



## Why Excretion is Needed

- Animals accumulates various wastes in their cells by metabolic reactions or by excess ingestion that needs to be excreted.

removed from body

totally or partially

$\downarrow$   
 $\text{NH}_3$

$\downarrow$   
Urea

Some amount is retained in kidney matrix to maintain osmolarity\*

- Nitrogenous wastes

$\downarrow$

Ammonia:  $\text{NH}_3$

Urea:  $\text{H}_2\text{N}-\overset{\text{O}}{\underset{\text{||}}{\text{C}}}-\text{NH}_2$  Mammals

Uric acid:  $\text{N}$ -base & similar

$\bullet \text{CO}_2, \text{H}_2\text{O}$

$\bullet \text{Ions: } \rightarrow \text{cations: } \text{Na}^+, \text{K}^+$

Anions:  $\text{Cl}^-, \text{SO}_4^{2-}, \text{PO}_4^{2-}$



$\downarrow$   
Waste



## Different Types of Nitrogenous Wastes

### Ammonia

- Toxicity: **highly**
- Water requirement for excretion: **requires ↑ quantity of H<sub>2</sub>O**
- Such animals are called: **Ammonotelic**
- Solubility: **is very high**
  - It is directly released in H<sub>2</sub>O via body surface or gill surface as NH<sub>4</sub><sup>+</sup> ions
- Role of kidney: **non-significant**
- Shown by: **Many bony fishes, aquatic amphibians & aquatic insects**

### Urea

- Toxicity: **medium**
- Water requirement for excretion: **medium**
- Such animals are called: **Ureotelic**
- Formed in: NH<sub>3</sub> → <sup>liver</sup> Urea  
↓ exc. by Kidney
- Role of kidney: **significant**
- Shown by: **Mammals, many terrestrial amphibians and marine fishes**

### Uric Acid

- Toxicity: **least**
- Water requirement for excretion: **least**
- Such animals are called: **Uricotelic**
- Excreted in form of: **paste or pellet**
- Shown by: **RBI-Snail i.e., Reptiles, Birds, Land Insects and Snails**



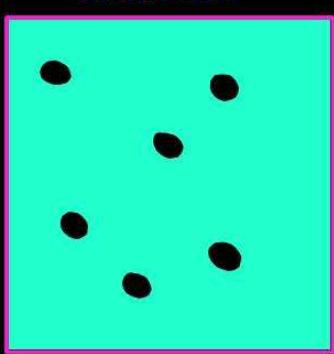
## Excretion and Osmoregulation

Removal of wastes

osmolarity regulate ઓરની  
↓  
Water/ion balance

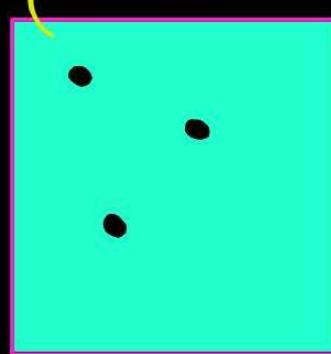
- Excretory organ always helps in osmoregulation

Ideal cond'n



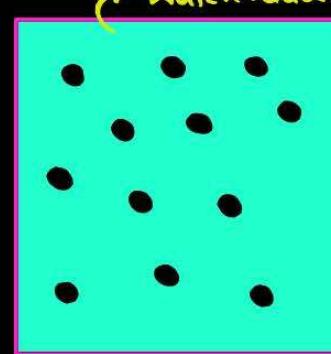
water: removed

salt: add



salt: remove

water: add





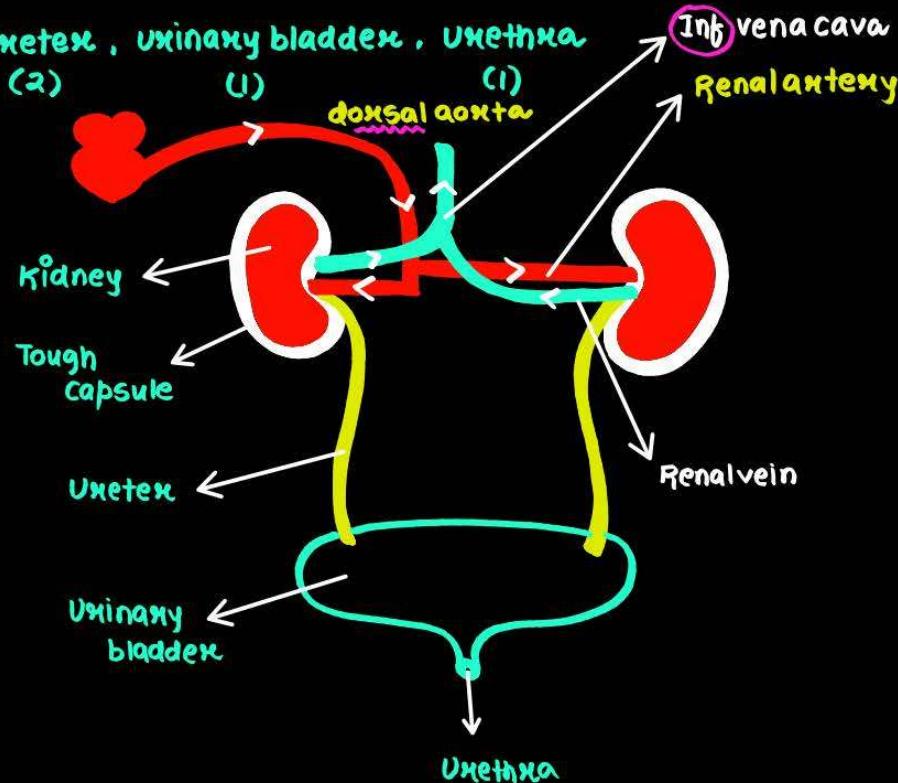
## Different Excretory Structure in Animals

Animals	Excretory Structures
Simple invertebrates	Simple tubular structures
Complex Vertebrates	Complex tubular structures
Platyhelminthes (Flatworms), Rotifers, some lower Flat annelids, cephalochordates (Amphioxus)	Flame cells / Solenocyte / proto-nephridia
Annelids (higher): Earthworm	Nephridia
Arthropods (Insects)	Malpighian Tubule
Aquatic Arthropods (Crustaceans: Prawn)	Grene / Antennal glands in Prawn
Vertebrates	Kidney (complex tubular structure)



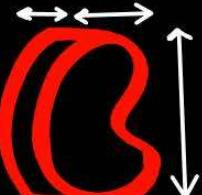
## Human Excretory System

- Consists of: Kidney, Uretex, urinary bladder, Urethra





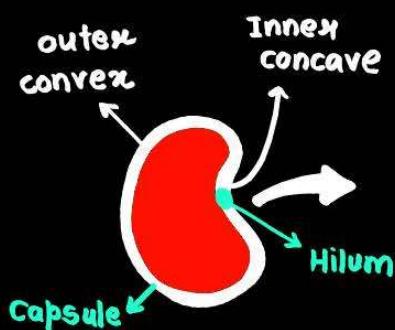
## Kidney: Features

- Color: Red to brown
- Shape: Bean shaped
- Situated between:  $T_{12} - L_3$  ↗ 3rd lumbar  
↙ last thoracic
- Size:  
  
Length: 10-12 cm  
width: 5-7 cm  
thickness: 2-3 cm
- Weight: 120-180 gm (avg. 150 gm)
- Cover is called: Tough capsule

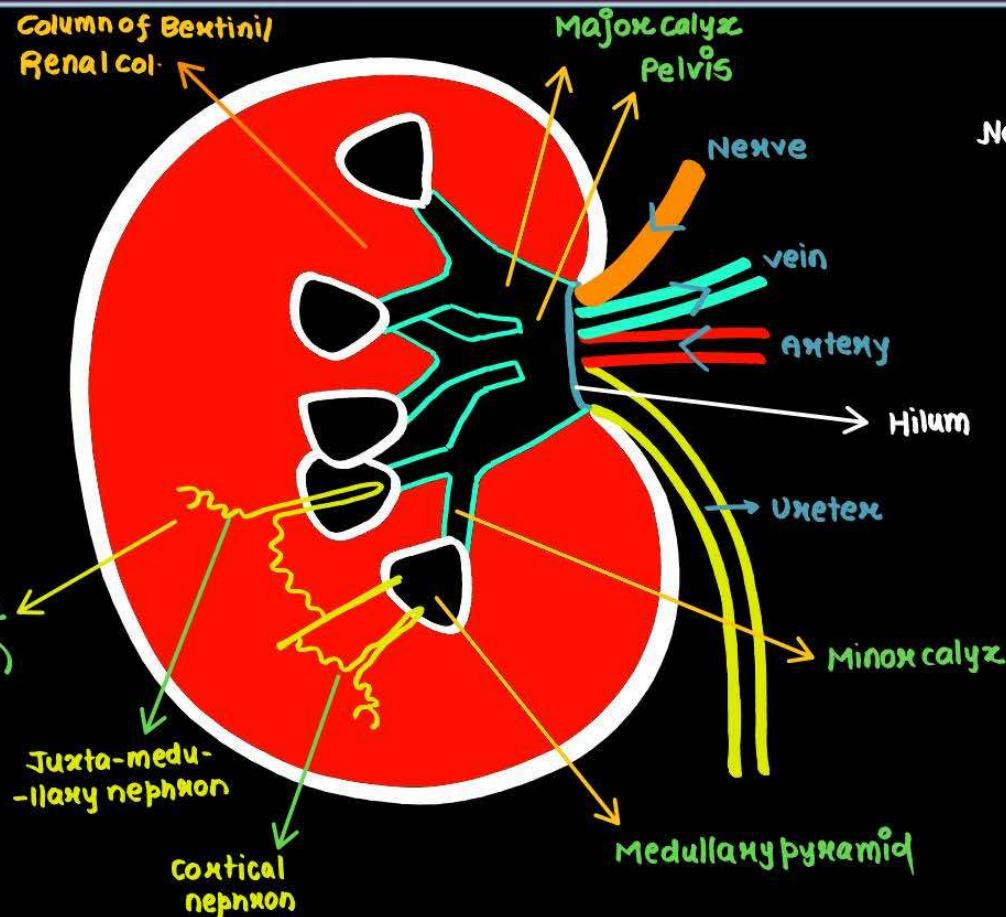


# Kidney: Structure

• Outer: Cortex  
Inner: Medulla

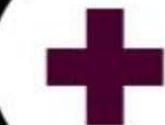


\* Renal column: cortex extends in b/w medullary pyramids



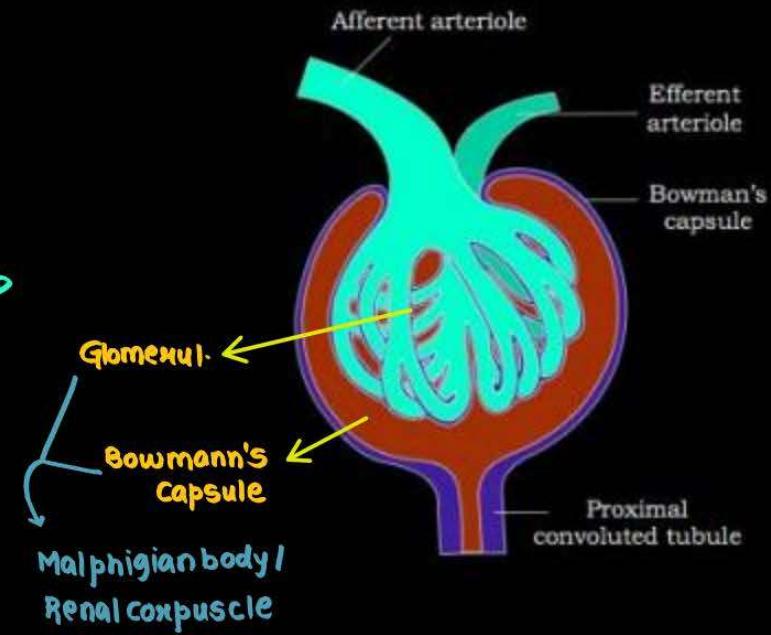
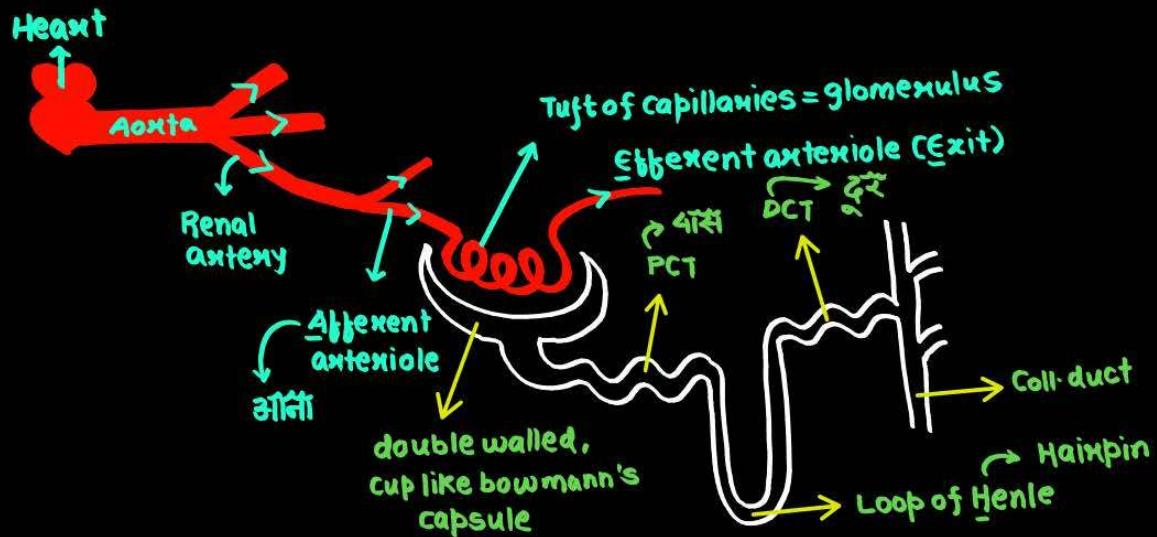
## Path of urine

Nephron's collecting duct  
↓  
Medullary pyramid  
↓  
Minor calyx  
↓  
Major calyx  
↓  
Pelvis  
↓  
Hilum  
↓  
Uretex  
↓  
Urinary bladder  
↓  
Urethra



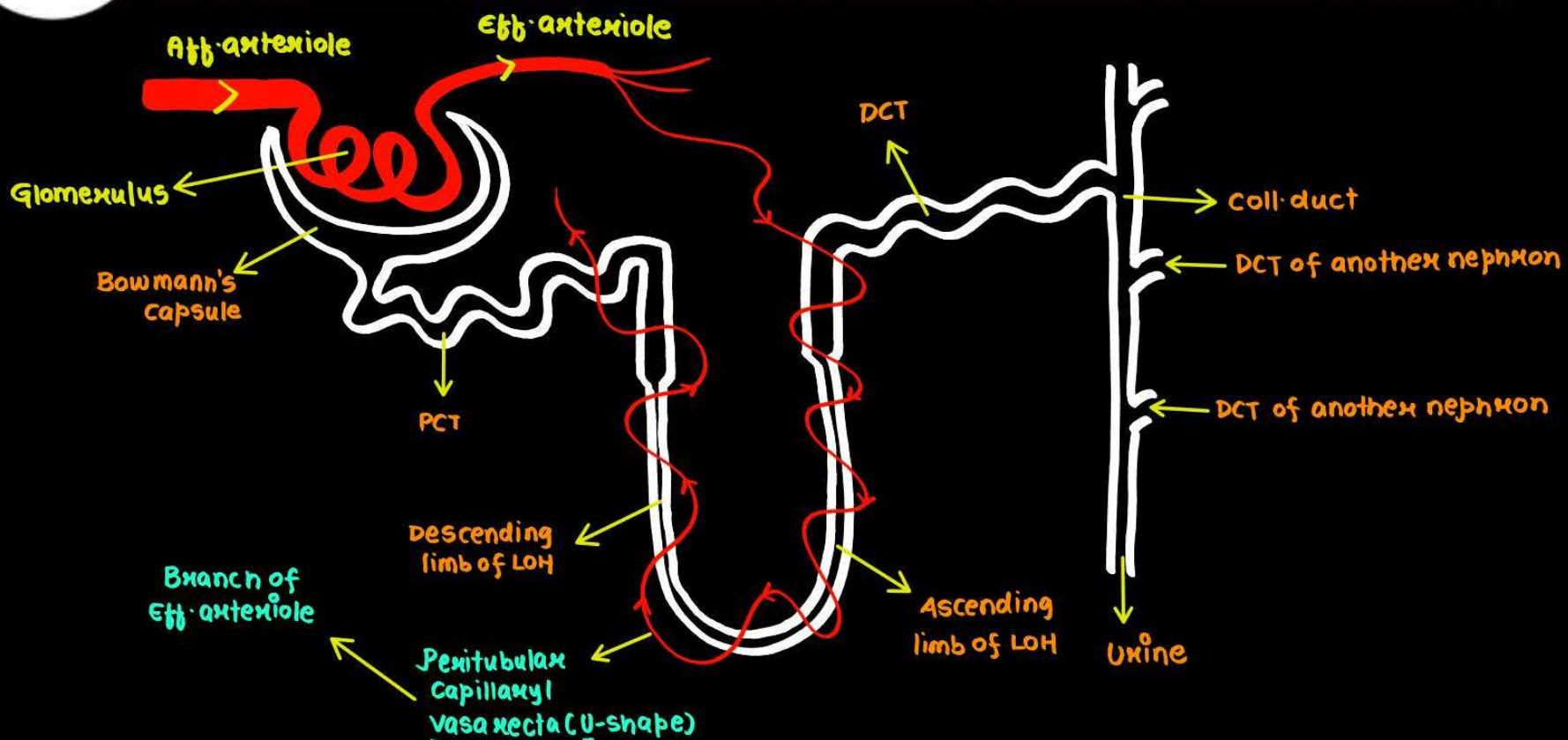
# Nephron

- Nephron: Structural & functional unit of kidney
- Numbers per kidney: 1 million (10 lakh)
- Consists of: Glomerulus & Tubular part  
(tuft of capillaries) ↗ Bowmann's capsule, PCT, LOH, DCT, CD





## Nephron: Structure

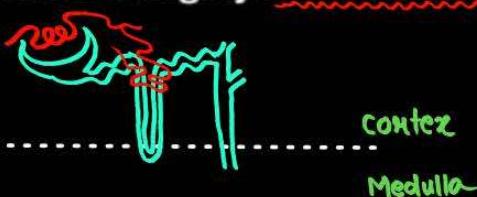




## Types of Nephrons

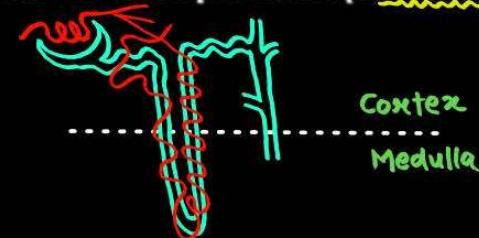
### Cortical Nephrons

- Majority of Nephrons (85%)
- Henle Loop is short and just dips into medulla
- Vasa recta is highly reduced or absent



### Juxta Medullary Nephrons

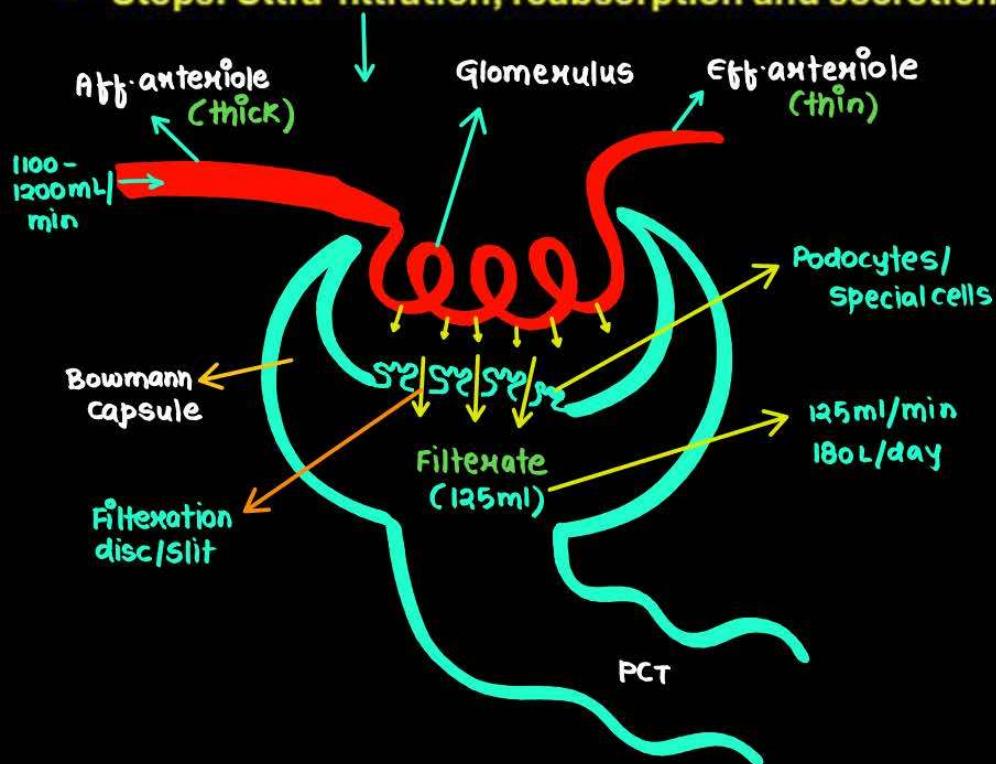
- Some of Nephrons (15%)
- Henle Loop is long and go deep into medulla
- Vasa recta is present (well developed)





## Urine Formation: Steps

- Steps: Ultra-filtration, reabsorption and secretion



- Ultrafiltration is done across 3 layers
  1. Endothelium of glomerulus
  2. Basement substance
  3. Epithelium of Bowman's capsule

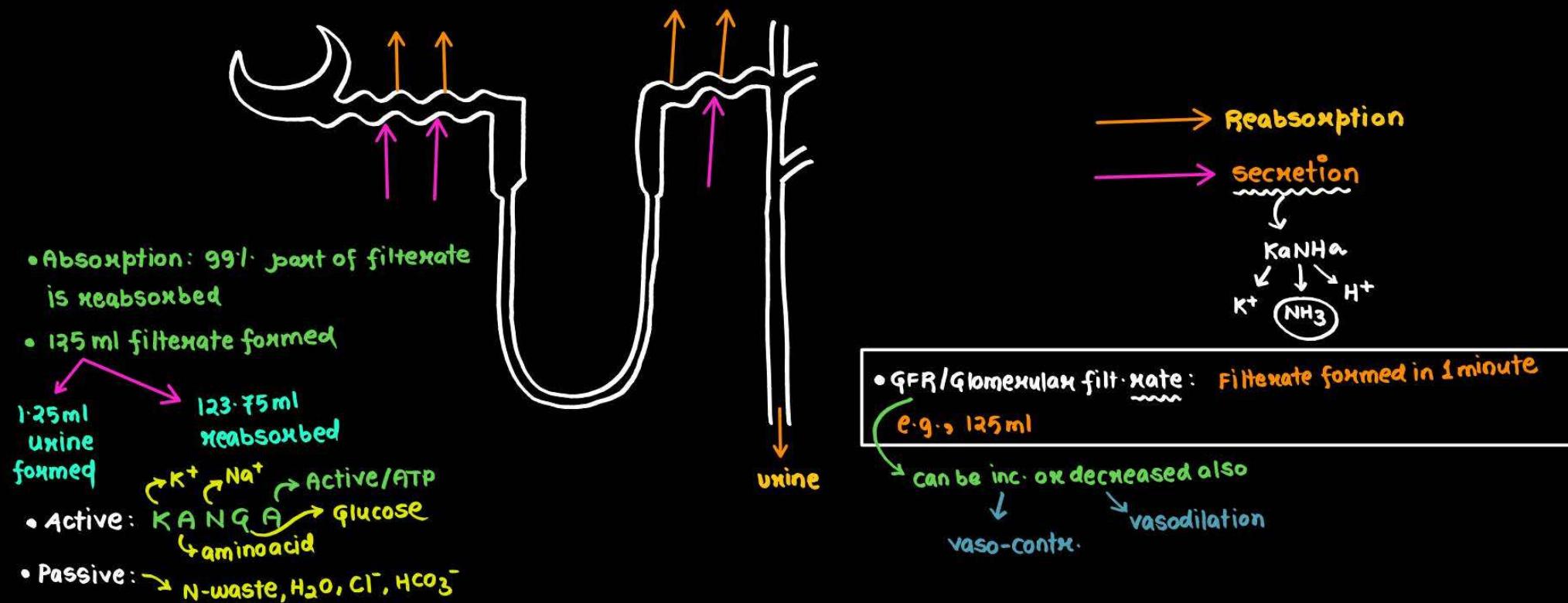
Filterate reaches in the lumen of Bowman's capsule

- $Sv$  (Stroke volume) =  $70\text{ml}$
- $CA = \text{Cardiac output} = 70\text{ml} \times f2 = 5040\text{ml}$ 

$\sim 5\text{L}$
- $\frac{1}{5}$  th or 20% comes in Kidney = 1100-1200mL



## Urine Formation: Steps



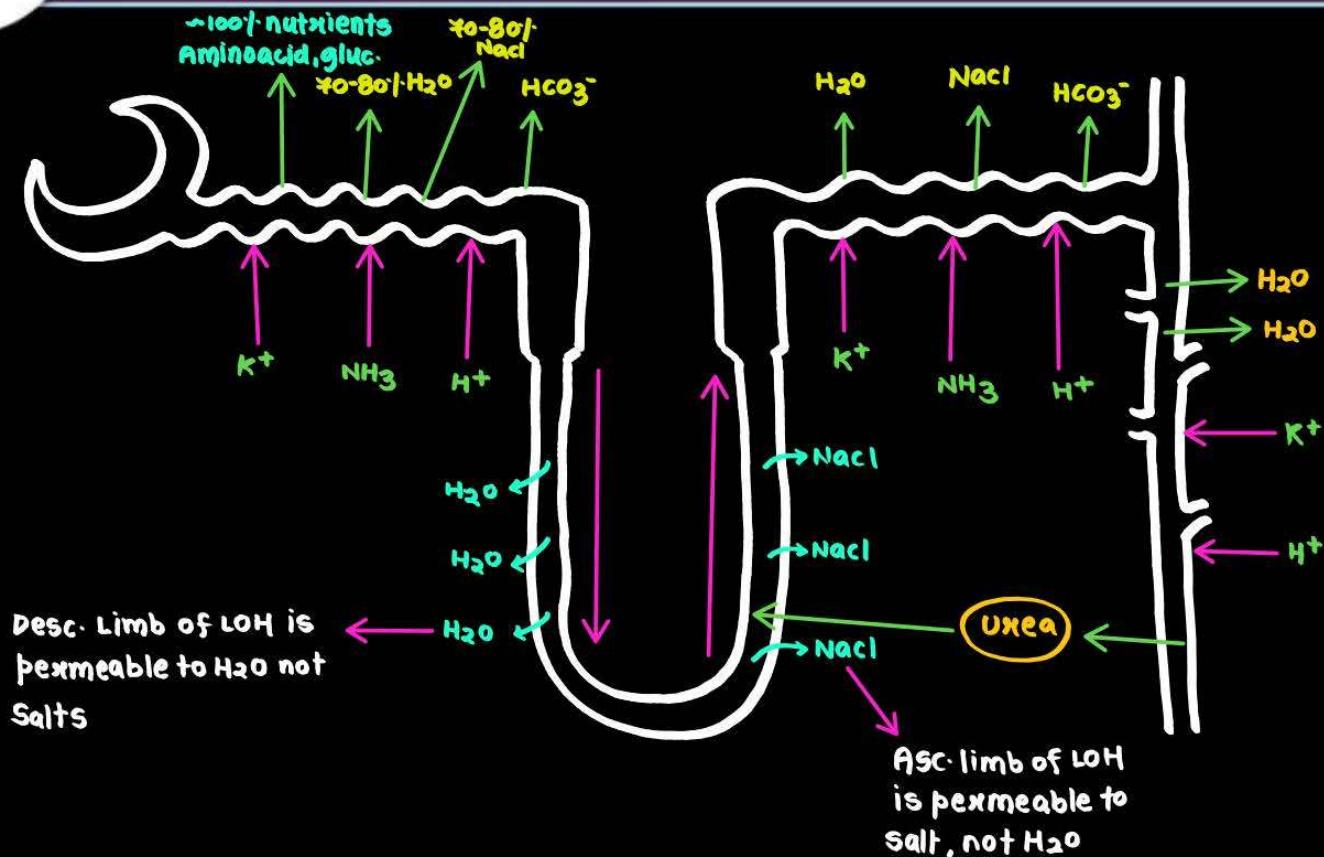


## Functions of Tubules

Part of Tubule	Reabsorbed material	Secreted material
PCT	Almost all essential nutrients; 70-80% of all electrolytes ( $\text{NaCl}$ ) and water; $\text{HCO}_3^-$ (max. reabs.)	$\text{K}^+$ , $\text{NH}_3^+$ , $\text{H}^+$
Descending limb of LOH	Water reabsorption	-
Ascending limb of LOH	Salt ( $\text{NaCl}$ ) reabsorption	Urea
DCT	Conditional reabsorption of $\text{Na}^+$ and water; $\text{HCO}_3^-$	$\text{K}^+$ , $\text{NH}_3^+$ , $\text{H}^+$
Collecting Duct	Water; some urea (for osmolarity)	$\text{K}^+$ , $\text{H}^+$



## Functions of Tubules

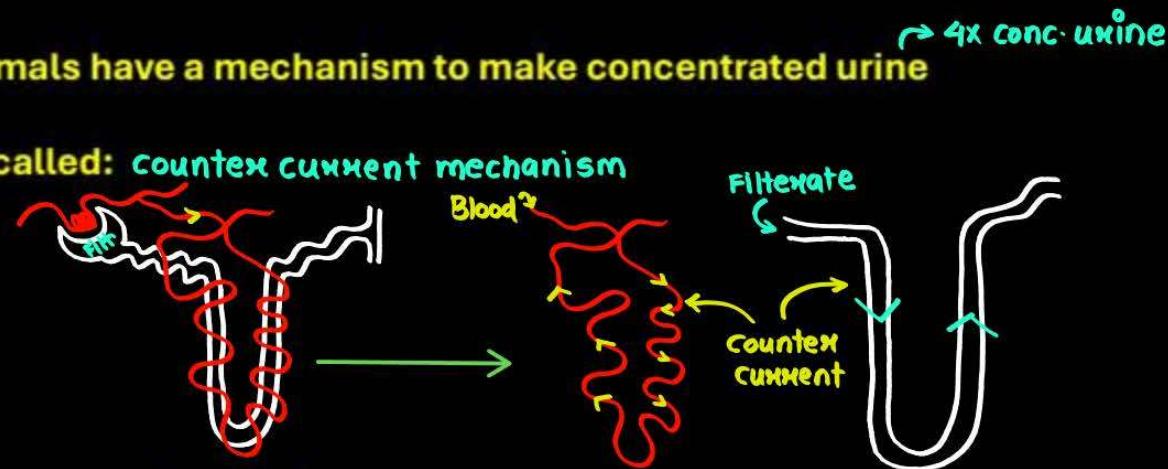




## Mechanism of Concentration of Filtrate

- Mammals have a mechanism to make concentrated urine

- Also called: **countercurrent mechanism**



- 4X concentration of urine**

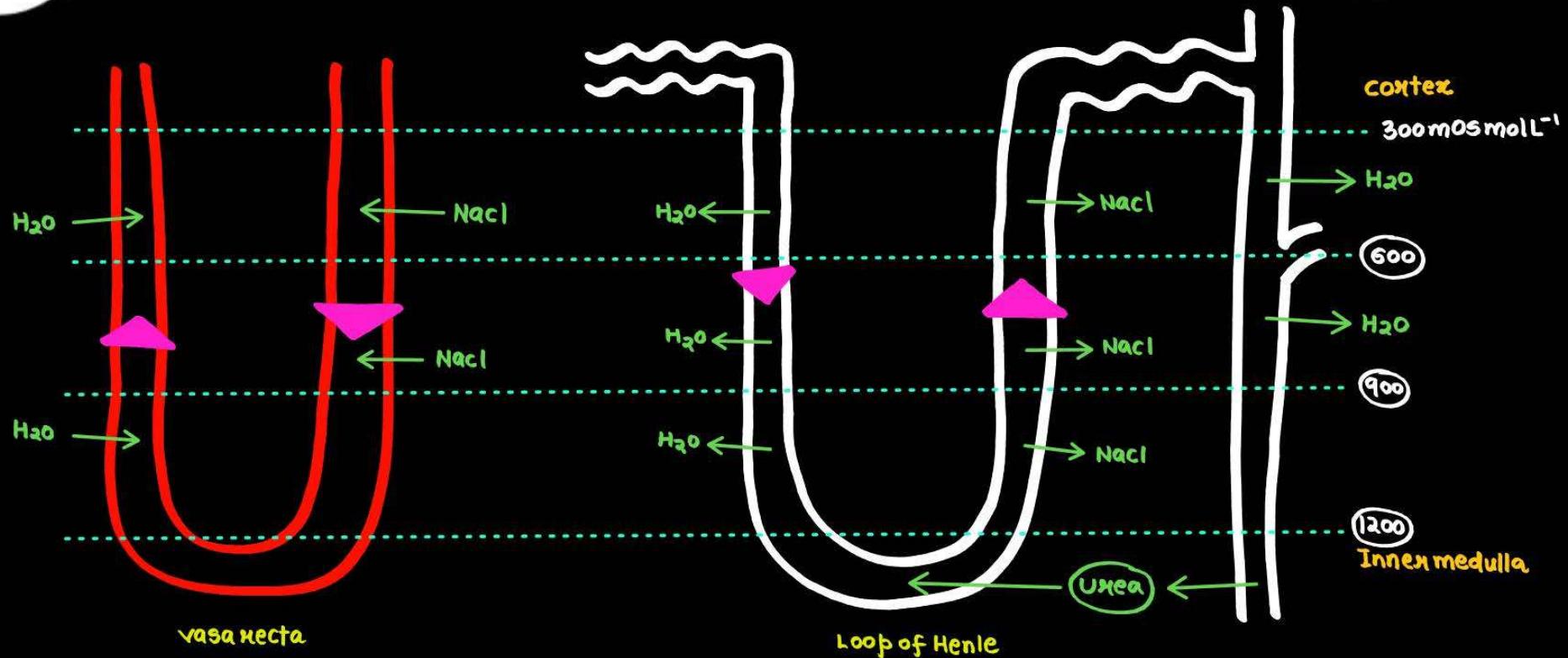
$300 \text{ mosmol L}^{-1}$   $\xrightarrow{4x}$   $1200 \text{ mosmol L}^{-1}$

(cortex) (medulla)

- Gradient is mainly caused due to: NaCl & Urea



## Mechanism of Concentration of Filtrate

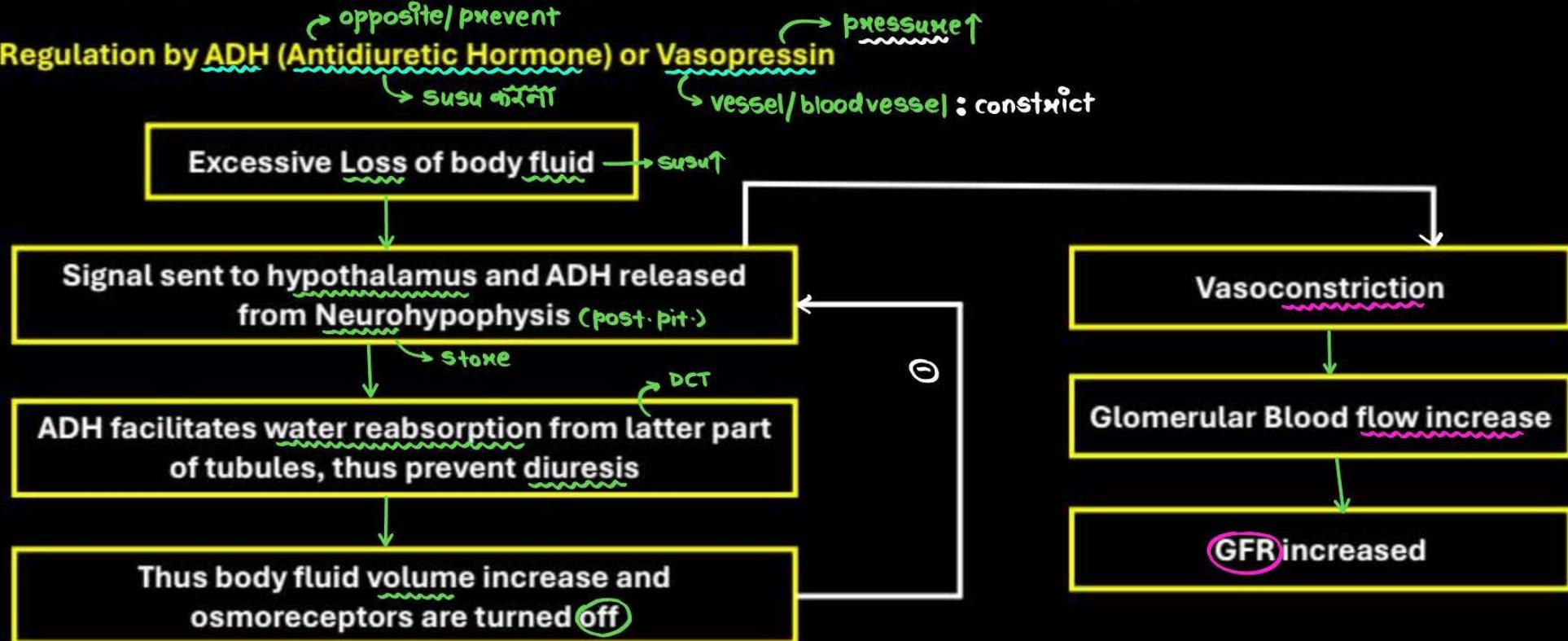




# Regulation of Kidney Functions

- Regulation is done by hormonal feedback mechanism involving hypothalamus, JGA and Heart

## 1. Regulation by ADH (Antidiuretic Hormone) or Vasopressin

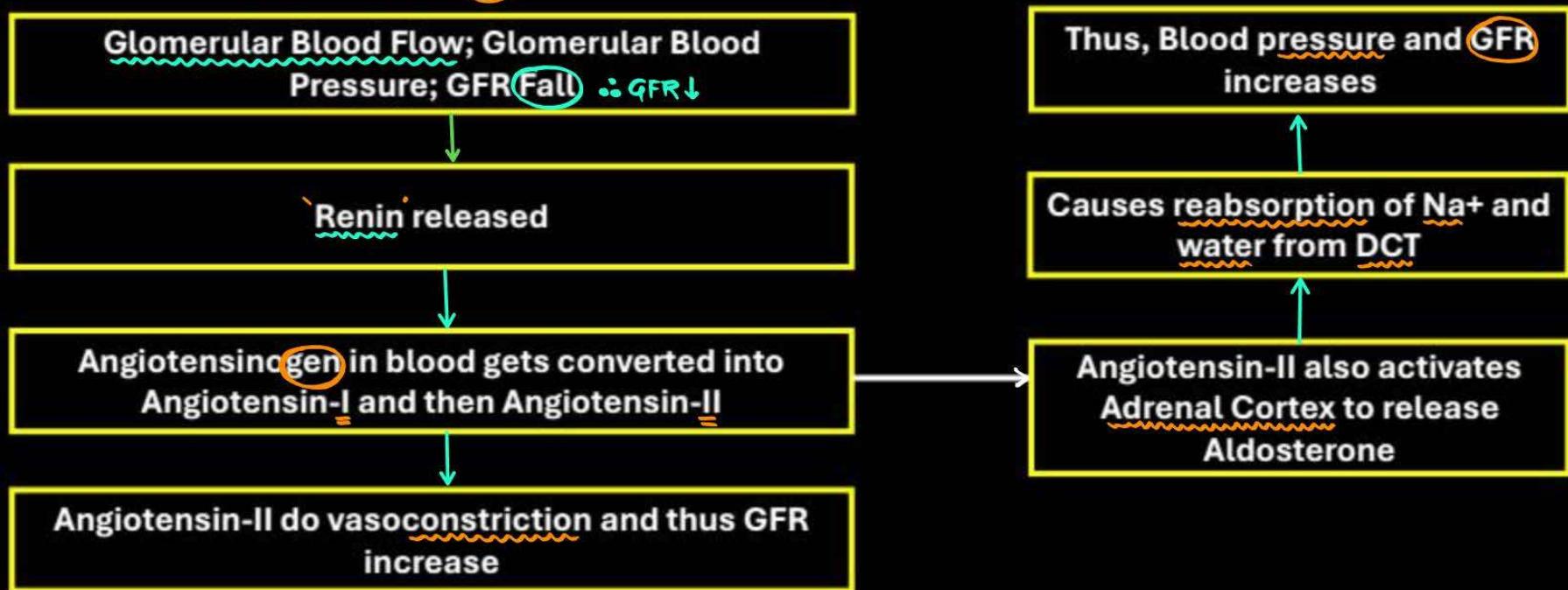


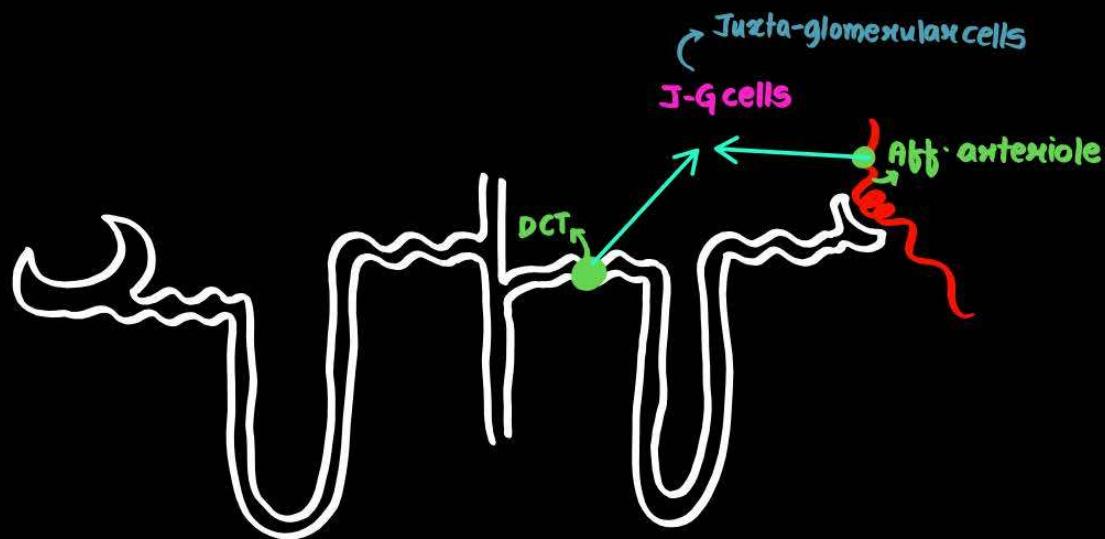


## Regulation of Kidney Functions

### 2. Regulation by RAAS (Renin Angiotensin Aldosterone System)

→ Renin-angiotensin-aldosterone  
(I → II)  
Adrenal cortex





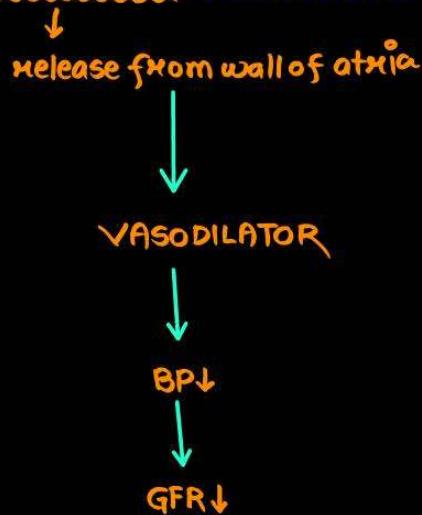
- The initial part & end part of nephron i.e., afferent arteriole & DCT have some cells called J-G cells
- Sense the fall of GFR
- Release Renin\*



## Regulation of Kidney Functions

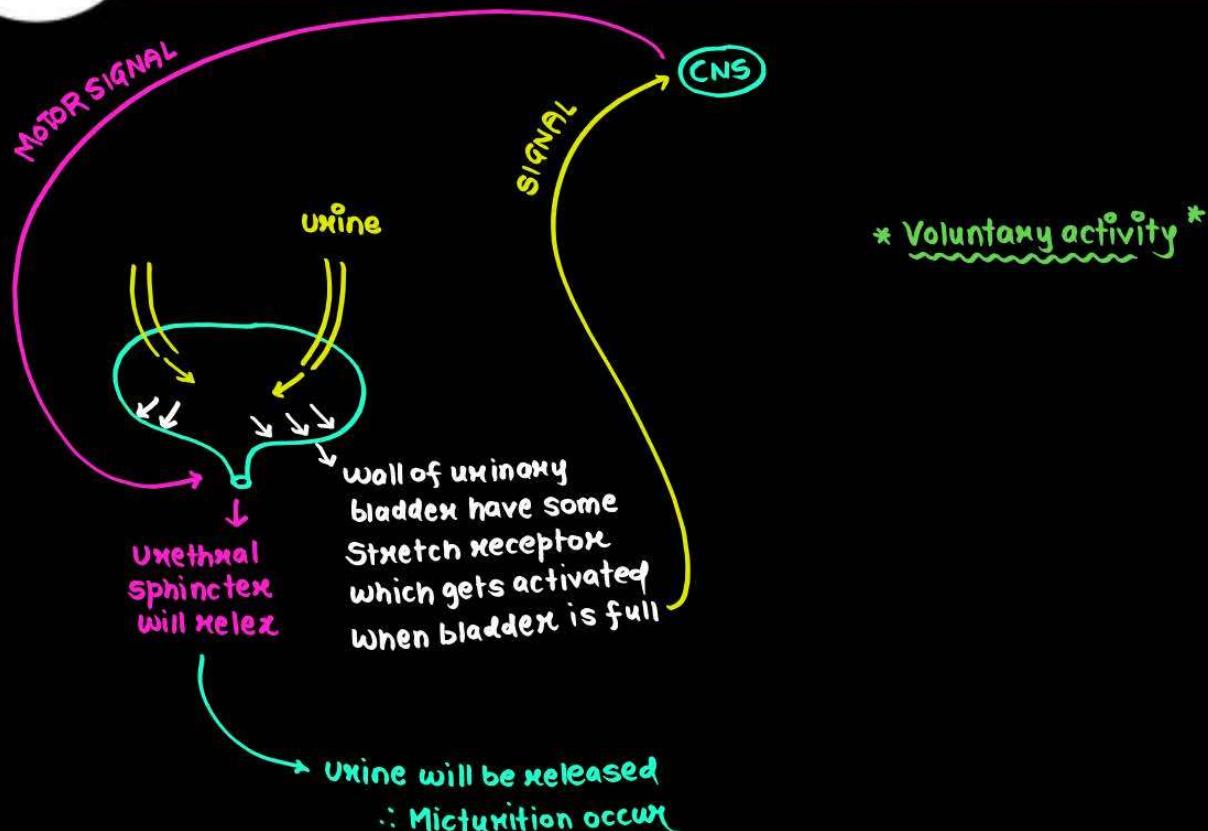


3. Regulation by Heart (Atrial Natriuretic Factor-ANF): It keeps a check on **RAAS**





## Micturition Reflex



\* Voluntary activity \*



## Micturition

- Amount of urine excreted per day: 1-1.5 L/day
- Color: pale yellow ↗ due to uro-chrome
- pH: 6 (slightly acidic)
- Amount of urea excreted per day: 25-30 gm
- Importance of proper urine:
  - If urine has some abnormal components, then, it can be indicative of disease

Glycosuria: Glucose↑

Ketonuria: Ketone bodies↑

Diabetes\*



## Role of Other Organs in Excretion

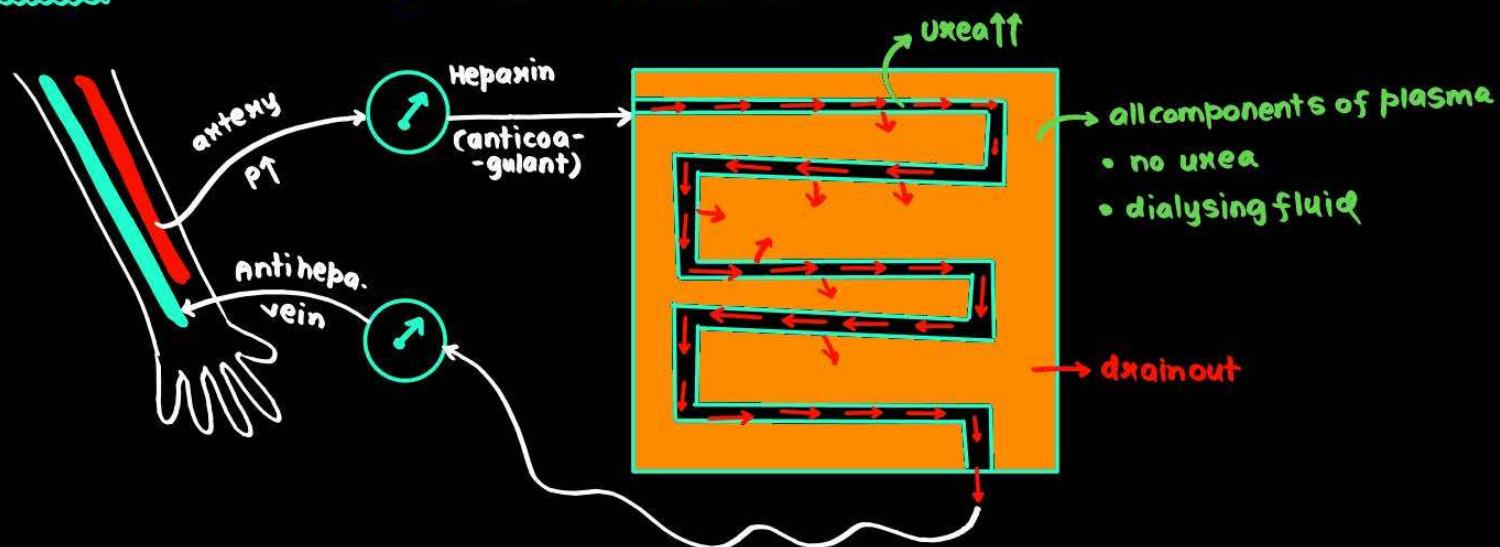
- Lungs: excrete  $\text{CO}_2$  (200ml/min) ; some  $\text{H}_2\text{O}$
- Liver: Largest gland: Bile pigments: Bilirubin, Biliverdin : they will get excreted alongwith undigested waste  
Degraded steroid hormones  
Vitamins, drugs  
Cholestanol, phospholipid
- Sweat and Sebaceous glands (oil):
  - ↳ Cool
  - ↳ oily covering
  - ↳ Sterols, hydrocarbons, wax
- Saliva:
  - ↳ small amt. of  $\text{N}_2$ -waste



## Disorders of Excretory System

- Uremia: Urea conc. ↑ due to kidney dysfunctioning

- Hemodialysis/ artificial kidney (Temporary solution)





## Disorders of Excretory System

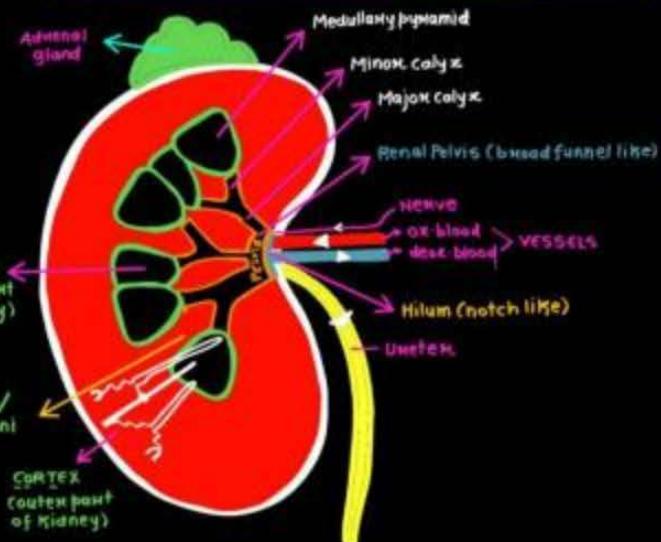
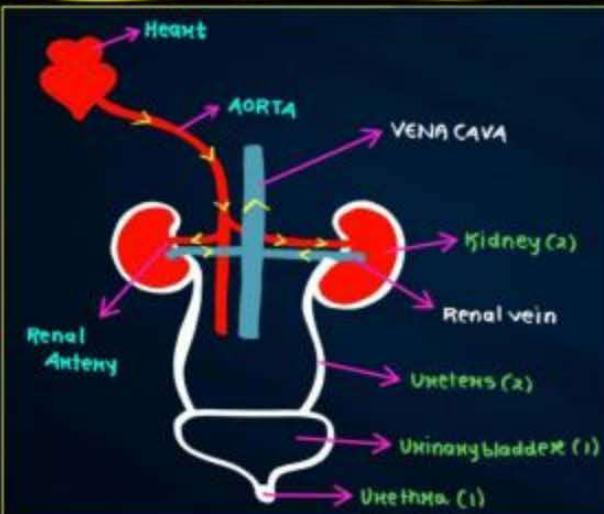
- **Kidney failure:** a donor is needed  
    ↓  
    Permanent  
    Solution  
    ↳ preferred from a close relative
- **Renal calculi:** ↗ Insoluble stones of Calcium oxalate  
    ↓  
    Kidney  
    ↗ Calcium
- **Glomerulonephritis:** Inflammation of Glomeruli  
    ↓  
    inflame

- Animals accumulate N-waste;  $\text{CO}_2$ ;  $\text{H}_2\text{O}$ , ions ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ) either by exo-ingestion or metabolism.
- Need to be removed partially or wholly
- Major focus on N-waste  
 $\text{NH}_3$ , urea, uric acid  
 ↳ Toxicity ↑   ↳ Toxicity ↓

### Excretory System

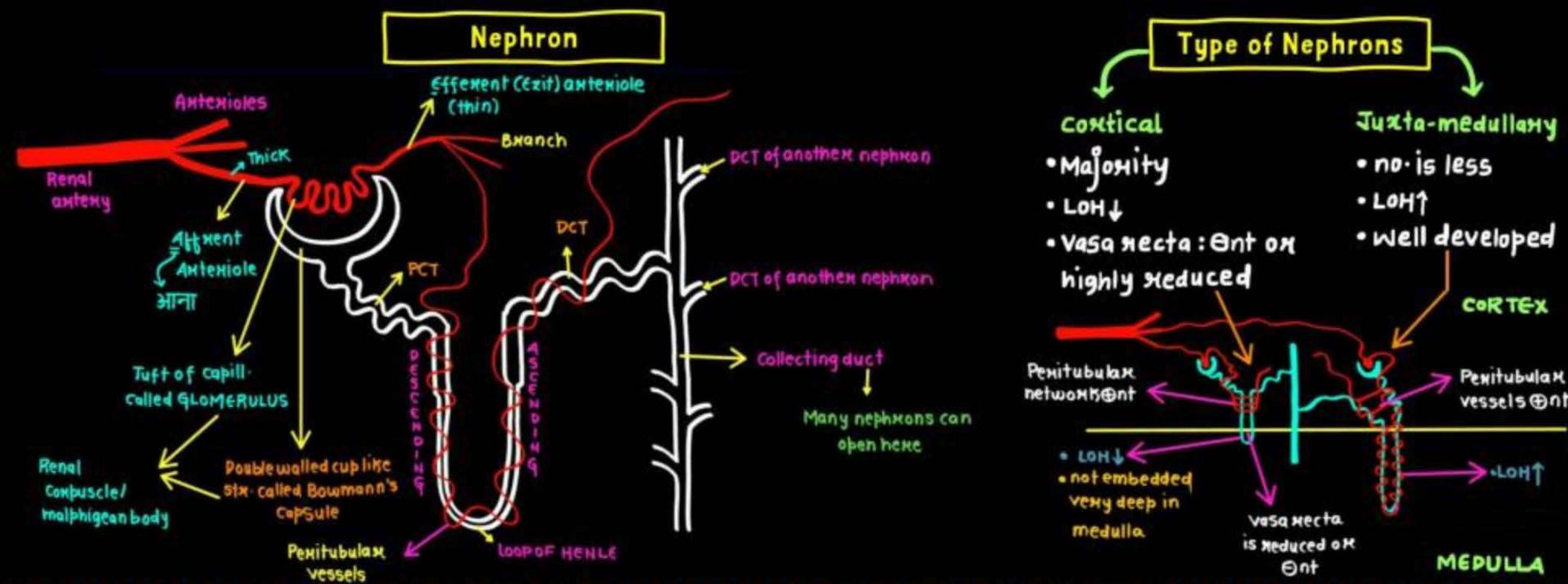
- Kidneys are reddish brown, bean shape
- Present between  $T_{12}$ - $L_3$  vertebrae
- close to dorsal inner wall of abd. cavity; avg. wt. 120-170 gm
- Length = 10-12 cm; width = 5-7 cm; thickness = 2-3 cm
- Each kidney has approx 1 million nephrons (complex tubular nephri.)  
 ↳ 2 parts: Glomerulus  
 Renal Tubule
- Malpighian body / renal corpuscles: Glomerulus + Bowman's capsule

### Excretory Products and their Elimination



N-waste	Examples
<b>Ammonia</b> Readily soluble; excreted by general body surface or gills (in fishes) by diffusion as ammonium ions	Many bony fishes; aquatic insects and aquatic amphibians  Kidneys do not play a significant role
<b>Urea</b> (save water)	Many terrestrial animals and marine fishes
<b>Uric Acid</b>	Reptiles, Birds, land insects, snails

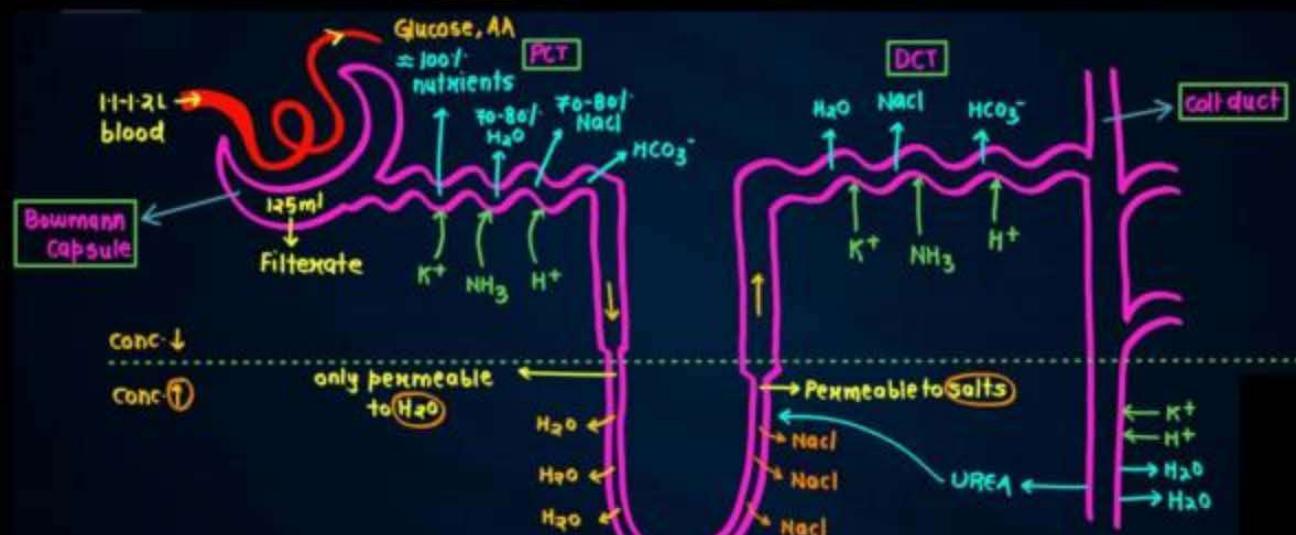
Excretory Structures	Examples
Protonephridia/ Flame cell/ Solenocyte	Platyhelminth, rotifers, some annelids (lower), cephalochordates (Amphioxus)
Nephridia	Earthworms and other annelids
Malpighian Tubule	Cockroach
Antennal gland/ Green gland	Crustacean (Prawn)



### Urine Formation

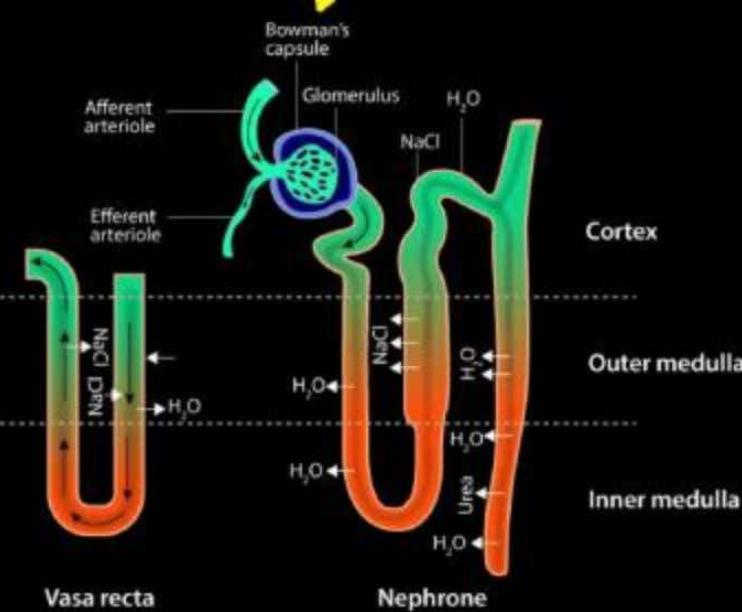
- Involves 3-steps: 1. Glomerular/ Ultrafiltration ; 2. Reabsorption ; 3. Secretion
- 1.1-1.2L blood is filtered by kidneys/min (20% of cardiac output)
- Filtration through 3-layers: Endothelium of capillary  
Basement membrane  
Epithelia of Bowman's capsule (slit pores)
- 99% filtrate reabsorbed
- Active:  $K^+$ ,  $AA$ ,  $Na^+$ , Glucose
- Passive:  $N$ -waste,  $H_2O$ ,  $Cl^-$
- For acid-base balance and osmo-regulation  
by  $K^+$ ,  $NH_3$ ,  $H^+$

### Functions of Tubules



### Counter Current Mechanism

- Due to opp. flow of filtrate in limbs of LoH.
- Due to opp. flow of blood in vasa recta
- 4x conc. from cortex to inner medulla ( $300 \text{ mosmol L}^{-1}$ ) ( $1200$ )
- Gradient is usually maintained by  $\text{NaCl}$  &  $\text{Urea}$



### Regulation of Kidney Function

- Usually regulated by Hormonal feedback: Hypothalamus, ANF & RAAS

① JG cells activate due to fall in GFR or BP↓ or Bl. flow  
 $\therefore$  Renin released  
 Convert angiotensinogen into A-I & then A-II  
 vasoconstriction

Activate adrenal cortex  
 to release aldosterone  
 conc. Meas. from DCT

ANF cause vasodilation & work as feedback for RAAS

### Regulation of Kidney Function

- Via Hypothalamus: Excessive loss of fluid → Receptors activated; Hypothalamus secretes ADH/Vasopressin



- ↑ H<sub>2</sub>O reabsorp. from latter part of Tubules
- Once blood vol. ↑; receptors go back to normal

### Micturition

- Urine stored in bladder → Stretch receptors activated → Vol. signals to CNS

CNS pass motor signals to smooth muscles of bladder ←

urethral sphincter relax

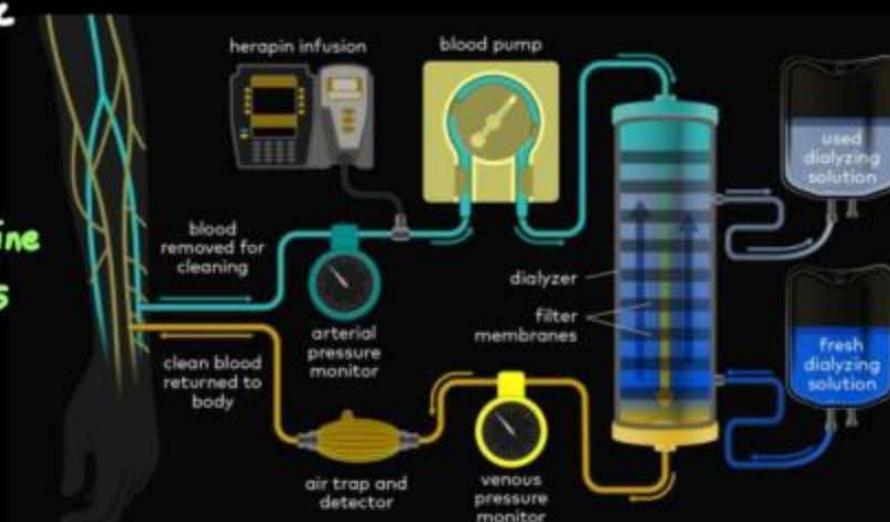
∴ Micturition

(pH = 6)



Glycosuria: glucose in urine

Ketonuria: ketone bodies in urine



Other excretory organs	Functions
Lungs	Remove large amount of carbon dioxide (200mL/min) and water
Liver	Bile pigments (bilirubin, biliverdin), cholesterol, steroid hormones (degraded), vitamins, drugs
Skin Sweat glands	NaCl, Urea (small amount), lactic acid; causes cooling
Sebaceous gland (oil)	Sterols, hydrocarbons, waxes
Saliva	Very small amount of N-wastes

Excretory Disorder	Features
Glomerulonephritis	Inflammation of Glomerulus
Renal Calculi (stone)	Deposition of crystallised oxalate salts in kidney
Uraemia	Accumulation of urea in blood that may lead to kidney failure and thus need haemodialysis
Kidney Failure	Transplant is ultimate method of correction



## QUESTION (NEET PYQ EXAM 2024)

Given below are two statements :

**Statement I** : In the nephron, the descending limb of loop of Henle is ~~impermeable~~ to water and permeable to electrolytes.

**Statement II** : The proximal convoluted tubule is lined by simple ~~columnar~~ brush border epithelium and increases the surface area for reabsorption ~~columnar~~ **cuboidal**

In the light of the above statements, choose the correct answer from the option given below :

- (1) Both Statement I and Statement II are true
- (2) Both Statement I and Statement II are false
- (3) Statement I is true but Statement II is false
- (4) Statement I is false but Statement II is true

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---

**QUESTION (NEET PYQ EXAM 2024)**

Choose the correct statement given below regarding juxta medullary nephron.

- (1) Juxta medullary nephrons are located in the columns of Bertini.
- (2) Renal corpuscle of juxta medullary nephron lies in the outer portion of the renal medulla.
- (3)  Loop of Henle of juxta medullary nephron runs deep into medulla.
- (4) Juxta medullary nephrons outnumber the cortical nephrons.

15-20%

(1)

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---



## QUESTION (NEET PYQ EXAM 2024)

Given below are two statements:

**Statements I:** Concentrated urine is formed due to counter current mechanism in nephron.

**Statement II:** Counter current mechanism helps to maintain osmotic gradient in the medullary interstitium.

In the light of the above statements, choose the most appropriate answer from the options given below.

- (1) Statement I is correct but Statement II is incorrect.
- (2) Statement I is incorrect but Statement II is correct.
- (3) Both Statement I and Statement II are correct.
- (4) Both Statement I and Statement II are incorrect.

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---



## QUESTION (NEET PYQ EXAM 2024)

Diuresis is prevented by:

- (1) Renin from JG cell via switching off the osmoreceptors
- (2) ANF from adrenal medulla
- (3) Aldosterone from adrenal medulla
- (4) Vasopressin from Neurohypophysis  
*(Anti-diuretic hormone)*

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---

## QUESTION (NEET PYQ EXAM 2023)

Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**. (Manipur 2023)

**Assertion (A):** Ascending limb of loop of Henle is impermeable to water and allows transport of electrolytes actively or passively. ✓

**Reason (R):** Dilution of filtrate takes place due to efflux of electrolytes in the medullary fluid. ✓

In the light of the above statements, choose the **correct** answer from the options given below.

- (1) Assertion (A) is true but Reason (R) is false.
- (2) Assertion (A) is false but Reason (R) is true.
- (3) Both Assertion (A) and Reason (R) are true Reason (R) is correct explanation of Assertion (A). ✓
- (4) Both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).

---

## FOR NOTES & DPP CHECK DESCRIPTION

---



## QUESTION (NEET PYQ EXAM 2023)

Arrange the events of Renin-Angiotensin mechanism in correct sequence.  
**(Manipur 2023)**

- ② (A) ✓ Activation of JG cells and release of renin
- ④ (B) ✓ Angiotensin II activates release of aldosterone
- ① (C) ✓ Fall in glomerular blood pressure → GFR ↓
- ⑤ (D) ✓ Reabsorption of  $\text{Na}^+$  and water from distal convoluted tubule
- ③ (E) ✓ Angiotensinogen is converted to Angiotensin I and then to Angiotensin II

Choose the **correct** answer from the options given below.

- (✓) (C), (A), (E), (B), (D) (2) (A), (D), (E), (C), (B)
- (3) (A), (D), (C), (B), (E) (4) (B), (A), (E), (D), (C)

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---

**QUESTION (NEET PYQ EXAM 2023)**

Match list-I with list-II. (2023)

	List-I		List-II
A.	<i>Taenia</i>	P.	Nephridia
B.	<i>Paramecium</i>	Q.	Contractile vacuole
C.	<i>Periplaneta</i>	R.	Flame cells
D.	<i>Pheretima</i>	S.	Urecose gland

Choose the **correct** answer from the options give below.

- (~~1~~) A-Q, B-P, C-S, D-R    (~~2~~) A-P, B-Q, C-R, D-S  
(3) A-P, B-Q, C-S, D-R    (~~4~~) A-R, B-Q, C-S, D-P

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---

## QUESTION (NEET PYQ EXAM 2023)

Given below are statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**. (2023)

**Assertion (A):** Nephrons are of two types: Cortical & Juxta medullary, based on their relative position in cortex and medulla.

**Reason (R):** Juxta medullary nephrons have short loop of Henle whereas, cortical nephrons have longer loop of Henle.

In the light of the above statements, choose the **correct** answer from the options given below.

- (1) Assertion (A) is false but Reason (R) is true.
- (2) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
- (3) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
- (4) Assertion (A) is true but Reason (R) is false.

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---



## QUESTION (NEET PYQ EXAM 2022)

Select the correct statements.

(2022 II)

- (A) Angiotensin II activates the cortex of adrenal gland to release aldosterone ✓
- (B) Aldosterone leads to increase in blood pressure ✓
- (C) ANF acts as a check on renin-angiotensin mechanism. ✓
- (D) ADH causes vasodilation ✗
- (E) Vasopressin is released from adenohypophysis ✗

Choose the most appropriate answer from the options given below.

- (1) (A), (B) and (C) only (2) (A), (B) and (D) only
- (3) (C), (D) and (E) only (4) (B), (C) and (D) only

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---



## QUESTION (NEET PYQ EXAM 2022)

Nitrogenous waste is excreted in the form of pellet or paste by; (2022)

- (1) *Pavo (Binda)*
- (2) *Ornithorhynchus*
- (3) *Salamandra*
- (4) *Hippocampus*

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---



## QUESTION (NEET PYQ EXAM 2021)

Erythropoietin hormone which stimulates RBC formation  
is produced by;

(2021)

- (1) alpha cells of pancreas
- (2) the cells of rostral adenohypophysis
- (3) the cells of bone marrow
- (4) juxtaglomerular cells of the kidney

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---



## QUESTION (NEET PYQ EXAM 2020)

Select the correct statement.

(2020 Covid)

- (1) Angiotensin II is a powerful vasodilator
- (2) Counter current pattern of blood flow is  observed in *vasa recta*
- (3) Reduction in glomerular filtration rate activates JG cells to release renin
- (4) Atrial natriuretic factor increases the blood pressure

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---



## QUESTION (NEET PYQ EXAM 2020)

The increase in osmolarity from outer to inner medullary interstitium is maintained due to; (2020 Covid)

- (i) close proximity between Henle's loop and vasa recta
  - (ii) counter current mechanism
  - (iii) selective secretion of  $\text{HCO}_3^-$  and hydrogen ions in PCT
  - (iv) higher blood pressure in glomerular capillaries  $\times$
- (1) (i) & (iv)      (2) (i), (ii) & (iv)  
(3) (i) & (ii)      (4) Only (ii)

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---

## QUESTION (NEET PYQ EXAM 2020)

Which of the following would help in prevention of diuresis?

(2020 I)

- (1) More water reabsorption due to ~~undersecretion~~ of ADH
- (2) Reabsorption of  $\text{Na}^+$  and water from renal tubules due to aldosterone ✓
- (3) Atrial natriuretic factor causes ~~vasoconstriction~~
- (4) Decrease in secretion of ~~renin~~ by JG cells

---

**FOR NOTES & DPP CHECK DESCRIPTION**

---