

**UNIT 10****URINARY SYSTEM**

The urinary system is one of the most important and chief parts of excretory system. The system plays a vital part in maintaining homeostatic of water and electrolyte concentration within the body.

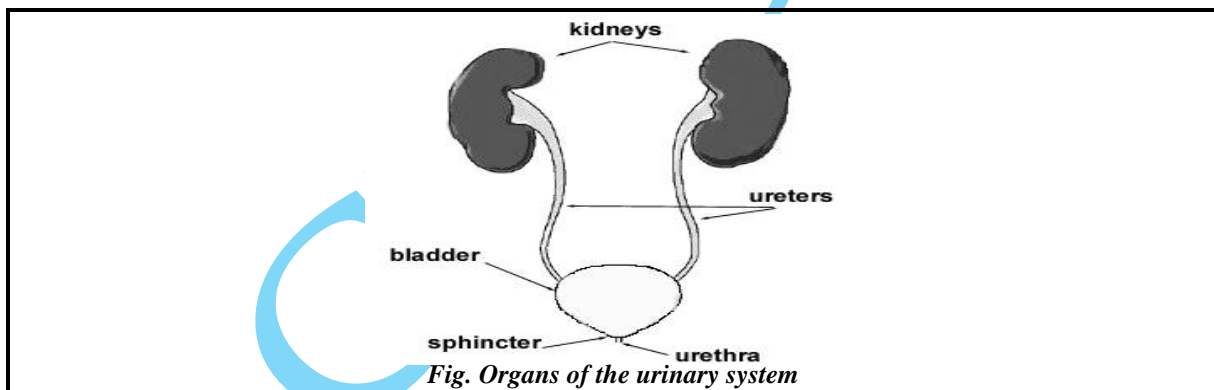
**Functions of Urinary System**

1. Secretion of urine.
2. Excretion urine from the body.
3. Excretion of metabolic wastes from the body. Examples: urea, uric acid, ammonia, creatinine etc.
4. Excretion of water and maintenance of water balance.
5. Regulation of the composition and volume of blood.
6. Regulation of the blood pressure.
7. Maintenance of electrolyte balance (mainly of  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{++}$ ,  $\text{Cl}^-$  etc)
8. Maintenance of pH of body fluid.

**Organs of the Urinary System**

The urinary system consists of following structures:

- |           |     |                   |     |
|-----------|-----|-------------------|-----|
| • Kidneys | : 2 | • Urinary bladder | : 1 |
| • Ureters | : 1 | • Urethra         | : 1 |



*Fig. Organs of the urinary system*

**KIDNEYS**

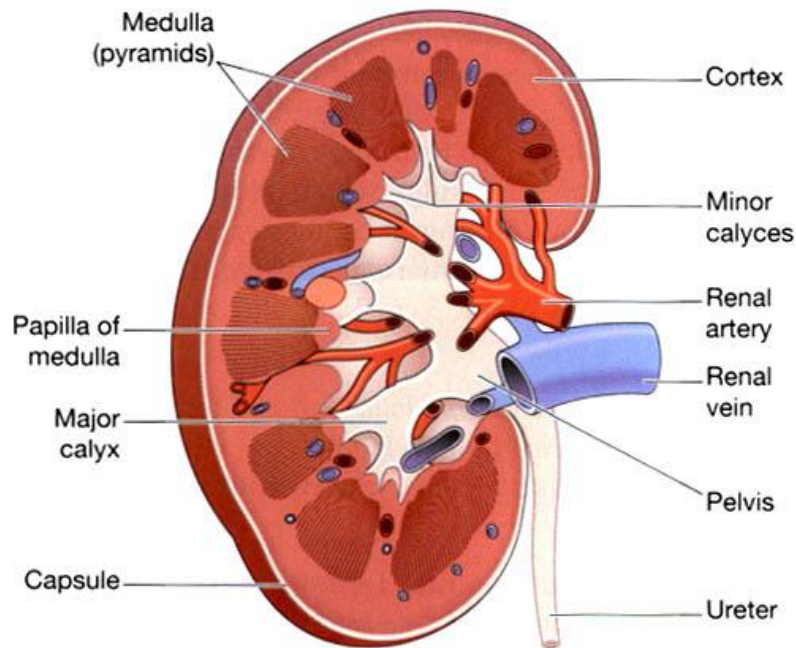
The kidneys are pair (two in numbers), bean shaped organs that lie on the posterior abdominal wall, one on each side of vertebral column, behind the peritoneum (retroperitoneal) and below the diaphragm. They are extending from the level of the  $\text{T}_{12}$  to  $\text{L}_3$  vertebra, when the body is in the erect position. The right kidney is usually slightly lower than the left kidney because of the considerable space occupied by the liver.

The kidneys are reddish brown in colour and about 12cm long, 6cm wide, 3cm thick and weight is about 150gm.

**Structure of Kidneys****1. Internal structure(macroscopic/gross) of kidney**

Internally, each kidney is divided into two parts:

- a. **Cortex:** The outer layer (part) of kidney is known as cortex. It is reddish brown in colour. It consists of 1/3 part of kidneys. It has glomeruli, Bowman's capsule and proximal and distal part of nephron.
- b. **Medulla:** The inner layer (part) of kidney is known as medulla. It is dark brown in colour. It consists of 10 to 18 striated pyramids and contains collecting ducts and loop of Helne.



*Fig. Internal structure of kidney*

## 2. Microscopic structure kidney

Microscopically, the cortex and medulla of the kidney are composed of nephron, blood vessels, lymph vessels and nerves.

### Nephron

The structural and functional unit of the kidney is known as nephron. Each kidney contains about one million nephrons. The length of each nephron is about 50 to 55 mm. Each nephron is capable of forming urine.

### Structure of nephron

A nephron consists of two major parts:

#### 1. Renal corpuscle or Malpighian corpuscle

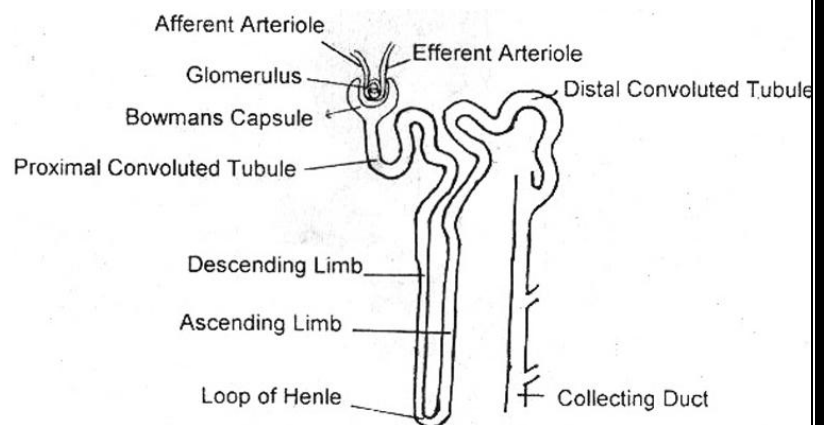
The renal corpuscles are formed by:

- Glomerulus
- Bowman's capsule

#### 2. Renal tubule

The renal tubules are formed by:

- Proximal convoluted tubule
- Descending limb of loop
- Loop of Henle
- Ascending limb of loop
- Distal convoluted tubule
- Collecting duct



### Blood supply of kidneys/Renal circulation

1. **Arterial supply:** In the adults, during resting conditions both kidneys receive about 1300ml of blood (22% of cardiac output) supplied by the renal arteries, which are the branches of abdominal aorta.
2. **Venous drainage:** The venous blood (deoxygenated blood) is collected from the kidney by renal veins which open into inferior venacava.

### Functions of the Kidneys

Kidneys perform several vital functions besides formation of urine. By excreting urine, kidneys play the principal role in homeostasis of the body. Thus, the functions of kidney are:

1. **Role in homeostasis:** Primary function of kidneys is maintenance of homeostasis by the formation of urine. During the formation of urine, kidneys regulate various activities in the body, which are concerned with homeostasis such as:
  - a. **Excretion of waste products:** Kidneys excrete the unwanted waste products, which are formed during metabolic activities:
    - Urea (end product of amino acid metabolism)
    - Uric acid (end product of nucleic acid metabolism)
    - Creatinine (end product of metabolism in muscles)
    - Bilirubin (end product of hemoglobin degradation)
    - Kidneys also excrete harmful foreign chemical substances such as toxins, drugs, heavy metals pesticides, etc.
  - b. **Maintenance of water balance:** Kidneys maintain the water balance in the body by conserving water when it is decreased and excreting water when it is excess in the body. This is an important process for homeostasis.
  - c. **Maintenance of electrolyte balance:** Kidneys maintain electrolyte balance especially sodium in relation to water balance. Kidneys retain sodium if the osmolarity of body water decreases and eliminate sodium when osmolarity increases.
  - d. **Maintenance of acid-base balance:** Kidneys excrete  $H^+$  ions through the urine. At the same time; the kidneys also conserve bicarbonate ions ( $HCO_3^-$ ), which are an important buffer of  $H^+$ .
2. **Hematopoietic function:** Kidneys secrete erythropoietin and thrombopoietin hormones. The erythropoietin stimulates the production of red blood cells and thrombopoietin stimulates the production of thrombocytes.
3. **Endocrine function:** Kidneys secrete many hormonal substances like:
  - Erythropoietin
  - Thrombopoietin
  - Renin, 1,25-dihydroxycholecalciferol (calcitriol)
  - Prostaglandins
4. **Regulation of blood pressure:** Kidneys play an important role in long term regulation of blood pressure by two ways:
  - By regulating the volume of extracellular fluid.
  - Through renin-angiotensin mechanism.
5. **Regulation of blood calcium level:** Kidneys play a role in the regulation of blood calcium level by activating 1, 25-dihydroxycholecalciferol into vitamin D. Vitamin D is necessary for the absorption of calcium from intestine.

### JUXTAGLOMERULAR APPARATUS

The juxtaglomerular apparatus is specialized organ situated near the glomerular of each nephron. It is formed by Macula densa, Extraglomerular mesangial cells and Juxtaglomerular cells. The juxtaglomerular apparatus secretes two hormones such as renin and prostaglandin.

### URETER

The ureters are two long, tubes like fibro muscular structure. It connects the kidneys to the urinary bladder in the pelvis. It is about 25 to 30cm long and the diameter is about 3mm.

#### Structure of Ureter

The walls of the ureters consist of three layers of tissues.

- The outer layer consists of fibrous tissue, continuous with the fibrous capsule of the kidney.

- The middle layer consists of interlacing smooth muscle fibers.
- The inner layer lining of mucous membrane, it is composed of transitional epithelium.

### **Function of Ureters**

It propels the urine from the kidneys into the bladder by peristaltic contraction of the muscular wall.

## **URINARY BLADDER**

Urinary bladder is hollow thin, elastic, sac like structure. It is situated in the pelvic cavity behind the pubis in front of the rectum in the male and in front of the anterior wall of the vagina and the neck of the uterus in the females. Its size and position vary depending on the volume of urine it contains, when distended, the bladder rises into the abdominal cavity.

### **Structure of Urinary Bladder**

The wall of bladder is composed of three layers:

- The outer layer consists of loose connective tissue, containing blood vessels, lymph vessels, and nerves, covered on the outer surface by peritoneum.
- The middle layer consists of smooth muscle and elastic tissue loosely arranged in three layers known as detrusor muscle, and when if contracted, it empties the bladder.
- The inner layer is mucosa (mucus membrane), composed of transitional epithelium.

### **Function of Urinary Bladder**

It stores urine and discharge outside the body through urethra.

## **URETHRA**

Urethra is the duct that connects the urinary bladder to the genitals for the removal of fluids out of the body.

### **Male Urethra**

The male urethra is about 18 to 20 cm long that extends from the neck of the bladder to the external meatus of the glans penis.

### **Female Urethra**

The female urethra is about 4 cm long. It extends from the neck of the bladder to the external meatus, where it opens into the vestibule about 2.5 cm below the clitoris.

### **Functions of Urethra**

1. It provides passage way of urine from the body.
2. In the male urethra: It is also terminal portion of the reproductive tract and serves as the passage way for the reproductive fluid (semen).

## **MECHANISM OF URINE FORMATION**

Urine formation is a blood clearing function. Normally, about 1300ml of blood (26% of cardiac output) enters the kidneys. Kidneys excrete the unwanted substances along with water from the blood as urine. Normal urine output is 1 to 1.5 liter per day.

### **Process of Urine Formation**

The mechanism of urine formation includes various processes:

#### **1. Glomerular Filtration/Simple Filtration**

Glomerular filtration is the process by which the blood is filtered while passing through the glomerular capillaries by filtration membrane. It is the first process of urine formation. The filtered blood is collected in Bowman's capsule as filtrate.

**Glomerular filtration rate (GFR):** The total quantity of filtrate formed in all the nephron is both kidneys in per minute is known as glomerular filtration rate (GFR). It is 125ml/min, about 180 liter/day. But, formation of urine is only about 1 to 1.5 liter, this result because of the fact that 99% of glomerular filtration is reabsorbed.

## 2. Tubular Reabsorption

Tubular reabsorption is the process by which the water and other substances are transported from renal tubules back to the blood, when the glomerular filtrate flows through the tubular portion of nephron. The large quantity of water (more than 99%), electrolytes and other substances are reabsorbed by the renal tubules.

- Proximal convoluted Part:** 65%-70% of the filtrate is reabsorbed and only 30% filtrate remains. Here glucose, amino acid, NaCl, vitamins are reabsorbed completely.
- Descending limb:**  $\text{Na}^+$  and water are reabsorbed. Only 20% of filtrate remains.
- Ascending limb:** Only  $\text{Na}^+$  reabsorption takes place.
- Distal convoluted tubule:** Water absorption takes place under the influence of ADH.  $\text{Cl}^-$  and  $\text{Na}^+$  are also reabsorbed.
- Collecting duct:** Reabsorption of  $\text{Na}^+$  and water (Due to ADH) takes place and the filtrate becomes hypertonic. Only 1% of the filtrate passes as urine.

## 3. Tubular Secretions

The transport of substances into the filtrate is called tubular secretion. These include  $\text{H}^+$ ,  $\text{K}^+$ ,  $\text{NH}_3$ , Urea, creatinine and some drugs.

- In proximal convoluted tubules:**  $\text{H}^+$ ,  $\text{K}^+$ ,  $\text{NH}_3$  is secreted.
- In descending limb:**  $\text{Na}^+$  by passive diffusion.
- In ascending tubules:** Urea by passive diffusion.
- In distal convoluted tubules:**  $\text{NH}_3$  is secreted and also  $\text{K}^+$  and  $\text{H}^+$  with the help of exchange pump.

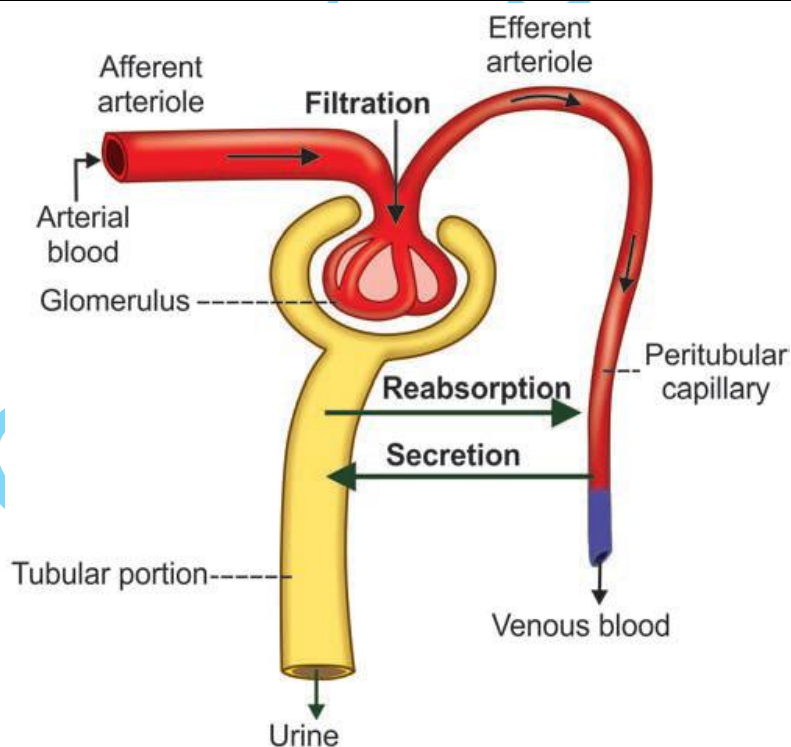


Fig: Mechanism of urine formation

## COMPOSITION OF URINE

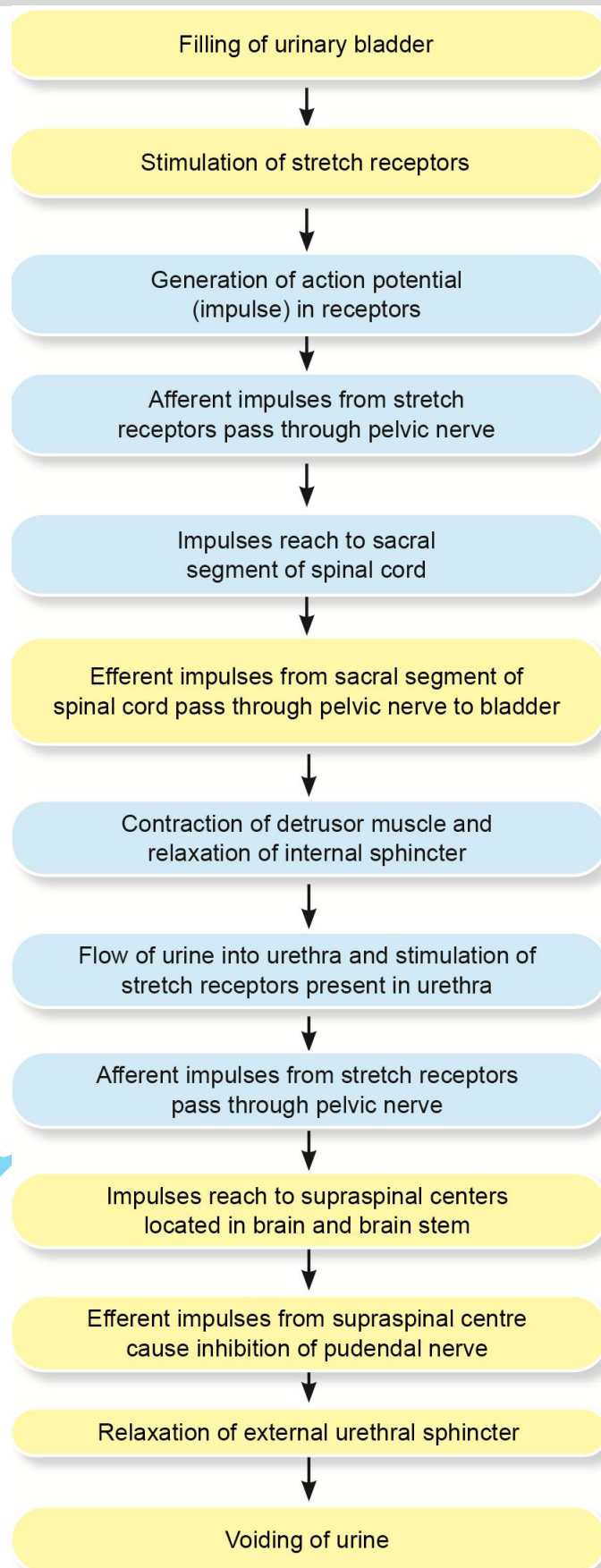
Normal constituents of urine include

- Water : 96%
  - Urea : 2%
  - Uric acid, Creatinine, Ammonia
  - Sodium, Potassium, Chloride  
Phosphate, Sulphate
- } 2%

## MICTURITION OF URINE

Micturition is the process by which urinary bladder empties when filled.

### Process of Micturition



**URINARY SYSTEM**  
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