EXCRETORY PRODUCTS & THEIR ELIMINATION

Excretion:- process of removal of metabollic waste from the body.
OR
removal of mainly nitrogenous substance from the body which are end product of metabolic activity.
OR
Metabolism + Excess Ingestion → Results in accumulation of
- N_2 waste : NH_3, urea, uric acid
- others : CO_2, H_2O,

- Egestion:- removal of undigested food is called defecation/egestion. end product is stools.

Function Of Excretion:-
1.) Maintains constant internal environment inside body i.e HOMEOSTASIS (Walter Canon).
2.) Removal of N_2 waste
3.) Maintains osmoregulation :- Salt & water balance - ionic & Acid water balance.
4.) Helps in blood formation

Excretory Products:-
1. Ammonia
2. Urea
3. Uric Acid
4. Trimethy Amine Oxide
5. Creatine
6. Creatinine
7. Hippuric Acid

Classification of Animals on their basis of Excretory Products :-

Ammonotellism	Ureotellism	Uricotellism
- Ammonia	- Urea	- Uric Acid

- most toxic form
- max. H_2O for removal
- Readily soluble in H_2O
- Ammonotellism
- Excret° through diffusion across through body surface

- Eg: Amoeba
Sponges
Hydra
Aquatic Insects
Cray fish
tadpole
Bony fishes.

- moderately toxic
- moderate H_2O for removal
- Moderately soluble in H_2O
- Ureotellism
- Ammonia in liver { converted into
↓
urea
via blood { kidney
↓
Excretion

- Eg: Mammals
Marine fish
Terristrial Amphibian

- least toxic
- least H_2O for soluble
- least soluble in H_2O.
- Uricotellism
- In form of paste / pellet.

- Eg: Aves
Reptiles
Land snail
Land insects

✲ ORNITHINE CYCLE :-

Gaka Krebs Hansleit cycle
G aka urea cycle.
G ♀molecule : NH_3
1 molecule : CO_2
3 molecule : ATP
} consumption

Excretory Organs :

- organs :- Protonephridia Nephridia Malphigian Tubules Green glands/ Antennal glands Kidney.

- organs :- Protonephridia | Nephridia | Malpighian Tubules | Green glands/ Antennal glands | Kidney.
- Examples :- 1. Platyhelminthes 2. Rotifers 3. Cephalchordate | 1. Annelids (earthworm) | 1. Insects (cockroach) | 1. Crustaceans (prawns) | 1. All vertebrates.

Regulation of Solute and Water movement:-

OSMOREGULATORS

- maintain internal environment (osmolarity), different from surrounding medium in their habitat.

- Hypertonic medium → take in water (compensate water loss)
- Hypotonic medium → eliminate excess water

(ATP is used)

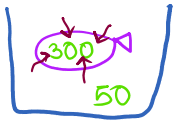
- Eg: Most vertebrates
  - *Except: Hagfish, Elasmobranch

OSMOCONFORMERS.

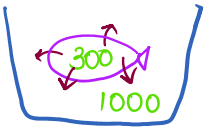
- can't actively control the osmotic conc of body fluids.
- they change the osmolarity of body fluids acc. to the medium
- Eg: All marine invertebrates, Hagfish : vertebrate
- can tolerate wide range of osmotic conc.

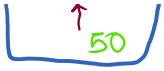
Water & Solute Regulation:-

In Fresh Water



In Marine Water





- Problem:
  - loss of body salt to outside
  - Excess water entry.
- Adaptation:
  - Scales / Adipose cover
  - dilute urine
  - Do not drink water.

- Problem:
  - Excess water is lost.
- Adaptation:
  - Drink water
  - conc. urine.

HUMAN EXCRETORY SYSTEM :-

1. kidneys } PAIRED
2. ureters
3. Urinary bladder } SINGLE
4. urethra

① KIDNEYS :-

- reddish-brown, bean shaped
- location: b/w last thoracic & 3rd lumbar vertebrae.
- Lt. kidney: higher than Rt kidney

- close to dorsal inner wall of abdominal cavity
- Rt kidney is slightly lower than left kidney.

aka retroperitoneal
- dorsally : abdominal wall
- ventrally : peritoneum

- L: 10-12cm, t: 2-3cm, W: 5-7cm, weight: 120-170g.
- Covering of kidney:
  - Renal capsule : innermost, NFD ICT
  - Adipose capsule: fat, shock absorption, middle
  - Renal fascia : outermost, fibrous covering.

- Internal Structure of kidney :-
  1. Pelvis:
     - inner to hilum is broad funnel shaped space called renal pelvis with projections.
     - calyces open into pelvis
     - pelvis opens into ureter.
  2. Zones → outer : cortex

↳inner : medulla

3. Medullary pyramids
   ↳ medulla is divided into few conical masses projecting into calyces.

4. Column of Bertini :
   ↳ Part of cortex which extends into medulla.

5. Renal papilla :
   ↳ Apex of pyramid is pointed & forms renal papilla
   ↳ 1-3 renal papilla opens into minor calyx.

NOTE : Types Of kidneys : 1. pronephros
2. mesonephros
3. metanephros

② URETERS :-

- paired
- distensible muscular tube
- 20-25 cm : L , 3mm : diameter
- emerges from hilum
  ↓
  descend into abdominal wall, bend obliquely
  ↓
  open into urinary bladder
- Histology :
  ↳ External : adventitia
  ↳ Middle : muscular ~ ↳ outer : longitudinal
  ↳ middle : circular
  ↳ outer : longitudinal
  ↳ Inner : Mucosa
- Always undergoing peristalsis

③ Urinary Bladder :-

- median, pyriform sac
- parts:
  - ↳ apex
  - ↳ body / fundus: triangular area called trigone
  - ↳ neck: two sphincters → internal: involuntary
    → external: voluntary.
    leads to urethra.
- openings & internal urethral orifice
- Histology:
  - ↳ external: Adventitia: soft C.T
  - ↳ middle: muscular: detrusor muscle
  - ↳ inner: mucosa: Loose C.T + Transitional Epithelium.
- capacity: approx 650ml
  urge to micturation: 150ml (approx).
  strong urge to micturate: 300ml (approx)

④ Urethra:-

↳ present only in mammals

In Males
1. Long (20cm)
2. common opening urinogenital aperture (urine + semen)
3. passes through prostate, cowpers gland & penis.

In females.
1. short (2-4cm)
2. Separate opening urethral orifice

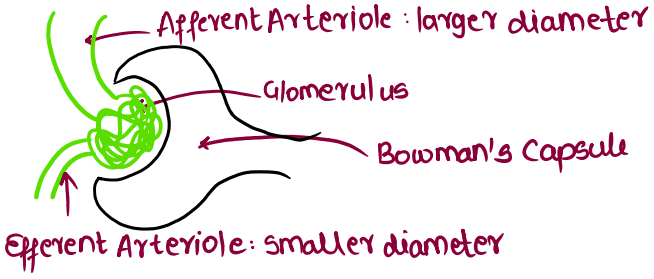
NEPHRONS :-

- aka uriniferous tubule
- Structural & functional unit of kidneys.
- 1 million / kidney.

- Parts:

GLOMERULUS
→ tuft of capillaries
→ Renal Artery
↓
Afferent Arteriole
↓
Glomerulus.
↓
Efferent Arteriole

RENAL TUBULE
1.) Bowman's Capsule
2.) Proximal Convulated Tubule
3.) Distal Convulated Tubule.



Functions of Renal Tubules:

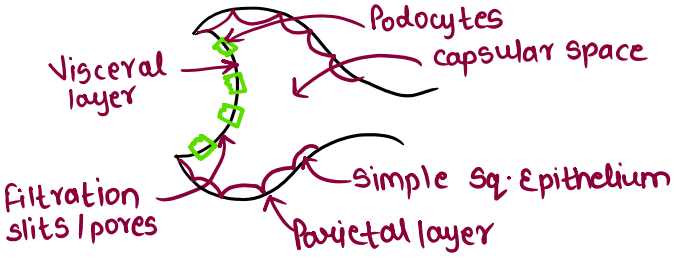
Ⓐ Bowman's Capsule :-
↳ blind, double wall, cup shaped
↳ two walls

outer
- parietal
- flat squamous epithelium
- Space b/w two

inner
- visceral
- flat squamous epithelium + Podocytes (Pedicels / feet)

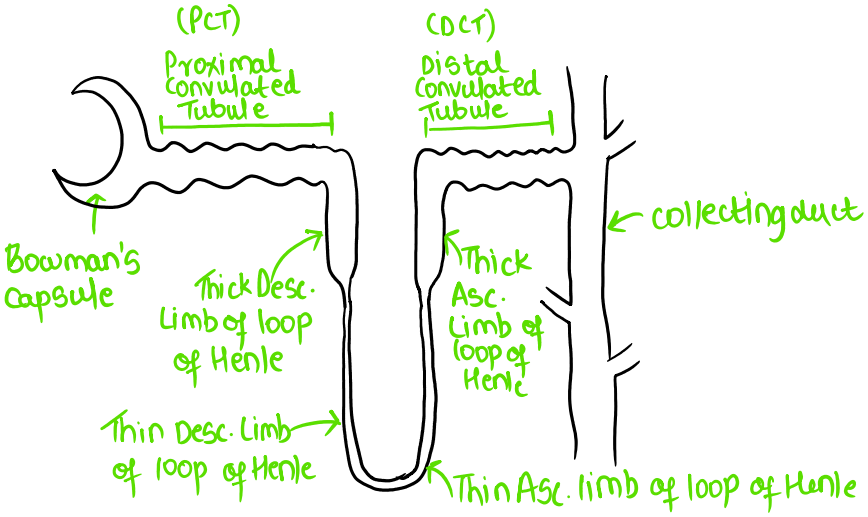
- flat squamous epithelium
- Space b/w two layers ⇓
LUMEN / CAPSULAR SPACE

- flat squamous epithelium + Podocytes (Pedicels / feet) enclose slit ↵ pores OR filtrat^{n} slits.
↳ Rest over Basement Membrane



NOTE: 1. Glomerulus + Bowman's Capsule = Malphigian Body / Renal Corpuscle.

2. Blood under high pressure get filtered to forms FILTRATE which accumulates in Bowman's capsular space



(B) Proximal Convulated Tubule:-
- found in cortex
- highly coiled, surrounded by peritubular capillaries
- lined by cuboidal epithelium with microvilli
- maximum reabsorption i.e (70-80%) → H_2O → electrolytes.

lined by cuboidal epithelium with microvilli
- Maximum reabsorption i.e (70-80%) → H_2O & electrolytes.

- ↑surface Area
- Absorbtion of HCO_3^- & tubular secretion of H^+ & NH_3 : maintains ionic & pH balance

© LOOP OF HENLE:-

- hair pin looplike
- extends into Renal Medulla
- types of limbs

• Thick → lined by cuboidal epithelium & Thin → lined by squamous epithelium

Descending
- permeable to H_2O
- impermeable to electrolytes

Ascending.
- permeable to electrolytes
- impermeable to H_2O.

Ⓓ Distal Convulated Tubule :-

- Ascending limb of LOH forms DCT
- cuboidal epithelium
- opens into collecting duct
- Surrounded by peritubular capillaries
- lies in cortex region.
- lies close to Malphigian body.
- conditioned reabsorption of H_2O & Na^+ takes place
- helps in maintaining osmolarity, pH & ionic balance

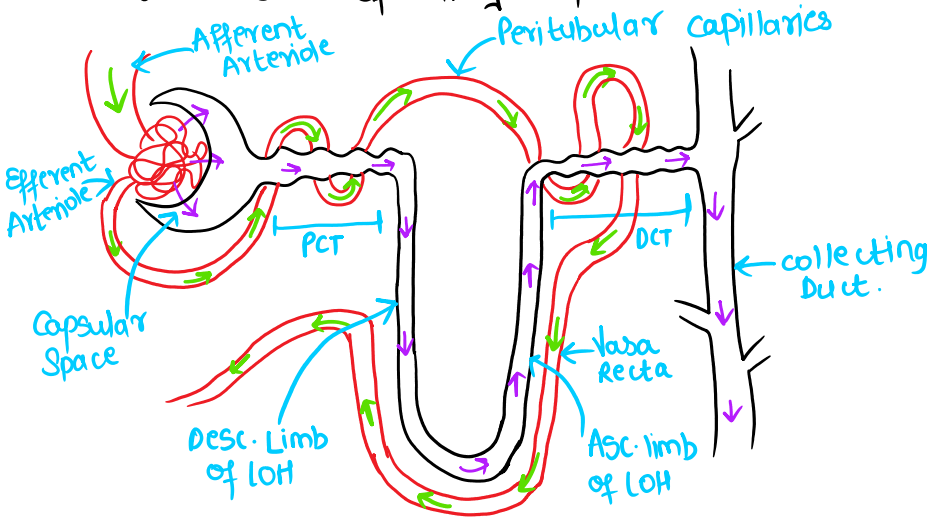
Ⓔ Collecting Duct:-

- Many DCT's open into collecting duct
- not part of renal tubule.

- DCT → Collecting Duct → Medullary Pyramids → Calyces → Renal Pelvis

- Enter medulla & forms DUCT OF BELLINI.
- water absorption takes place place here
- filtrate moves through collecting duct & urine is concentrated.
- Release of small amount of urea to maintain osmolarity of medullary interstitium.

Blood Vessels of kidney & Nephron :-



Aorta ← HEART ← Inf. Vena cava

↓ ↑

Renal Artery — Renal vein

↓ ↑

Afferent Arterioles — Renal Venule

↓ ↑

Glomerulus — Vasa Recta & Peritubular capillaries

↳ Efferent Arteriole ↑

Types of Nephron :

Juxta Medullary Nephrons

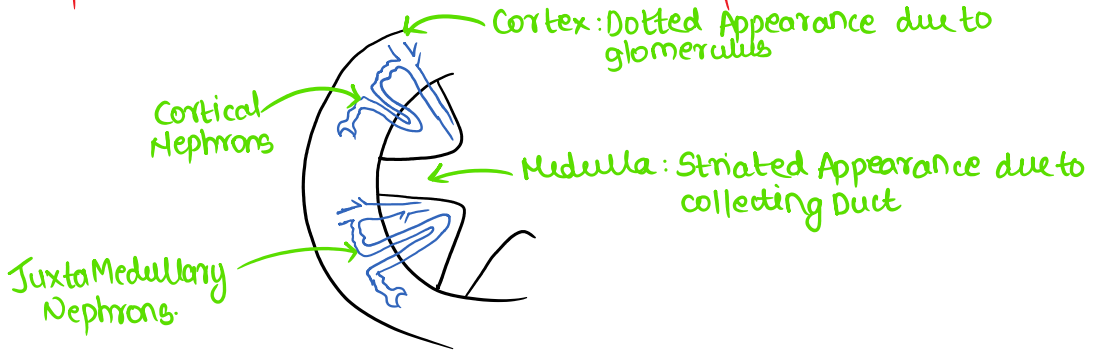
1. 15-20%
2. Long LOH
3. developed Vasa Recta
4. counter current mechanism
5. lies in cortex + medulla
6. less developed peritubular capillaries

Cortical Nephrons.

1. 80-85%
2. Short LOH
3. No / undeveloped Vasa Recta
4. No role in water conservation
5. only cortex
6. well developed peritubular capillaries.

5. lies in cortex + medulla
6. less developed peritubular capillaries

5. only cortex
6. well developed peritubular capillaries.

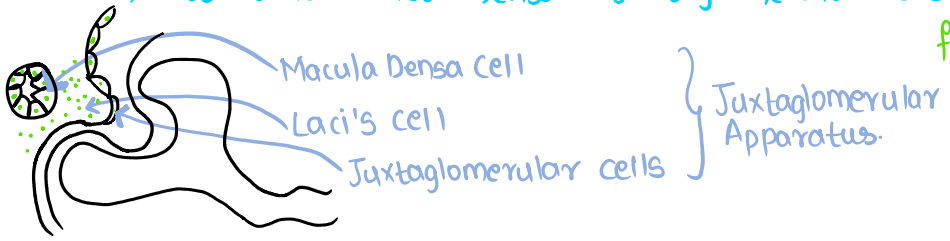


#JUXTA GLOMERULAR APPARATUS :-

① Juxtaglomerular Cells:
↳ Smooth Muscle Cell : Afferent Arteriole : secrete renin

② Macula Densa :-
↳ Modified cells of DCT : detection of Na^+ ion in cell

③ Laci's Cell / Polkissen :-
↳ present blw Macula Densa & Juxtaglomerular cells : unknown function.



Physiology of urine formation:

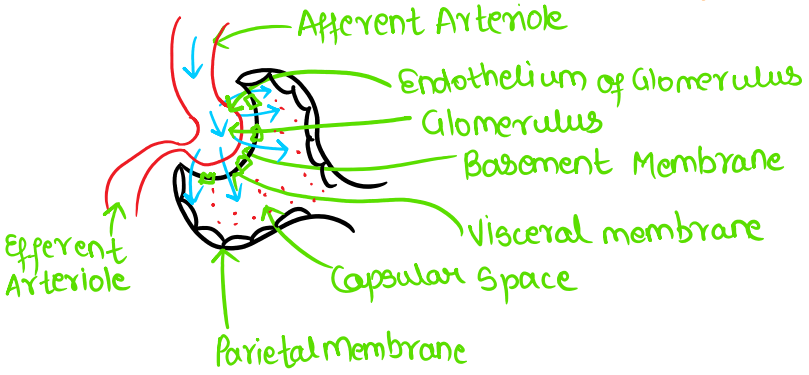
① formation of urea:
- Ammonia is converted into urea
- occurs in liver by hepatocytes
- urea cycle / ornithine cycle / Krebs-Hansleit cycle

② formation of urine:
3 steps:
- Ultrafiltration: filtration of blood
- Tubular Secretion: tubular cells secrete metabollic waste
- Reabsorption: useful substance are reabsorbed.

(A) ULTRAFILTRATION:-

- 1st step
- process occurs in malphigian corpuscle
- Glomerular Capsular Membrane [filtration membrane]
  a. Endothelium of glomerular blood vessels
  b. Epithelium of Bowman's capsule (podocytes & filtration pore).
  c. basement membrane b/w two layers.
- filtration of Blood under ↑↑ pressure.
- FILTRATE = BLOO - CELLS - PROTEIN
  = PLASMA - PLASMA PROTEIN

- GFR: Glomerular filtrate Rate = 125 ml/min, 180L/day.
- Renal Blood flow = 1100-1200 ml/min
  Renal Plasma flow = 700 ml/min
- Net filtration pressure = 15-25 mm Hg



(B) REABSORTION :-

- Filtrate = 180L/day
  Urine = 1.5L/day.
- 99% of formed filtrate is reabsorbed (90-95%)
- Glucose, Amino Acid, Na^+ : ACTIVE PROCESS.
  H_2O, Cl^- & N_2 waste : PASSIVE PROCESS.

(C) TUBULAR SECRETION :-

- Peritubular Capillaries ~~metabolic Waste~~> PCT & DCT
- Renal tubules secrete excretory substance from blood capillaries into filtrate.
- Active process occurs in DCT, PCT & collecting duct.
  - H^+, K^+, NH_3^+, Creatinine, Uric Acid, Hippuric Acid, Pigments : PCT } other substance
  - H^+, K^+, NH_3^+ : DCT
- maintains ionic balance of body
- only mechanism in organisms not having glomerular kidney like marine, desert amphibian.

EXCRETION = Ultrafiltration - Reabsorption + Tubular Secretion

Urine Composition :-

- 90-95% = H_2O
  2% = Salts
  2.7% = Urea
  0.3% = Hippuric Acid + Uric Acid + Pigments

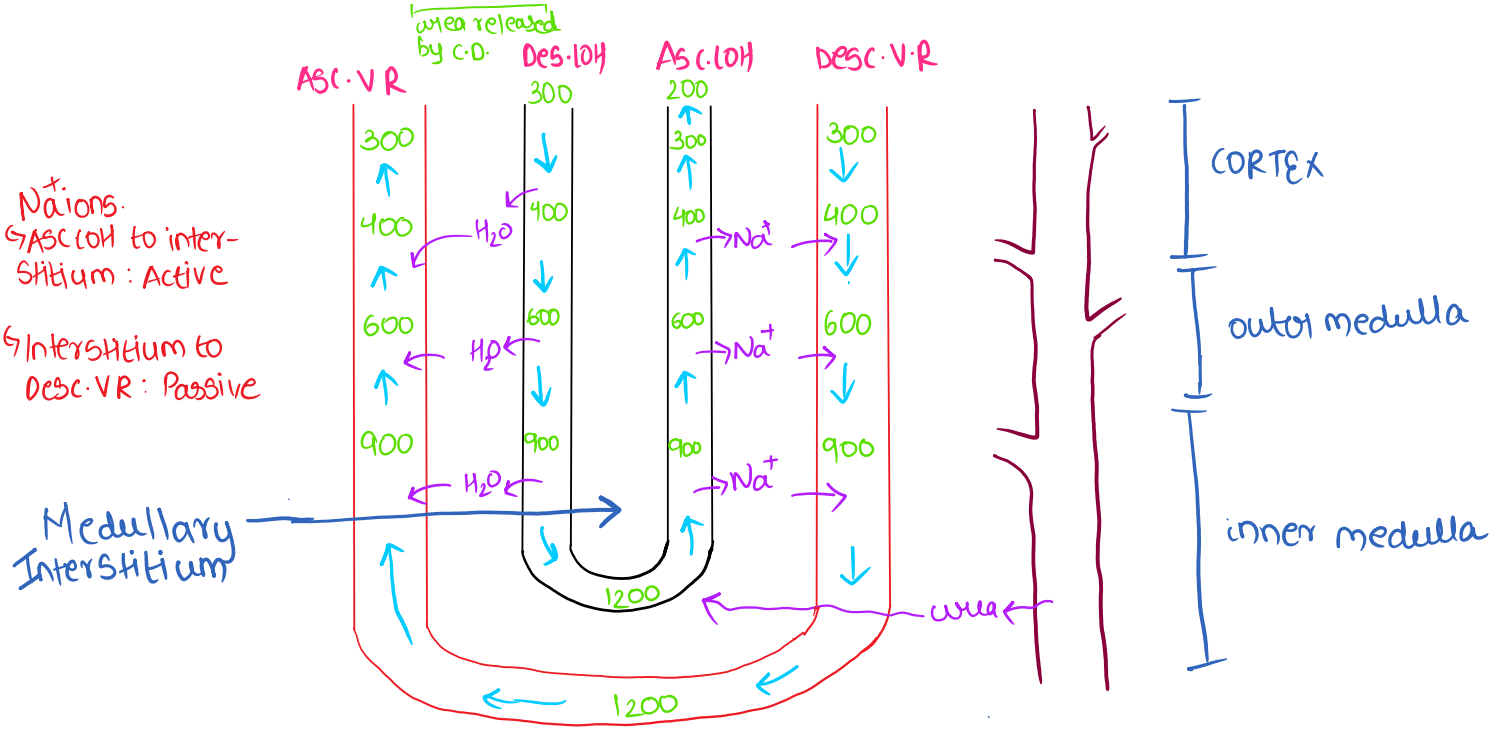
- organic → urea, urobillinogen, Hippuric Acid, creatinine
- inorganic → Na^+, K^+, Ca^{++}, Cl^-, SO_4^-, HCO_3^-

- 1 - 1.5 L/day : urine
- urochrome pigment : yellow colour
- 20-25gm urea
- Normal urine slightly Acidic = 6.0.

Mechanism of Urine concentration :

- counter (opposite) current (flow) mechanism
- counter current multiplier mechanism

NOTE
- NaCl & urea : causes gradient
- urine nearly 4 times conc.



✱ Regulation Of kidney function :-

① ADH : Hypothalamus
② RAAS : JuxtaGlomerular Apparatus
③ ANF : Heart.

• ANTI DIURETIC HORMONE :

↳ aka Vasopressin
↳ Diuresis : Excessive Urination
↳ prevents excessive loss of H_2O in urine
↳ ↑ Reabsorption of H_2O in DCT & collecting Duct
↳ causes vasoconstriction (↑BP).

⇒ Released when : a.) ↑↑ H_2O loss (↓Blood Volume) — sweating, Diarrhoea, cholera

b.) Use of diuretics : Alcohols, coffee, Drugs
↳ Causes excessive urination by suppressing ADH

⇒ Produced by : HYPOTHALAMUS

⇒ Released by : POSTERIOR PITUITARY

⇒ OSMORECEPTORS are present in blood which detect osmolarity

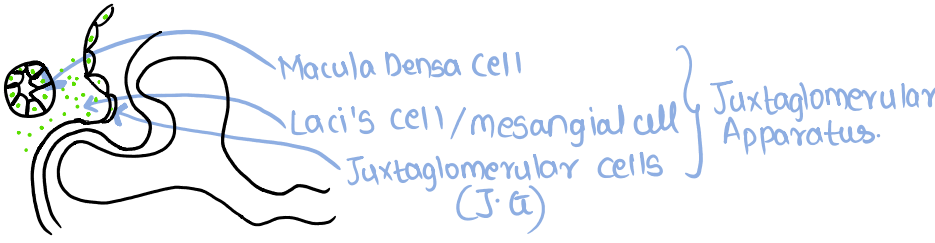
When osmolarity ↑ (during summers)
↑ salt
Hypertonic
↓ H_2O
↓
Sends signal to Hypothalamus
↓
Hypothalamus produces ADH
↓
Release of ADH from post. pituitary
↓
↑ Reabsorbtion of H_2O from DCT & CD
↓
less H_2O in urine
↓
↑ Blood volume
↓
↓ urine formation

When osmolarity ↓ (or normal) (during winters)
↓
H_2O levels normal in body
↓
Sends signal to hypothalamus
↓
No secretion of ADH
↓
No Reabsorption of H_2O from DCT
↓
↑ volume of H_2O in urine
↓
↓ Blood volume
↓
↑ urine formation

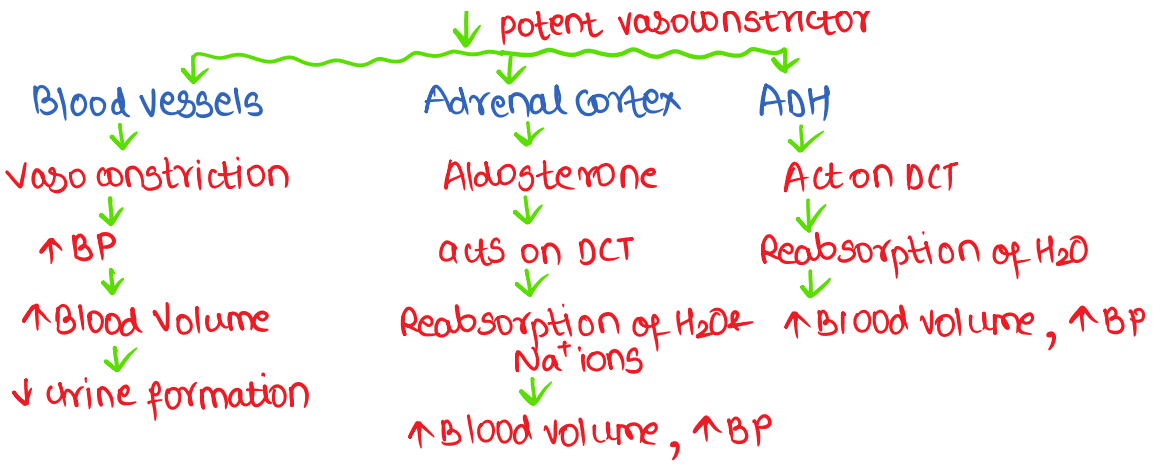
- **RAAS:-**

Renin Angiotensin Aldosterone System:-
↓ ↓ ↓
Kidneys Liver Adrenal cortex

- Stimulated when: (works)
  - ↓ BP
  - ↓ Na^+ ion concentration
  - ↓ GFR



Renin (kidneys)
↓
Angiotensinogen (liver)
↓
Angiotensin-I
Vasoconstrictor ↓ Angiotensin converting enzyme (lungs)
Angiotensin-II
↓ potent vasoconstrictor



- ANF:
  - produced by Atrial wall of Heart
  - detects: 1.) ↑ BP
    2.) ↑ Na^+ conc
  - Results in: 1.) ↓ BP
    2.) ↓ Blood volume
  - Acts as checkpoints on ADH system & RAAS system

Inhibits Reabsorption of Na^+ & H_2O from DCT

↑Blood pressure
↓
Excessive stretching in Atrial wall
↓
Atrial Natriuretic Factor is released
↓
No Reabsorption of Na^+ & H_2O
↓
↓Blood Volume
↓
↓ BP

MICTURATION: Emptying /Voiding of Urinary Bladder

↳ It is process of voiding or emptying of urinary bladder
↳ urge to micturate = 150ml
strong urge to micturate = 300-350ml
Capacity of urinary bladder = 600-650ml

Micturation Reflex

Urinary bladder starts getting filled
↓
Stretch receptors detected stretching in Detrusor Muscles
↓
Sends signal to Brain & Spinal Cord
↓
Brain sends voluntary motor signals to Detrusor Muscle & Sphincters
↓ ↓
Relaxation of Sphincters | contraction of muscle
↓
Empty of urinary Bladder

Role of kidneys In Blood formation:

Hypoxia
↓
↓ oxygen conc. in Blood
↓
Stimulates kidney to release ERYTHROPOEITIN
↓
Stimulats Red Bone Marrow formation
↓
formation of Red Blood cells

Role of other organs :-

① LUNGS: a) CO_2 (200ml/min)
b) H_2O

② LIVER : a) cholesterol → Bilirubin
b) Bile pigments ↔ Biliverdin.
c) Steroid hormones
d) Vitamins & drugs

③ Skin :

Sweat
- NaCl
- urea
- amino acid
- Glucose

Sebaceous
- Sterol
- Hydrocarbon
- waxes

DISORDERS OF KIDNEY:-

1) Abnormal constituent in urine :
a) Proteinuria
↳ protein in urine

b) Glycosuria
↳ Glucose in urine

c) Uremia
↳ Excessive urea in urine

d) Ketonuria
↳ ketone bodies in urine

e) Bile pigments in urine
↳ Jaundice

f) Creatinine in urine
↳ Hyperthyroidism, Starvation.

2) Diabetes

2.) Diabetes
- Insipidus
  - ↳ deficiency of ADH
  - ↳ polyuria
  - polydypsia
- Mellitus
  - ↳ deficiency of Insulin
  - ↳ ↑ Glucose levels

3.) Renal Failure
- ↳ kidneys fail to function properly

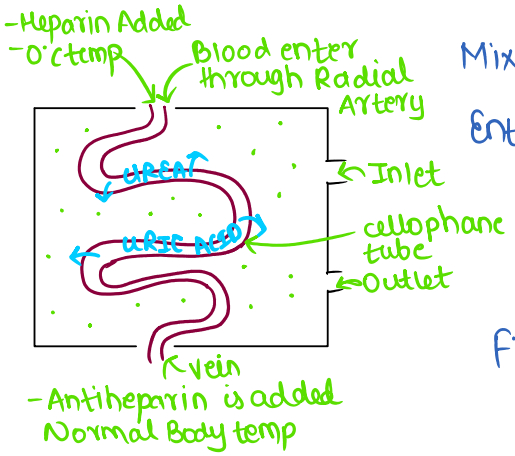
4.) Glomerulonephritis
- ↳ inflammation of Glomerulus

5.) Renal calculi
- ↳ kidney stones
  - uric acid
  - calcium oxalates.

6.) Hematuria
- ↳ Blood in urine.

Treatments :

① Hemodialysis : process to remove urea from blood.



Blood drained from artery
↓
Mixed with heparin
↓
Enters dialysing unit
- ↳ Artificial kidney
- ↳ It contain porous cellophane membrane surrounded by dialysing fluid [Plasma - urea]

↓
Filtration occurs inside chamber
↓
Clear Blood
↓
Addition of Anti Heparin
↓
Pumped back to body through vein.

② Kidney Transplant:

- Only method in correction of Renal failure
- Prefered Donors are chosen for transplant.

Identical twins > Siblings > Parents > Relatives > unknown.