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SUCCESSION OF KIDNEY IN DIFFERENT VERTEBRATE GROUPS

Q.What is the basis of succession of kidney in different vertebrate groups?

From fishes to humans basic architectural pattern of kidney is same. (i) Marine fishes and tetrapods conserve water and freshwater vertebrate used to get rid of it by evolving some special modifications, (ii)Urinary organs assist in saving or excreting blood borne solutes,

Q.State the osmoregulatory role of kidney. /Q.Define osmoregulation./ Q.'Kidney maintain appropriate concentration of water and salt in body tissues'— Justify/ Q.Describe succession of kidney in respect of osmoregulation.

Vertebrate life began in water and the early stages of the evolution of kidneys took place in that medium. When vertebrate kidneys subjected to changing environments during geologic time, they were adaptable for life in salt water, in freshwater, on land and even in a desert.

Type of organism	Features
Fishes submerged in fresh water	i)Inevitably acquire water by absorbing it through the *gills, oropharyngeal membranes** or *skin* and by un avoidable swallowing it with their food. ii)For the maintenance of osmotic state it is essential that freshwater organisms excrete water and conserve salts.
Fishes submerged in salt water	i)Instead accumulating too much water, they are in danger of accumulating too much salt. ii)They evolved survival strategy in respect of conservation of water and excretion of salt.
Land vertebrates	Area of concern: Dehydration.
Tetrapods kidney	Has an additional role, the elimination of nitrogenous wastes, which are the product of the metabolic breakdown of proteins.
The major role of kidney is ***osmoregulation****, the maintenance of a ratio between the quantity of salt and water in the body fluids such that the organism can survive in its natural habitat, whether it be in winter or on land.* Kidneys maintain appropriate concentrations of water and salt in body tissues by eliminating any excess water, by preventing the escape of water when necessary and by regulating the excretion of certain salts.	

***Oropharyngeal membrane**: A transient ectodermal membrane formed in embryos where the anterior aspect of the primitive gut contacts the abdominal wall, separating the depression of the stomadeum from the primitive pharynx.

Q.Mention the basic pattern of kidney ./ Q.What do you mean by Archinephros.

Vertebrate kidneys are built in accordance with a basic architectural pattern consisting **of glomeruli, renal tubules** and a pair of **longitudinal excretory ducts.**

1.**Glomeruli—**

i)Tufts of microscopic capillary like arterial loop, or retia mirabilia on the pathway of an arteriole where water, ions, metabolic waste products and certain other constituents are removed from the blood-stream.

Q.What is an external glomerulus. Give suitable example

ii)The most primitive glomeruli are suspended in the coelom surrounded by peritoneum. They discharge their filtrate into the coelomic fluid, which is then swept into a peritoneal funnel or **nephrostome**, leading to a tubule **(EXTERNAL GLOMERULI).**

In today's vertebrates, external glomeruli are confined to **embryos and larvae.**

iii)Glomeruli in adults are embedded within the dorsal body wall **(Q.Why glomeruli in adult known as retroperitoneal?)** and ensheathed by **Bowman's capsule.**

iv)Maintaining blood pressure –Supplying a glomerulus is a an afferent glomerular arteriole and emrging from the glomerulus is an efferent Glomerular arteriole of lesser diameter. This has the effect of increasing the blood pressure within the glomerulus.

In Agnatha- The afferent arterioles are supplied directly from the dorsal aorta by segmental arteries. They alone lack peritubular capillaries, but as compensation, the longitudinal kidney ducts are surrounded bu usually rich capillary beds that take their place functionally.

In Gnathostomes- They are terminal branches of renal arteries.

v)Efferent Glomerular arterioles supply **peritubular capillaries** along with blood from the renal portal system (Figure 3 and 4).

In Placental mammals- Efferent Glomerular arterioles are the sole source of blood in the peritubular capillaries, since *a renal portal system is lacking*.

vi)In terrestrial reptiles and anurans (habitat- arid environment) have very small glomeruli or none at all, a water conservation adaptation.

v)Endocrine role in tetrapods—Dehydration is the principal stimulus for release of pituitary hormones that induce water reabsorption from Glomerular filtrate in tetrapods. *These same hormones induce reabsorption of water from amphibian and reptilian urinary bladders, when necessary.*

2. Bowman's capsule—

i)A delicate double walled outgrowth from a kidney tubule.

ii)Its inner wall adheres to the surfaces of the vascular loops.

iii)The capsular cavity collects the Glomerular filtrate, which then passes into a renal tubule. These are **INTERNAL GLOMERULI (Q.What do you mean by internal glomeruli? Give suitable example).**

3.**Renal corpuscle—**

i)A glomerulus and the surrounding capsule constitute a renal capsule.

ii)A renal capsle, renal tubule and the associated peritubular capillaries **constitute a nephron.**

iii)Some specialized form—

Organism	Specialization in renal corpuscle
Marine teleosts	Poorly vascularised renal corpuscles , cystic or vestigial.
In others	i)The distal segment of their tubules is abbreviated or lost. Loss of glomeruli, the major site of water removal, results in increased water retention.
Freshwater teleost	Water excretion is chiefly tubular and these fresh water fishes seem to compensate for any salt deficiency by active uptake of salt via the gills. *There is reason to believe that these are former saltwater species that were seasonally migratory into freshwater streams* (anadromous) and eventuallybecame fully adapted to freshwater habitat.
Elasmobranch	i)They are exceptional. They have unusually **large glomeruli**, and they also have tubule that are unsually long for a fish. ii)Those living permanently in salt water produce very small amounts of highly concentrated urine in any unit of time, thereby conserving water. Iii0**Rectal glands-** they also have these glands that secrete large amounts of chlorides into the caudal end of the intestine. iii)The total effect of the activity of their glomeruli, tubules, gills and rectal gland is to enable, sharks to maintain their body fluids in an osmotic state that assures their survival, *whether in freshwater or in the sea.*

4.Renal tubules-

i)Differentiate from a ribbon of embryonic **nephrogenic(intermediate) mesoderm** that lies lateral to the mesodermal smites and extends the length of the embryonic trunk from immediately behind the head to the cloaca.

ii)The earliest tubules appear at the anterior end of the ribbon and additional tubules are added as the embryonic trunk elongates(Figure 5).

iii)Adult kidneys remain retroperitoneal throughout life, although in mammals they bulge into the roof of the coelom.

iv)Several renal tubules empty (*exception-primitive metanephric kidneys*) into a single common collecting tubule and this in turn, empties into one of the two longitudinalkidney ducts (Figure 6).

The longitudinal duct collects fluid from all the common collecting tubules ans empties into the cloaca or a derivative thereof.

v)Complexity of renal tubules-

Increases among the vertebrate classes, exhibiting increasing degrees of histologic and functional specialization along the course of the tubule.

They are short and straight in **Agnathans**, longest and with the greatest regional specialization in mammals. (Figure 1 and 3)

vi)Several of most anterior kidney tubules of some adult **fishes and many tetrapod embryos** and larvae have **nephrostome** (Figure 1a, b) and vestigial nephrostomeslacking a lumen are often found in avian and mammalian embryos.

Nephrostomes in every body segment of marine annelids gather coelomic fluid for subsequent excretion.

Q.What do you mean by archinephros?

Nephrostomes may be vestiges of the kidneys of a postulated ancestral protochordate in which there may have been one external glomerulus, one nephrostomeand one unonvoluted tubule in each body segment along the entire length of the coelom. This hypothetical ancestral kidney has been termed an **archinephros** (Figure 7)

Q.Is there any resemblance of archinephros? Give suitable example.

The nearest approach of archinephros type of kidney in living vertebrates seen in larval hagfishes, in which a transient series of segmental external glomeruli, nephrostomes and tubules is formed throughout much of the extent of the nephrogenic mesoderm (Figure 1a). However at this stage of body elongation the kidney is still elongating.

Q.What are the holonephros type of kidney?

Segmental tubules with closed nephrostomes and renal corpuscles develop farther caudad. This transient larval hagfish kidney has been termed a **holonephros**. The adult hagfish kidney is a mesonephros.

Q.What are the major processes of urine formation?

Three major processes are at work in urine formation- *Glomerular filtration, tubular reabsorption and tubular secretion.*

Q.State the functional significance of glomeruli and tubules.

Functional significance of glomerulus:

1.Because of elevated blood pressure within the glomerulus resulting partly from the smaller size of the different glomerular arteriole, water, certain salts, glucose and other solutes in the blood plasma are filtered into the space between the outer and inner wall of bowman's capsule.

2.Some constituent of the glomerular filtrate may not be expendables and those are selectively reabsorbed during passage through specific segments of the tubule. As a result the composition of the filtrate becomes altered in the passage.

3.All the glucose for example is ordinarily reabsorbed. It is the sole immediately available circulating source of energy it is not readily acquired and it is not ordinarily in excess in the bloodstream because once acquired is quickly stored in the liver, water and certain salts may or may not be in excess depending on the environment. 4.When in excess water is allowed to pass through the length of the tubules and to enter the kidney ducts without having been reabsorbed. Under conditions that tend to lead to dehydration water is reabsorbed from segments of the tubule. Certain salts also are selectively reabsorbed when appropriate.

5.Tubular secretion removed from the circulation useless or harmful substances that were not removed by filtration. Among these are for instance wastes from protein breakdown (nitrogen is wastes) in tetrapods. (Nitrogenous wastes, Sodium ion and chloride ion in most fishes are eliminated by external means).

6.In marine fishes in salts (Mg^{++}, Ca^{++}, SO^{-}_{4}, phosphate) are tubular secretions, glomerular filtration being low. Glomerular filtration, tubular reabsorption and tubular secretion produce the final excretion, urine, which varies in the amount of water salt and other constituents depending on the environment and the species the constituents of urine may vary in a single organism from hour to hour if not from minute to minute.

7.By varying the length of the kidney tubules, either salt or water, as necessary can be recovered from the glomerular filtrate or salt can be expected abundantly. In general, glomeruli are larger in freshwater fishes and aquatic amphibians and smaller in marine fishes and report specially tetrapods living in arid environment.