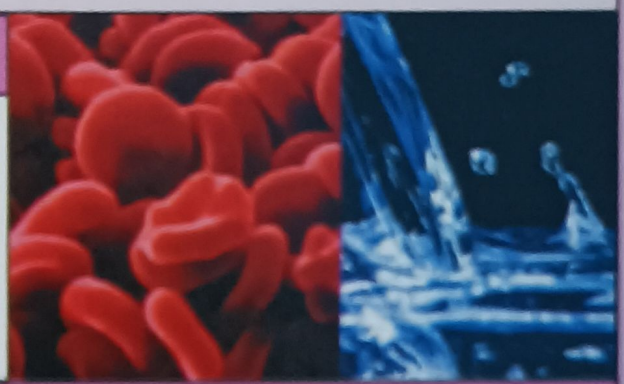
EXCRETORY PRODUCTS & ELIMINATION

EXCRETION

Elimination of nitrogenous waste (Ammonia/Urea/Uric acid)

OSMOREGULATION

Process to regulate the osmotic pressure of body fluids and electrolytic balance in organisms.



Ammonotelic

- Organisms which release ammonia as excretory products.
- Ammonia is the most toxic & requires large amount of water for excretion.
- Can be removed by diffusion (via skin/gills).

Eg.,- Bony fishes, aquatic amphibians & aquatic insects.

Ureotelic

- Organisms that release urea as excretory products.
- Less toxic, water is conserved.
- Some amount of urea may be retained in kidneys (osmoregulation).

Eg.,- Mammals, amphibians, marine fishes.

Uricotelic

- Organisms that release uric acid as excretory product
- In form of pallet/paste (min. loss of water)

Eg; Reptiles, Snails, Birds, insects.

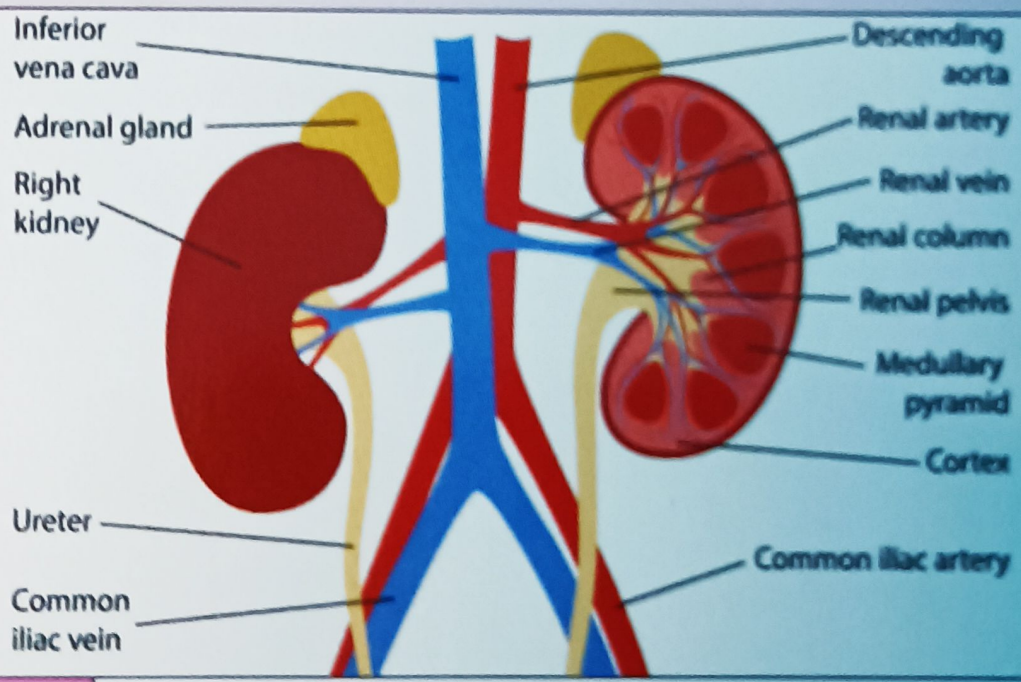
Note - In Ornithine cycle $CO_2 + NH_3$ are removed as waste

Excretory Organs	Organisms
Protonephridia / Flame cells	Platyhelminthes, rotifers, some annelids (eg - *Planaria*)
Nephridia	Annelids (eg - Earthworm)
Malphigian Tubules	Insects, cockroaches
Antennal glands/ Green glands	Crustaceans (prawns)

Human Excretory System

Kidneys (Pair)	Ureters (Pair)	Urinary Bladder	Urethra

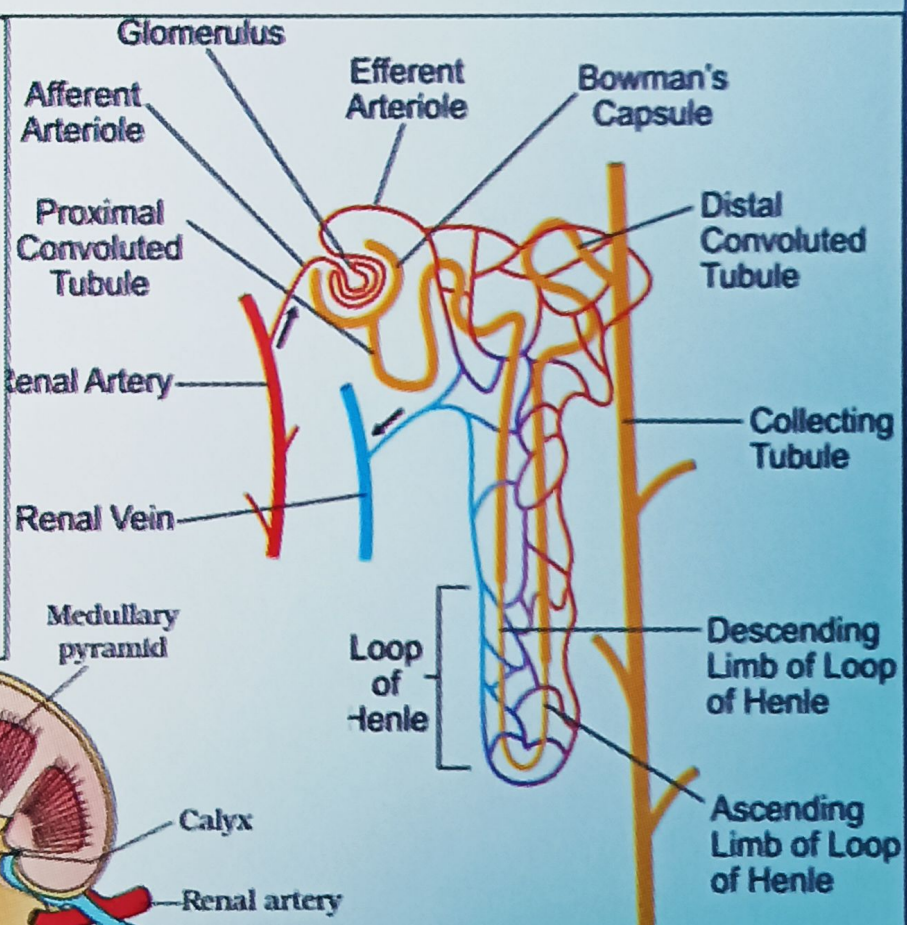
- Note - Kidneys filter 1100-1200 mL blood per min (1/5th of what is pumped by ventricles).



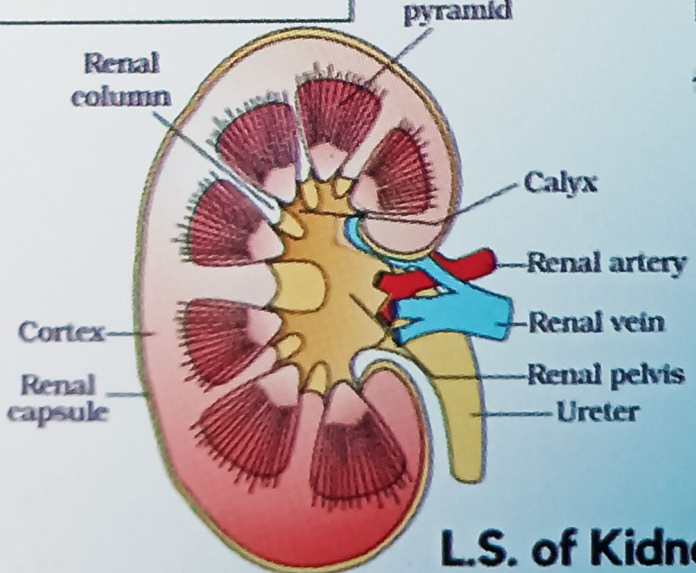
Kidneys	Reddish brown, bean shaped.
Size	10 - 12 cm (length) ,5 - 7 cm (width), 2 - 3 cm (thick)
Weigth	120 - 170 gm
Location	Level of last thoracic & 3rd lumbar vertebra; close to dorsal inner wall (abdomen).

Structure

- Hilum - Notch at concave side of kidney (Ureter, blood vessels enter)
- Calyces - projections in funnel shaped space(renal pelvis)
- Capsule - outer layer (tough)
- There are two zones in Kidney- Cortex and Medulla.
- Medulla is divided in medullary pyramids, projecting in calyces
- Column of Bertini - cortex extending b/w medullary pyramids
- Nephrons (structural & functional units) are 1 million per Kidney and consist of Glomerulus, Renal Tubule



Representation of a nephron



L.S. of Kidney

Glomerulus - Network of capillaries by afferent arteriole.

Bowman's Capsule-double walled cup enclosing glomerulus (Podocytes- by epithelial cells).

→ both forms Malphigian body / Renal Corpuscle

Proximal convoluted tubule (PCT) → Henle's Loop (Hairpin shaped) → Distal convoluted tubule (DCT) → conducting duct → renal pelvis

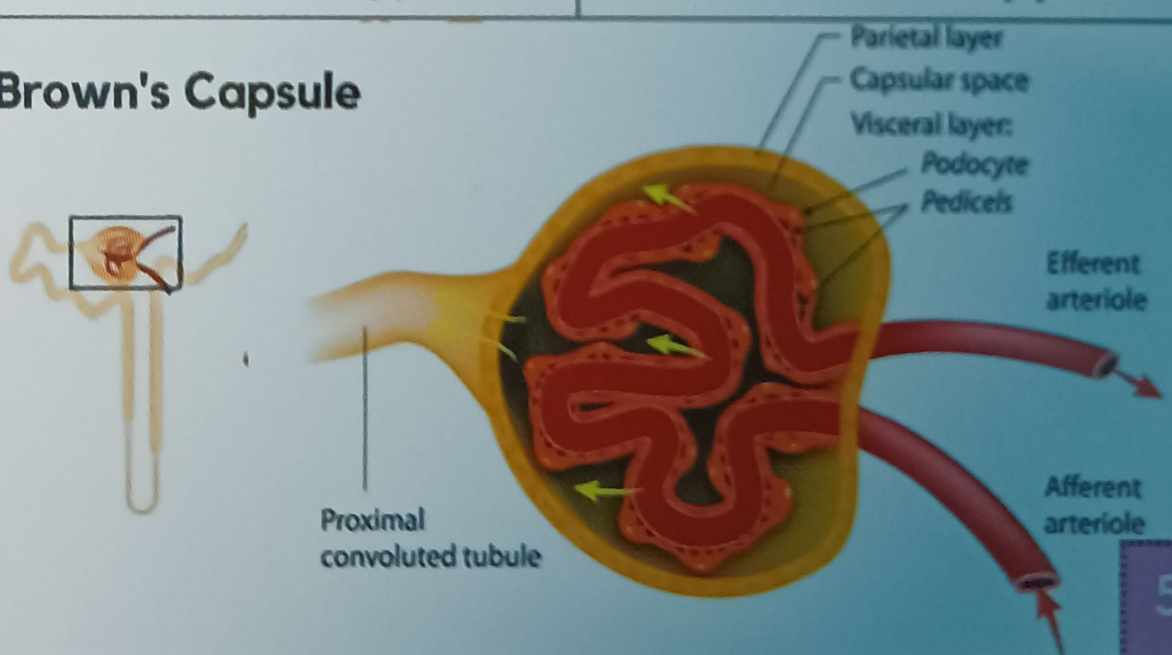
Henle's Loop (Hairpin shaped): descending limb, ascending limb

Medulla region

- PCT, DCT - cortical region

Cortical Nephrons	Juxta medullary nephrons
Henle's Loop- very short	Henle Loop - Long
Extends in very little medullary region	Runs deep into medulla
85% nephron	15% nephrons
Vasa recta (-)	Vasa recta (+)

Brown's Capsule



- Peritubular capillaries- Network of capillary made by efferent arteriole around renal tubule.
- Vasa recta-Vessel network running parallel to Henle's Loop

Urine Formation

Glomerular Filtration	Reabsorption	Secretion

(1) GLOMERULAR FILTRATION (or ULTRAFILTRATION)

- Blood pressure in glomerular capillary causes filtration.
- Filtration occurs by via 3 Layers
  -Endothelium (blood vessel)
  -Bowman's capsule (epithelium)
  -Basement membrane
- Glomerular/Nephric filtrate = Blood-(Blood cells + Plasma protein)
- Glomerular filtration rate (GFR)- Amount of filtrate formed by kidneys per min. ≈125mL/min or 180 L/day.

Note- In Bowman's capsule, podocytes arrangment forms slit pores.

Juxta Glomerular Apparatus (JGA)

- Cellular modification of DCT and afferent arteriole.
- Fall in GFR, activates JG cells (brings GFR back to normal)

(2) REABSOPRTION

- Substances filtered (Na, K, glucose, AA, bicarbonate, 75% water) are reabsorbed by renal tubules (PCT) actively.
- Some nitrogenous waste and water also reabsorbed passive.

(3) SECRETION

- Secretion of H^+ ,K^+ & ammonia into filtrate by tubular cells.
- Important for urine formation, maintaining acid-base ionic balance by fluids.

FUNCTIONS OF TUBULES -

PCT	Henle's Loop	DCT	Collecting Duct

Proximal convoluted tubule (PCT)

- Lined by brush border cuboidal epithelium (High surface area
- 70-80% reabsorption of H_2O & electrolytes
- Maintain pH, Ionic balance
- secretion of H^+, K^+ & NH^{+4} ions; absorption of HCO_3^- ions.

Henle's Loop

Ascending limb	Descending Limb
Reabsorption (v. Less)	Permeable to H_2O
Maintains osmolarity of medullary interstitial fluid	Impermeable to electrolytes
Impermeable to H_2O ,Permeable to electrolytes ,Dilutes filtrate	concentrates filtrate.

Distal convoluted tubule (DCT)

- Reabsorption of Na^+, H_2O, HCO^{3-}
- Secretion of H^+, K^+, NH_3,
- maintains pH & Na^+ - K^+ balance in blood

Collecting Duct

- extends from cortex to medulla
- forms concentrated urine (reabsorb H_2O)
- mainatain osmolarity, pH, Ionic balance
- selectively secretes H^+,K^+ ions

Counter Current Mechanism

Flow of filtrate in two limbs of Henle's Loop and blood in both Limbs of vasa recta in opposite direction.

- Osmolarity increases from cortex to medulla (300 mOsmol/L to 1200 mOsmol/L)
- due to NaCl & urea.
- Helps urine to get concentrated (4 times).

Regulation of Kidney Functiom

Hormonal feedback mechanism - Hypothalamus, JGA, heart

Loss of fluids from blood → stimulates hypothalamus → Activate ADH (Antidiuretic hormone) or Vasopressin → Helps reabsorption → increases body fluid volume

*Feedback mechanism suppresses ADH receptors

Renin - Angiotensin mechanism

(Falls in GFR) activates JG cells and Releases Renin

Angiotensinogen (Blood) → Renin → Angiotensin I → Angiotensin II

Angiotensin II → also activates adrenal cortex → Release aldosterone → reabsorbs Na^+ & H_2O from DCT → BP increases, GFR increases

Angiotensin II → Vasoconstriction → GFR increases

A check to the Renin-Angiotensin mechanism

High blood flow in atria → Atrail Natriuretic Factor (ANF) → Vasodilation → BP decreases

MICTURITION

- Process to release urine - Micturition
- Signals from CNS are received, in response to stretch receptors of walls of the urinary bladder; contracts smooth muscles; urethral sphincter relaxes.
- Average - 1-1.5 L/day urine.
- Acidic (pH-6) in nature, 25-30gm of urea per day

Presence of glucose in urine - Glycosuria
Presence of ketone bodies in urine - ketonuria → diabetes mellitus

Other organs

- Lungs- Remove CO_2 (200mL/min) and water
- Liver- Secrete bilirubin, biliverdin, cholesterol, steroid hormones, vitamins (released as digestive waste)
- Sweat glands - Sweat contains H_2O, NaCl, urea (small amount), lactic acid etc.
- Sebaceous glands - eliminates small amount of nitrogenous waste, Steroids, hydrocarbons

DISORDERS

- Uremia - Kidney malfunction due to urea accumulation.
- . Renal calculi - Stone/insoluble mass of crystallised salts (oxalates, etc) in kidney.
- Glomerulonephritis - Inflammation of glomeruli of kidney.
- Renal failure/Kidney failure

- Urea can be removed by hemodialysis (use of artificial kidney for clearing blood)
- Artificial kidney contains a cellophane tube that helps passing nitrogenous waste to dialysing fluid (same composition as plasma)
- Heparin is used as anticoagulant.