Course material for 25.03.2020

URINOGENITAL SYSTEM part-1

Course: B.Sc.(H) Zoology IV semester

Paper: Comparative Anatomy

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UROGENITAL SYSTEM

- Combination of excretory and reproductive system.
- **Kidney** is the main excretory organ of vertebrates.
  - Concerned with the elimination of metabolic waste products.
- **Ovary** is the female reproductive organ or gonad.
- **Testis** is the male reproductive organ.
  - These are concerned with the production of the reproductive cells (egg and sperm).
- **Ducts** are passageways for the excretory waste products and reproductive cells from where they are produced to the outside.

EXCRETORY SYSTEM

- Waste products of metabolism include: urea, ammonia, uric acid, creatinine, various pigments, inorganic salts, and water.
- These are excreted through the **kidney**.
- **Nephrons** are the functional units of the kidney, where the blood is filtered with these metabolic wastes.
- Metabolic wastes pass to the outside through **ducts**.

Basic structure and origin of a Vertebrate kidney

- A pair of compact organs
- Lie dorsal to coelom in trunk region
- One on either side of dorsal aorta
- Each kidney is composed of a large number of units called **uriniferous tubules** or **nephrons**.
- Their number, complexity and arrangement differ in different groups of vertebrates
- Kidney tubules arise in the embryo in a linear series from a special part of mesoderm called **mesomere** or **nephrotome**
  - It is the ribbon-like intermediate mesoderm, running between segmental mesoderm (epimere) and lateral plate mesoderm (hypomere) on either side along the entire trunk from heart to cloaca

A uriniferous tubule is differentiated into three parts:

- **Peritoneal funnel**:
  - Near the free end of a uriniferous tubule
  - Ciliated
  - opens into coelom via **coelomostome** or **nephrostome**, for draining wastes from coelomic fluid.
  - Present in embryos and larvae only
- **Malpighian body**:
  - **Bowman's capsule** and enclosed **glomerulus** together form a **Renal Corpuscle** or **Malpighian body**.
  - **Bowman's capsule** is a blind, cup-like, hollow, double-walled sac that encloses a tuft of blood capillaries, called **glomerulus**.
  - A branch of renal artery, called **afferent glomerular arteriole** supplies blood to the glomerulus
  - An **efferent glomerular arteriole** emerges out of glomerulus to join the capillary network surrounding the tubule
    - Encapsulated glomeruli are termed **internal glomeruli** which are common.
    - Glomeruli without a capsule and suspended freely in coelomic cavity are called **External glomeruli** (embryos and larvae).
    - Bowman's capsules without glomeruli are termed **Aglomerular**, as found in embryos, larvae and some fishes.
- **Tubule**: Malpighian bodies filter water, salts and other substances from blood. During passage through tubules more substances are secreted into filtrate, while some are reabsorbed. All the tubules of embryonic kidney are **Convoluted ductules** that conduct the final filtrate to a longitudinal duct which opens behind into **embryonic cloaca**.

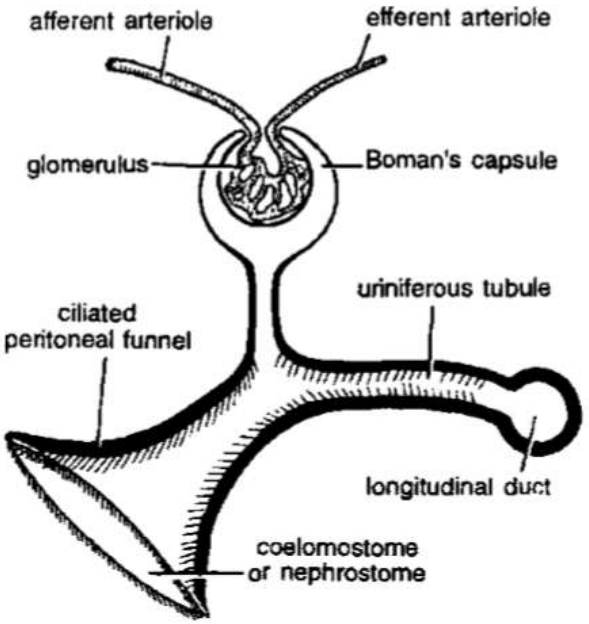


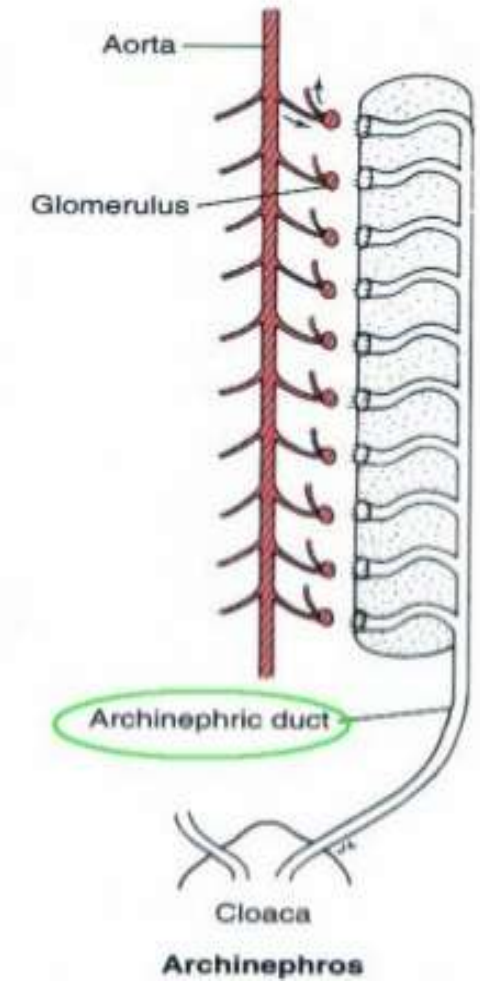
Fig. 1. Structure of an embryonic kidney tubule.

Succession of kidney in Vertebrates

Archinephros
Pronephros
Mesonephros
Metanephros

Archinephros: *the holonephros*

- hypothetical primitive kidney of ancestral vertebrates
- regarded as a complete kidney or holonephros as it extended the entire length of coelom
- Its tubules were segmentally arranged, one nephron for each body segment.
- Each tubule opened by a Peritoneal Funnel or Nephrostome into coelom. Near each nephrostome was suspended in coelom an External Glomerulus (without capsule).
- All the tubules were drained by a common longitudinal Archinephric Duct opening behind into Cloaca.



- **Found today in the larvae of certain cyclostomes (Myxine), but not in any adult vertebrate.**
- **supposed to have given rise to all the kidneys of later vertebrates during the course of evolution.**
- **Tissue fluid discharge: glomerulus → coelom → nephrostomes → tubules → archinephric duct → cloaca → outside**

*** *Modern vertebrates exhibit three different kinds of adult kidneys : pronephros, mesonephros and metanephros. These might represent the sequence or 3 successive stages of development of the ancestral archinephros, and all 3 are never functional at the same time.***

PRONEPHROS: *the anamniote kidney*

- The first kidney tubules to appear in the embryos of all vertebrates
- Found dorsal to the anterior end of coelom, on either side
- Called pronephros as they are first to appear in the embryo
- also termed Head Kidney due to its anterior position immediately behind the head.
- A pronephros consists of 3 to 15 tubules segmentally arranged, one opposite each of the anterior mesodermal somites.
- There are only 3 pronephric tubules in frog embryo, 7 in human embryo and about a dozen in chick embryo.
- Each tubule opens into coelom by a funnel or nephrostome.
- Also projecting into coelom near each tubule and not connected with may lie an external or naked glomerulus without capsule. Most have internal glomeruli.

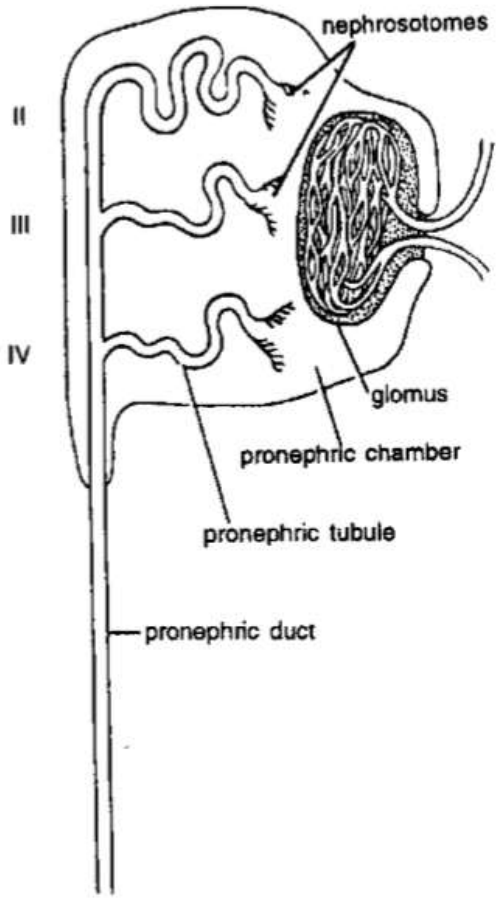


Fig. 3. Encapsulated pronephric kidney

- **In some cases, glomeruli unite to form a single compound glomerulus, called Glomus.**
- **Glomus and tubules become surrounded by a large Pronephric Chamber derived from pericardial or paraperitoneal cavity.**
- **Originally each tubule has its individual external aperture, but secondarily, all tubules of a pronephros open into a common pronephric duct, leading posteriorly into the embryonic cloaca.**
- **It is mostly transitory and soon replaced by the next stage or mesonephros.**
- **Functional only in embryonic or larval stage of amphibians and fishes**
- **Retained throughout life in adult cyclostomes and a few teleost fishes, but it is non-urinary and mostly lymphoidal in function.**
- **Tissue fluid discharge: Blood→ Afferent Arteriole →Glomerulus → Efferent arteriole → Postcardinal vein → Heart**

MESONEPHROS

- Develops from the middle part of intermediate mesoderm, posterior to each pronephros soon after its degeneration - in the embryo
- At first, the new mesonephric tubules join the existing pronephric duct and are segmentally disposed.
- Later on the tubules multiply by budding so that their segmental arrangement is disturbed due tc increased number of tubules per segment.
- Tubules of pronephros and mesonephros develop similarly and are homologous.
- However, ***mesonephros is functionally better than pronephros*** because mesonephric tubules are more numerous, longer and develop internal glomeruli enclosed in capsules forming Malpighian bodies. Thus, they remove liquid wastes directly from glomerular blood rather than indirectly from coelomic fluid as in case of a pronephros.

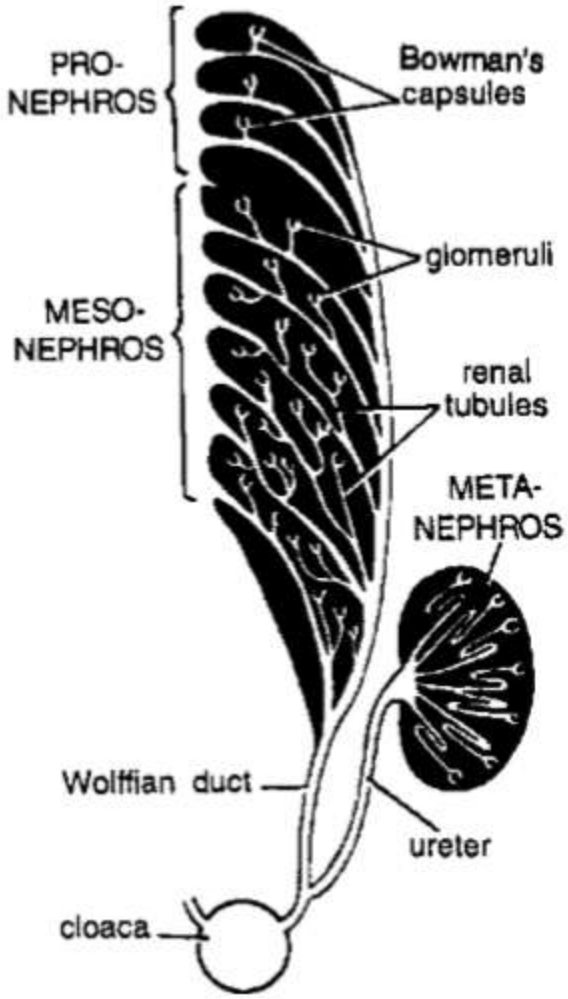
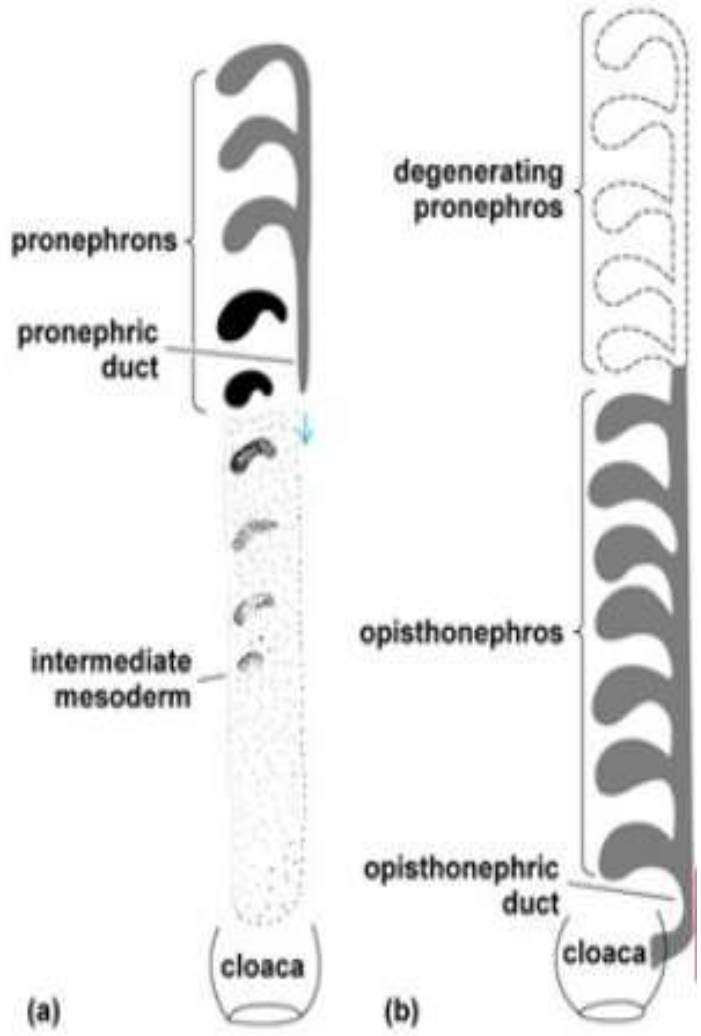


Fig. 4. Diagrammatic plan of pronephros, mesonephros and metanephros in vertebrates.

- **The mesonephros is also termed Wolffian body.**
- **With disappearance of pronephros, the old pronephric duct becomes the Wolffian or mesonephric duct**
- **In amniotes (reptiles, birds and mammals), mesonephros is functional only in the embryos, replaced by metanephros in the adults.**
- **In fishes and amphibians, mesonephros is functional both in embryos as well as adults.**
- **Mesonephric kidney is not metameric but in myxinoids it is segmental and sometimes called a HOLONEPHROS.**

Opisthonephros

- In sharks and caecilians, the mesonephric tubules extend posteriorly throughout the length of coelom. Such a kidney is sometimes called a posterior kidney or opisthonephros
- Drained by mesonephric duct
- Opisthonephros is similar to mesonephros but mesonephros appears during embryonic development in reptiles, birds & mammals.
  - But when it serves as an adult kidney, it is called opisthonephros
- Nephrostomes are generally lacking
- Renal corpuscles with internal glomeruli present



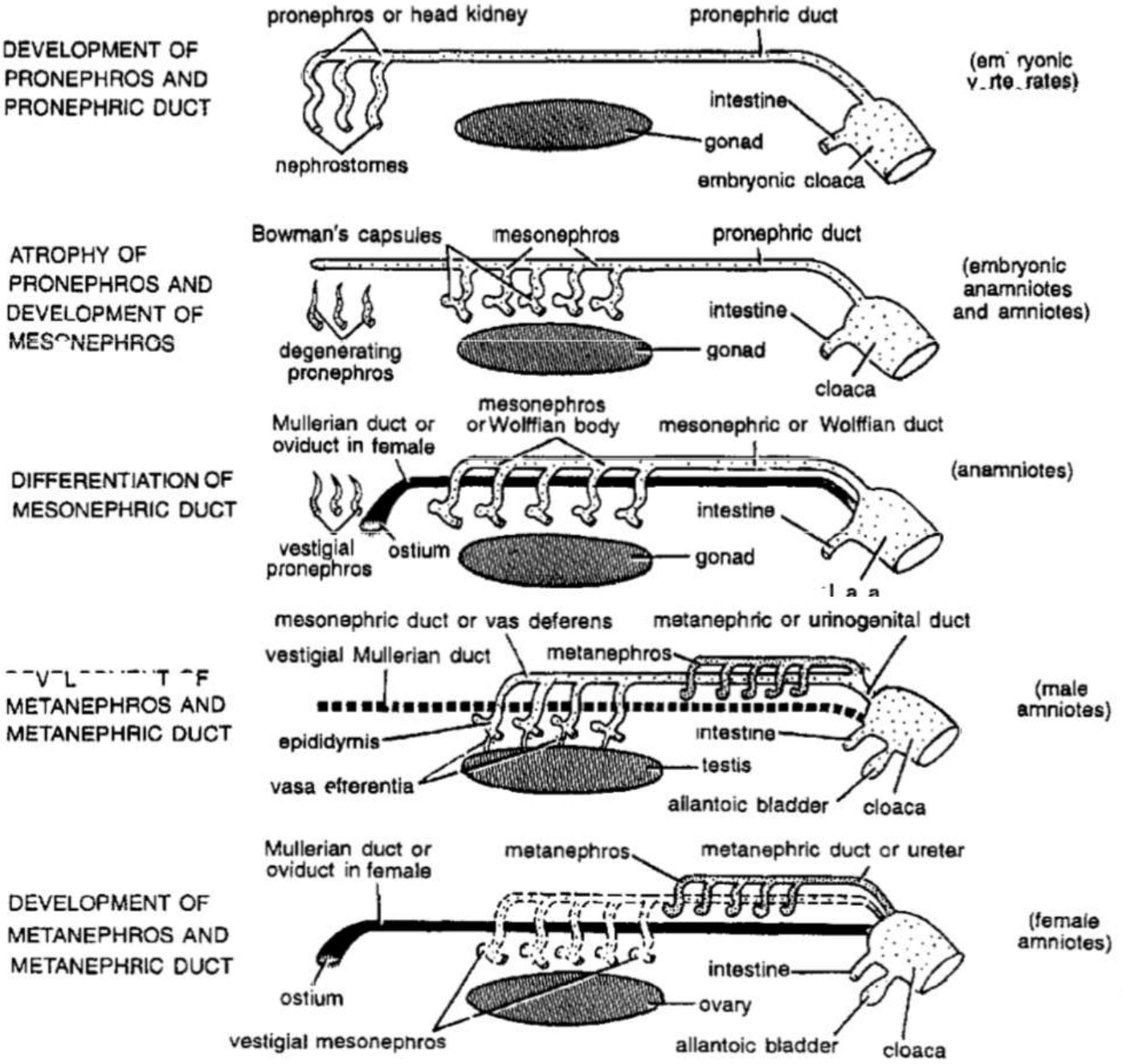


Fig. 5. Evolution of kidney in vertebrate.

METANEPHROS

- **The functional kidney of higher vertebrates or amniotes**
- **It is formed from the posterior end of the nephrogenic mesoderm which is displaced somewhat anteriorly and laterally.**
- **When metanephric tubules develop, all the mesonephric tubules disappear except those associated with the testis in male and forming vasa efferentia.**

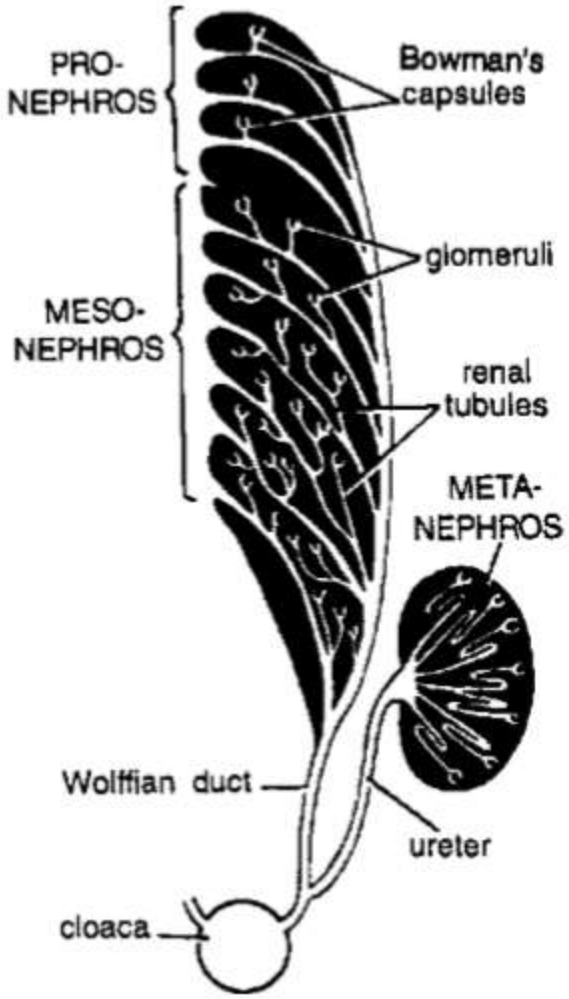


Fig. 4. Diagrammatic plan of pronephros, mesonephros and metanephros in vertebrates.

- **The adult kidney (metanephros) of amniotes differs from that of anamniotes (mesonephros or opisthonephros) chiefly in:**
  1. **Its origin from only caudal end of nephrogenic mesoderm**
  2. **In greater multiplication and posterior concentration of nephrons or tubules. They are particularly very large in number and highly convoluted in birds and mammals, hence the large size of kidney. It is estimated that each kidney of man is composed of about 1 million nephrons. The high rate of metabolism yields a large amount of wastes to be excreted**
  3. **In developing a new urinary duct, called metanephric duct or ureter. It is budded off from the base 'of the Wolffian duct (mesonephric duct). It grows anteriorly and dorsally, and eventually the metanephric tubules open into it. Its dilated distal tip forms pelvis which forks several times to become the collecting tubules. Its proximal portion becomes the metanephric duct or ureter that empties into cloaca or urinary bladder in mammals.**

The mammalian metanephros shows greatest organization of all, with several additional features:

- **A thin, U-shaped loop of Henle between proximal and distal convolutions of a metanephric tubule. Such loops are absent in reptiles and rudimentary in birds.**
- **Kidney shows an outer cortex with concentration of renal corpuscles, and an inner medulla having collecting tubules and loops of Henle, which are aggregated into one or several pyramids tapering into pelvis.**
- **Mammalian kidneys do not receive afferent venous blood supply as there is no renal portal system**

DRAW THE STRUCTURE OF HUMAN NEPHRON HERE (DIY)