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Excretory products and their elimination Handwritten Notes

Human Physiology

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EXCRETORY PRODUCTS AND THEIR ELIMINA

Animals Accumulate →

Ammonia > Urea > Uric Acid

Toxicity.

CO_2, H_2O and ions like K^+, P^+, S, Cl^-, Na^+

Excretion of Ammonia → Ammonotelism

Ammonotelic → Bony fishes, aquatic amphibians and aquatic insects.

Ammonia → Readily Soluble, excreted by diffusion, by gills as ammonium ions.

→ No Role of Kidney in excretion

Excretion of Urea → Ureotelic

→ Mammals, Terrestial amphibians, marine fishes.

Ammonia → Urea (Liver) → Released into blood, filtered through Kidneys

Excretion of Uric Acid → Uricotelic

→ Reptiles, birds, land snails, insects.

→ In form of pellet/paste (Secreation) with minimum loss of water.

Excretory Structures

Invertebrates → Simple Tubular forms

Vertebrates → Complex tubular Organ (Kidney).

→ Protonephridia/ Flame Cells

- → Platyhelminthis (Flatworms, e.g. – Planaria)
- → Rotifers
- → Some annelids
- → Cephalochordate → Amphioxus.

Protonephridia → Ionic and fluid volume regulation (Osmoregulation)

→ Nephridia → (tubular excretory structure)

- → Annelids
- → e.g. – Earthworms.

→ Help to remove nitrogenous waste

→ Osmoregulation.

→ Malphigian Tubules →

Insects (Cockroaches)

→ Removal of Nitrogenous Waste

→ Osmoregulation

→ Antennal/ Green land →

→ Crustaceans (prawns)

Human Excretory System.

→ Pair of Kidneys

→ Pair of Ureters

→ A Urinary Bladder

→ A Urethra

Kidney

→ Bean Shaped, Reddish Brown

→ Location – Last thoracic and 3rd lumbur Vertebrea

→ Length → 10-12 cm

→ Width → 5-7 cm

→ Thickness → 2-3 cm

Wt. → 120-170 gram

→ Unit → Nephron

→ Each Kidney → 1 million Nephron

→ Inner concave surface

↓

Notch

↓

Hilum Centre of)

Blood Vessels, Nerves, Ureter

→ Renal Pelvis (Broad funnel Shape)
↓
Inner to hilum
↓
Projection c/a Calyces.

→ Outer layer - tough capsule.

→ 2 Zones → Outer → Cortex → b/w pyramids
↓
Inner → Column ← (Renal Columns) of Bertini
↓
Medulla
↓
Conical masses (Medullary pyramids)
↓
project into Calyces.

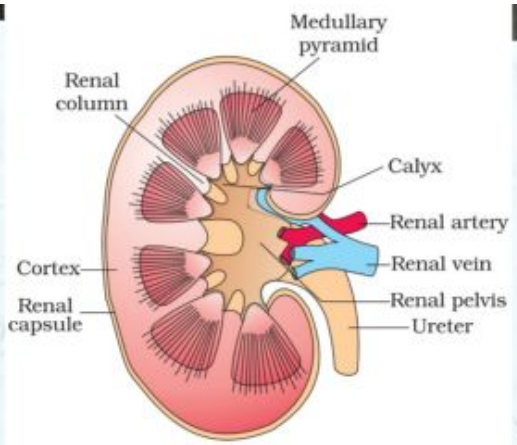
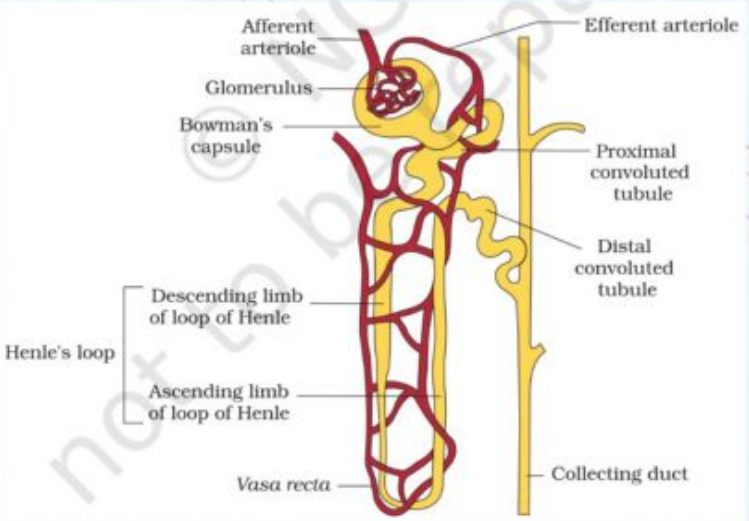


Figure 19.2 Longitudinal section (Diagrammatic) of Kidney

Nephrons → functional Unit of Kidney
→ 1 million
→ 2 parts
↓ → Renal Tubule
Glomerulus



Glomerulus → Tuft of capillaries
↓
afferent arteriole (fine branch of renal artery)
↓
Blood
↓
efferent artiole
↓
Peritubular capillaries around renal tubule.

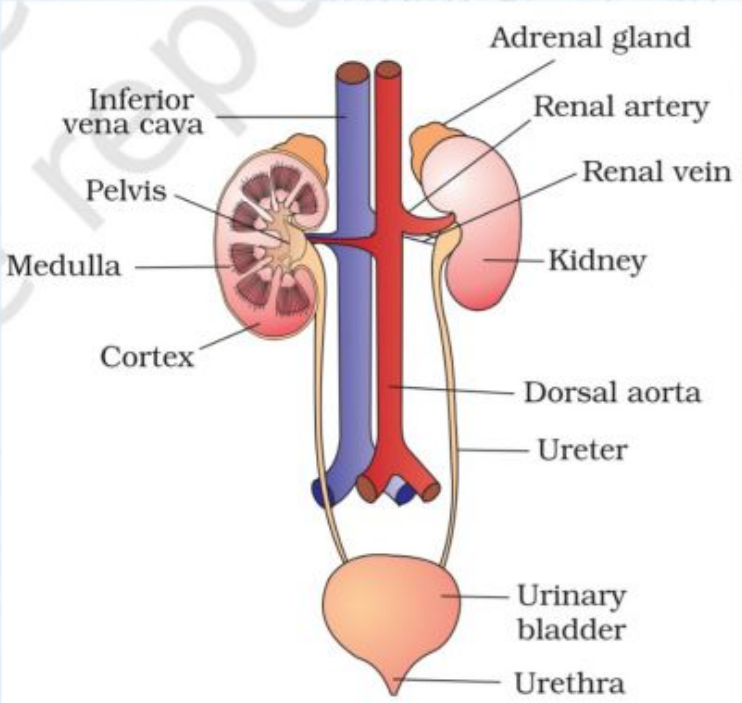


Figure 19.1 Human Urinary system

Renal Tubule → Bowman's Capsule (beginning)
↓
Cup like, Double Walled
↓
encloses glomerulus.

Bowman's Capsule + Glomerulus → Malphigian Body

Tubule Continues
↓
Proximal Convolated Tubule (highly coiled)
↓
Henle's loop (hair pin shaped)
(Medullary Region)

Henle's loop
↓ descending limb
↓ Ascending limb
↓
distal convolated tubule (highly coiled)
Cortical region
↓
collecting duct (straight tube)
↓
Medullary pyramids
↓
Renal Pelvis

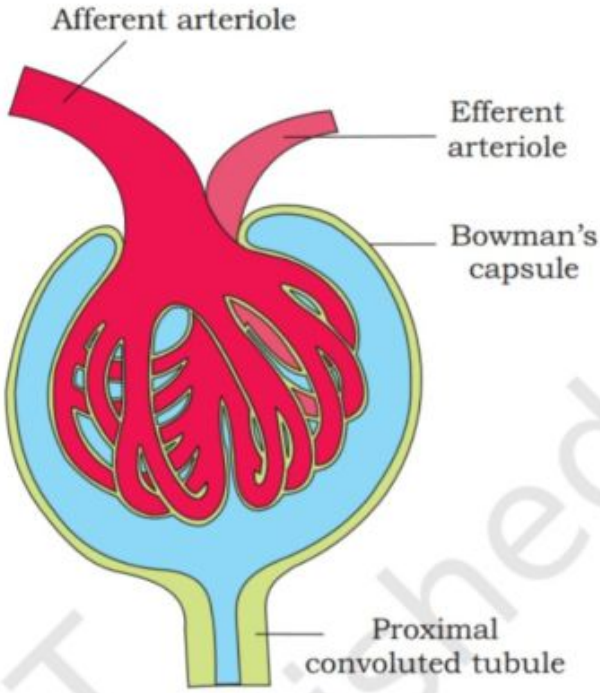


Figure 19.4 Malpighian body (renal corpuscle)

Excretion and Osmoregulation

Nephron → Collecting Duct → Renal papilla ↓ Renal Calyx (minor, major) ← Renal pelvis ← Ureter ↓ Urinary Bladder → Out

GHP = 60-65 mm Hg
COP = 30-32 mm Hg
CHP = 10-16 mm Hg

NET = GHP - COP - CHP
= 10-25 mm Hg

BP ∝ GHP

→ Renal Plasma flow (RPF)
↳ input.

→ GFR (Glomerular filteration Rate)
↳ Output.

3 layer Filteration
↓
Ultra filteration in Glomerulus

Urine formation

① Glomerular Filteration
→ Filteration of blood by glomerulus.
→ Rate 1100-1200 ml blood/min.

→ Glomerular Capillary Pressure ↑↑
↓
Filteration through 3 layers.

① Endothelium of glomerular blood vessels.

② Epithilium of Bowman's Capsule (c/a podocytes) → spaces (slit pores)

③ Basement membrane b/w these two.

→ All constituents of plasma, except proteins are pass onto the lumen of Bowman's Capsule.

→ c/a Ultra filteration.

→ Amt. of filterate formed/min.
= Glomerular filteration Rate (GFR)
= 125 ml/min = 180 lit/day

Juxtra Glomerular Apparatus.

→ Mech. to control GFR is carried out.

→ Cellular modification in DCT and afferent artiole at the location of their Contact.

→ GFR↓ → JG Cells activated (Renin)
↓
stimulates glomerular blood flow
↓
GFR back to normal

② Reabsorption

→ Filterate → 180 litre/day,
Urine released → 1.5 lit/day.

→ 99% filterate reabsorbed by renal tubules.

→ Glucose, amino acids, Na^+ etc. reabsorbed actively.

→ Nitrogenous waste reabsorbed by passive transport.

→ Water reabsorbed passively in initial segments.

③ Secretion

→ H^+, K^+ and ammonia released by tubular cells.

→ Helps in maintenance of Ionic and acid-base balance of body fluids.

Nephrons

Cortical Nephrons	Juxta Medullary.
85%	15%
Vasa Recta ✗	Vasa Recta ✓
P TC ✓ (Peritubular capillaries)	P TC not well developed ✗
Loop is confined to Cortex (v. short in medulla)	Loop is deep penetrating in Medulla

Functions of Tubules

① PCT (Proximal Convolated Tubule)

→ Reabsorption (Maxium)

→ all glucose, fatty acids, amino acid are reabsorbed.

→ all essential elements, 70-80% nutrients reabsorbed. (electrolytes)

→ Active Reabsorption → Consume energy

→ Passive Reabsorption → 60-65% water and Cl^- ions.

→ Simple Cuboidal Brush border epithilium.

DCT (Distal Convolated Tubule)

Conditional reabsorption of Na^+, Water, HCO_3^-.

Selective secreation of Hydrogen, pottasium ions, NH_3.

Maintain pH and Sodium pottasium balance.

Work Under influence of ADH, RAAS, aldosterone.

PCT → pH, Ionic balance maintain

Selective Secreation — H^+, NH_3, K

PCT	DCT
More MicroVilli	Less MicroVilli
More absorption	Less absorption
Max reabsorption	Less reabsorption

Filtrate — Glucose, Fatty acids, amino acids, H_2O, Ions.

Henle's Loop

Ascending limb

Reabsorption min

Maintainance of high osmolarity of medullary interstitial fluid.

Impermeable to Water.

Pereable to electrolytes

Dilute filterate

Descending limb

permeable to Water

Impermeable to electrolytes

Concentrate filterate.

Collecting Duct →

H_2O reabsorbed → Concentrated Urine.

Some amt. of Urea reabsorbed and maintain osmolarity of medullary interstitium.

pH, Ionic Balance maintain.

Secreation — H^+ and K^+ ions.

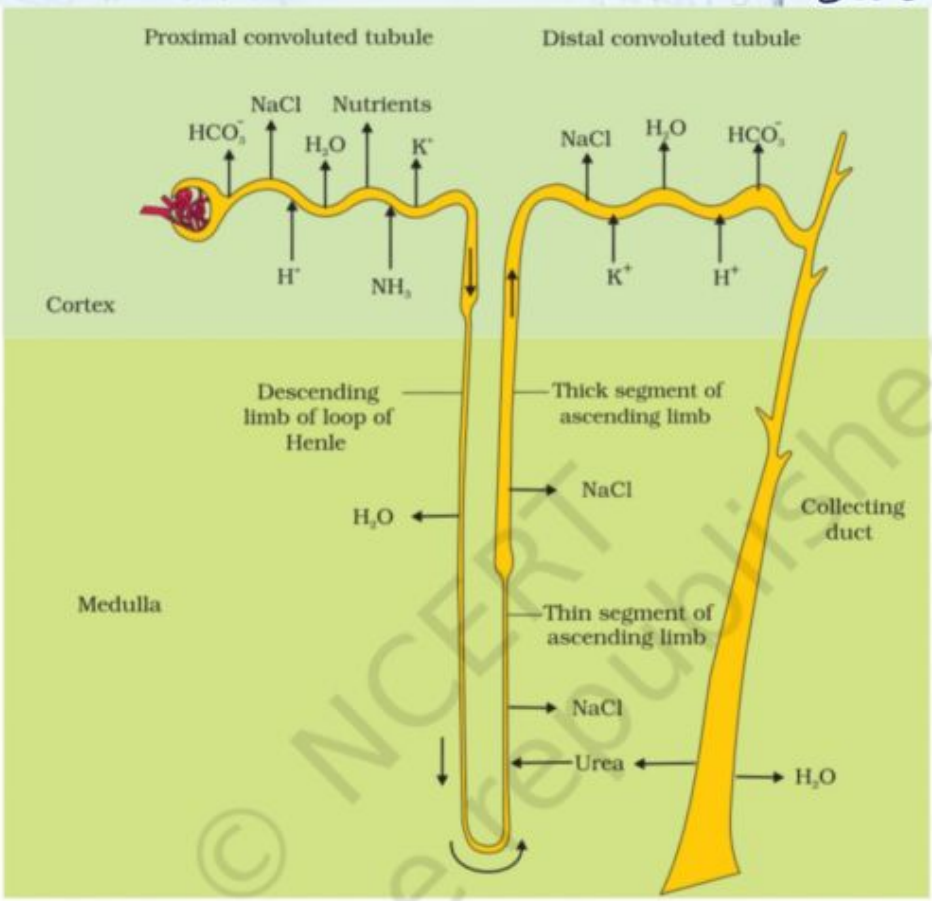


Figure 19.5 Reabsorption and secretion of major substances at different parts of the nephron (Arrows indicate direction of movement of materials.)

Counter Current Mechanism

Created as — flow of filtrate in 2 limbs of Henle's loop and Vasa recta is in opposite direction.

Helps in → Urine Concentration

Urine → 4 times more concentrated than initial filtrate.

Osmolarity (mOsmol/l)

Cortex	Medulla
300	1200

Gradient Caused by → NaCl, Urea.

Regulation of Kidney Functions →

By hormonal feedback mechanism involving → Hypothalamus, JGA, Heart (to certain extent).

→ Change in blood Volume, blood fluid Volume, Ionic Concentration, } activates osmoreceptors

→ excessive loss of fluids → activates receptors
↓
Stimulate hypothalamus
↓
Release ADH
↓
Facilates water reabsorption from latter parts of tubules and prevent diuresis.

→ Increase in body fluid Volume
↓
Switch off osmoreceptors
↓
Suppress ADH release.

→ ADH affect Kidney by constrictory effect on blood vessels.
↓
Blood pressure ↑↑
↓
Glomerular Blood flow ↑↑
↓
GFR ↑↑

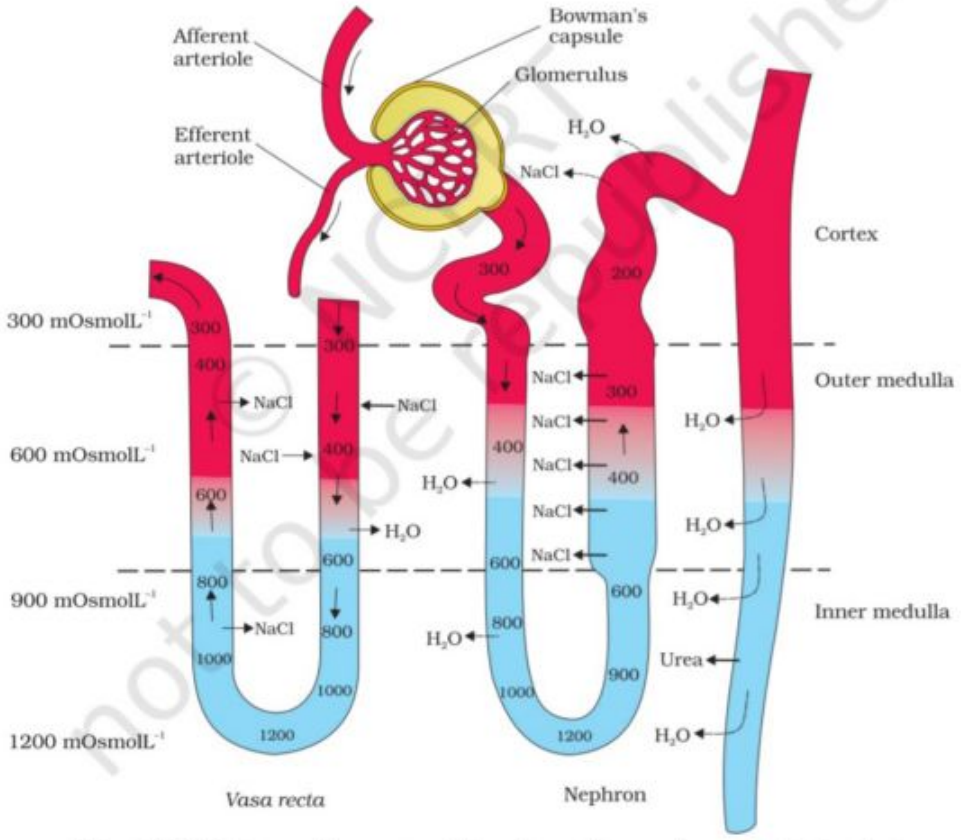


Figure 19.6 Diagrammatic representation of a nephron and *vasa recta* showing counter current mechanisms

→ ↓↓GFR / Glomerular Blood Flow
↓
activates JG Cells
↓
Release Renin
↓
Converts Angiotensinogen → Angiotensinogen I → Angiotensinogen II.
(powerful Vaso-constrictor)
↓
↑GFR and glomerular blood pressure.

→ Angiotensinogen II → activates adrenal Cortex → Release Aldosterone
↓
Causes reabsorption of Na^+ and water from DCT.
↓
↑ B.P / GFR.

→ This complex mech. is c/a Renin-Angiotensin Mechanism

→ ↑↑ is Blood flow to Atria
↓
Release of atrial natriuretic factor (ANF)
↓
Cause Vasodilation
↓
↓↓ Blood Pressure

→ ANF checks on Renin-Angiotensin Mechanism.

Micturation →

Urine formed by Nephron
↓
Carried to Urinary Bladder
↓
Stored till Volume Signal given by CNS.
↓
Due to stretching of Bladder, as it get filled with Urine
↓
Contract.ⁿ of Smooth Muscle.
↓
Relaxat.ⁿ of Urethral Sphincter
↓
Release of Urine.

→ process of Urine Release = Micturition reflex.
→ Neural mech. causing it = Micturation
→ Adult Human → 1-1.5 lit/day.

Urine →

→ Light Yellow Coloured, Watery fluid.
→ Slightly acidic (ph=6)
→ 2.5-3g Urea/day
→ presence of Glucose in Urine → Glcosuria.
→ Ketone Bodies → Ketonuria
Indicative of diabetes mellitus

Role Of Other Organs In Excretion →

Lungs, Liver, Skin.

① Lungs → Removes CO_2, (approx 200 ml/min) and water.

② Liver → Secreate bile containing substance (bilirubin, biliverdin, cholestrol, degraded steroid hormone, Vitamins, Drugs.

③ Sweat → Produce by Sweat glands.
↳ NaCl, Urea, Lactic Acid etc..
→ Primary function = Cooling Body

④ Sebaceous Glands → Sterols, Hydrocarbon and waxes through sebum

Disorders

① Uremia → Malfunctioning of Kidney leads to accumulation of Urea in Blood.
→ May lead to Kidney failure.
→ Urea can be removed using haemodialysis.
→ Kidney transplantation → Ultimate method in Correction of acute Renal failure.

Haemodialysis

Blood drained from Convenient artery
↓
Pumped into dialysing unit (Artificial Kidney)
↓
after adding anti-Coagulant (Heparin)
↓
Unit contains Cellophane tubes surrounded by dialysing fluid (have same composition of plasma except N_2-Wastes)
↓
Porous membrane of Cellophane tube allow passable of molecule based on conc. gradient.
↓
Blood Cleared
↓
Cleared blood pumped back to body through vein after adding anti-heparin.

This method is boon to 1000's of Uremic patients all over World.

② Renal Calculi
→ Stone / Insoluble mass of crystallised salts (oxolates etc.) formed within Kidney

③ Glomerulonephritis
Inflammation of Glomeruli of Kidney