EXCRETORY SYSTEM

SYNOPSIS:

- Elimination of nitrogenous metabolites and other waste products from the body is excretion.
- Regulation of concentration of water and metabolites in the body is osmoregulation.
- Homeostasis requires both excretion and osmoregulation.
- Ammonia, urea and uric acid are the major forms of nitrogenous wastes excreted by animals.
- Ammonotelism is the process of excreting ammonia. It requires more water. So it is the most common feature in aquatic species. E.g., sponges, coelenterates, many bony fishes.
- Ureotelism is the process of eliminating urea. As the water intake is limited terrestrial animals they are transformed into ureotelic.
- Ammonia formed in metabolism is converted into Urea in the liver of those animals and released into the blood which filter and excrete out by kidneys. E.g., amphibians, mammals and marine fishes.
- Sharks produce urea and retain it in their blood as a major osmolyte to balance the osmolarity of the body fluids with surrounding sea water medium.
- Ornithine cycle is known as urea cycle or Krebs-Hanseleit cycle. In this cycle Ornithine reacts with one molecule of NH_3 and CO_2 and gives Citrulline. It reacts with 2^{nd} molecule of ammonia and form Arginine. Arginase splits arginine into urea and ornithine.
- Uricotelism is the elimination of uric acid in the form of pellets with negligible loss of water.
- Uricotelism is shown by birds, reptiles, insects and land snails. Uric acid is less toxic.
- Humans generate uric acid as product of purine breakdown.

Excretory organs in different animals:

Type of excretory organ	Present in	Special features
1.Protonephridia	Platyhelminthes, rotifers, lancelets, some annelids	Mainly concerned with osmoregulation.
2.Metanephridia	Earthworms, annelids	Excretion & osmoregulation
3.Malpighian tubules	Insects, terrestrial arthropods like myriapods and arachnids	Osmoregulatory
4.antennal glands(green)	Crustaceans	Excretion
5.Kidneys	Vertebrates	Excretion and osmoregulation.

HUMAN EXCRETORY SYSTEM:

- It consists of a pair of kidneys, ureters, a urinary bladder and a urethra.
- Kidneys are reddish brown, bean-shaped organs present between the levels of last thoracic and third lumbar vertebrae. They are protected by eleventh and twelfth pairs of ribs.
- Kidneys are retroperitoneal organs as they are located posterior to the peritoneum of abdominal cavity.
- Kidney is covered by a tough renal capsule.
- Hilum is a notch present at centre of inner concave surface of kidney.
- Pelvis is a broad funnel shaped space from which ureter begins.
- Pelvis has projections known as calyces.
- Kidney is divided into outer cortex and inner medulla.
- Medulla is divided into conical medullary / renal pyramids which project into calyces.
- Columns of Bertini are projections of cortex among the renal pyramids.
- Each kidney has nearly 1 million tubular structures known as nephrons. They are functional units.
- Nephron has the glomerulus and renal tubule.
  RENAL ARTERY → AFFERENT ARTERIOLE → GLOMERULUS → EFFERENT ARTERIOLE → PERITUBULAR NET (around convoluted tubules) & VASA RECTA (around Loop of Henley) → RENAL VENULES → RENAL VEIN.
- Renal tubule begins with a double walled cup like Bowman's capsule with podocytes. It encloses the glomerulus.
- Bowman's capsule along with glomerulus is considered as Malpighian body/renal corpuscle.
- Other parts of renal tubule are
  a) Proximal convoluted tubule (PCT) b) Henle's loop with descending and ascending limbs
  c) Distal convoluted tubule (DCT)
- DCTs of nephrons open into a straight tube known as collecting duct. All the collecting ducts converge and open into renal pelvis through medullary pyramids in calyces.

TYPES OF NEPHRONS

Character	Cortical nephrons	Juxtamedullary nephrons
1.loop of Henle	Short	Long
2.extension of loop of Henle	Very little in medulla	Deep into the medulla
3.position of renal corpuscle	Outer margin of cortex	Near medulla but in cortex

TYPES OF EPITHELIA IN VARIOUS PARTS OF NEPHRON

Part of nephron	Type of epithelia
1.Bowman's capsule	Simple squamous (podocytes)
2.Proximal convoluted tubule	Simple cuboidal with brush border of microvilli
3.descending limb & thin part of ascending limb	Simple squamous
4. thick part of ascending limb	Simple cuboidal
5.distal convoluted tubule	Small cuboidal cells
6.terminal part of DCT & collecting duct	a)principal cells – more number with receptors for antidiuretic hormone and aldosterone. b) Intercalated cells – less number. Role in the homeostasis of blood pH.

- Urinary bladder is present in pelvic cavity posterior to the pubic symphysis.

URINE FORMATION:

Urine formation occurs in three stages.... glomerular filtration, selective reabsorption and tubular secretion.

- A) Glomerular filtration: i) it is the movement of water and most solutes of blood plasma across the wall of blood capillaries into lumen of Bowman's capsule.

  ii) Filtration membrane consist podocytes of capsule and endothelium of capillaries.

  iii) Glomerular blood hydrostatic pressure (GBHP) is the blood pressure in glomerular capillaries. It is about 60 mm Hg.

  iv) It is opposed by Capsular Hydrostatic pressure (CHP) and Blood colloid osmotic pressure (BCOP). CHP is about 18 mm Hg while BCOP is about 32 mm Hg. (Total of 50mm Hg)

  v) Net Filtration Pressure is 60 – (18 + 32) = 10 mm Hg.

  vi) Filtration occurs in glomerulus because of NFP which results in the collection of glomerular filtrate or primary urine in capsule.

  vii) The nature of glomerular filtrate is hypotonic to interstitial fluid.

- B)selective reabsorption/tubular reabsorption :

When the glomerular filtrate/primary urine passes through renal tubule, water and different materials of filtrate reabsorb at various places in the following manner:

Part of nephron	Selective reabsorption(tubular)		Tubular secretion	Nature of urine
	Water	Others		
1.Proximal convoulted Tubule	67%(obligatory Reabsorption)	Na^+ , Cl^{--},	H^+, organic acids, bases,	Isotonic
2. Descending limb of Loop of Henle	15 % (obligatory Reabsorption)	Na, Cl,	Urea	Isotonic to medullary fluid
3.Ascending limb of Loop of Henle	---------	Ions	H^+	Hypotonic
4.Distal convoluted tubule	9% (facultative)	Na,K, bicarbonates	H^+	Isotonic
5. Collecting duct	10% (facultative	Urea,Na	H^+	Isotonic to medullary fluid and hypertonic to blood

CONDITIONS WHICH HELP IN THE FORMATION OF HYPERTONIC URINE :

- Mammals are able to produce concentrated urine.
- Counter current mechanism helps in this production of concentrated urine.
- Flow of filtrate in both descending and ascending limbs of Henle's loop is in opposite directions which are considered as counter current flow.
- Flow of blood through both limbs of vasa recta is also in opposite directions.
- Counter current flow increases osmolarity towards hair pin bend by adding NaCl and urea.
- Counter current mechanism maintains a concentration gradient in the medullary interstitial fluid which helps easy entry of water from the collecting tubule and thus results the formation of concentrated filtrate/urine.

REGULATION OF KIDNEY FUNCTION:

- Hormonal feed back which involves hypothalamus, Juxta Glomerular Apparatus and heart regulates the functioning of kidney.
- Osmoreceptors of hypothalamus are activated due to any excess loss of fluid and initiates the releasing of antidiuretic hormone/vasopressin from neurohypophysis.
- ADH facilitates reabsorption of water from tubule and prevents dieresis.
- ADH increases blood pressure which increases glomerular filtration rate.

- Juxta Glomerular Apparatus has a complex regulatory role. GFR activates the JG cells to release rennin which converts anagiotensinogen in blood to angiotensis I and further to angiotenisn II.
- Angiotensin II increases the GFR. It activates adrenal cortex to release aldosterone. It helps in the reabsorption of Na and water from distal parts of tubule.
- An increase in blood pressure stimulates heart to secrete Atrial natriuretic factor (ATF) which causes vasodilation and decreases the blood pressure.
- Micturition is the releasing of urine to outside.
- Urine is first carried to urinary bladder and stored there till CNS sends voluntary signal.
- CNS motor messages initiate the contraction of muscles of urinary bladder and relaxation of urethral sphincter and causes the release of urine.
- An adult human excretes 1-1.5 litres of urine per day..
- Urine is light yellow fluid with the pH of 6.0 (slightly acidic).
- Presence of glucose in urine indicates the occurence of diabetes mellitus.
- Lungs eliminate large amounts of CO_2 and water.
- Liver prepares bile substances like bilirubin, bileviridin etc., and release them out along with digestive wastes.
- Sweat glands and sebaceous glands of skin eliminate some substances.
- Sebaceous glands eliminate sterols, hydrocarbons and waxes through sebum. It provides a protective oily covering for skin.

HAEMODIALYSIS:

- Malfunctioning of kidneys leads to accumulation urea in blood which is known as uraemia
- Excess urea can be removed by haemodialysis. Blood from artery is pumped into a dialysing unit after adding an anticoagulant like heparin.
- Unit consists of a coiled cellophane tube surrounded by a dialysing fluid with same concentration like that of plasma without the nitrogenous wastes.
- Porous cellophane membrane allows passage f molecules based on concentration gradient.
- As nitrogenous wastes are absent in dialysing fluid, these substances freely move out and clear the blood and pumped back to body through vein.
- Transplantation of kidney is the ultimate solution to renal failures.
- Inflammation of glomeruli is known as glomerulonephritis.