PRACHAND NEET

ONE SHOT

ZOOLOGY

Excretory Products and their Elimination

By: Vipin Sharma Sir

Topics *to be covered*

1. Excretory System
2. Structure of Kidney and Nephron
3. Counter Current Mechanism
4. Questions and PYQs


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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

- NH_3
- Urea ⇓ Some amount is retained in Kidney matrix to maintain osmolarity*

- Nitrogenous wastes ⇓
  - Ammonia : NH_3
  - Urea : $H_2N-C(=O)-NH_2$ → Mammals
  - Uric acid : N-base से similar
- CO_2 , H_2O
- Ions : → Cations : Na^+, K^+
  Anions : Cl^-, SO_4^{2-}, PO_4^{2-}

$C_6H_{12}O_6 + O_2$ → $6CO_2 + 6H_2O + ATP$ → Waste

Different Types of Nitrogenous Wastes

Ammonia

- Toxicity: highly
- Water requirement for excretion: requires ↑ quantity of H_2O
- Such animals are called: Ammonotelic
- Solubility: is very high
  - It is directly released in H_2O via body surface or gill surface as NH_4^+ 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: $NH_3 \xrightarrow{\text{Liver}} \text{Urea}$ ↓ exc. by Kidney
- Role of kidney: significant
- Shown by: Mammals, many terrestrial amphibians and marine fishes

Uric Acid

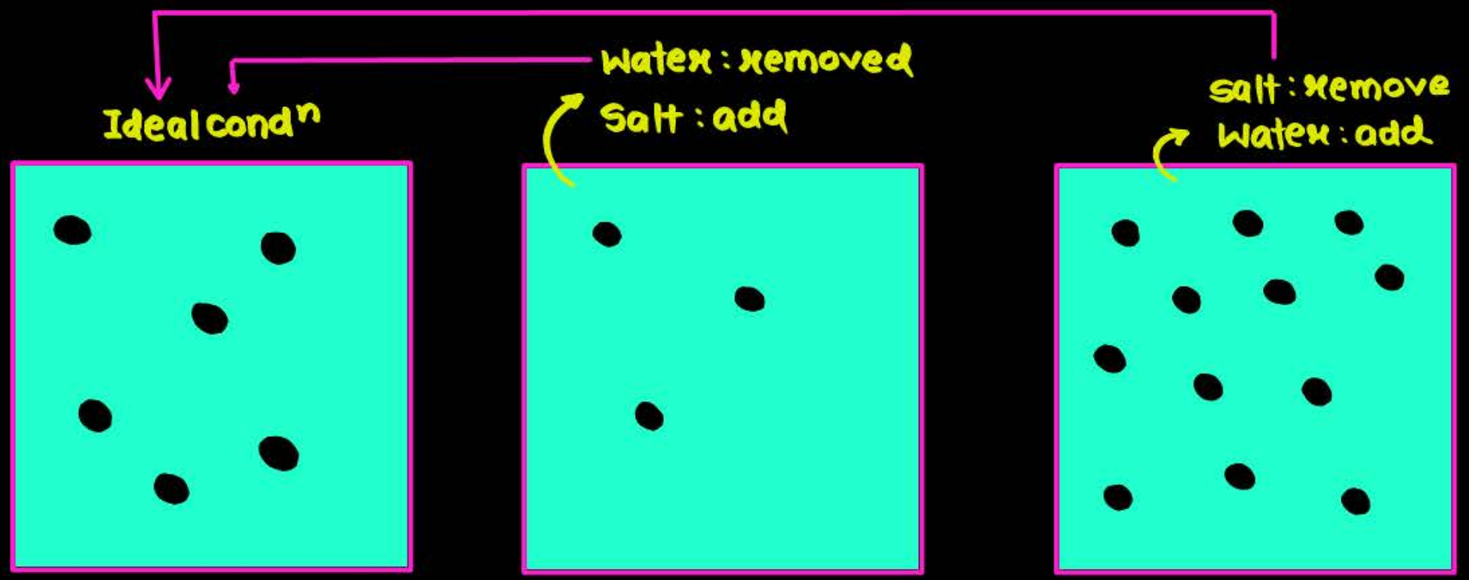
- Toxicity: least
- Water requirement for excretion: least
- Such animals are called: Uricotelic
- Excreted in form of: paste or pellet
- Shown by: RBI-Snail i.e., Reptiles, Birds, Land insects and Snails

Excretion and Osmoregulation

Removal of wastes

osmolarity regulate करना
⇓
Water/ion balance

- Excretory organ always helps in osmoregulation

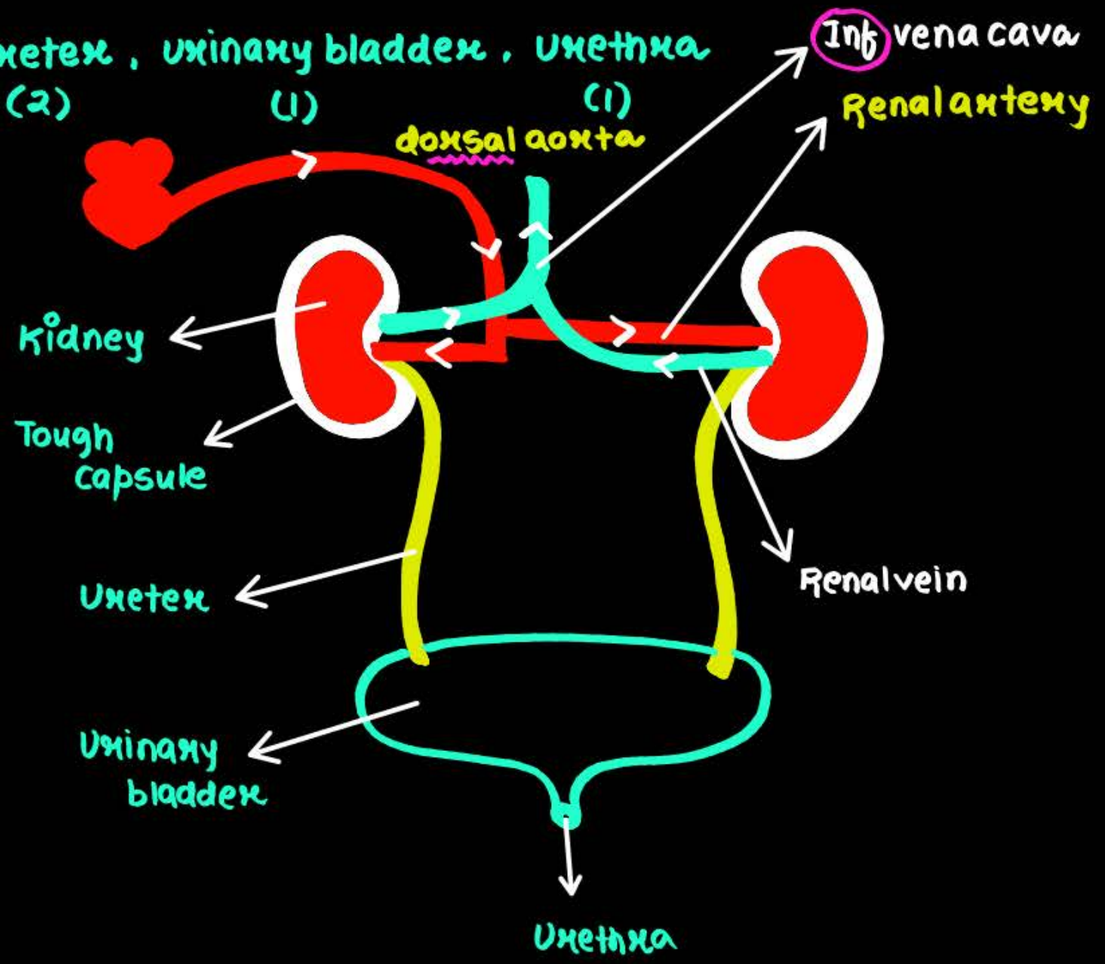


Different Excretory Structure in Animals

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

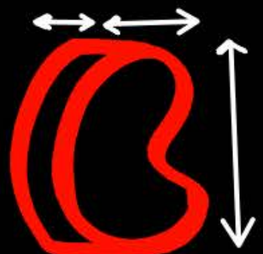
Human Excretory System

- Consists of: Kidney (2), Ureter (2), Urinary bladder (1), Urethra (1)



Kidney: Features

- Color: Red to brown
- Shape: Bean shaped
- Situated between: $T_{12} - L_3$ (Posterior part; dorsal part of body; L_3 → 3rd lumbar; T_{12} → last thoracic)
- Size:

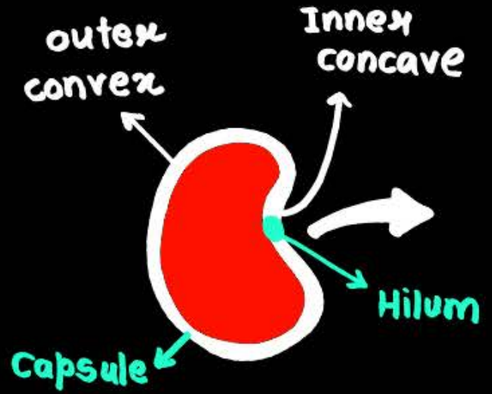


Length: 10-12 cm
width: 5-7 cm
thickness: 2-3 cm

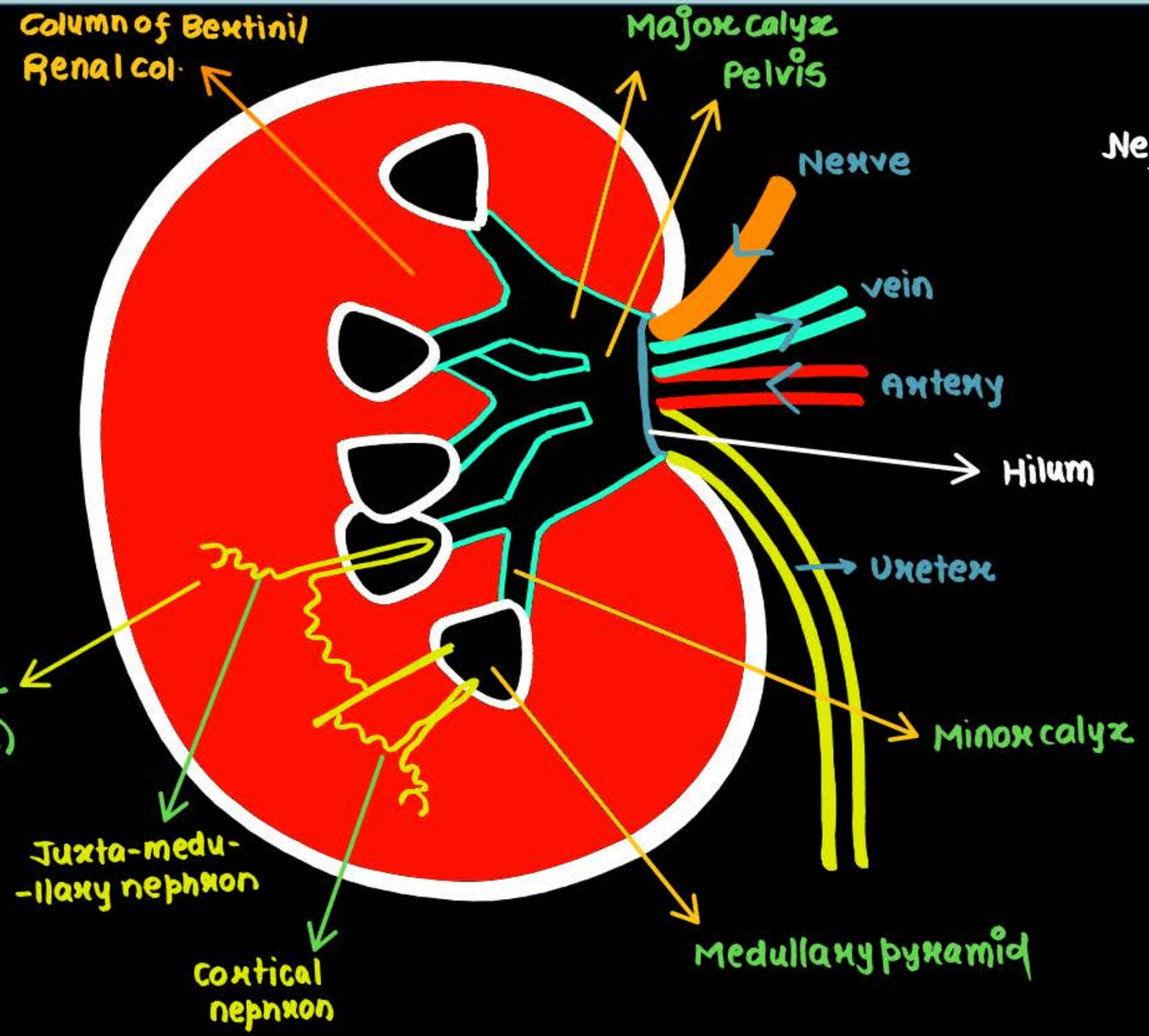
- Weight: 120-170 gm (avg. 150 gm)
- Cover is called: Tough capsule

Kidney: Structure

- Outer: Cortex
  Inner: Medulla



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

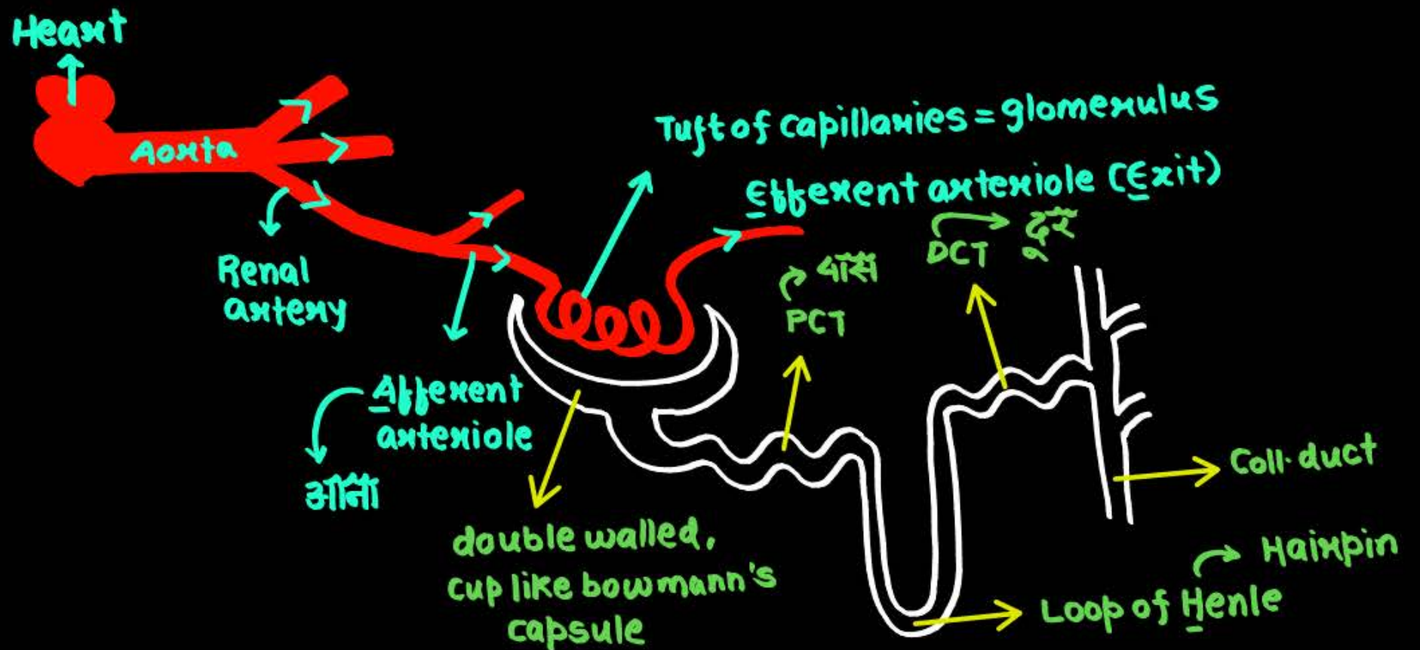


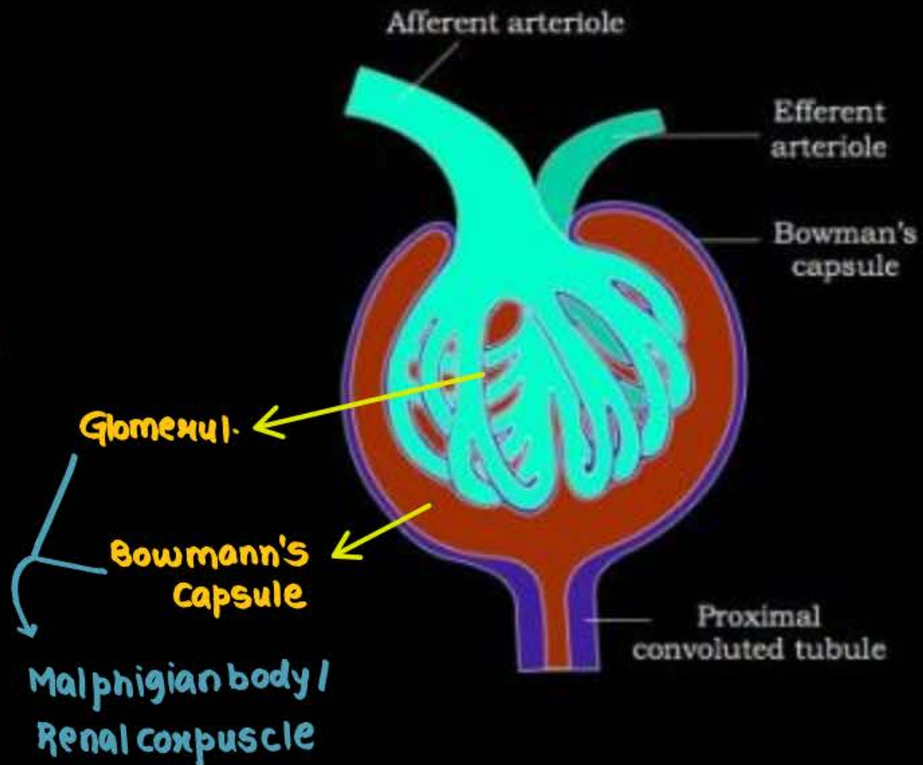
Path of urine

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

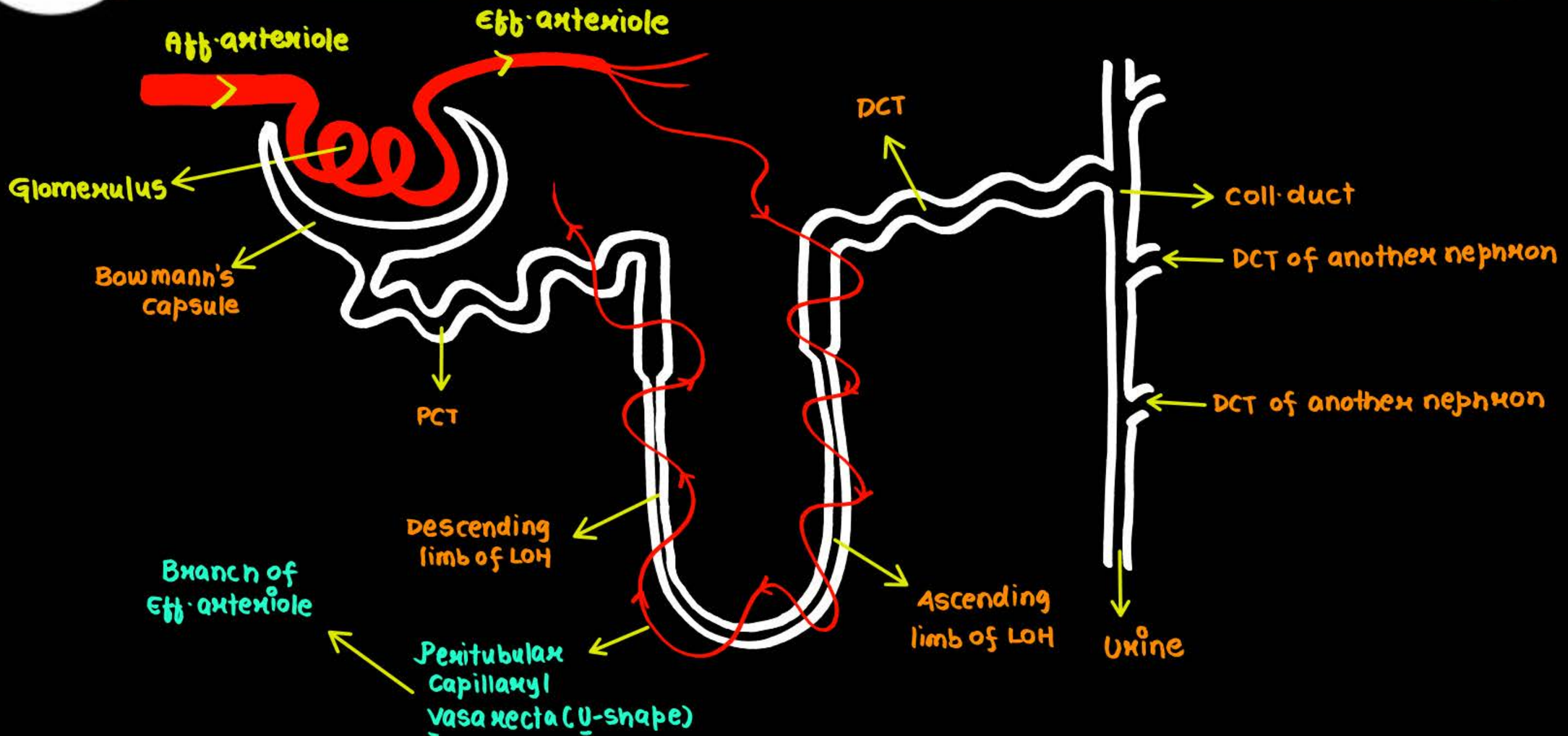
Nephron

- **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

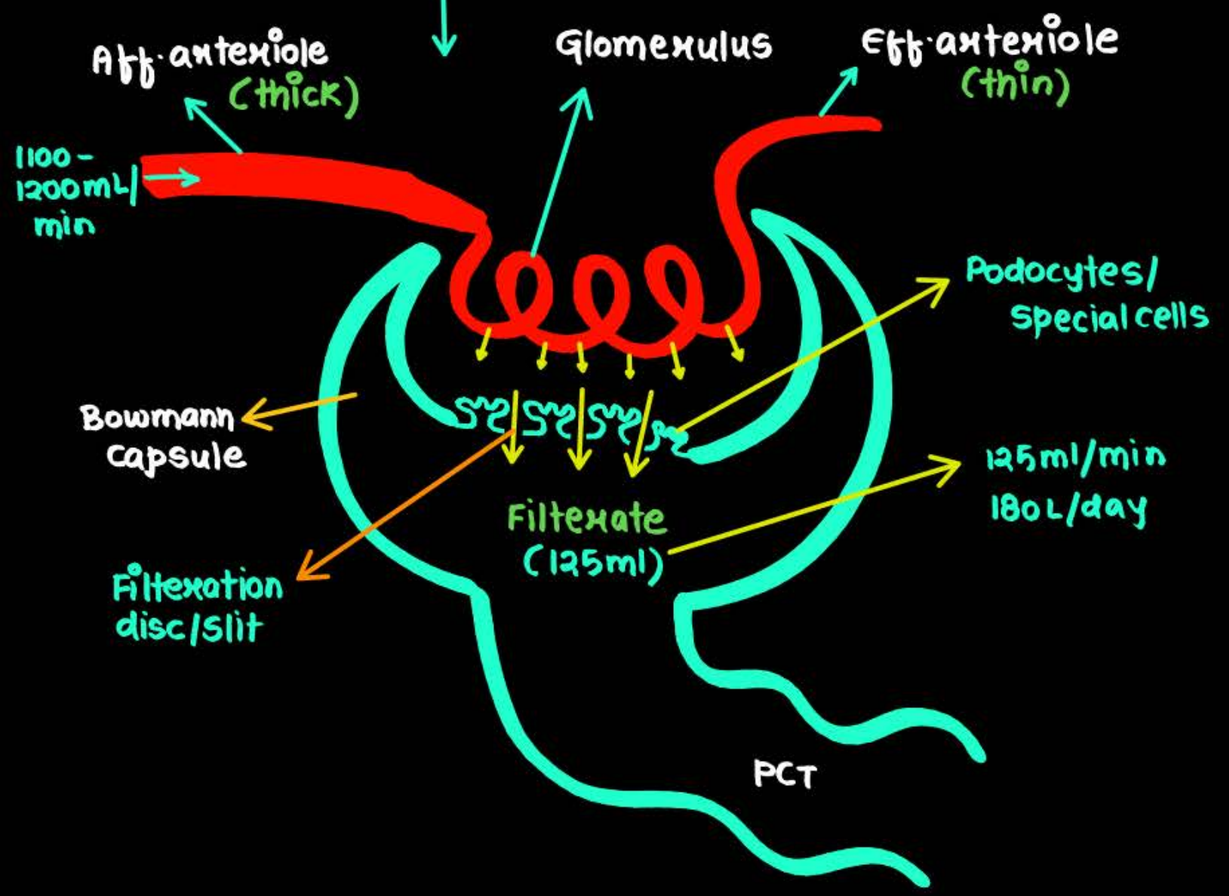
- Majority of Nephrons (85%) 80-85%
- Henle Loop is short and just dips into medulla
- Vasa recta is highly reduced or absent

Juxta Medullary Nephrons

- Some of Nephrons (15%) → 15-20%
- Henle Loop is long and go deep into medulla
- Vasa recta is present (well developed)

Urine Formation: Steps

- **Steps: Ultra-filtration, reabsorption and secretion** → osmoxegulation



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

  ↓

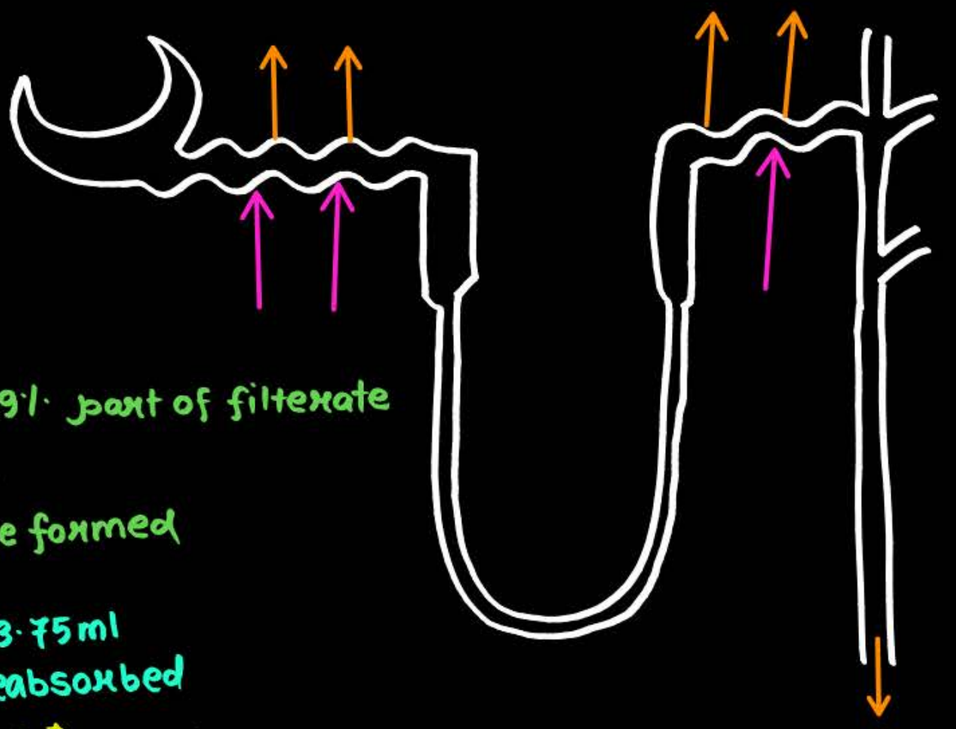
  Filtrate reach in the lumen of Bowmann's capsule

- SV (Stroke volume) = 70ml
- CA = Cardiac output = = 70ml × 72 = 5040ml ~ 5L

  ↓

  1/5th or 20% comes in Kidney = 1100-1200mL

Urine Formation: Steps



- Absorption: 99% part of filtrate is reabsorbed
- 125 ml filtrate formed
  - 1.25 ml urine formed
  - 123.75 ml reabsorbed
- Active: K^+ Na^+ Active/ATP — KANGA — Glucose, aminoacid
- Passive: → N-waste, H_2O, Cl^-, HCO_3^-

→ Reabsorption

→ Secretion

KaNHa

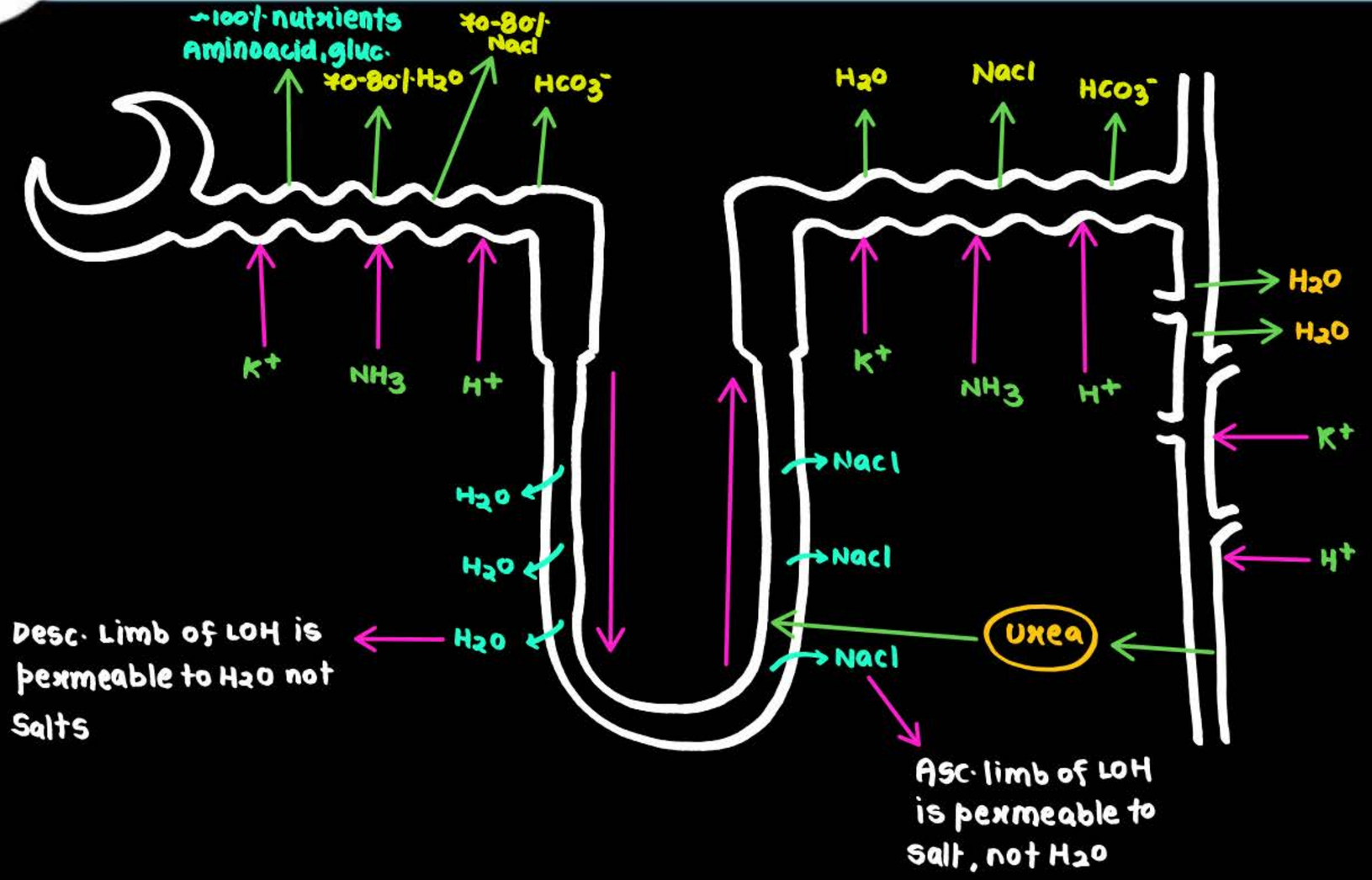
K^+ NH_3 H^+

- GFR/Glomerular filtrate: Filtrate formed in 1 minute
  - e.g., 125 ml
  - Can be inc. or decreased also
    - ↓ vaso-contr.
    - ↑ vasodilation

Functions of Tubules

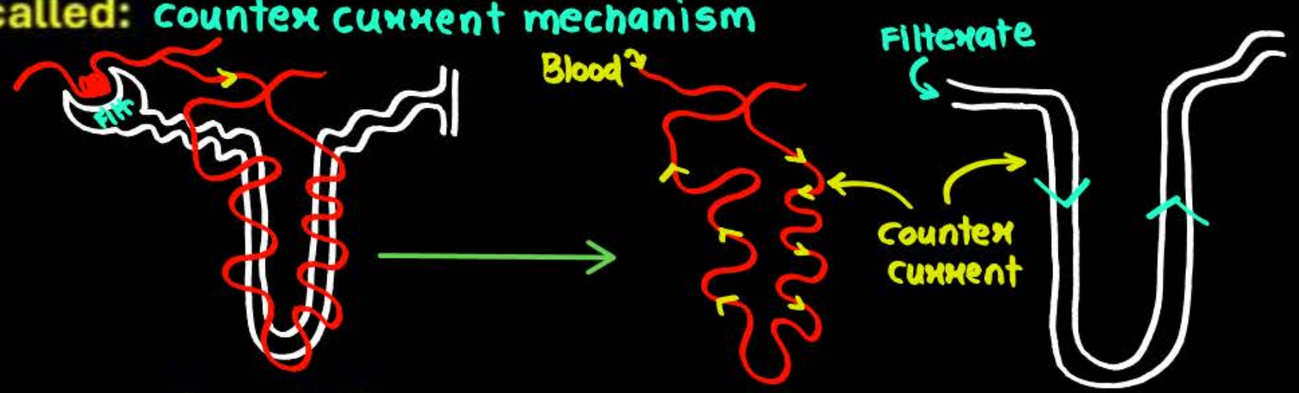
Part of Tubule	Reabsorbed material	Secreted material
PCT	Almost all essential nutrients; 70-80% of all electrolytes (NaCl) and water; HCO_3^- (max reabs.)	K^+, NH_3^+, H^+
Descending limb of LOH	Water reabsorption	-
Ascending limb of LOH	Salt (NaCl) reabsorption	Urea
DCT	Conditional reabsorption of Na^+ and water; HCO_3^-	K^+, NH_3^+, H^+
Collecting Duct	Water; some urea (for osmolarity)	K^+, H^+

Functions of Tubules



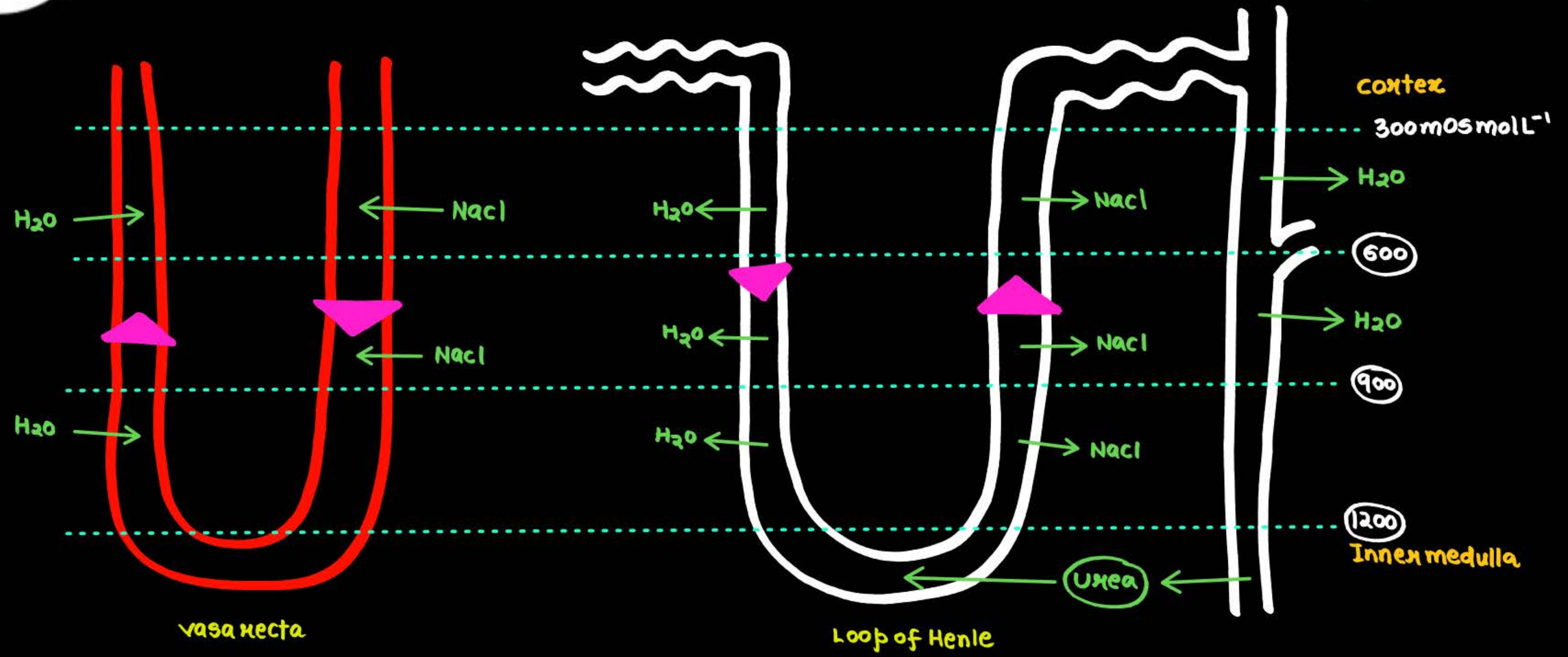
Mechanism of Concentration of Filtrate

- Mammals have a mechanism to make concentrated urine → 4x conc. urine
- Also called: Counter current mechanism



- 4X concentration of urine
  - 300 mosmol L^{-1} —4x→ 1200 mosmol L^{-1}
  - (cortex) (medulla)
- Gradient is mainly caused due to: NaCl & Urea

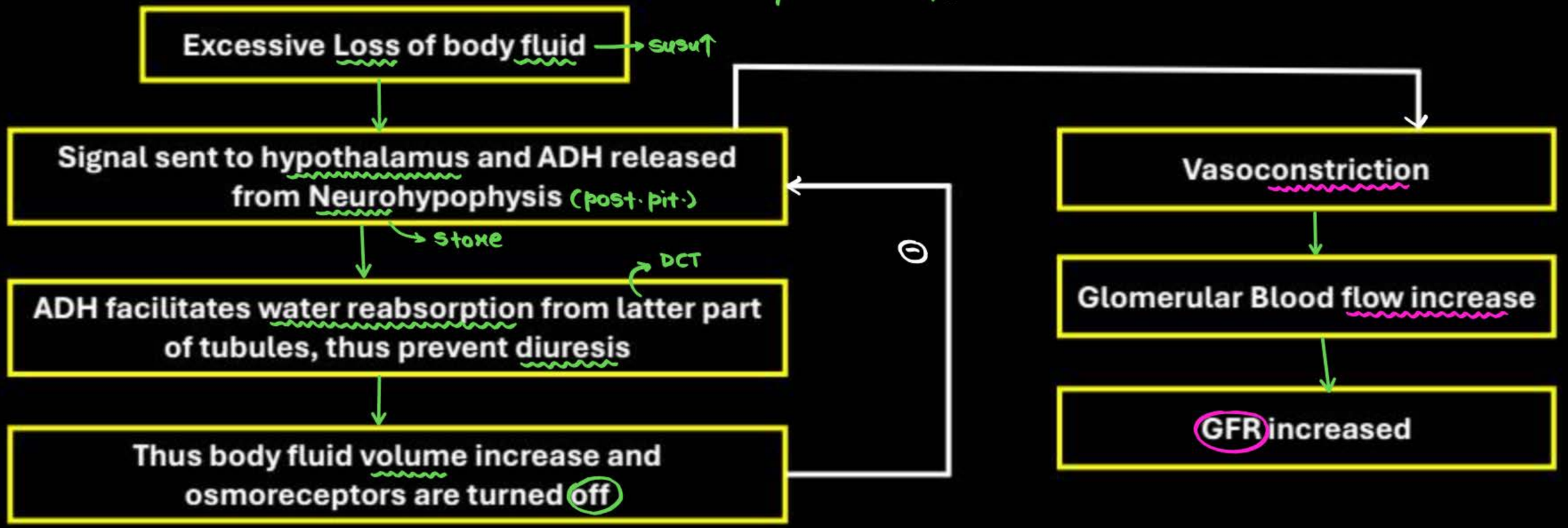
Mechanism of Concentration of Filtrate



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)

Glomerular Blood Flow; Glomerular Blood Pressure; GFR Fall ∴ GFR ↓

↓

Renin released

↓

Angiotensinogen in blood gets converted into Angiotensin-I and then Angiotensin-II

↓

Angiotensin-II do vasoconstriction and thus GFR increase

→

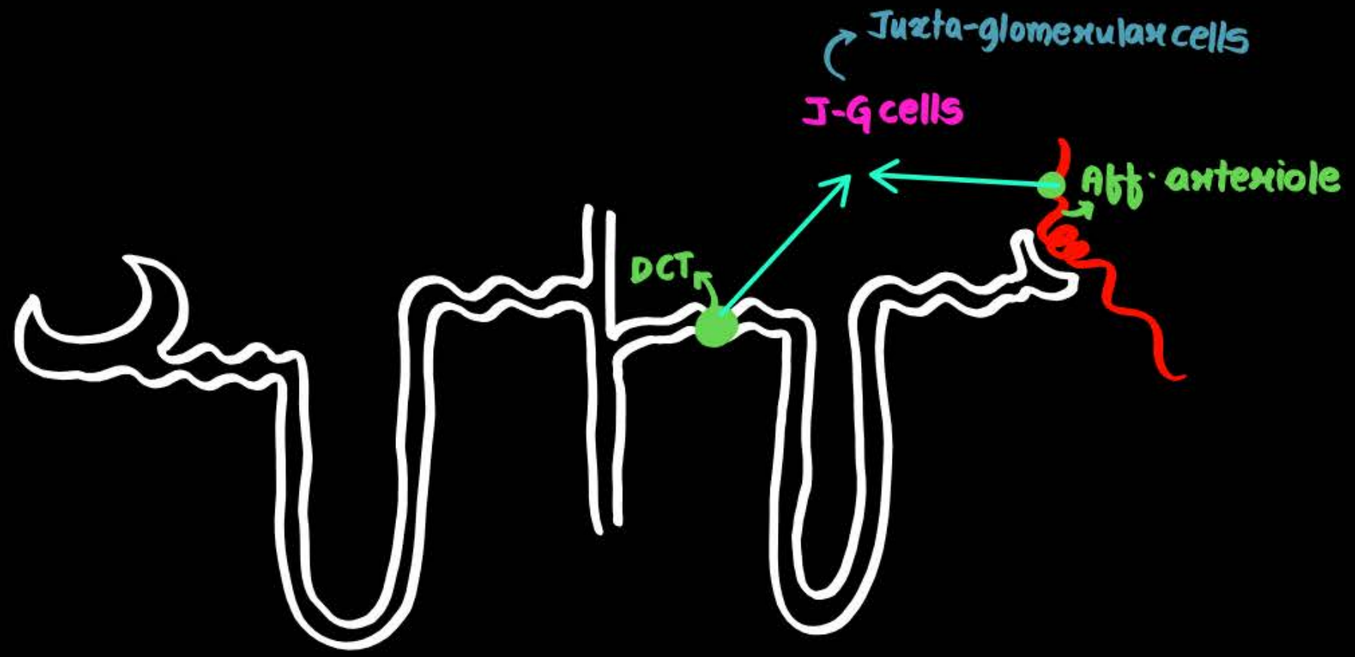
Angiotensin-II also activates Adrenal Cortex to release Aldosterone

↑

Causes reabsorption of Na+ and water from DCT

↑

Thus, Blood pressure and GFR increases



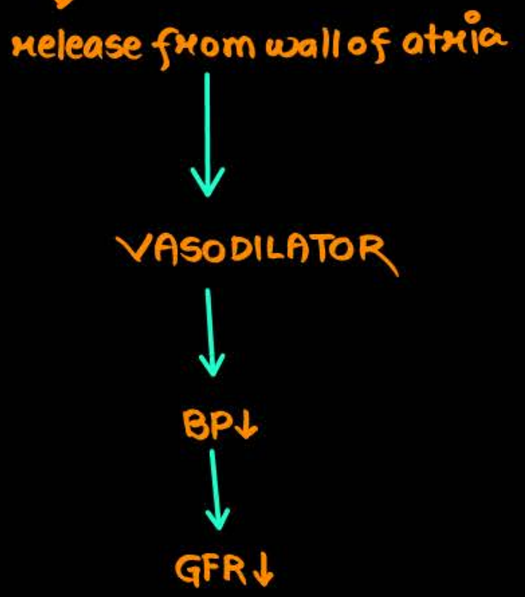
- The initial part & end part of nephron i.e., afferent arteriole & DCT have some cells called JG cells

→ Sense the fall of GFR

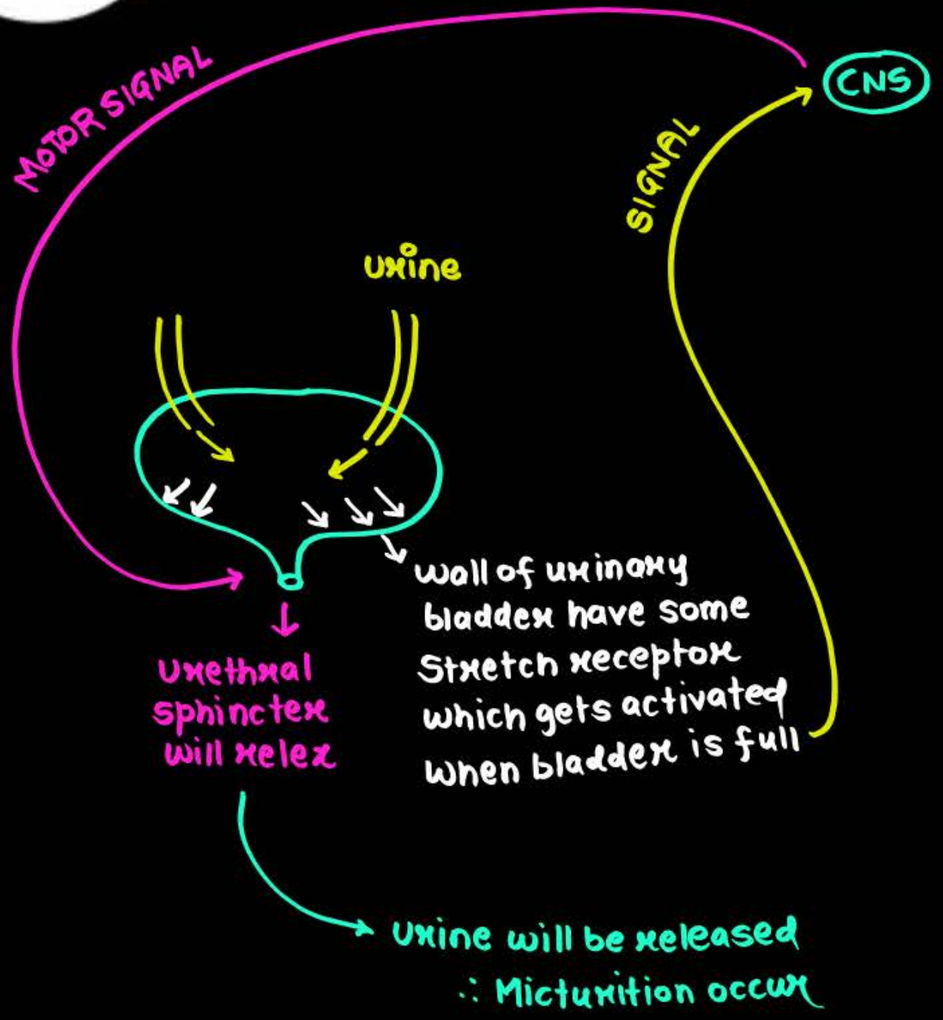
→ Release Renin*

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

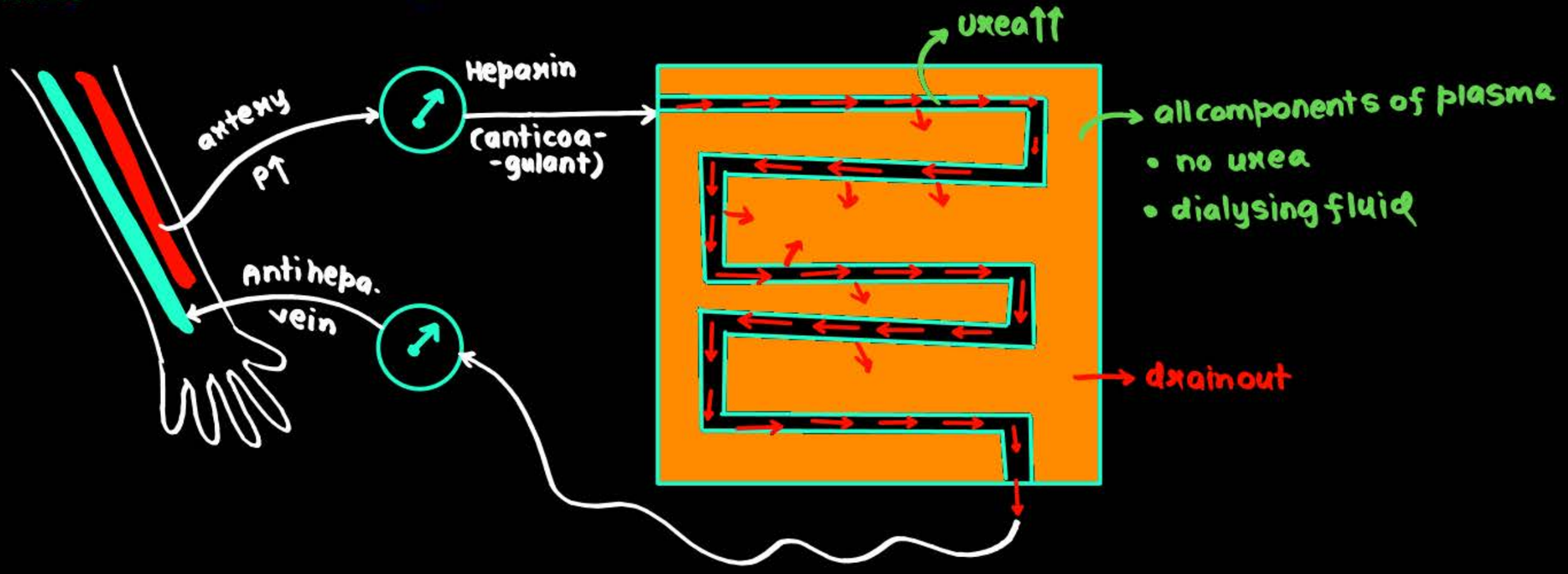
Role of Other Organs in Excretion

- **Lungs:** excrete CO_2 (200ml/min) ; some H_2O
- **Liver:** Largest gland: Bile pigments: Bilirubin, Biliverdin : they will get excreted alongwith undigested waste
  - Degraded steroid hormones
  - Vitamins, drugs
  - Cholesterol, phospholipid
- **Sweat and Sebaceous glands (oil):**
  - Sweat → Cool → H_2O, salt, Lactic acid, urea ↓
  - Sebaceous (oil) → oily covering
  - Sebaceous (oil) → Sterols, hydrocarbons, wax
- **Saliva:** → Small amt of N_2-waste

Disorders of Excretory System

- **Uremia:** Urea conc. ↑ due to Kidney disfunctioning

- **Hemodialysis/ artificial kidney** (Temporary solution)



Disorders of Excretory System

- **Kidney failure:** a donor is needed
  - ↓ Permanent solution
  - ↳ preffered from a close relative
- **Renal calculi:** ↗ Insoluble stones of calcium oxalate
  - ↓ Kidney
  - ↳ Calcium
- **Glomerulonephritis:** Inflammation of Glomoxuli
  - ↓ inflammate

Excretory Products and their Elimination

- Animals accumulate N-waste; CO_2; H_2O, ions (Na^+, K^+, Cl^-, SO_4^{2-}, PO_4^{3-}) either by exc. ingestion or metabolism.
- Need to be removed partially or wholly
- Major focus on N-waste

  NH_3, urea, uric acid

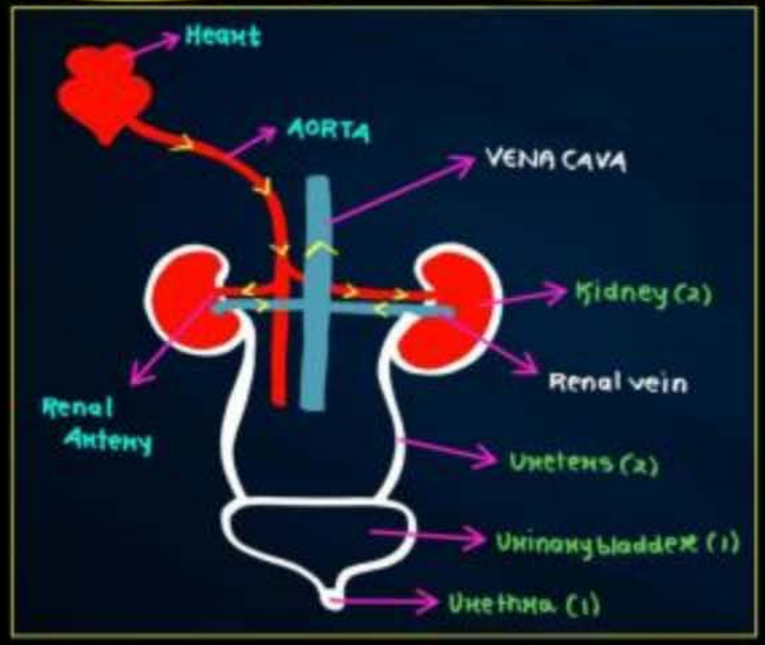
  ↳ Toxicity↑ ↳ Toxicity↓

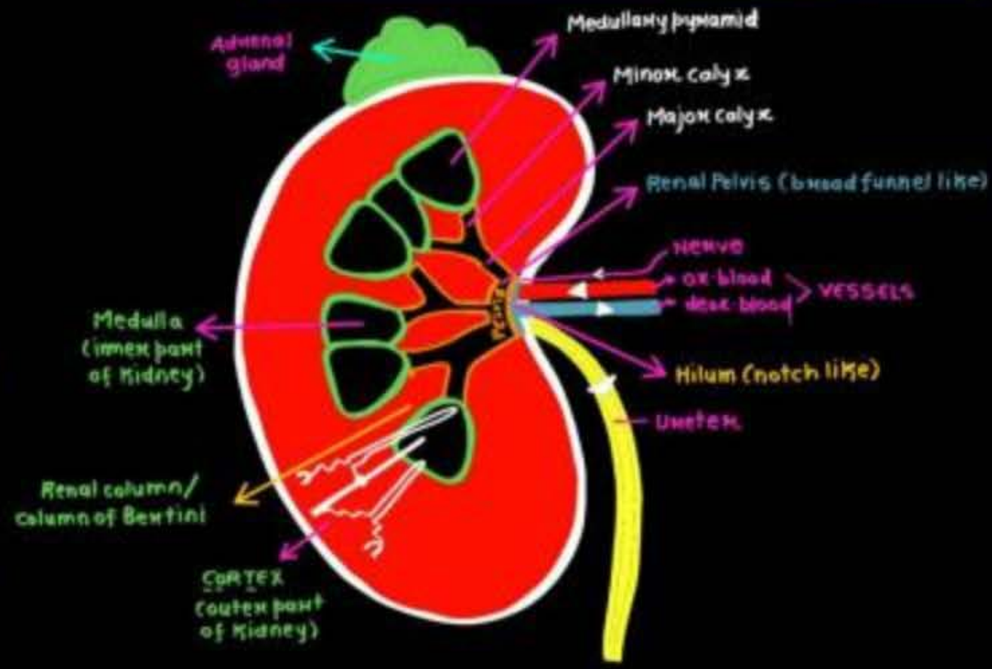
Excretory System

- Kidneys are reddish brown, bean shape
- Present between T_{12}-L_3 vertebra
- close to dorsal inner wall of abd. cavity; avg. wt. 120-170gm
- Length = 10-12cm; width = 5-7cm; thickness = 2-3 cm
- Each kidney has approx 1 million nephrons (complex tubular nephr.)

  ↳ 2 parts: Glomerulus

  Renal Tubule
- Malpighian body/renal corpuscles: Glomerulus + Bowmann's capsule

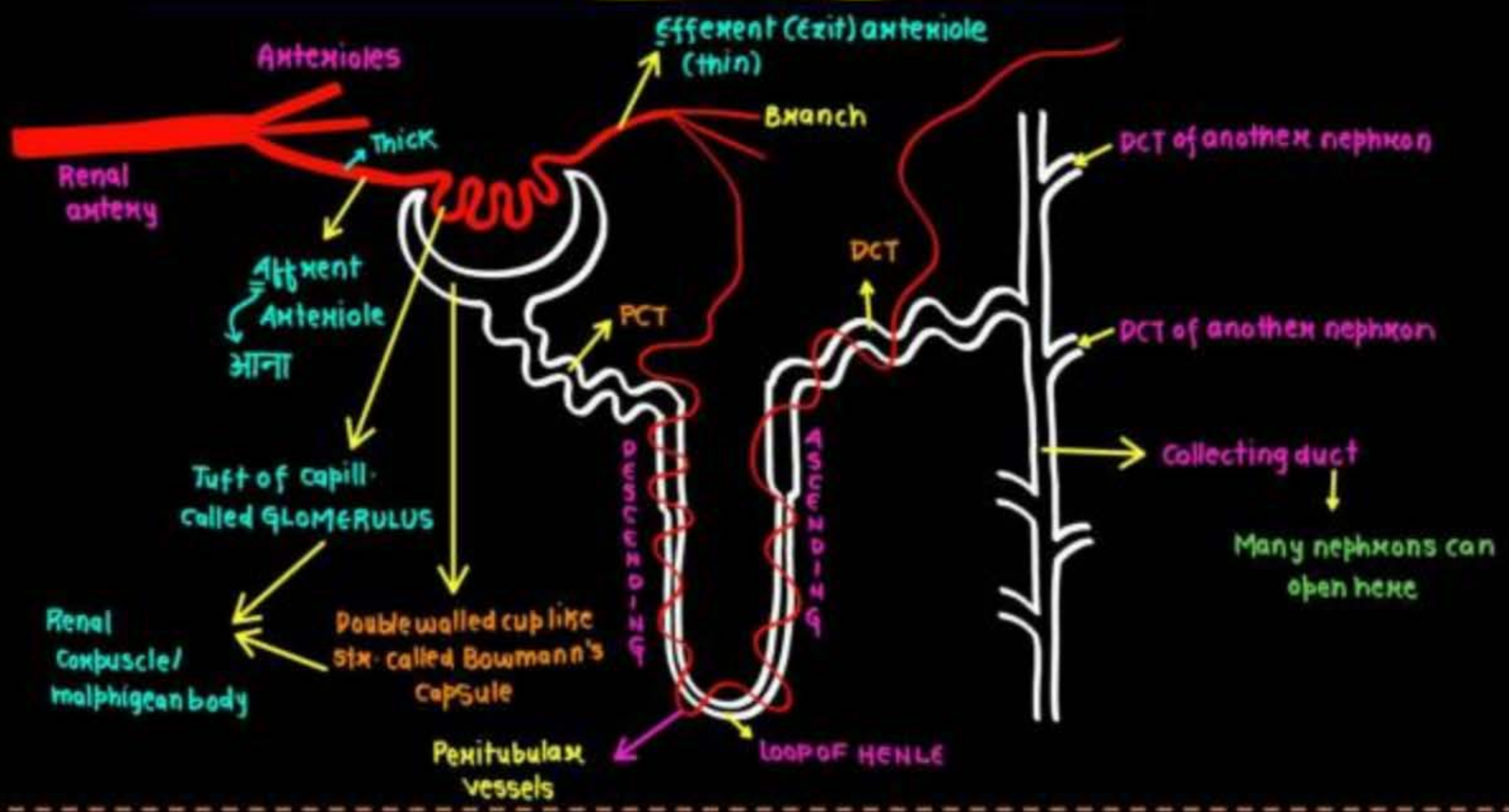




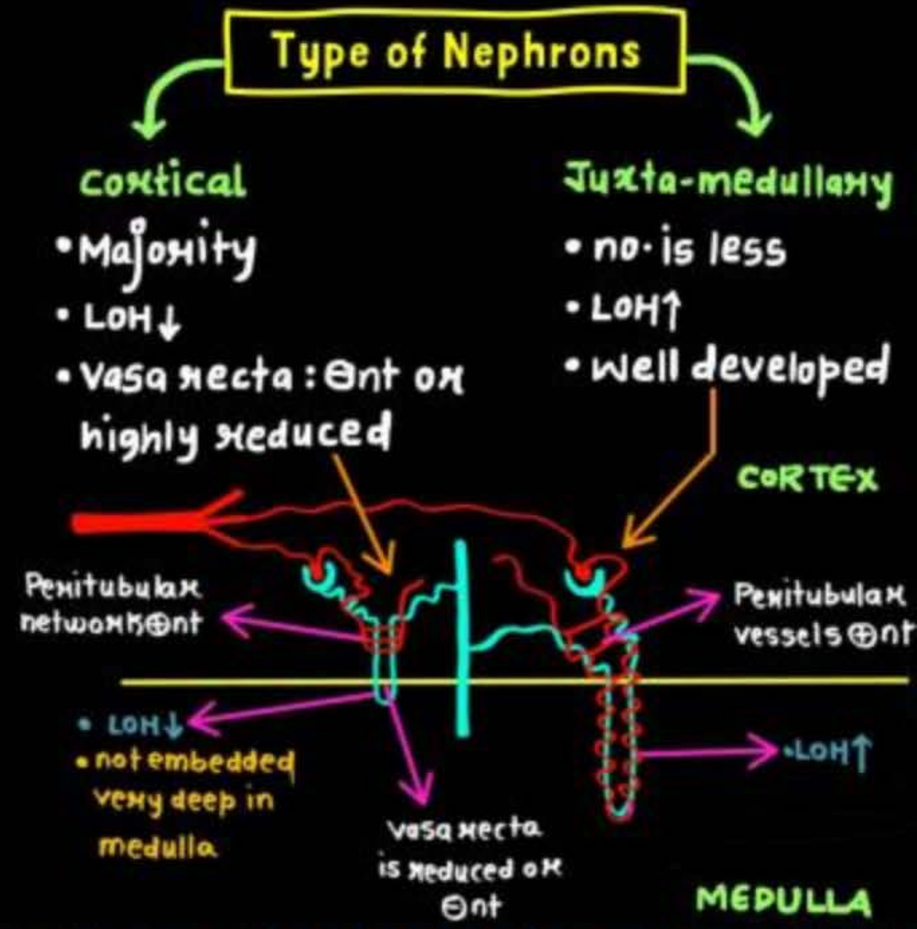
N-waste	Examples
Ammonia Readily soluble; excreted by general body surface or gills (in fishes) by diffusion as ammonium ions	Many bony fishes; aquatic insects and aquatic amphibians Kidneys do not play a significant role
Urea (save water)	Many terrestrial animals and marine fishes
Uric Acid	Reptiles,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

Nephron



Type of Nephrons



Urine Formation

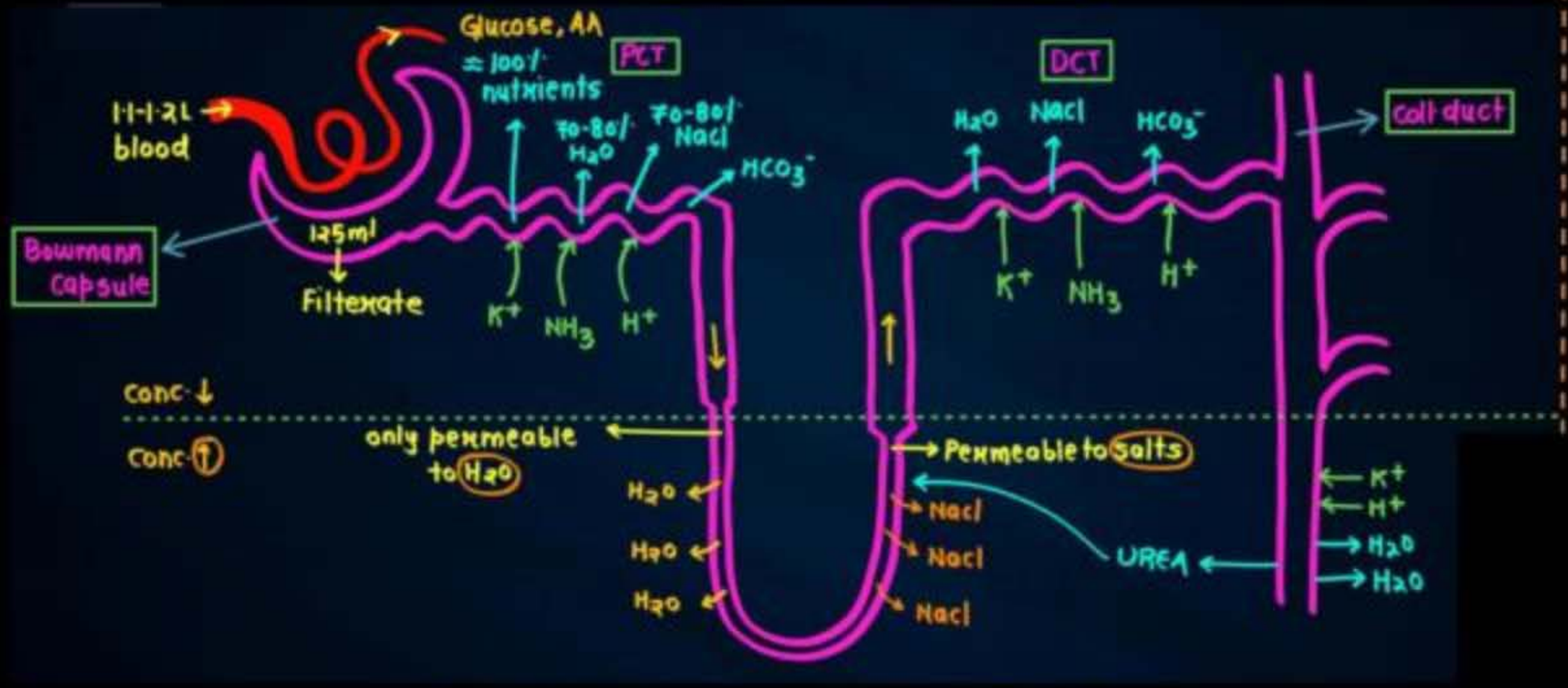
Involves 3-steps: 1. Glomerular/ Ultrafiltration ; 2. Reabsorption ; 3. Secretion

- 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 Bowmann 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



Regulation of Kidney Function

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

JG cells activates due to fall in GFR or BP↓ or Bl. flow

∴ Renin released

Convert angiotensinogen into A-I & then A-II

Vasoconstriction

Activate adrenal cortex to release aldosterone

cond. reab. from DCT

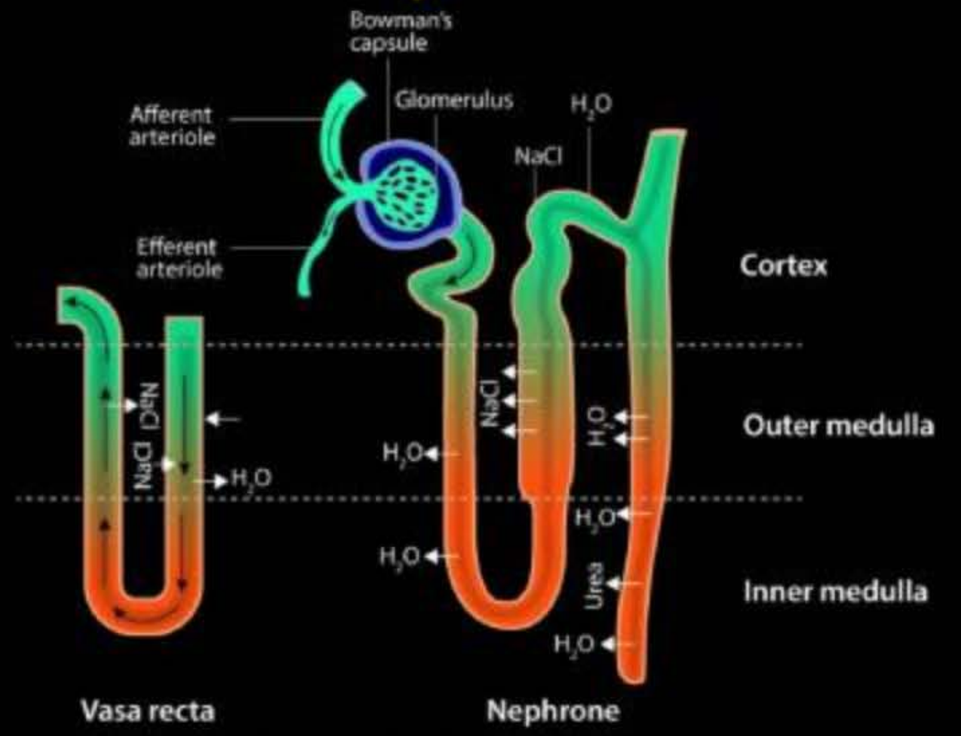
ANF cause vasodilation & work as feedback for RAAS

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 mosmol L^{-1}) (1200)

- Gradient is usually maintained by NaCl & Urea



Regulation of Kidney Function

- Via Hypothalamus: Excessive loss of fluid ➡ Receptors activated ; Hypothala. secretes ADH/vasopressin
  ⬇
  ↑ H_2O 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 Sebaceous gland (oil)	 NaCl, Urea (small amount), lactic acid; causes cooling 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 ~~im~~permeable to water and permeable to electrolytes.

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

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

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%

(↑)

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.

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)

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)**.

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 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.

(1) (C), (A), (E), (B), (D) (2) (A), (D), (E), (C), (B)

(3) (A), (D), (C), (B), (E) (4) (B), (A), (E), (D), (C)

QUESTION (NEET PYQ EXAM 2023)

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

	List-I		List-II
A.	*Taenia*	P.	Nephridia
B.	*Paramoecium*	Q.	Contractile vacuole
C.	*Periplaneta*	R.	Flame cells
D.	*Pheretima*	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

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.

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 (E) only

(3) (C), (D) and (E) only (4) (B), (C) and (D) only

QUESTION (NEET PYQ EXAM 2022)

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

(1) *Pavo* (Bird)

(2) *Ornithorhynchus*

(3) *Salamandra*

(4) *Hippocampus*

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

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 not observed in *vasa recta*

(3) Reduction in glomerular filtration rate activates JG cells to release renin

(4) Atrial natriuretic factor increases the blood pressure

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 HCO_3^- and hydrogen ions in PCT

(*iv*) higher blood pressure in glomerular capillaries

(1) (*ii*) & (*iv*)

(2) (*i*), (*ii*) & (*iv*)

(3) (*i*) & (*ii*)

(4) Only (*ii*)

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 Na^+ and water from renal tubules due to aldosterone

(3) Atrial natriuretic factor causes vasoconstriction

(4) Decrease in secretion of renin by JG cells


THANK YOU