PHYSIOLOGY

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LECTURE 10, PART (1): INTRODUCTION OF THE URINARY SYSTEM

Objectives

1. Discuss **introduction of the urinary system.**
2. Describe **overview of kidney functions**.
3. Explore **glomerular filtration.**

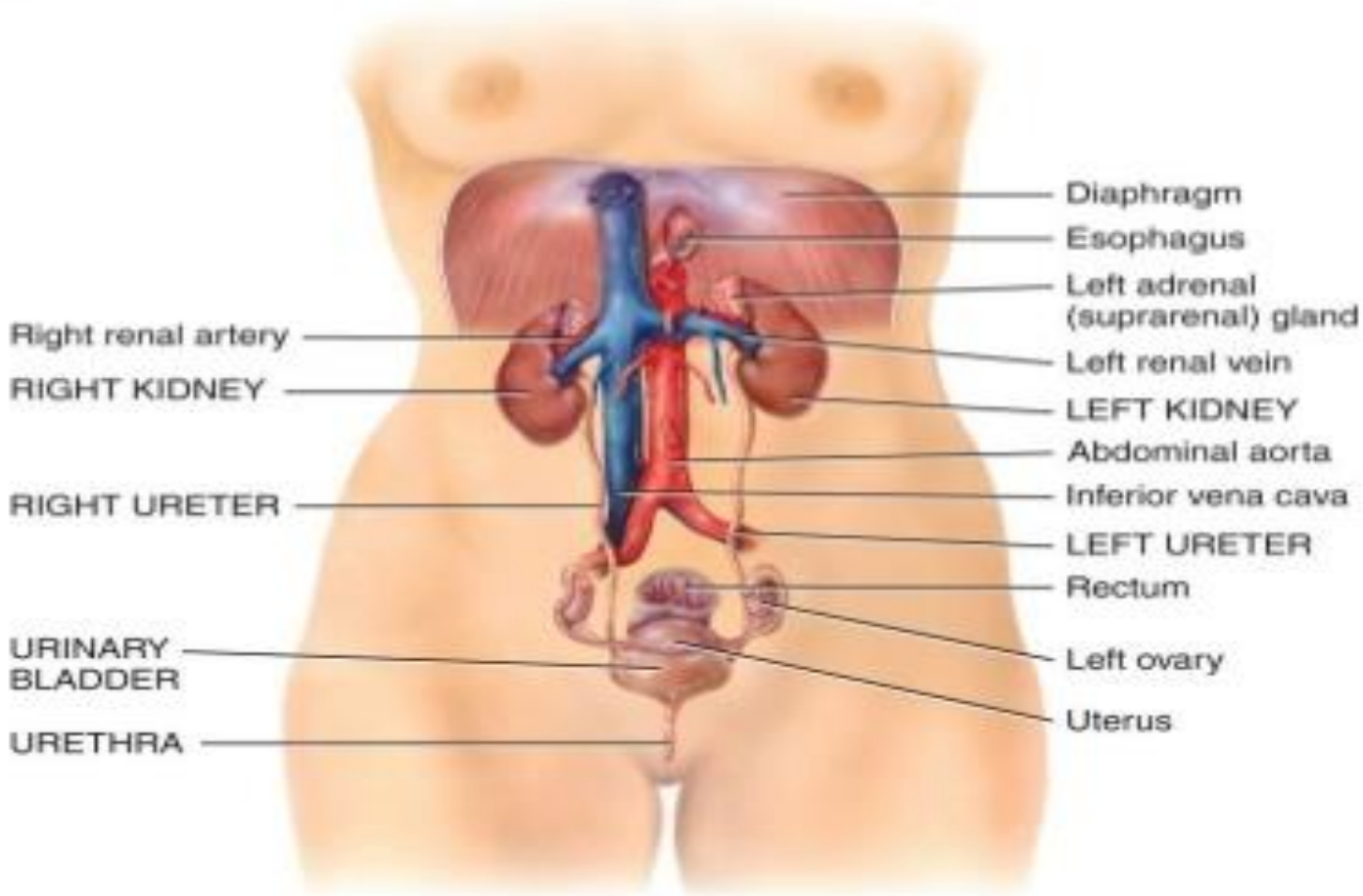
(Pages 991- 993 of the reference)

THE URINARY SYSTEM

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

- **The urinary system consists of** two kidneys, two ureters, one urinary bladder, and one urethra.

Organs of the urinary system in a female



(a) Anterior view of urinary system

THE URINARY SYSTEM

- **After the kidneys filter blood plasma, they return 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 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**.

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.

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.

OVERVIEW OF KIDNEY FUNCTIONS

3. **Regulation of blood volume:** The kidneys adjust blood volume by conserving or eliminating 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 the enzyme renin, which activates the renin–angiotensin–aldosterone pathway. Increased renin causes an increase in blood pressure.

OVERVIEW OF KIDNEY FUNCTIONS

5. **Maintenance of blood osmolarity:** By separately 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).

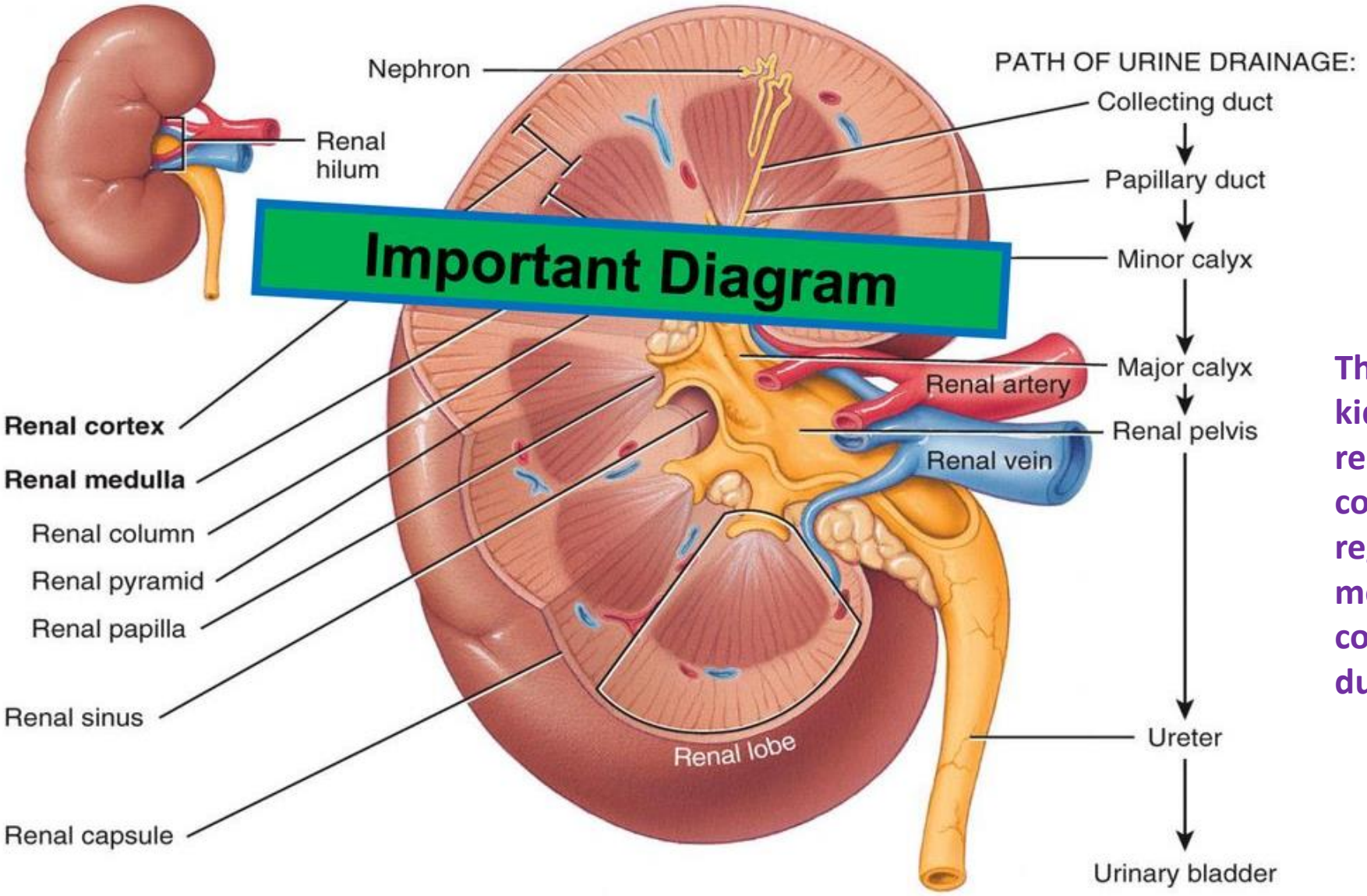
6. **Production of hormones:** The kidneys produce two hormones. **Calcitriol**, the active form of vitamin D, helps regulate calcium homeostasis, and **erythropoietin** stimulates the production of red blood cells.

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.**

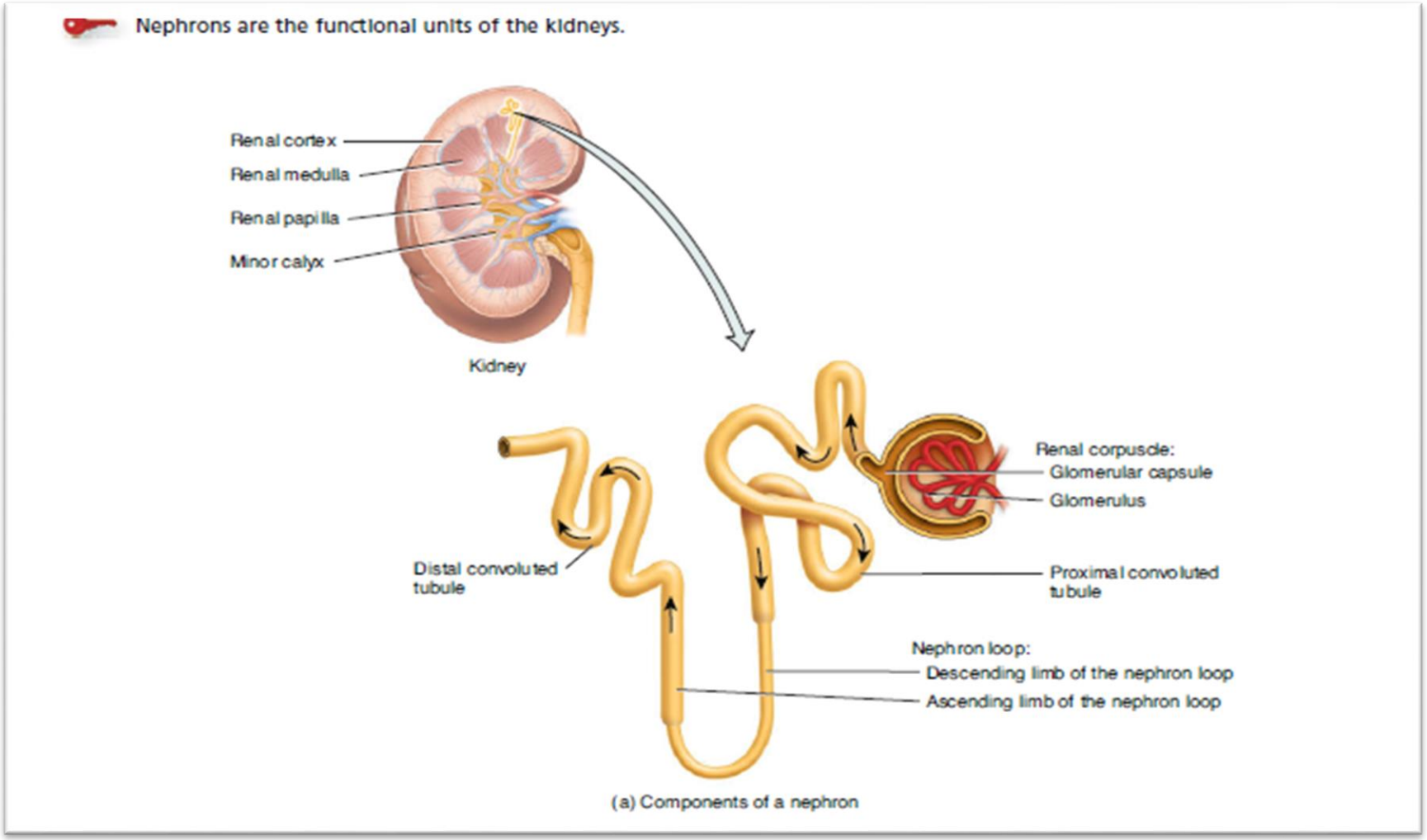
Figure 26.3 Internal Anatomy of the Kidneys



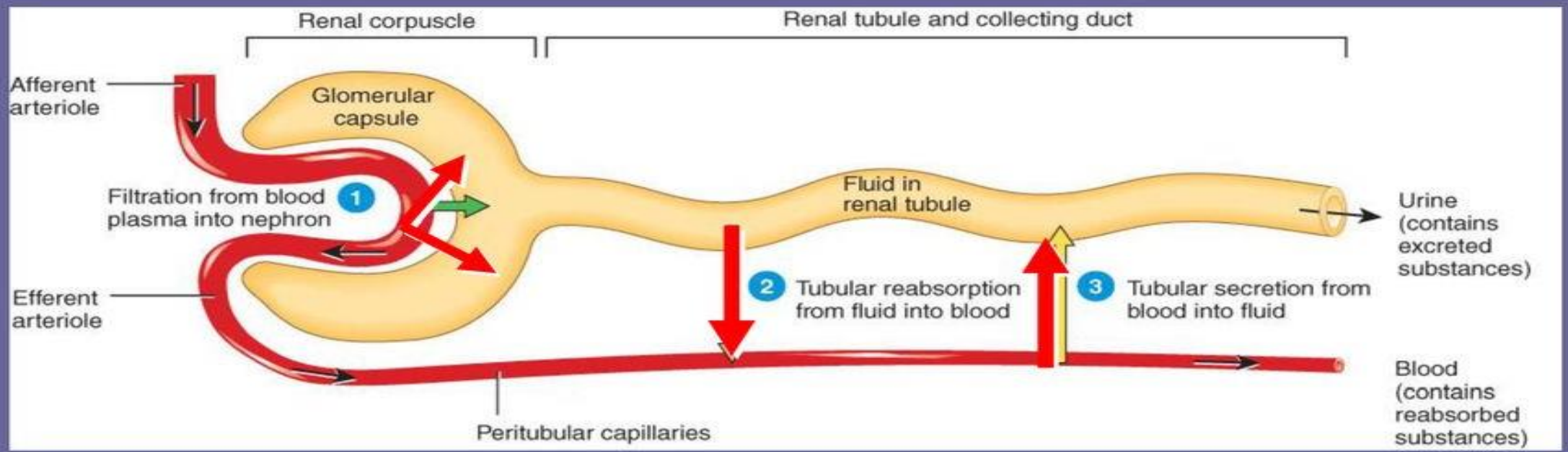
Important Diagram

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.

THE STRUCTURE OF NEPHRONS AND ASSOCIATED BLOOD VESSELS



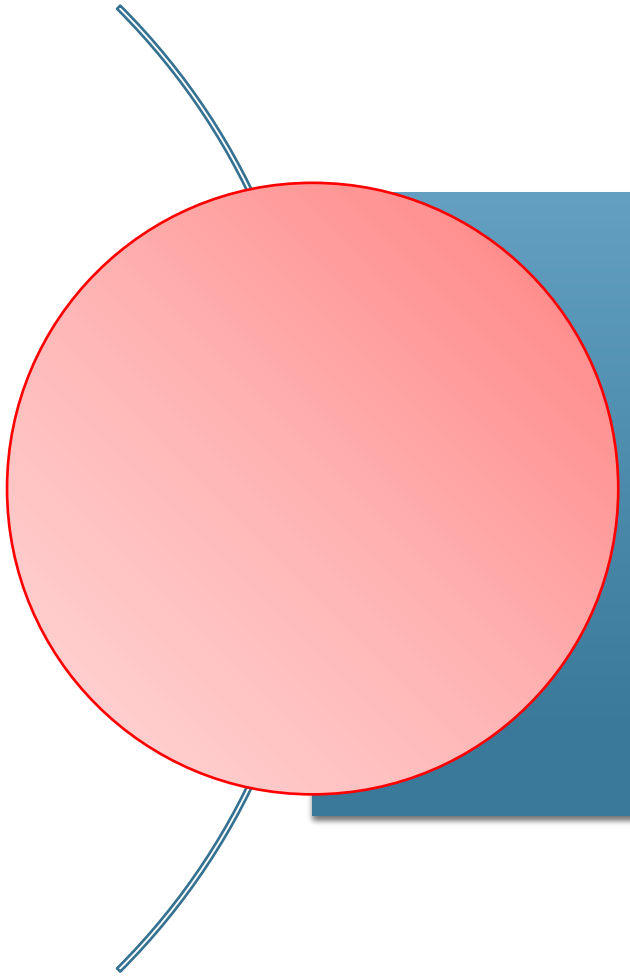
Overview of Renal Physiology



- 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.

OVERVIEW OF RENAL PHYSIOLOGY

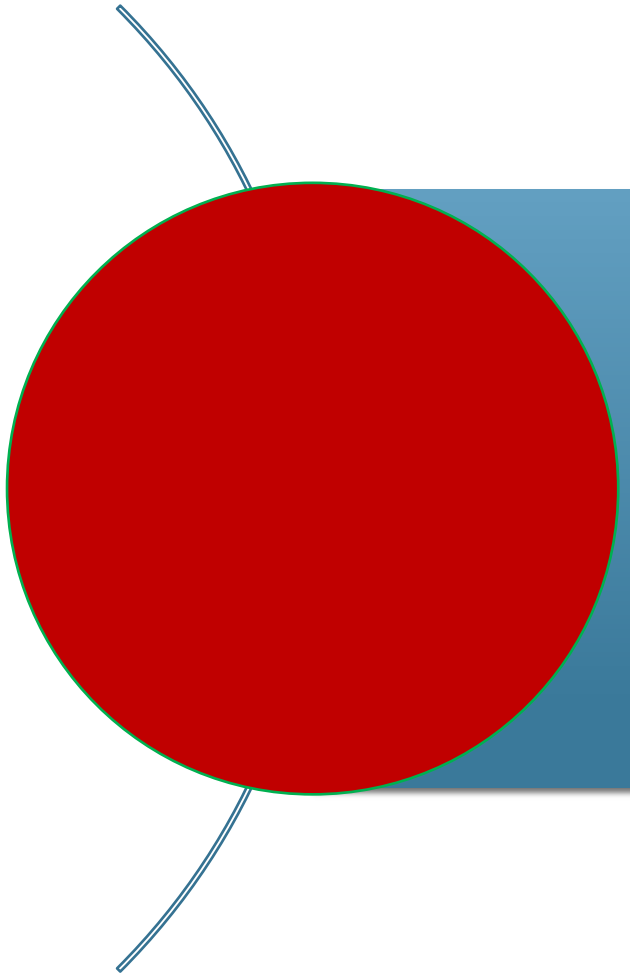


Glomerular filtration: In the **first step of urine production, water and most solutes in blood plasma move across the wall of glomerular capillaries**, where they are filtered and move into the **glomerular capsule** and **then into the renal tubule**.

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

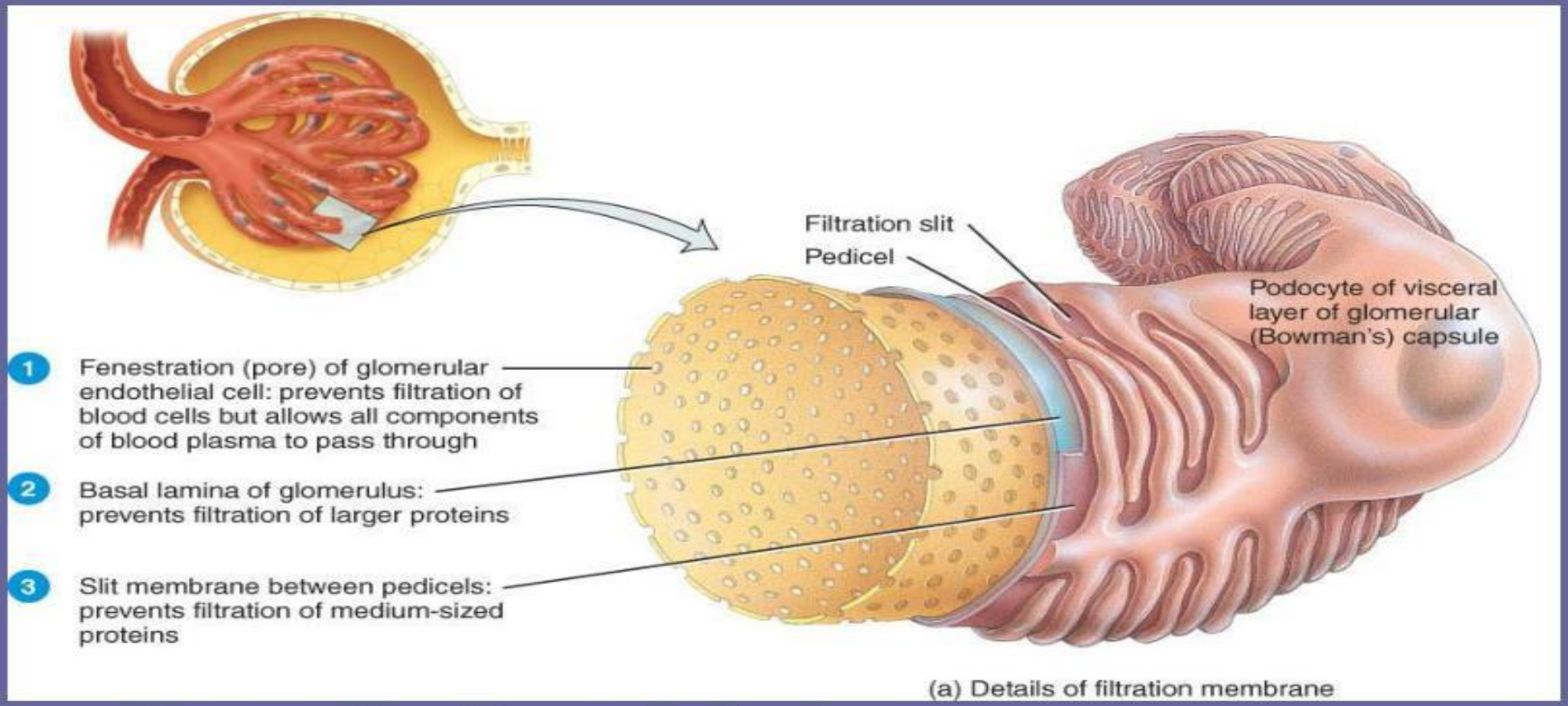


Tubular secretion: As filtered fluid flows through the renal tubules and collecting ducts, the renal tubule and duct cells secrete other materials, **such as wastes, drugs, and excess ions, into the fluid**. **Notice that tubular secretion removes a substance from the blood**.

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.

Filtration Membrane



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

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 0.07–0.1 μm in diameter.

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.

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.

THANK YOU

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