Urinogenital system in vertebrates

Urinary system in vertebrates consist of kidneys and their ducts while reproductive system consists of male and female gonads and their ducts.

However, these two systems are connected in make vertebrates. It is because male urinary ducts are also used to discharge gametes. Thus, these two systems are together described as Urinogenital system.

Origin and basic structure of vertebrate kidneys and ducts

Vertebrate kidney is a paired organ. It has a basic structural and functional unit called as uriniferous tubules or nephrons.

These tubules arise in the embryo in a linear series from a part of mesoderm called as mesomere or nephrotome. It is ribbon like intermediate mesoderm that runs between segmental mesoderm (epimere) and lateral plate mesoderm (hypomere) on either side along the entire trunk from heart to cloaca.

A tubule is differentiated into three parts i.e. peritoneal funnel, tubule and Malpighian body.

A. **Peritoneal funnel:** It is a funnel like ciliated structure near the free end of a nephron. It opens into coelom via nephrostome, a wide aperture, it drains wastes from coelomic fluid.
   Nephrostomes are usually confined to embryos and larvae. They are considered as vestiges of a hypothetical primitive kidney.
B. **Malpighian body:** Tubule begins as blind, cup – like, hollow, double walled Bowman`s capsule. This capsule encloses a tuft of blood capillaries called glomerulus.
   Bowman`s capsule and enclosed glomerulus together form renal corpuscle or Malpighian body.
   When glomeruli are:
   - encapsulated, it is called as internal glomeruli. It is common.
   - not encapsulated and suspended freely in coelomic cavity it is called external glomeruli. It is found in larvae and embryo.

   Bowman`s capsule without glomeruli are termed aglomerular. These are found in embryo and larvae.

C. **Tubule:** Malpighian bodies filter water, salts and waste from blood. This filtrate passes through convoluted ductules called tubule. In this passage, it undergoes reabsorption and secretion.
   The final filtrate so formed is finally drained into longitudinal duct that opens into embryonic cloaca.

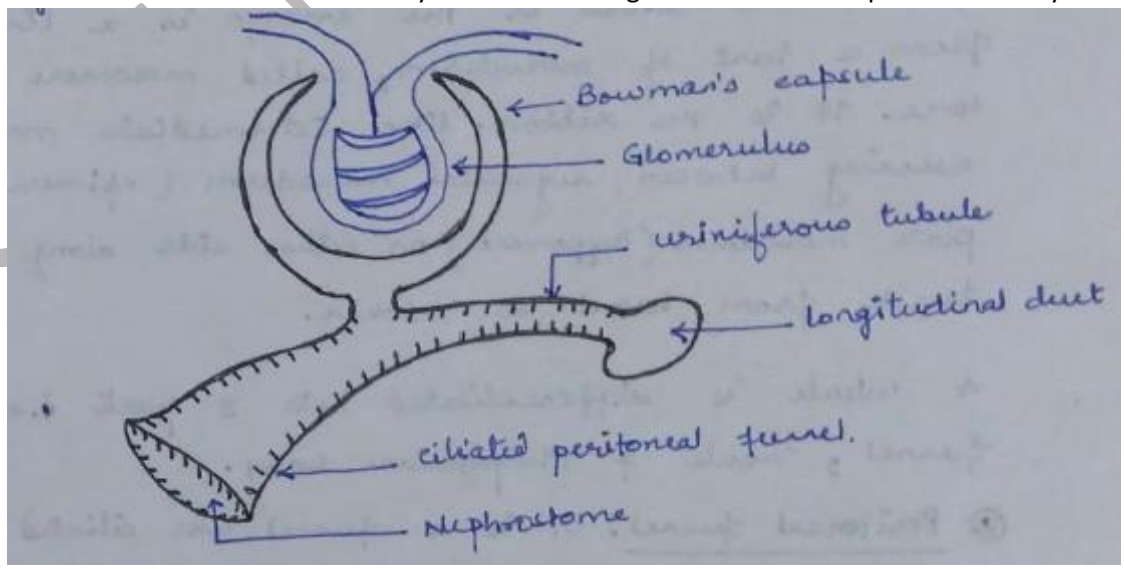

Figure: Structure of embryonic kidney tubule

Archinephros: It is name for the hypothetical primitive kidney of ancestral vertebrates. It is regarded as holonephros or complete kidney because it runs the entire length of coelom.

Its tubules have one segment, one nephron arrangement in all body segments. Each tubule opens by nephrostome into coelom. The glomerulus is external and suspended in coelom near each nephrostome.

All the tubules are drained by a common longitudinal Wolffian or archinephric duct. It opens into cloaca. This Archinephros arrangement is found in larva of some cyclostomes (e.g. *Myxine*) but not in adult vertebrates.

The modern vertebrates show three different kinds of adult kidneys viz. pronephros, mesonephros and metanephros. These represent three successive stages of development from ancestral Archinephros. All three types are never functional at the same time.

1. **Pronephros:** It is the 1st to appear during embryonic development, hence, called pronephros. It appears just behind head, on either side, dorsal to the anterior end of coelom.
   A pronephros has tubules arranged one opposite each of the anterior mesodermal somites. There are three such pronephric tubules in frog embryo, seven in human embryo and twelve in chick embryo. Each tubule opens into coelom by nephrostome.
   External glomeruli project in coelom near nephrostome of each tubule. Sometimes, glomeruli unite into a single compound glomerulus, called glomus. Glomus and tubules are surrounded by large pronephric chamber derived from pericardial or pleuroperitoneal cavity.
   All pronephric tubules open into common pronephric duct that leads posteriorly into embryonic cloaca.

   Pronephros is functional only in larval stages or embryo. It is soon replaced by mesonephros type. However, it serves lymphoidal function in adult cyclostomes and some teleostei fishes.

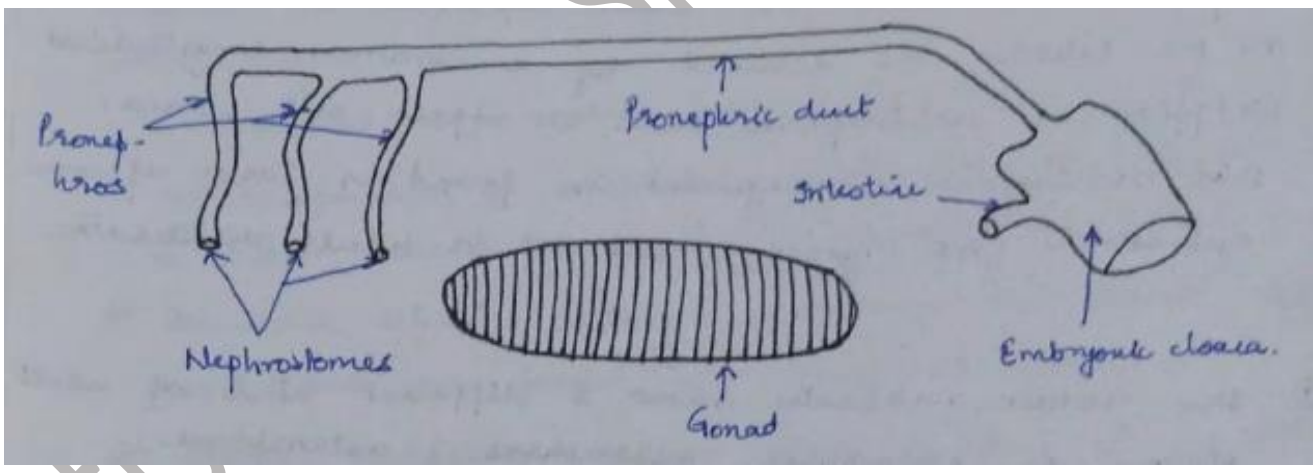

Figure: Pronephros kidney

2. **Mesonephros:** It develops from middle part of the intermediate mesoderm just posterior to pronephros, once pronephros has degraded.
   New mesonephric tubules join pronephric duct and are segmentally disposed. These tubules further multiply to increase their number and disrupt segmental disposition. These tubules have internal glomeruli enclosed by Bowman`s capsule.
   Thus, mesonephros removes wastes directly from blood in glomerulus unlike indirect waste removal from coelom performed by pronephros.

   Mesonephros is also called Wolffian body and the old pronephric duct they join is called Wolffian duct.

Mesonephros if functional throughout life in **fishes** and **amphibia** while it is found in embryonic stage of amniotes i.e. reptiles, birds and mammals.

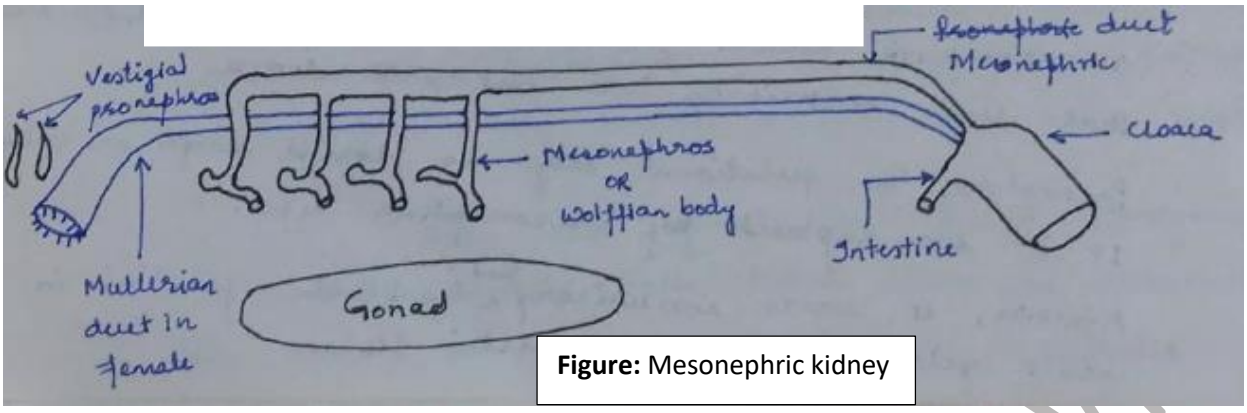

Figure: Mesonephric kidney

3. **Metanephros:** The functional kidney of amniotes is called metanephros. It is formed from posterior end of nephrogenic mesoderm. When metanephric tubules develop, all mesonephric tubules disappear except those forming vasa efferentia in male testis. Metanephros shows following advancements over mesonephros.
    - Greater multiplication and thus, large number of nephrons or tubules. This leads to more efficient waste removal from internal glomeruli.
    - It develops a new urinary duct called as metanephric or Wolffian duct and grows anteriorly and dorsally. Its dilated distal tip forms pelvis into which metanephric tubules open while its proximal end develops into ureter. This ureter empties into cloaca or urinary bladder in mammals.
    - Mammalian metanephros shows highest organization and has an additional feature of loop of Henle between PCT and DCT in tubule.

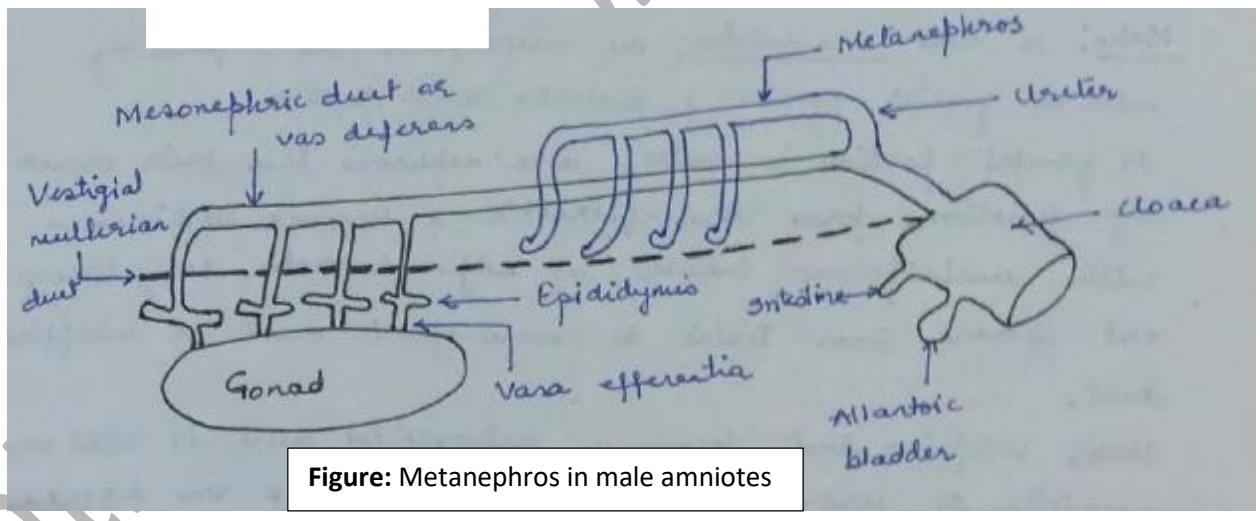

Figure: Metanephros in male amniotes

Urinary bladder:

The kidney ducts drain into a urinary bladder to store urine before its excretion. This urinary bladder is found in most vertebrates. However, it is absent in cyclostomes, elasmobranchs, some reptiles and most birds.

In most fishes, it is a simple, terminal enlargement of mesonephric duct and called a tubal bladder. In dipnoi fishes, it originates from dorsal wall of cloaca.

In tetrapods, it originates from ventral wall of cloaca.

In amphibians, it is called cloacal bladder. However, in amniotes, adult bladder is derived from proximal part of embryonic allantois, hence called also called as allantoic bladder.

Kidney ducts normally open into cloaca, dorsally. But in mammals, except monotremes, ureters enter directly into urinary bladder and it opens to outside via urethra. Mammals also lack cloaca because dorsal part of embryonic cloaca forms the rectum and ventral part becomes urethra.

Interlinkage between development of kidneys and gonoducts:

Males: In male **anamniotes**, the mesonephros has two parts viz. anterior genital portion and posterior renal portion. In genital portion in males, some nephrons lose their excretory function, form vasa efferentia and become continuous with seminiferous tubules of adjacent testis.

They transport sperms from testes to mesonephric duct or Wolffian duct. Thus, Wolffian duct forms a urinogenital duct in male anamniotes and this duct serves as ureter for urine and vas deferens for sperm.

In male **amniotes**, metanephric kidney has a separate duct for urine, so, Wolffian duct becomes solely a genital duct or vas deferens. The remnants of embryonic mesonephros and a coiled portion of mesonephric duct form epididymis in adult testis.

The sperm carried by these modifications of mesonephric duct or Wolffian duct are ejaculated to outside via urethra, a modification of ventral cloaca.

Females: In all vertebrate embryos, except cyclostomes, the coelomic epithelium outside mesonephric duct develops into Mullerian duct. It is degenerated in males and functions in females as gonoducts.

In female **anamniotes**, Mullerian duct exists as gonoducts alone while Wolffian duct exists as ureter, the urinary duct alone. This arrangement is unlike male anamniotes.

In female **amniotes**, Wolffian duct degenerates due to development of separate ureter for metanephric kidney.

In **viviparous mammals**, posterior ends of both Mullerian ducts fuse and are modified in a uterus that supports embryonic development.