

# **Excretory System**

**B.Sc Second year Honours (Zoology) Paper - 4**

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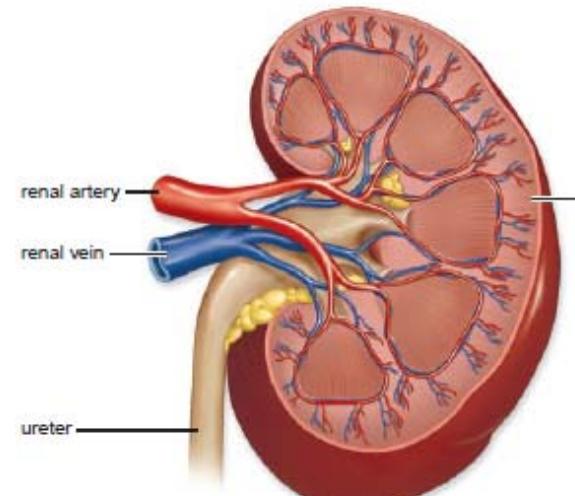
## *Kidney Structure*

- When a kidney is sliced lengthwise, it is possible to see that many branches of the renal artery and vein reach inside the kidney. If the blood vessels are removed, it is easier to identify the three regions of a kidney.
- 1. The renal cortex is an outer, granulated layer that dips down in between a radially striated inner layer called the renal medulla.

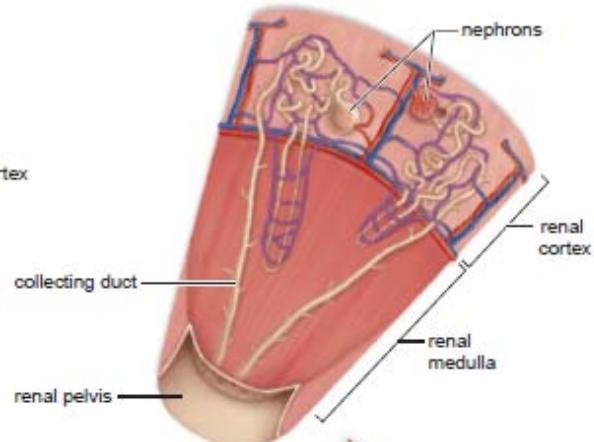
2. The renal medulla consists of cone-shaped tissue masses called renal pyramids.
3. The renal pelvis is a central space, or cavity, continuous with the ureter.
  - Microscopically, the kidney is composed of over 1 million nephrons, sometimes called renal, or kidney, tubules.
  - *The nephrons filter the blood and produce urine.*
  - Each nephron is positioned so that the urine flows into a collecting duct. Several nephrons enter the same collecting duct.
  - The collecting ducts eventually enter the renal pelvis.

### ***Anatomy of a Nephron***

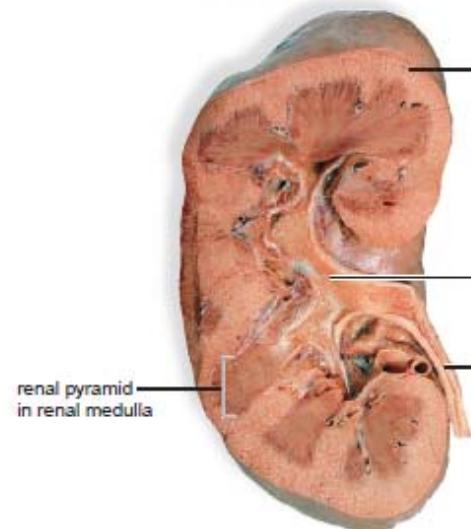
- Each nephron has its own blood supply including two capillary regions.
- From the renal artery, an afferent arteriole transports blood to the **glomerulus**, a knot of capillaries inside the glomerular capsule.



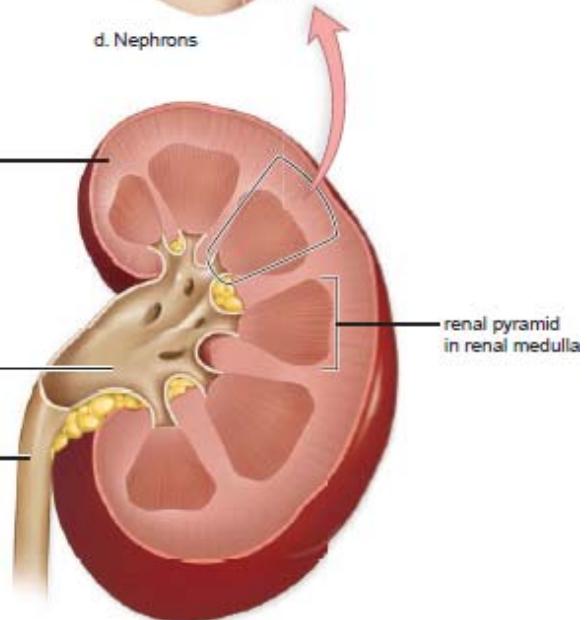
a. Blood vessels



d. Nephrons



b. Gross anatomy, photograph

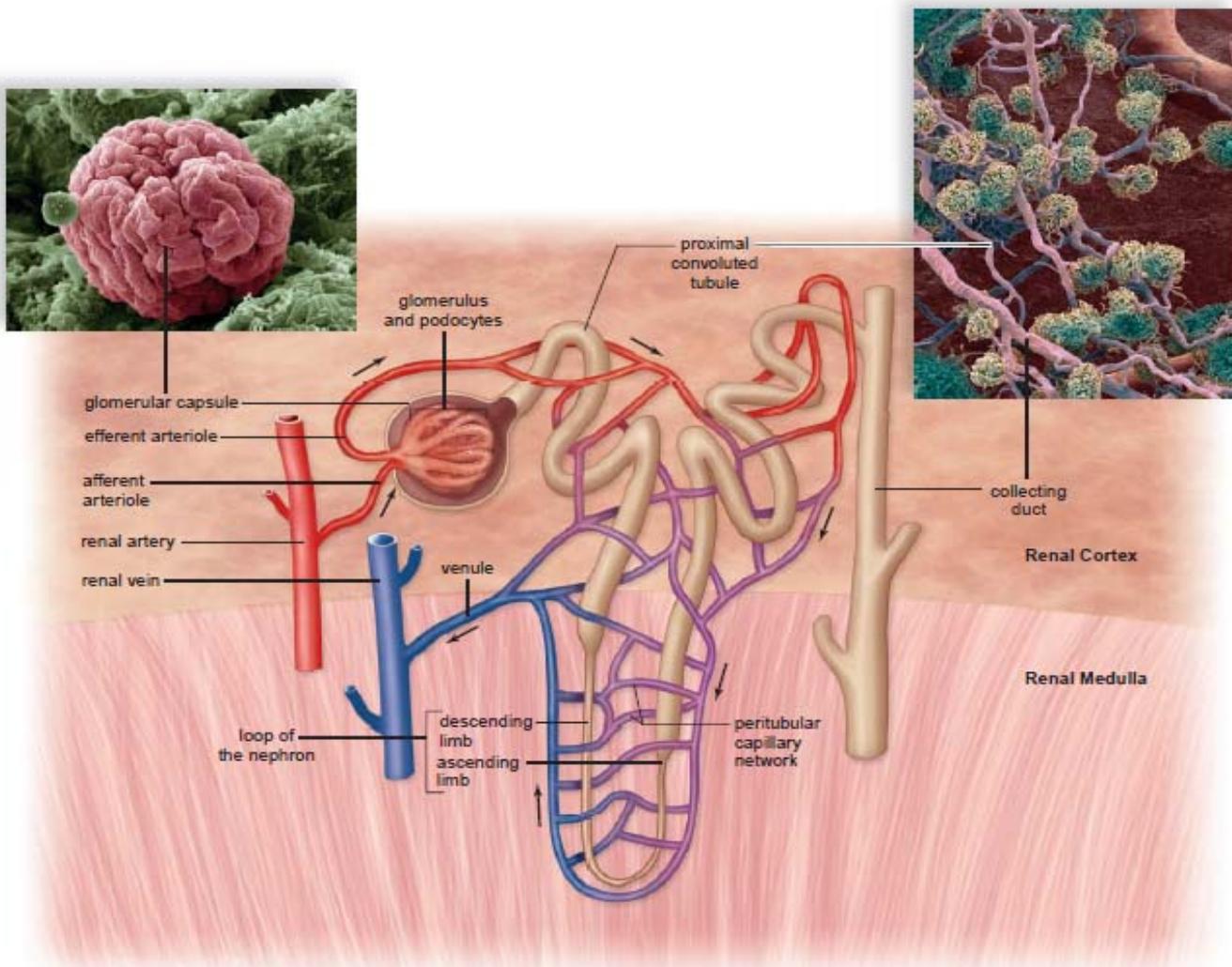


c. Gross anatomy, art

- Blood leaving the glomerulus is carried away by the efferent arteriole. Blood pressure is higher in the glomerulus because the efferent arteriole is narrower than the afferent arteriole.
- The efferent arteriole divides and forms the peritubular capillary network, which surrounds the rest of the nephron.
- Blood from the efferent arteriole travels through the peritubular capillary network.
- Then the blood goes into a venule that carries blood into the renal vein.

### ***Parts of a Nephron***

- Each nephron is made up of several parts. Some functions are shared by all parts of the nephron. However, the specific structure of each part is especially suited to a particular function.
- First, the closed end of the nephron is pushed in on itself to form a cuplike structure called the **glomerular capsule (Bowman's capsule)**.



- The outer layer of the glomerular capsule is composed of squamous epithelial cells.
- The inner layer is made up of podocytes that have long cytoplasmic extensions.
- The podocytes cling to the capillary walls of the glomerulus and leave pores that allow easy passage of small molecules from the glomerulus to the inside of the glomerular capsule.
- This process called glomerular filtration, produces a filtrate of the blood.
- Next, there is a **proximal convoluted tubule**. The cuboidal epithelial cells lining this part of the nephron have numerous microvilli, about 1  $\mu\text{m}$  in length, that are tightly packed and form a brush border.
- Each cell also has many mitochondria, which can supply energy for active transport of molecules from the lumen to the peritubular capillary network.
- Simple squamous epithelium appears as the tube narrows

and makes a U-turn called the loop of the nephron (loop of Henle).

- Each loop consists of a descending limb and an ascending limb.
- The descending limb of the loop allows water to diffuse into tissue surrounding the nephron.
- The ascending limb actively transports salt from its lumen to interstitial tissue.
- As we shall see, this activity facilitates the reabsorption of water by the nephron and collecting duct.
- The cuboidal epithelial cells of the distal convoluted tubule have numerous mitochondria, but they lack microvilli.
- This means that the distal convoluted tubule is not specialized for reabsorption. Instead, its primary function is ion exchange.
- During ion exchange, cells reabsorb certain ions, returning them to the blood. Other ions are secreted from the blood into the tubule. The distal convoluted tubules of several nephrons enter one collecting duct.

- Many **collecting ducts** carry urine to the **renal pelvis**.
- The glomerular capsule and the convoluted tubules always lie within the renal cortex. The loop of the nephron dips down into the renal medulla.
- A few nephrons have a very long loop of the nephron, which penetrates deep into the renal medulla.
- Collecting ducts are also located in the renal medulla, and together they give the renal pyramids their appearance.

## ***Urine Formation***

Urine formation, which is divided into three processes:

### ***Glomerular Filtration***

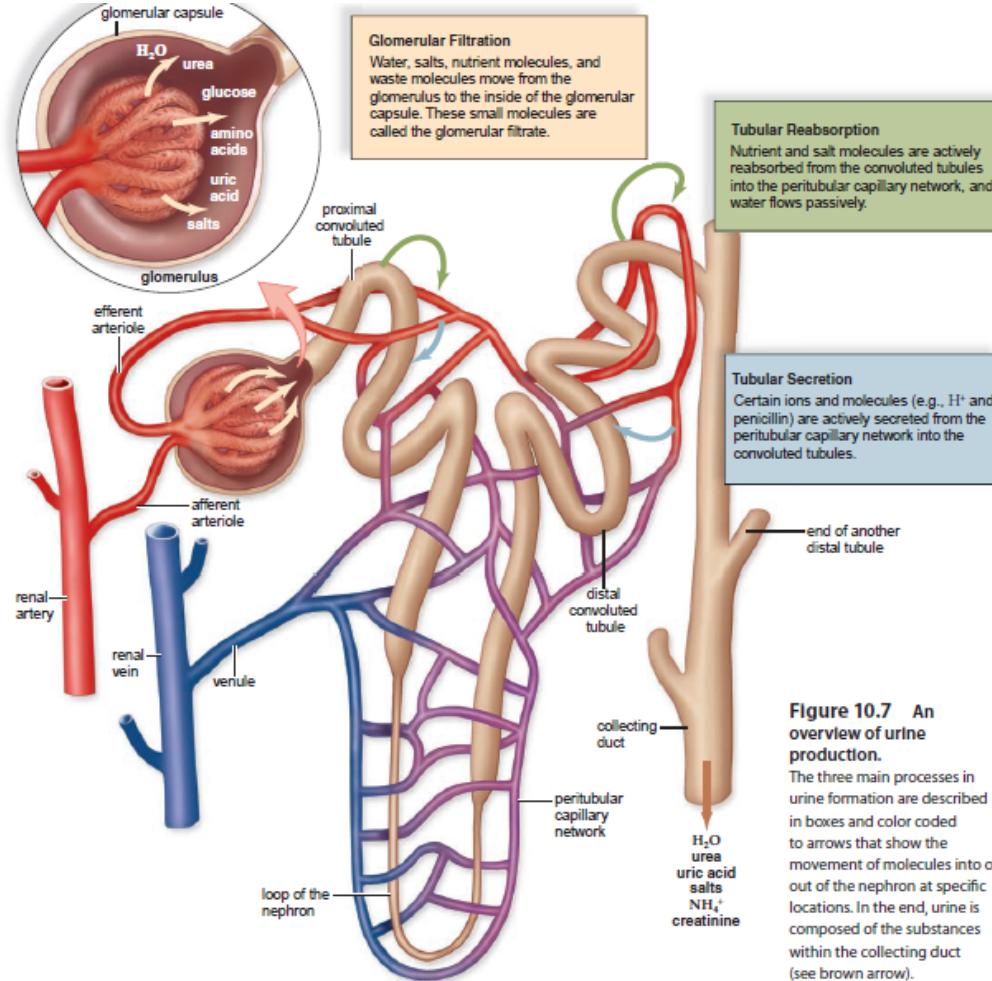
- Glomerular filtration occurs when whole blood enters the glomerulus by way of the afferent arteriole.
- Due to glomerular blood pressure, water and small molecules move from the glomerulus to the inside of the glomerular capsule.
- This is a filtration process because large molecules are formed

elements are unable to pass through the capillary wall.

- In effect, then, blood in the glomerulus has two portions: the filterable components and the non-filterable components.
- The non-filterable components leave the glomerulus by way of the efferent arteriole.
- The glomerular filtrate inside the glomerular capsule now contains the filterable blood components in approximately the same concentration as plasma. If the composition of urine were the same as that of the glomerular filtrate, the body would continually lose water, salts, and nutrients.
- Therefore, we can conclude that the composition of the filtrate must be altered as this fluid passes through the remainder of the tubule.

### ***Tubular Reabsorption***

- Tubular reabsorption occurs as molecules and ions are passively and actively reabsorbed from the nephron into the blood of the peritubular capillary network.



**Figure 10.7** An overview of urine production.

The three main processes in urine formation are described in boxes and color coded to arrows that show the movement of molecules into or out of the nephron at specific locations. In the end, urine is composed of the substances within the collecting duct (see brown arrow).

- The osmolarity of the blood is maintained by the presence of plasma proteins and salt.
- When sodium ions ( $\text{Na}^+$ ) are actively reabsorbed, chloride ions ( $\text{Cl}^-$ ) follow passively. The reabsorption of salt ( $\text{NaCl}$ ) increases the osmolarity of the blood compared with the filtrate. Therefore, water moves passively from the tubule into the blood.
- About 65% of  $\text{Na}^+$  is reabsorbed at the proximal convoluted tubule.
- Nutrients such as glucose and amino acids return to the peritubular capillaries almost exclusively at the proximal convoluted tubule. This is a selective process because only molecules recognized by carrier proteins are actively reabsorbed.
- We have seen that the filtrate that enters the proximal convoluted tubule is divided into two portions: components reabsorbed from the tubule into blood, and components not

reabsorbed that continue to pass through the nephron to be further processed into urine.

- The substances not reabsorbed become the tubular fluid, which enters the loop of the nephron.

### ***Tubular Secretion***

- Tubular secretion is a second way by which substances are removed from blood and added to the tubular fluid.
- Hydrogen ions ( $H^+$ ), creatinine, and drugs such as penicillin are some of the substances moved by active transport from blood into the kidney tubule.
- In the end, urine contains substances that have undergone glomerular filtration but have not been reabsorbed and substances that have undergone tubular secretion.

<b>Reabsorbed Filtrate Components</b>	<b>Nonreabsorbed Filtrate Components</b>
Most water	Some water
Nutrients	Much nitrogenous waste
Required salts (ions)	Excess salts (ions)