurs during exercise or hemorrhage, vasoconstriction of the afferent arterioles predominates. As a result, blood flow into glomerular capillaries is greatly decreased, and GFR drops.
- **This lowering of renal blood flow has two consequences:** (1) It reduces urine output, which helps conserve blood volume. (2) It permits greater blood flow to other body tissues.

HORMONAL REGULATION OF GFR

Two hormones contribute to regulation of GFR:

قوي

1. Angiotensin II (very potent vasoconstrictor) reduces GFR.

2. Atrial natriuretic peptide (ANP) increases GFR because ANP increases the capillary surface area available for filtration.

TABLE 26.2

Regulation of Glomerular Filtration Rate (GFR)

TYPE OF REGULATION	MAJOR STIMULUS	MECHANISM AND SITE OF ACTION	EFFECT ON GFR
Renal autoregulation			
Myogenic mechanism	Increased stretching of smooth muscle fibers in afferent arteriole walls due to increased blood pressure.	Stretched smooth muscle fibers contract, thereby narrowing lumen of afferent arterioles.	Decrease.
Tubuloglomerular feedback	Rapid delivery of Na^+ and Cl^- to the macula densa due to high systemic blood pressure.	Decreased release of nitric oxide (NO) by juxtaglomerular apparatus causes constriction of afferent arterioles.	Decrease.
Neural regulation	Increase in activity level of renal sympathetic nerves releases norepinephrine.	Constriction of afferent arterioles through activation of α_1 receptors and increased release of renin.	Decrease.
Hormone regulation			
Angiotensin II	Decreased blood volume or blood pressure stimulates production of angiotensin II.	Constriction of afferent and efferent arterioles.	Decrease.
Atrial natriuretic peptide (ANP)	Stretching of atria of heart stimulates secretion of ANP.	Relaxation of mesangial cells in glomerulus increases capillary surface area available for filtration.	Increase.

TUBULAR REABSORPTION AND TUBULAR SECRETION

- **Reabsorption:**
  - The return of most of the filtered water and many of the filtered solutes (as sodium, potassium, chloride, bicarbonate and phosphate ions) to the bloodstream.

- **Tubular secretion:**
  - the transfer of materials (as hydrogen, potassium ions and ammonium ions, creatinine, and certain drugs such as penicillin) from the blood and tubule cells into glomerular filtrate. Tubular secretion has two important outcomes:
  - (1) The secretion of hydrogen ions helps control blood pH.
  - (2) The secretion of other substances helps eliminate them from the body in urine

اخراج

Substances Filtered, Reabsorbed, and Excreted in Urine per Day

TABLE 21.1

Substances Filtered, Reabsorbed, and Excreted in Urine per Day

SUBSTANCE	FILTERED* (ENTERS RENAL TUBULE)	REABSORBED (RETURNED TO BLOOD)	SECRETED IN URINE
Water	180 liters	178–179 liters	1–2 liters
Chloride ions (Cl^-)	640 g	633.7 g	6.3 g
Sodium ions (Na^+)	579 g	575 g	4 g
Bicarbonate ions (HCO_3^-)	275 g	274.97 g	0.03 g
Glucose	162 g	162 g	0
Urea	54 g	24 g	30 g[2]
Potassium ions (K^+)	29.6 g	29.6 g	2.0 g[3]
Uric acid	8.5 g	7.7 g	0.8 g
Creatinine	1.6 g	0	1.6 g

*Assuming glomerular filtration is 180 liters per day.
[2]In addition to being filtered and reabsorbed, urea is secreted.
[3]After virtually all filtered K^+ is reabsorbed in the convoluted tubules and loop of Henle, a variable amount of K^+ is secreted in the collecting duct.