# EXCRETORY PRODUCTS AND THEIR ELIMINATION

## 1 EXCRETORY WASTE

**METABOLISM** **EXCESS INGESTION**

Results in accumulation of

- **Nitrogenous wastes** – $NH_3$, Urea, Uric acid
- Other contents $CO_2$, $H_2O$, ions ($Na^+$, $K^+$ $Cl^-$, $PO_4^{3-}$, $SO_4^{2-}$)

↓

Removed Partially/Completely

## 2 NITROGENOUS WASTES

- Nature of nitrogenous waste formed and their excertion vary among anilmals depending on tne **habitat/availability of water**

| Major Nitrogenous Waste | Nature & Examples | Toxicity And Water Required | Typical |
|---|---|---|---|
| • Ammonia | **Ammonotelic** | Maximum | • Diffusion through gills surface or body surface ammonium ions |
| • Urea | **Ureotelic** | Less | • **Kidneys** filter urea from blood |
| • Uric acid | **Urecotelic**<br>• Land snads<br>• Insects<br>• Reptiles<br>• Birds | Least | Pellet/Paste |

- Ammonia converts into urea in liver via ornithine cycle.
- Elimination of urea, uric acid is meant for conservation or water i.e., a type of terrestrial adaptation.
- Kidneys do not play a significant role in removal of ammonia
- Some amount of urea may be retained in the kidney
- matrix of some animals to maintain desired osmolarity

## 3 EXCRETORY STRUCTURES

- Most invertebrates - Simple tubular forms
- Vertebrates - Complex tubular organs called kidneys

**Structures**

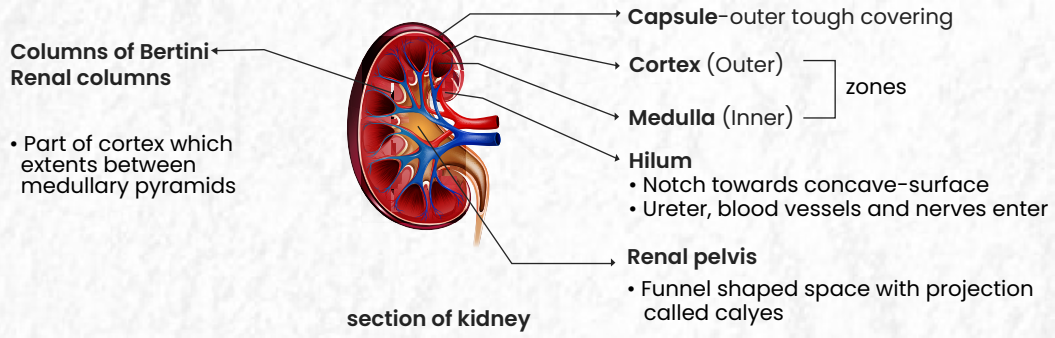
- Protonephridia/flame cells
- Nephridia
- Malpighian tubules
- Antennal/Green glands

**Examples**

- Platyhelminthes (Planaria)
- Rotifers
- Some annelids
- Cephalochordates (Amphioxus)
- Annelids (Earthworms)
- Insects (Cockroaches)
- Crustaceans (Prawn)

- **Protonephridia** are primarily concerned with **osmoregulation**
- **Functions of excretory structures**
- Eliminate nitrogenous wastes
- Maintan ionic and acid-base balance of body fluids. i.e., osmoregulation

## 5 KIDNEY




section of kidney

Medullary pyramids are conical masses that project into calyces.

### MICTURITION

- Process of release of urine
- Mechanism - **Micturition reflex**

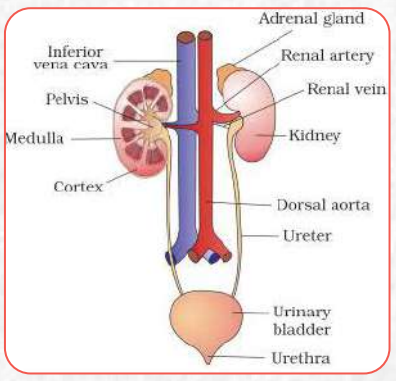
Urinary bladder (Store Urine)
Activates
Stretch receptors

signals

CNS (voluntary signal)
↓ Send motor message
Urinary bladder
- Smooth muscle contract
- Urethral sphincters relax

↓ Release
Urine

## 4 HUMAN EXCRETORY SYSTEM




### KIDNEY

- 1 pair, bean shaped, reddish brown.
- Length 10-12 cm, Width 5-7 cm Thickness 2-3 cm.
- Weight 120-470 g.
- Between $T_{12}$ – $L_3$ vertebra, close lo dorsal inner wall of abdominal cavity.

### URINARY BLADDER

- Have stretch receptors.
- Store urine till voluntary signals from CNS carries out its release.

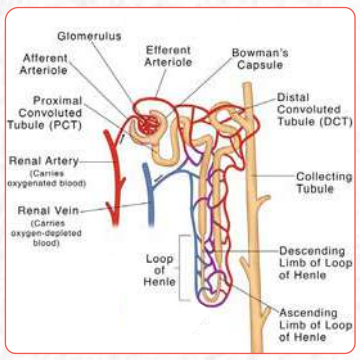
### URETHRA

- Guarded by sphincters.
- Meant for release of urine.

## 6 NEPHRON

- **Functional unit of kidney**
- Each nephron has two parts
- Nearly **1 million/kidney**

**Parts**: (i) Glomerulus (ii) Renal tubule



| Parameters | Cortical | Juxtamedullary |
|---|---|---|
| • Number | More | Less |
| • Loop of Henle | Too short | Very long |
| • Extension Into medulla | Very Mild | Deep |
| • Vasa recta | Absent/reduced | Present |

• **Juxtaglomerular apparatus (JGA)**
Sensitive region formed by cellular modifications in **distal convoluted tubule** and **afferent arteriole** at the location of their **contact**

• Nephrons are dipped in interstitial fluid having specific osmolarity
- Cortex - 300 mOsm/L - Medulla - upto 1200 mOsm/L (Gradient)

• **Glomerulus** is a tuft of capillaries formed by Afferent Arteriole. A fine branch of Renal Artery.
• **Malpighian Corpuscle, PCT, DCT – Located In Cortex.**
• Loop of Henle – Dips into Medulla.
•Many Ducts open into straight tube called collecting duct, many of which converge into renal pelvis through mediullary Pyramids in the calyces.
• **Efferent Arteriole** emerging from glomerulus forms peritubular capillaries around renal tubule
• **Vesa recta:**
Branch of petitubular capillaries
Parallel to loop of Henle
'U' shaped

## 7 URINE FORMATION

**Main Processes**

1. Glomerular filtration
180 L filtrate/day

2. Tubular reabsorption
Near **99%** of filtrate get **reabsorbed** by renal tubules By
- **Active process**: • Glucose, $Na^+$ amino acid
- **Passive process**: • Nitrogenous wastes, $H_2O$

3. Tubular secretion
•$H^+$, $K^+$ and ammonia secreted into filtrate
• Maintains ionic and acid base balance

**Urine 1-1.5 L/day**

**Glomerular Filtration/Ultra filtration**
-1/5 of cardiac output or 1100-1200 ml blood/min is filtered by kidneys

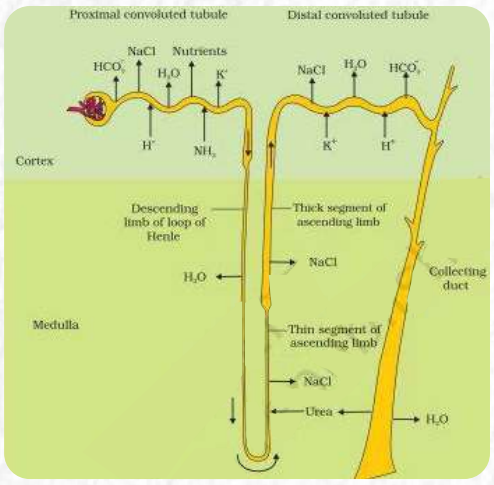
Renal Artery
↓
Arterioles
↓
Endothelium of glomerular blood vessels
↓
Basement membrane
↓
Epithelium of Bowman's capsule
↓
Glomenular filtrate
(Plasma except proteins)

**Filtration membrane**

Bowman's capsule have **poducytes** arranged in intricate manner so as to leave some spaces called slit pores/**filtration slits**

• Filtration is due to pressure in the glomerular capillaries.
• **Glomerular filtration rate (GFR) = Filtration/min 125ml/min**
• Kidney has an ability to regulate GFR.

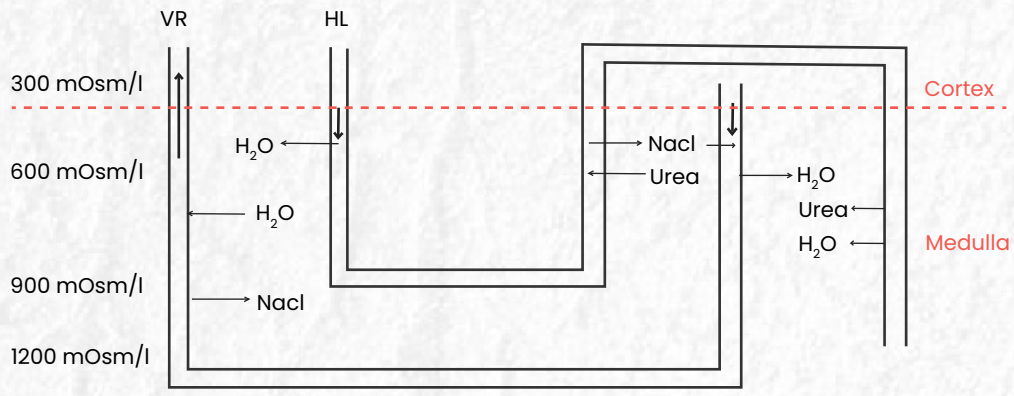
• Lined by simple cuboidal brush border epithelium
• Nearly all essential nutrients, 70-80% electrolytes and water ere reabsorbed
• Major site of reabsorption & selective secretion



# 8 COUNTER CURRENT MECHANISM TO CONCEITTRATE FILTRATE

• Flow of filtrate in different limbs of following structures are in opposite direction (**Counter** current)

• Loop of Henle (HL) • Vasa Recta (VR) • HL and VR




- Proximity of HL and VR and counter current in them increase osmolarity towards inner medullary interstitium (300 mOsm/L in cortex to 1200 mOsm/L)
- **Interstitium gradient is caused by NaCl and urea.**
- NaCl transported by ascending limb of HL exchanged with descending limb of vasa recta and is returned to medullary interstitium by ascending limb of VR.
- Urea which enters in thin part of ascending limb of HL is transported back to interstitium by collecting tubule
- This mechanism maintain interstitial concentration gradient that helps in easy passage of water from collecting tubule thereby concentrating filtrate (urine).

- Mammals have ability to poroduce concentrated urine.
- HL primarily helps to maintain osmolarity gradient in kidney intetstitium.

# 9 REGULATION OF KIDNEY FUNCTION/GLOMERULAR FILTRATION RATE

## Hypothalamus

**Low blood volume**
**Body fluid volume**
**Ionic concentration**

↓

**Activate**

**Osmoreceptors** of Hypothalamus to release ADH/Vasopressin from Neurohypophysis

↓

**Work**

- Constrict blood vessels
- Increase reabsorption of water from DCT (Prevent diuresis)

↓

**Result**

- Blood volume increases
- Blood pressure increases
- GFR increases

→ **Increase in blood volume** → Switch off → Osmoreceptors → Suppress → ADH/Vasopressin

## JGA

**Low GFR/Glomerular blood flow**
**Glomerular blood pressure**

↓

**Activate**

JG cells to release **renin**

↓

Liver

↓

Angiotensinogen

↓

**Angiotensin I**

↓

**Angiotensin II**

↓

**work**

- Constrict blood vessel
- Activate adrenal cortex to release Aldosterone, that causes reabsorption of $Na^+$ and water

↓

**Result**

- Blood pressure increases
- GFR increases

**(Renin-Angiotensin** mechanism**)**

## Heart

**Increase blood flow to atria of heart**

↓

Release of ANF (Atrial natriuretic factor)

↓

**work**

Vasodilation

↓

**Result**

- Blood pressure increases decrease
- GFR increases

**ANF mechanism acts as a check on Renin-Angiotensin mechanism**

# 10 CHARACTERISTICS AND COMPOSITION OF URINE

**Colour -** Light yellow

**pH =** 6

**Odour -** Characteristic

Human kidneys can produce urine nearly **4 times** concentrated than initial filtrate.

**Urea -** 25-30 gm/day

Various conditions can affect characteristics of urine.

| Abnormal constituents of urine | Condition | Indicate |
|---|---|---|
| Glucose | Glucosuria | Diabetes mellitus |
| Ketone bodies | Ketonuria | Diabetes mellitus |

# 11 DISORDERS OF EXCRETORY SYSTEM

| Disorders | Symptoms or Treatment |
|---|---|
| Renal catculi | Stone or insoluble mass of crystalised salts (e.g. oxalates) |
| Glomerulonephritls | Inflammation of glomeruli of kidney |
| Renal/kidney failure | Malfunctioning of kidneys leads to accumulation of urea in blood (Uremia); highly harmful, may lead to kidney failure.<br>**Treatment**<br>**(i) Haemodialysis: Process to remove urea from blood**<br>Method is a boon for thousands of uremic patients all over the world.<br>Blood drained from artery → Mix with **Heparin (Anticoagulant)** → Pumped through **Dialysing unit** (**Artificial kidney**: Porous cellophane tubes surrounded by dialysing fluid.) → Filtration based on concentration gradient: Nitrogenous wastes freely move out → Clear blood → Mix with Anticoagulant → Pumped back to body through Vein<br>**(ii) Kidney transplantation**<br>Ultimate method in correction of **acute** renal failure<br>• Functional kidney is taken from donor<br>• To minimize rejection, **close relatives** are **preferred** as donor<br>• Modern clinical problems have increased success rate of such complicated techniques |
| Composition of dialysis fluid is same as plasma except the nitrogenous wastes | |

# 12 ROLE OF OTHER ORGANS IN EXCRETION

| Accessory structure | substances | Basic Work |
|---|---|---|
| Lungs | $CO_2$, water | • Remove large amount of $CO_2$, approximately 200 mL/min<br>• Remove significant quantity of water |
| Liver (Largest gland) | Bilirubin, vitamins biliverdin, drugs cholesterol, degraded steroid hormones | • Most of these substances pass out alongwith digestive wastes |
| **Skin**<br>• Sweat glands | Sweat contains<br>• NaCl<br>• Urea<br>• Lactic acid | • Primary function of sweat is to facilitate cooling effect on body surface |
| • Sebaceous glands | Sebum contains<br>• Sterols<br>• Hydrocarbons<br>• Waxes | • Sebum provides a protective oily covering for the skin |
| Salivary glands | | • Small amount of nitrogenous wastes are eliminated through saliva |