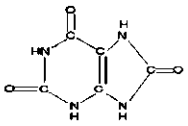
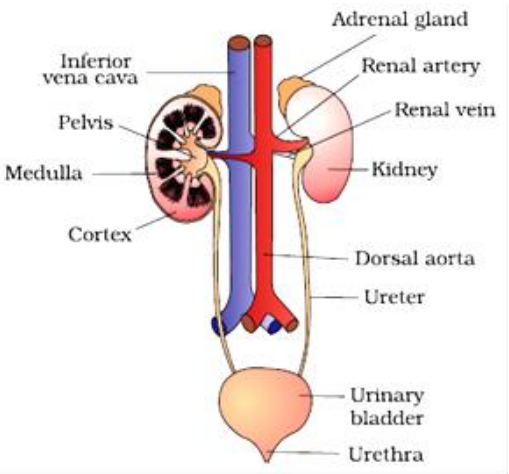
# Excretory Products & Their Elimination

- **Excretion:** Elimination of metabolic waste products from the animal body to regulate the composition of body fluids and tissues. These waste products include ammonia, uric acid, urea, carbon dioxide and ions like $Na^+$, $K^+$, $Cl^-$ and phosphates and sulphate.
- **Osmolarity** :The concentration of solutes in a solution, expressed as osmoles per liter of solvent.

### Types of Excretion:

| Ammoniotelic | Ureotelic | Uricotelic |
|---|---|---|
| • Excrete Ammonia/$NH_3$<br>• Ammonia is the most toxic<br>• Readily soluble in water<br>• Requires large amount of water for its elimination.<br>• Excreted through Body surface or gills as ammonium ion.<br>• Kidney do not play significant role.<br>• Ex- Bony fishes, aquatic amphibians and aquatic insects. | • Excrete Urea ($NH_2$ CO $NH_2$)<br>• Less toxic than ammonia<br>• Ammonia is converted into less toxic Urea in liver.<br>• Require moderate amount of water for elimination<br>• Kidney play significant role in elimination.<br>• Some amount of urea may retain in kidney to maintain osmolarity.<br>• Ex: Bony fishes, aquatic amphibians and aquatic insects | • Excrete Uric Acid<br>• Least toxic<br>• Insoluble in water<br>  <br>• Do not require water for elimination.<br>• Contribute to water conservation.<br>• Produce concentrated Urine.<br>• Ex: Reptiles, birds, land snails, crustaceans and insects |

| Animals | Excretory organs |
|---|---|
| Flatworms, some annelids & cephalochordates. | Protonephridia or flame cells. |
| Earthworms and annelids | Nephridia |
| Insects including cockroaches | Insects including cockroaches |
| Mammals | Kidney |

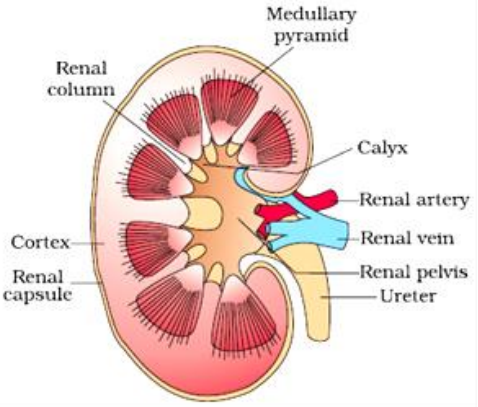



## Human Excretory System

According to the chapter on excretory products and their elimination, the human excretory system consists of:

1. **A pair of Kidneys:** Situated between the T12 and L3 vertebra, bean-shaped and reddish-brown in colour.
   10-12 cm long, 5-7 cm wide, 2-3 cm thick with an average weight of 120- 170 g. Divided into 2 layers: the outer cortex and an inner medulla.
2. **A pair of ureters:** *Muscular Tube carry urine from the kidneys to the bladder. Approximately 25-30 cm long* consist of smooth muscle.
3. **A urinary bladder-** A hollow, muscular organ that temporary stores the urine. Consist of 4 layers. Mucosa (innermost) layer with folds, Submucosa contains blood vessels, Muscularis made of Smooth/Detrusor muscles responsible for contraction of bladder and the outermost Serosa.
4. **A urethra:** A tube that carries urine from the urinary bladder to the external environment. In females it is 3-4 cm long. In males it is 20-25 cm long and serve as common passage for semen & urine.

## Human Kidney- Divides into two zone outer cortex & inner medulla.




**Renal Cortex:** The outer region of the kidney containing nephrons and renal corpuscles, where filtration of blood occurs. Malpighian body, PCT & DCT lies in Cortex region.

**Renal Medulla:** The inner region of the kidney containing renal pyramids and collecting ducts, responsible for the concentration and transportation of urine. 8-18 pyramids present in each kidney. Henle's loop lies in Medullary region.

**Renal Capsule:** A tough fibrous tissue covering that act as a barrier to the kidney.

**Hilum**- Notch present on concave side of kidney through which the ureter, blood vessels, and nerves enter the kidney.

**Columns of Bertini :** The renal columns formed when the cortex extends between the medullary pyramids.

**Renal pelvis:** A broad funnel shaped space inner to hilum that collects urine from calyces

**Calyces (Sing: Calyx):** Funnel shape projections from renal pelvis that collects the urine from renal pyramids.

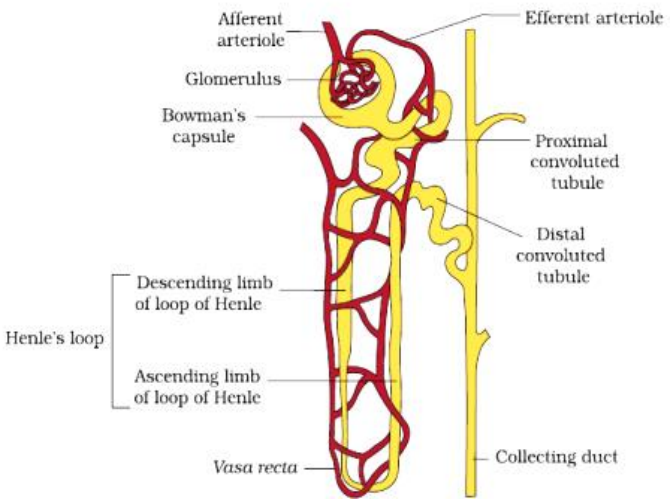
**Nephrons**: The structural & functional unit of kidney. Each kidney has an average of 1 million nephrons. It consists of :

1. **Malpighian Body** or Renal corpuscle (glomerulus)

- **Bowman's capsule:** A double-walled cup-like structure at the beginning of the renal tubule, which encloses the glomerulus
- **Glomerulus:** A cluster of capillaries formed by the arteriole within Bowman's capsule.

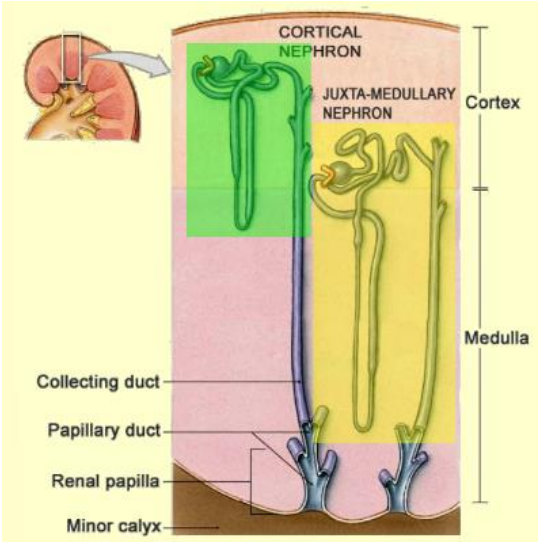
  **Afferent Arteriole:** Brings blood to glomerulus.

  **Efferent Arteriole:** Takes away blood from Glomerulus.




**Renal tubule**

- **Proximal Convoluted Tubule** : A highly coiled tubular structure that carries the filtrate forms Bowmans Capsule.
- **Henle's loop:** U shaped tube that extends from PCT & descends into renal medulla. It has an ascending and descending limb.
- **Distal convoluted tubule:** Another highly tubular coiled into which ascending limb of Henle's open.




- ❖ **Vasa recta:** U - shaped blood vessel that runs parallel to Henle's loop.
- ❖ **Collecting Duct:** Straight tube in which DCTs of many nephrons opens.
- ❖ **Peritubular capillaries:** The fine network of capillaries emerging from glomerulus' efferent arteriole that surrounds the renal tubule.

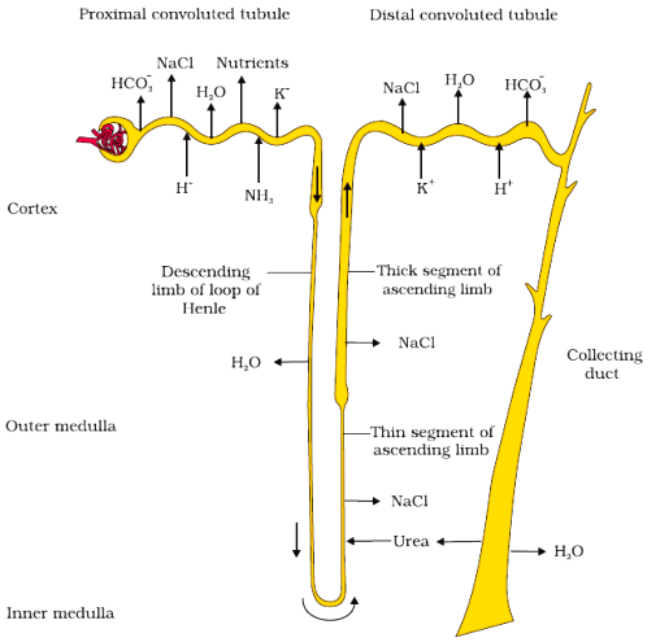
**Types of Nephrons:**

1. **Cortical Nephron (85%):** In this Henle's loop is short and extends only very little into medulla. Vasa recta is absent or highly reduced.
2. **Juxtamedullary Nephron (15%):** In this Henle's loop is long and runs deep into medulla. Vasa recta is present. It plays a crucial role in establishing the concentration gradient necessary for water reabsorption and urine concentration.

**Urine Formation:** Involves 3 main processes namely:

1. **Glomerular Filtration (ultrafiltration)**

- Filtration of blood in glomerulus.
- An average of 1100-1200 ml (1/5 of blood pumped by each ventricle per min) of blood is filtered by the kidneys per minute.
- Almost all the constituents except proteins are filtered onto the lumen of Bowman's capsule.
- Blood Filter through three layers, endothelium of blood vessels, the epithelium (also called podocytes are arranged in an intricate manner leaving some minute spaces called filtration slits or slit pores) of Bowman's capsule and a basement membrane between these two layers.




- Glomerular filtration rate (GFR)- amount of the filtrate formed by the kidneys per minute (approx 125 ml/minute, i.e., 180 litres per day).
- **Juxta glomerular apparatus (JGA):** Sensitive region formed at contact of DCT and afferent arteriole. Fall in GFR activates JG cells to release Renin which increase Blood flow & bring GFR to normal.

2. **Selective Reabsorption**

- 180 litres of filtrate formed every day out of which 99% is reabsorbed. 1.5 litres of urine is produced.
- Glucose, amino acids, Na+ , etc., in the filtrate are reabsorbed actively whereas the nitrogenous wastes are absorbed passively.
- Reabsorption of water passively.

**3. Tubular Secretion**

- H+ , K + and ammonia into the filtrate during urine formation. Maintenance ionic and acid base balance of body fluids.