Revision Notes on Excretory Products and their Elimination

Excretion is the process by which waste products of metabolism and other non-useful materials are eliminated from an organism

Excretory organs of different organisms

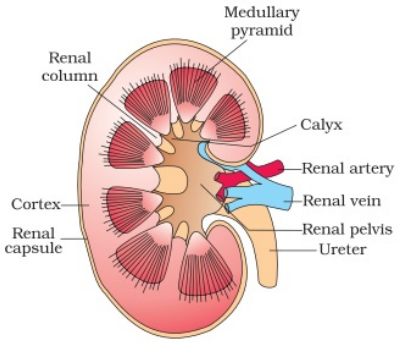
No.	Phylum	Excretory/osmoregulatory Organ/Organelle and principal N_2-waste	Function	Example
I. Invertebrates				
(1)	Protozoa	Contractile vacuole Ammonia	Ammonotelic Osmoregulatory	Amoeba Paramecium
(2)	Porifera	General surface of body	Ammonotelic	Sycon, Leucon
(3)	Coelenterata	Ammonia, General surface of body	Ammonotelic	Hydra
(4)	Platyhelminthis	flame cells (=Solenocytes) form the protonephridial system	Ammonotelic	Taenia, fasciola
(5)	Nematoda	H-shaped excretory organ, Renette cells	Ammonotelic	Ascaris
(6)	Annelida	Nephridial system, (Metameric), various types	Ammonotelic	Pheretima
(7)	**Arthropoda**			
a.	Class-Insecta	Malpighian tubule (Uric acid)	Uricotelic	Periplaneta
b.	Class crustacea	Antennary (=green) gland Uric acid	Uricotelic	Palaemon
c.	Class Arachnida	Coxal glands Malpighian tubule Hepato pancreas Nephrocytes	Uricotelic	Spider
(8)	Mollusca	(a) Kidney (=organ of Bojanus) or Renal organ (b) Keber's organ Aquatic forms excrete Ammonia Terrestrial forms Excrete uric acid	Ammonotelic Uricotelic	Pila Pulmonate Mollusc Limax
(9)	Echinodermata	Dermal branchiae (primitive gills) tube feet,	Ammonotelic	Cucumaria

		body surface (Ammonia)		Asterias

Excretory system of man

Mammalian (human) urinary system consists of a pair of kidneys, a pair of ureter, a urinary bladder and a urethra.

(i) Kidneys : The kidneys are dark-red, bean-shaped organs about 11 *cm* long, 5 *cm* wide and 3 *cm* thick, each weight about 150 *gm* in an adult male and about 135 *gm* in adult female.



Differences between cortical and Juxtamedullary nephrons

Cortical Nephrons	Juxtamedullary Nephron
1. Form 80% of total nephrons.	1. Form only 20% of total nephrons.
2. Are small in size.	2. Are large in size.
3. Lie mainly in the renal cortex.	3. Have Bowman's capsules in the cortex near its junction with the medulla.
4. Henle's loops are very short and extend only a little into the medulla	4. Henle's loop are very long and extend deep into the medulla.
5. Control plasma volume when water supply is normal.	5. Control plasma volume when water supply is short.

(ii) **Ureters:** From the hilum of each kidney emerges a whitish tube the ureter. The ureters are about 28 *cm* long. Their wall consists of transitional epithelium surrounded by a layer of muscle fibres. Openings of the two ureters in the bladder are separate, but closely placed. These are oblique, so that the urine cannot regurgitate into the ureters when the bladder contracts. Peristalsis of ureters also cheeks regurgitation of urine.

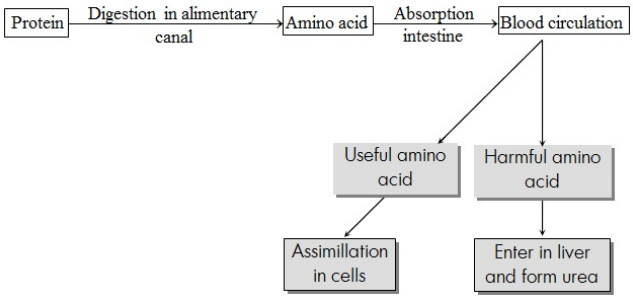
(iii) **Urinary bladder and Urethra:** The urinary bladder is pear-shaped which is made up of smooth and involuntary muscles. The muscles are also known as detrusor muscles (muscles that has the action of expelling a substance). The lower part or neck of the bladder leads into the urethra.

Differences between male and female urethra

Male urethra	Female urethra
1. It is about 20 cm long.	1. It is just 3 – 5 cm long.
2. It has 3 regions : prostatic urethra (3–4 cm), membranous (1 cm) and penial (15 cm)	2. It is not differentiated into regions.
3. It opens out at the tip of the penis by urinogenital aperture.	3. It opens into the vulva by urinary aperture.
4. It carries urine as well as semen to the exterior.	4. It carries only urine to the exterior.
5. It has 2 sphincters.	5. It has a single sphincter.

Physiology of Excretion

Major nitrogenous excretory substance in frog, rabbit and human is urea, i.e. these are ureotelic animals. The excretory physiology in these animals may be considered under two phases, viz urea synthesis and formation and excretion of urine.



(i) **Synthesis of urea in liver:** Urea is formed in liver by two processes.

(a) Deamination

(b) Ornithine cycle

(ii) **Urine formation:** Urine formation occurs in the kidneys. It involves three processes glomerular filtration, reabsorption and tubular secretion.

(iii) **Mechanism of urine concentration (Counter current mechanism of urine concentration) :** Mammals form hypertonic urine. The urine is made hypertonic with the help of counter current multiplier system. This process takes place in the Henle's loop and vasa recta and it involves mainly Na^+ and Cl^-. In P.C.T. urine is isotonic. The descending limb of loop of Henle is permeable to water. Its surrounding tissue fluid is hypertonic. Hence, the water moves out and the Na^+ and Cl^- move in the descending limb by passive transport. Therefore, the filtrate in the descending limb finally becomes hypertonic.

Summary of events occurring in a nephron

Materials transferred	Nephron region	Process involved	Mechanism
1. Glucose, Amino acids, Vitamins, Hormones, Na^+, K^+, Mg^{2+}, Ca^{+2}, H_2O, Urea, Uric Acid, Creatinine, Ketone Bodies.	Bowman's capsule	Glomerular filtration	Ultrafiltration
2. Glucose, Amino Acids, Hormones, Vitamins, Na^+, K^+, Mg^{2+}, Ca^{+2}	Proximal convoluted tubule	Reabsorption	Active transport
3. Cl^-	Proximal convoluted tubule	Reabsorption	Passive transport
4. Water	Proximal convoluted tubule	Reabsorption	Osmosis
5. Urea	Proximal convoluted tubule	Reabsorption	Diffusion
6. H_2O	Narrow region of descending limb of Henle's loop	Reabsorption	Omosis
7. Na^+,K^+,Mg^{+2},Ca^{+2},Cl^-	Narrow region of ascending limb of Henle's loop	Reabsorption	Diffusion
8.Inorganic ions as above	Wide part of ascending limb of Henle's loop	Reabsorption	Active transport
9.H_2O	Distal convoluted tubule.	Reabsorption with	Osmosis

	collecting tubule, collecting duct	ADH Help	
10. Na^+	Distal convoluted tubule, collecting tubule, collecting duct	Reabsorption with aldosterone help reabsorption secretion	Active transport
11. Urea	Last part of collecting duct	Reabsorption with aldosterone help reabsorption secretion	Diffusion
12. Creatinine, Hippuric Acid, Foreign substances	Proximal convoluted tubule	Reabsorption with aldosterone help reabsorption secretion	Active transport
13. K^+, H^+	Distal convoluted tubule	Reabsorption with aldosterone help reabsorption secretion	Active transport
14. NH_3	Distal convoluted tubule	Reabsorption with aldosterone help reabsorption secretion	Diffusion
15. Urea	Ascending limb of Henle's loop (Thin part)	Reabsorption with aldosterone help reabsorption secretion	Diffusion

Urine constituents in man (in %)

1.	Water	96%
2.	Urea	2%
3.	Uric acid	0.2%
4.	NH_3	0.25%
5.	Creatinine	0.5%
6.	Hippuric acid	0.025%
7.	Salt	1 %

Differences between Rennin and Renin

S.No.	Rennin	Renin
1.	It is secreted by peptic (zymogen) cells of gastric glands into the stomach.	It is secreted by specialised cells in the afferent arterioles of the kidney cortex.
2.	Its secretion is stimulated by food.	Its secretion is stimulated by a reduction of Na^+ level in tissue fluid
3.	It is secreted as an inactive form prorennin which is activated to rennin by *HCl*.	It is secreted as renin.
4.	It is a proteolytic enzyme.	It is a hormone that acts as an enzyme
5.	It helps in the digestion of milk protein casein.	It converts the protein angiotensinogen into angiotensin.

(i) Waste products of protein metabolism

(a) **Amino acids:** These are end products of protein digestion absorbed into the blood from small

intestine. Certain invertebrates, like some molluscs (*eg Unio, Limnae, etc.*) and some echinoderms (*eg* Asterias) excrete excess amino acids as such. This is called aminotelic excretion or aminotelism.

(b) **Ammonia:** In most animals, excess amino acids are deaminated, i.e. degraded into their keto and ammonia groups. The keto groups are used in catabolism for producing ATP, whereas ammonia is excreted as such or in other forms.

(c) **Urea:** This is less toxic and less soluble in water than ammonia. Hence, it can stay for some time in the body.

(d) **Uric acid:** Animals living in dry (arid) conditions, such as land gastropods, most insects, land reptiles (snakes and lizards), birds *etc* have to conserve water in their bodies.

(f) **Guanine:** Spiders typically excrete their ammonia in the form of guanine. Some guanine is also formed in amphibians, reptiles, birds and earthworms. It is insoluble in water. Hence, no water is required for its excretion.

Differences between ammonotelism, ureotelism and uricotelism

S.No.	Ammonotelism	Ureotelism	Uricotelism
1.	Means excretion of nitrogenous waste mainly as ammonia.	Means excretion of nitrogenous waste mainly as urea.	Means excretion of nitrogenous waste mainly as uric acid.
2.	Uses very little energy in forming ammonia.	Uses more energy in producing urea.	Uses far more energy in producing uric acid.
3.	Its product is very toxic.	Its product is less toxic.	Its product is least toxic.
4.	Causes considerable loss of body's water.	Causes less loss of body's water.	Causes least loss of body's water
5.	Occurs in aquatic animals.	Occurs in aquatic as well as land animals.	Occurs in land animals.
6.	Examples: *Amoeba, Scypha, Hydra, Earthworm, Unio, Prawn, Salamander, Tadpole or frog, bonyfish*.	Examples: Earthworm, Cartilaginous fishes, frog, turtles, alligators, mammals (man).	Examples: Insects, land crustaceans, land snails, land reptiles birds.
7.	Animals excreting NH_3 are called ammoniotelic.	Animals excreting urea are termed uroetelic.	Animals excreting uric acid are called uricotelic.