

Comparative Anatomy

THE URINOGENITAL SYSTEM

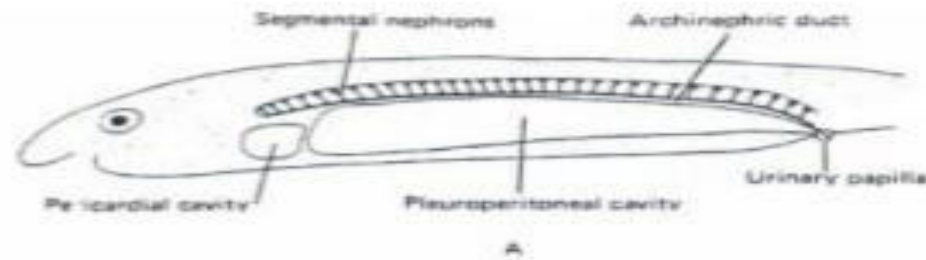
Presented By:
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ZOO CC- 408
SEMESTER-IV
UNIT -3

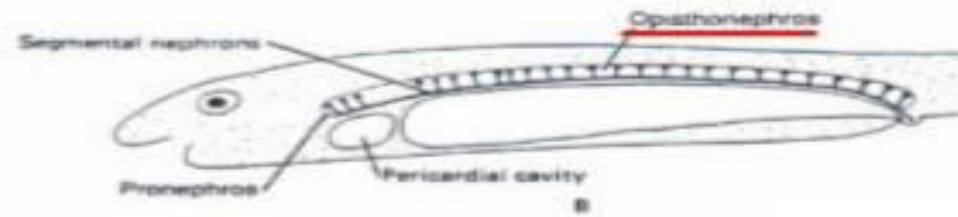
URINOGENITAL SYSTEM

- URINARY SYSTEM OF VERTEBRATES INCLUDE KIDNEYS AND THEIR DUCTS.
- REPRODUCTIVE SYSTEM INCLUDES MALE AND FEMALE GONADS AND THEIR DUCTS.
- THE 2 SYSTEMS ARE INTIMATELY RELATED MORPHOLOGICALLY IN VERTEBRATES HENCE THE TWO SYSTEM ARE AS DESCRIBED AS **UROGENITAL OR URINOGENITAL SYSTEM**

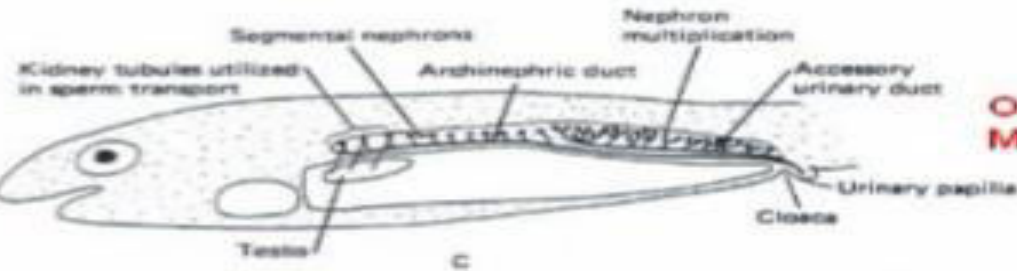
○ Ducts of excretory and reproductive systems are intimately associated



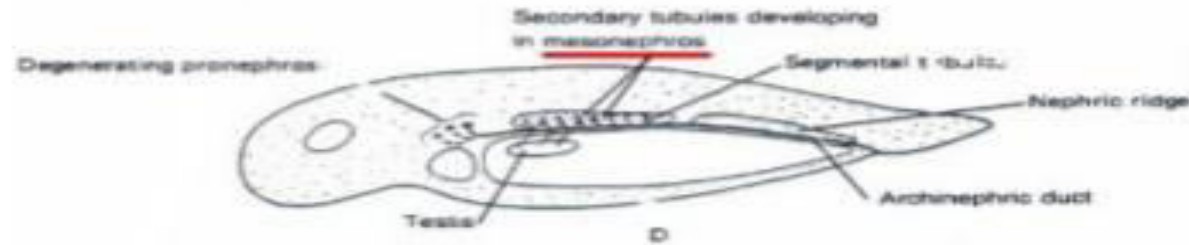
Larval hagfish
caecilians



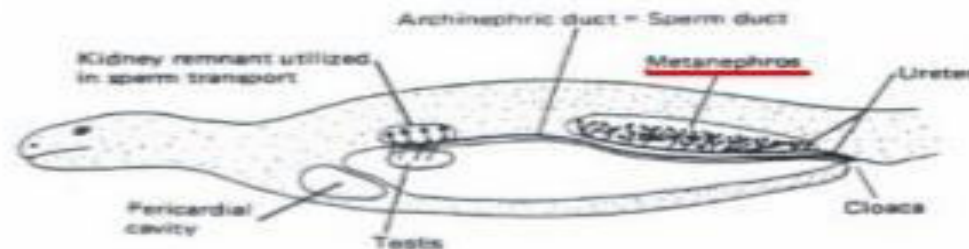
Adult hagfish



Opisthonephros
Most anamniotes



Mesonephros
Embryonic amniotes



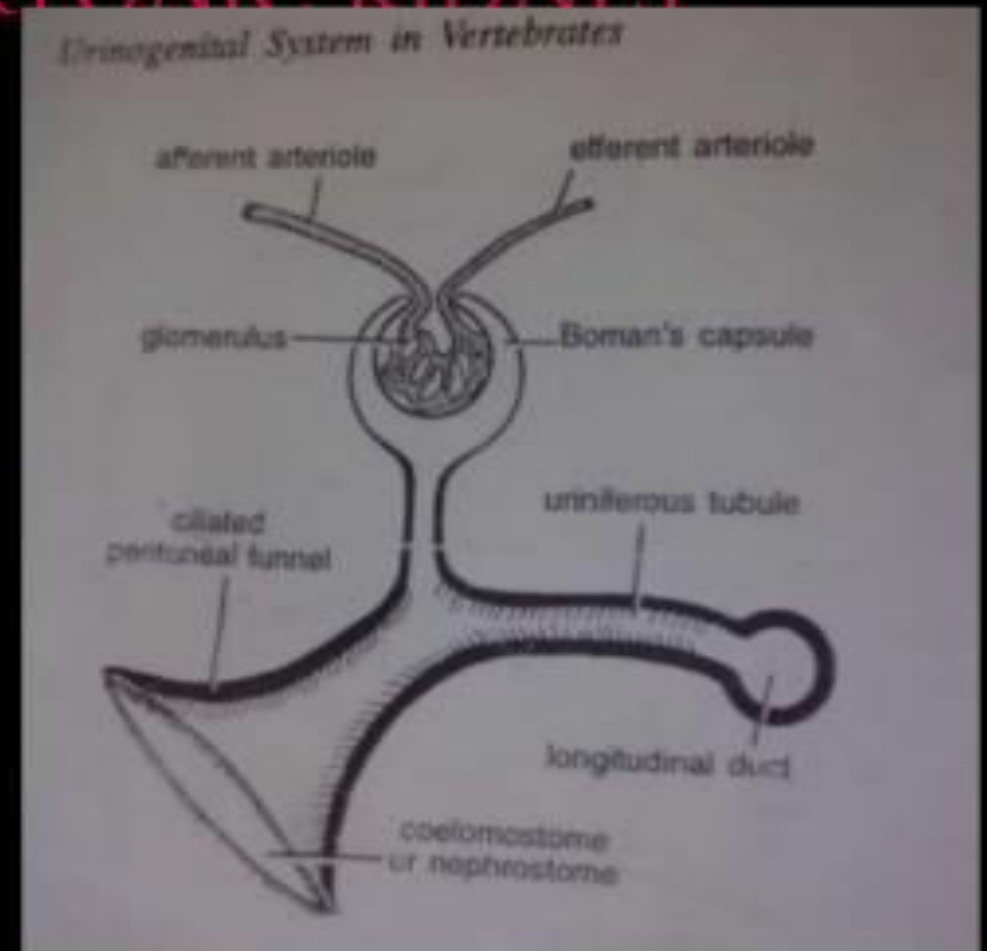
Metanephros
Adult amniotes

BASIC STRUCTURE OF EMBRYONIC KIDNEY

Pair of compact organs lying on either side of dorsal aorta.
Each kidney is composed of large no of units called as **URINIFEROUS TUBULES OR NEPHRONS.**

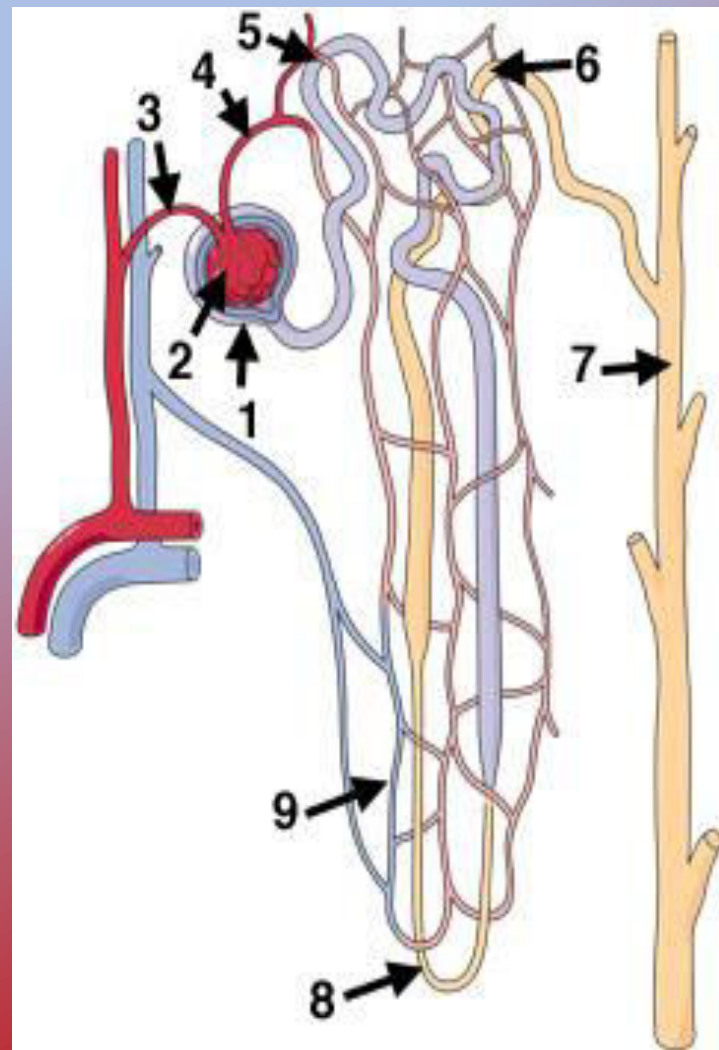
Kidney tubules arise in the embryo in a linear series from mesoderm.
Each uriniferous tubule is differentiated into 3 parts.

1. PERITONEAL FUNNEL
2. MALPIGHIAN BODY
3. TUBULE



Vertebrate Kidney

- Vertebrate kidneys consist of glomeruli, tubules surrounded by peritubular capillaries, & longitudinal ducts.
- Variations in kidney structure among vertebrates are primarily in the number & arrangement of the glomeruli & tubules.
- Glomeruli are masses of capillaries that (along with Bowman's capsule) 'filter' the blood - the first step in eliminating waste products from the blood.
- Kidney tubules collect the glomerular filtrate & conduct it to a longitudinal duct.
- Tubules consist of several segments & begin as a Bowman's (or glomerular) capsule. A glomerulus plus its surrounding Bowman's capsule is called a renal corpuscle.
- Longitudinal ducts = begin developing at anterior end of kidney & grow caudally until opening into the cloaca

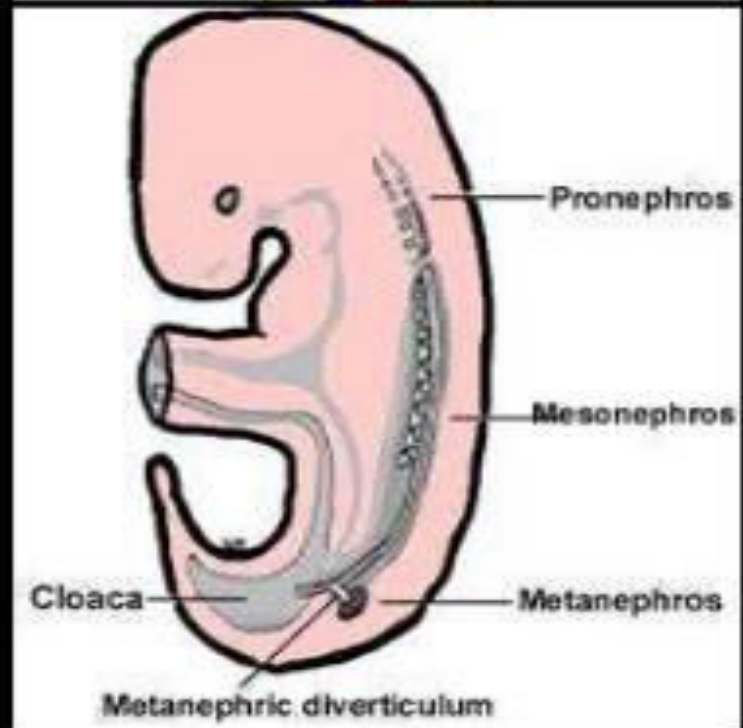
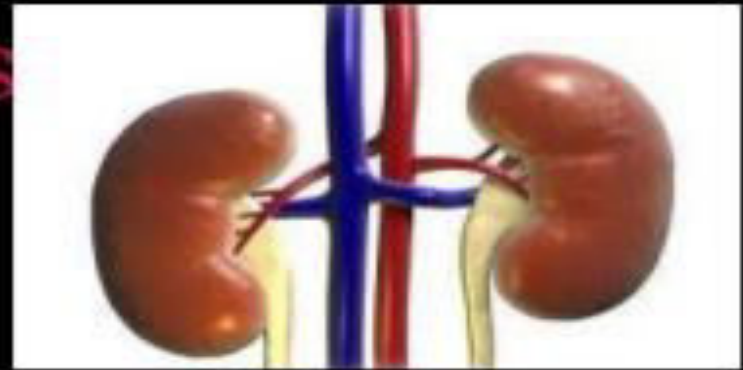


1 = Bowman's capsule, 2 = glomerulus, 3 = afferent arteriole, 4 = efferent arteriole,
5 = proximal convoluted tubule, 6 = distal convoluted tubule, 7 = collecting duct,
8 = loop of Henle, 9 = peritubular capillaries

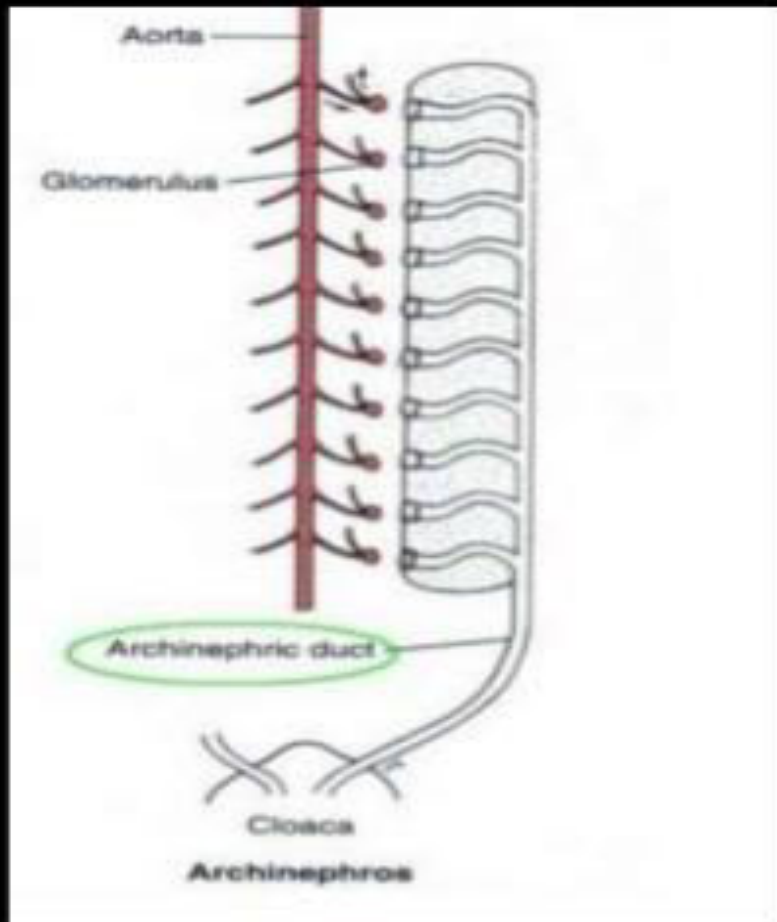
Urinary System - Kidneys

*Kidneys are pair of compact organs lying on either side of dorsal aorta.
Evolution of kidney takes place as:*

ARCHINEPHROS
PRONEPHROS
MESONEPHROS
METANEPHROS



ARCHINEPHROS



Excretory organ of ancestral vertebrates. Also called as **HOLONEPHROS** or complete kidney as it runs throughout the entire length of coelom.

Composed of pair of archinephric ducts. Each duct has a pair of tubules to a segment.

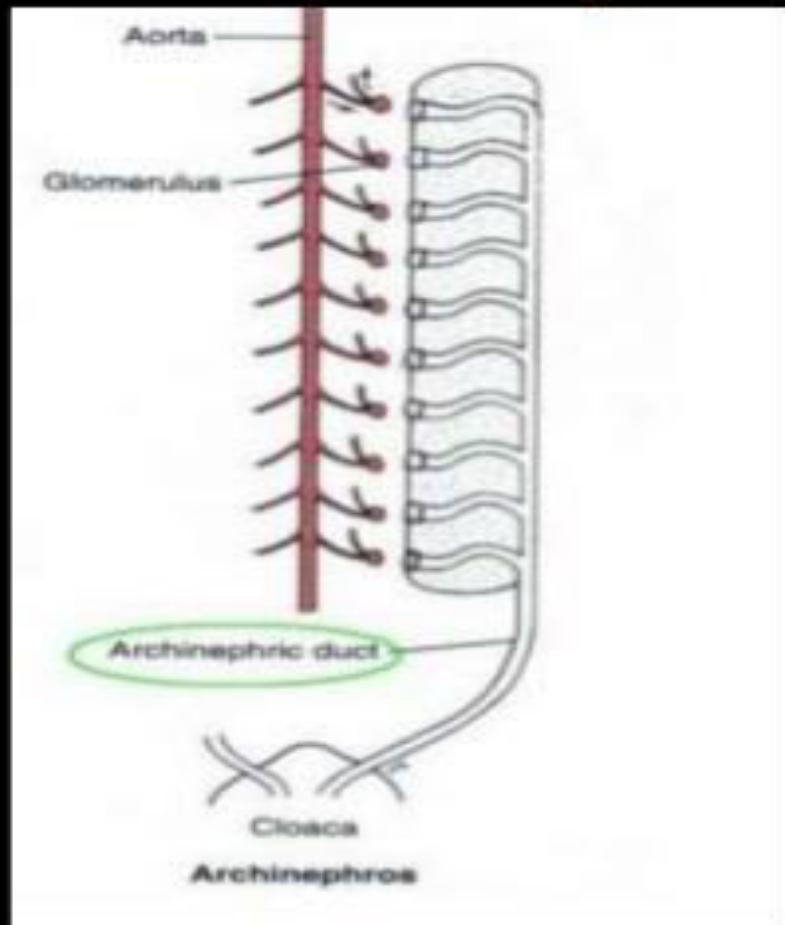
Each tubule is opened by a nephrostome in coelom.

Near each nephrostome there is an external glomerulus.

All tubules are drained into duct Which opens in cloaca.

3 kidneys are a part of one organ

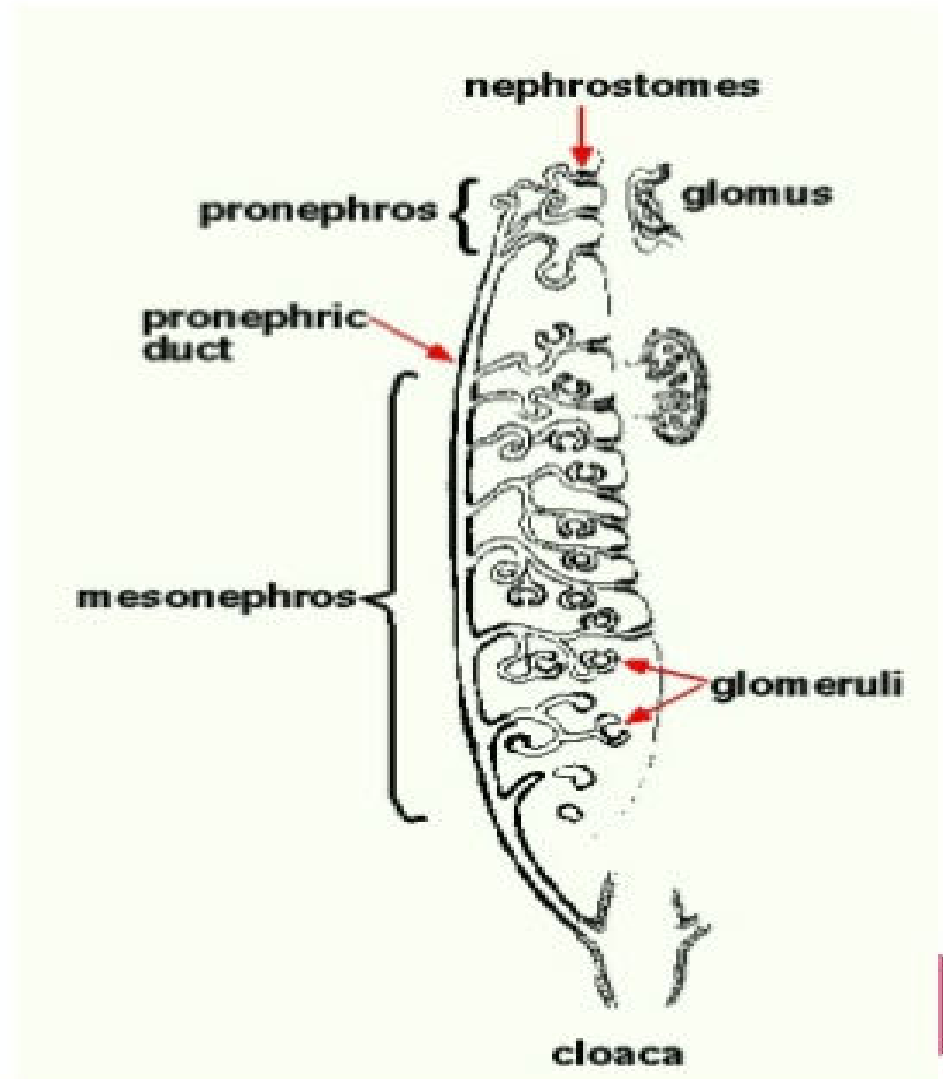
Archinephros



- *Larvae of caecilians and Hagfish have this type of excretory system.*
- *Tissue fluid discharge from glomerulus << coelom <<*
- *Nephrostome << tubules <<*
- *Archinephric ducts << cloaca.*

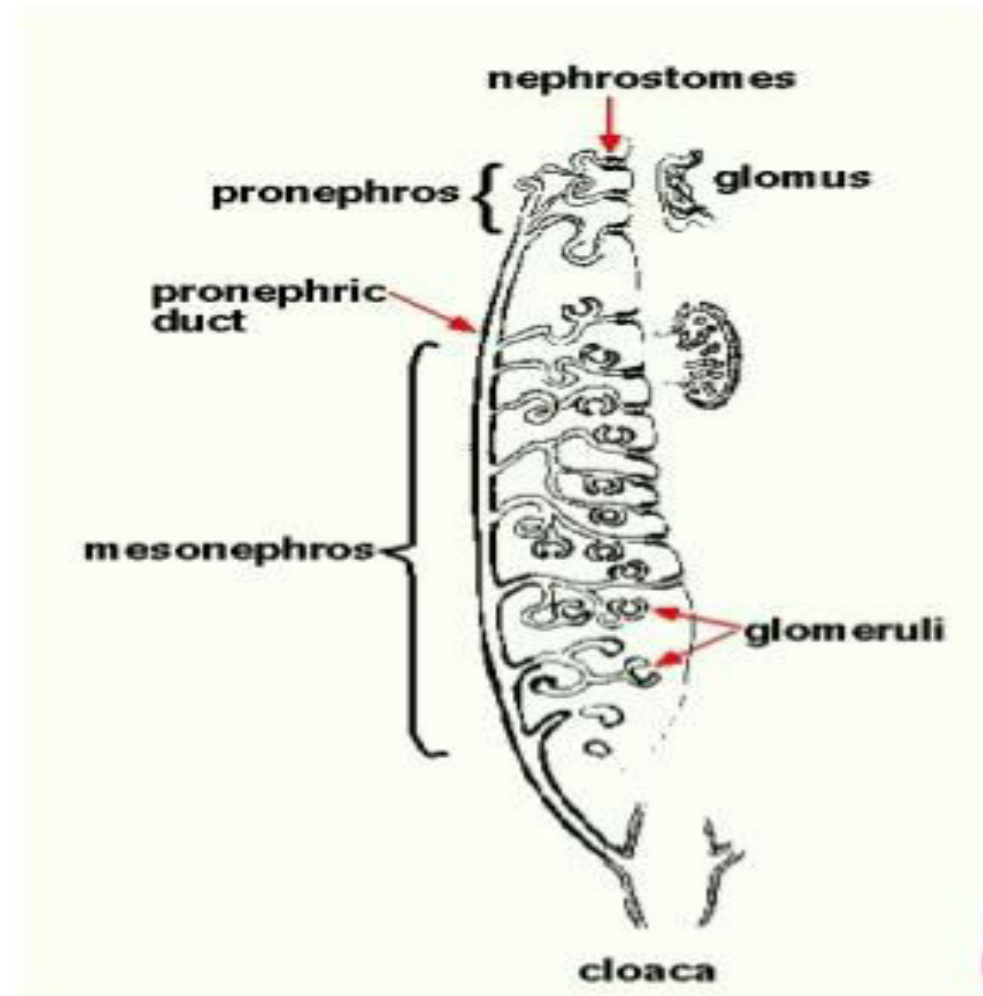
PRONEPHROS

- 1st embryonic tubules in all vertebrates
- called **pronephric tubules** because they are the 1st to develop & are anteriorly located
- The duct that drains the pronephros is called the **pronephric duct**.
- The pronephros is temporary & function only until glomeruli & tubules further back become functional.



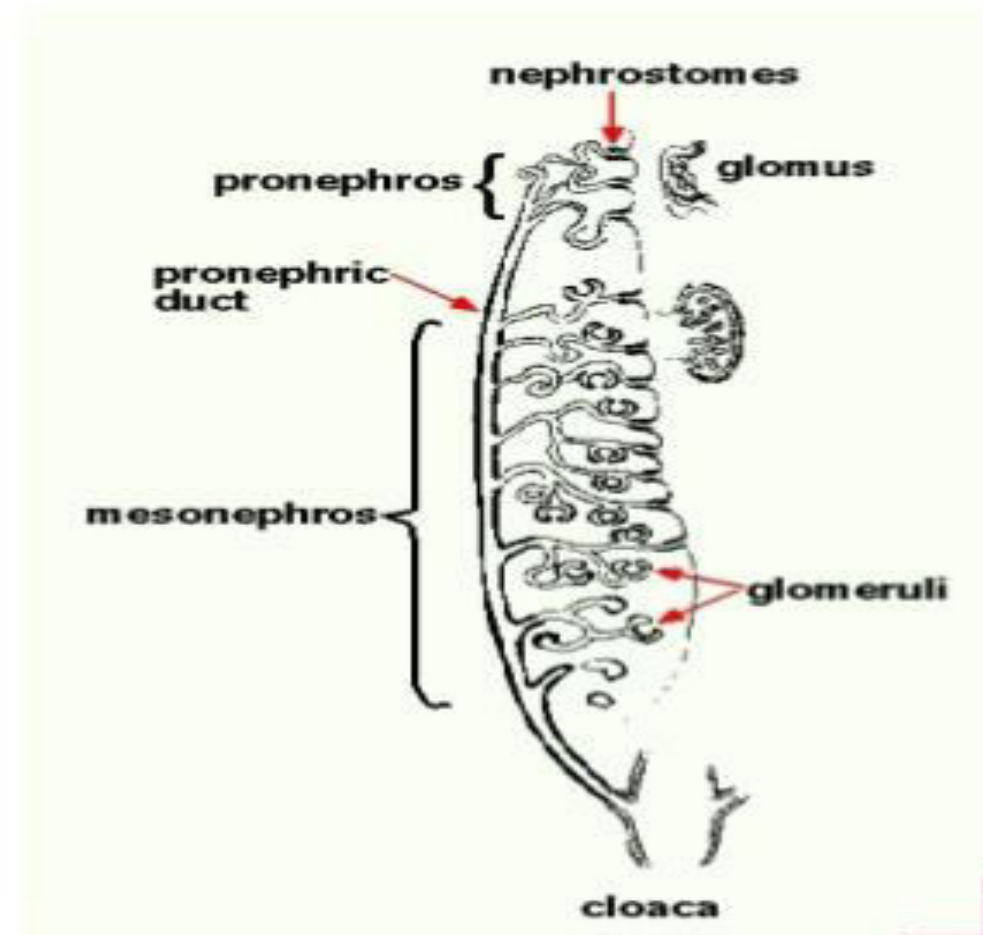
THE ANAMNIOTE KIDNEY: PRONEPHROS

- Some have **external glomerulus**, while most have **internal glomeruli**.
- Internal glomeruli are small knots of arterial capillaries surrounded by the **Bowman's capsule**.
- **Renal or Malphigian corpuscle** is composed of the glomerulus and the Bowman's capsule



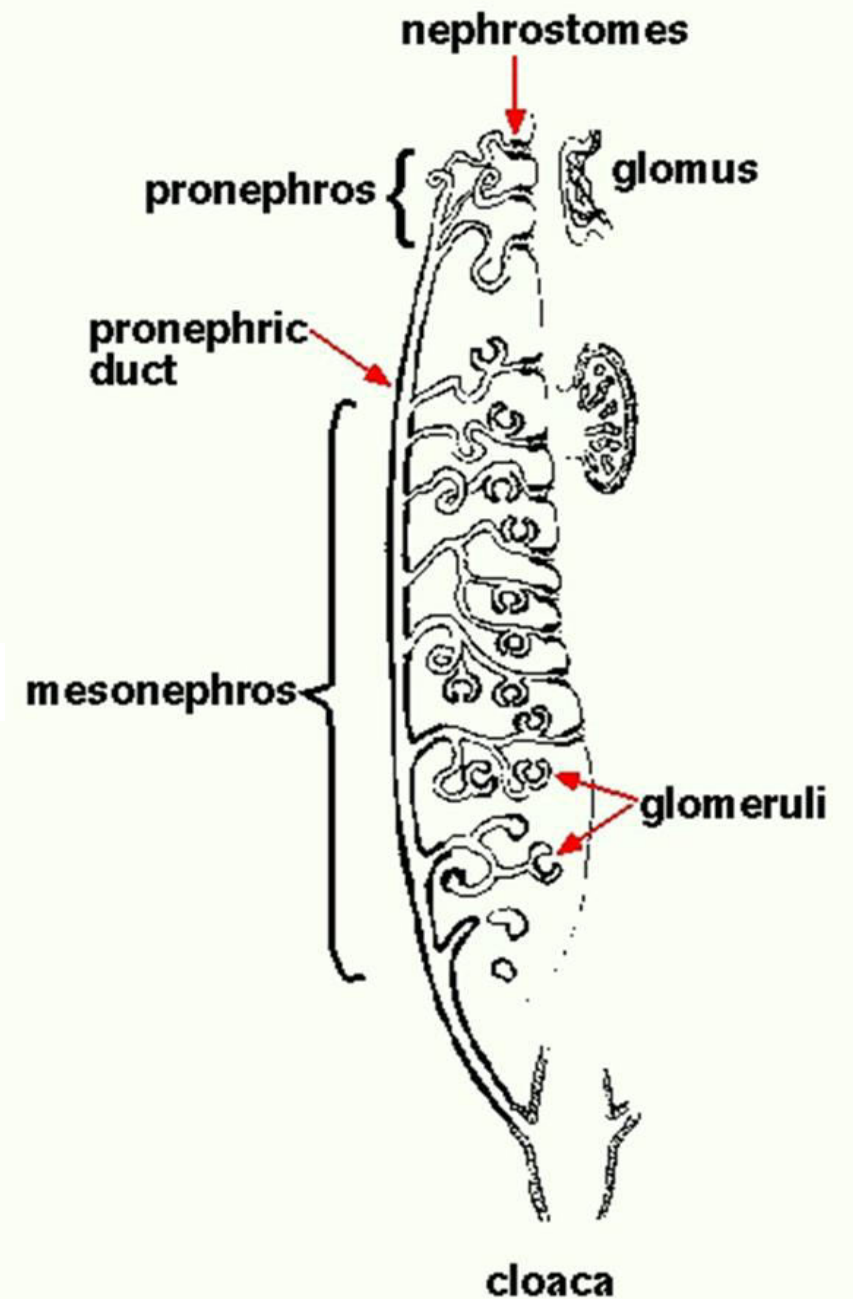
THE ANAMNIOTE KIDNEY: PRONEPHROS

- Blood → afferent arteriole → glomerulus → efferent arteriole → postcardinal vein → heart
- Filtrate of blood plasma → glomerulus → coelom or cavity of the Bowman's capsule → tubule → pronephric duct → cloaca
- Selective reabsorption of water and other constituents may occur as fluid passes down the tubule.



THE ANAMNIOTE KIDNEY PRONEPHROS

- Pronephric tubules function only until the end of the larval stage in amphibians and equivalent stage in fishes.
- **Glomus** is the term for several united glomeruli.
- **Pronephric chambers** are larger chambers formed by expansion of the pronephric tubules.



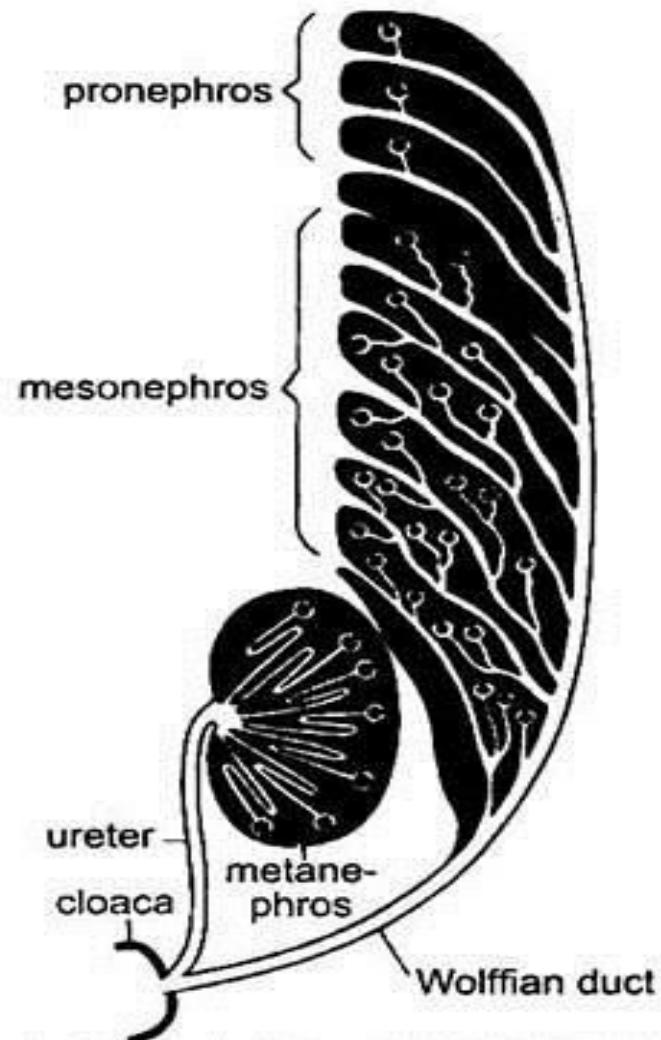
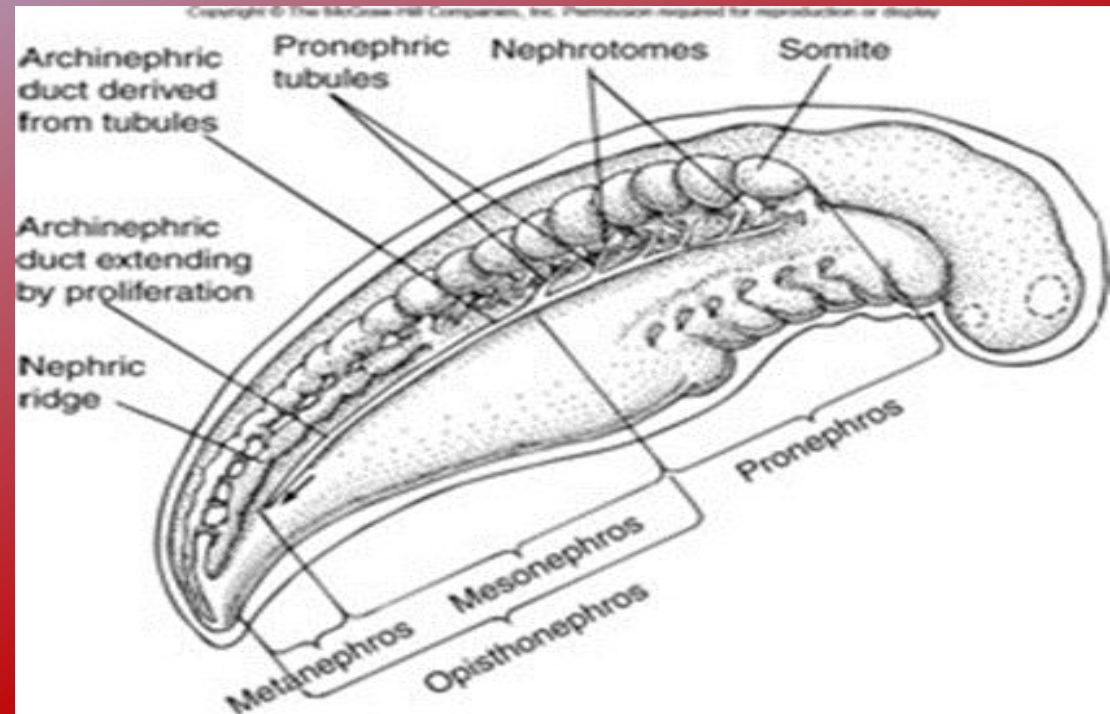



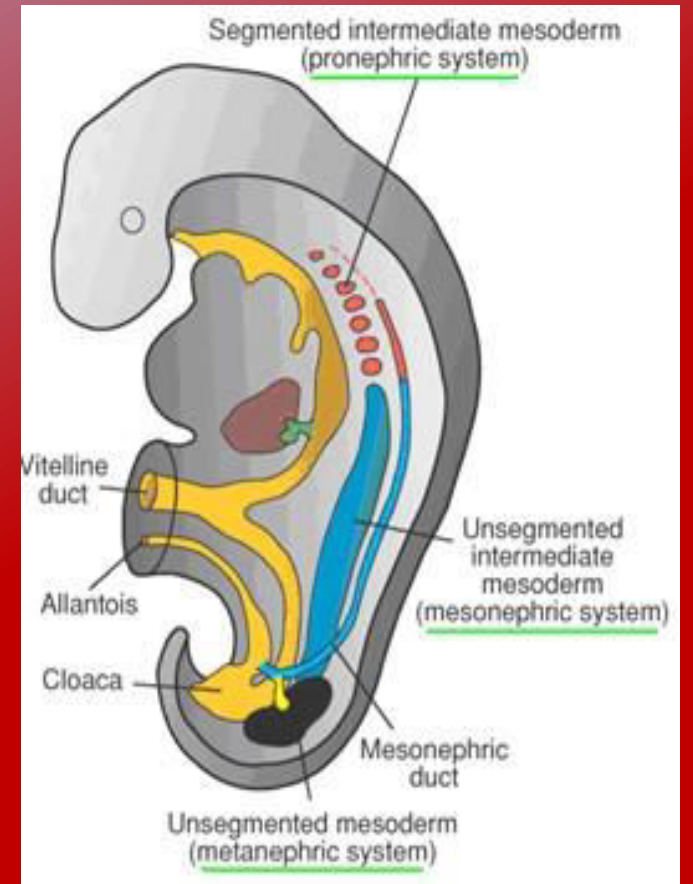
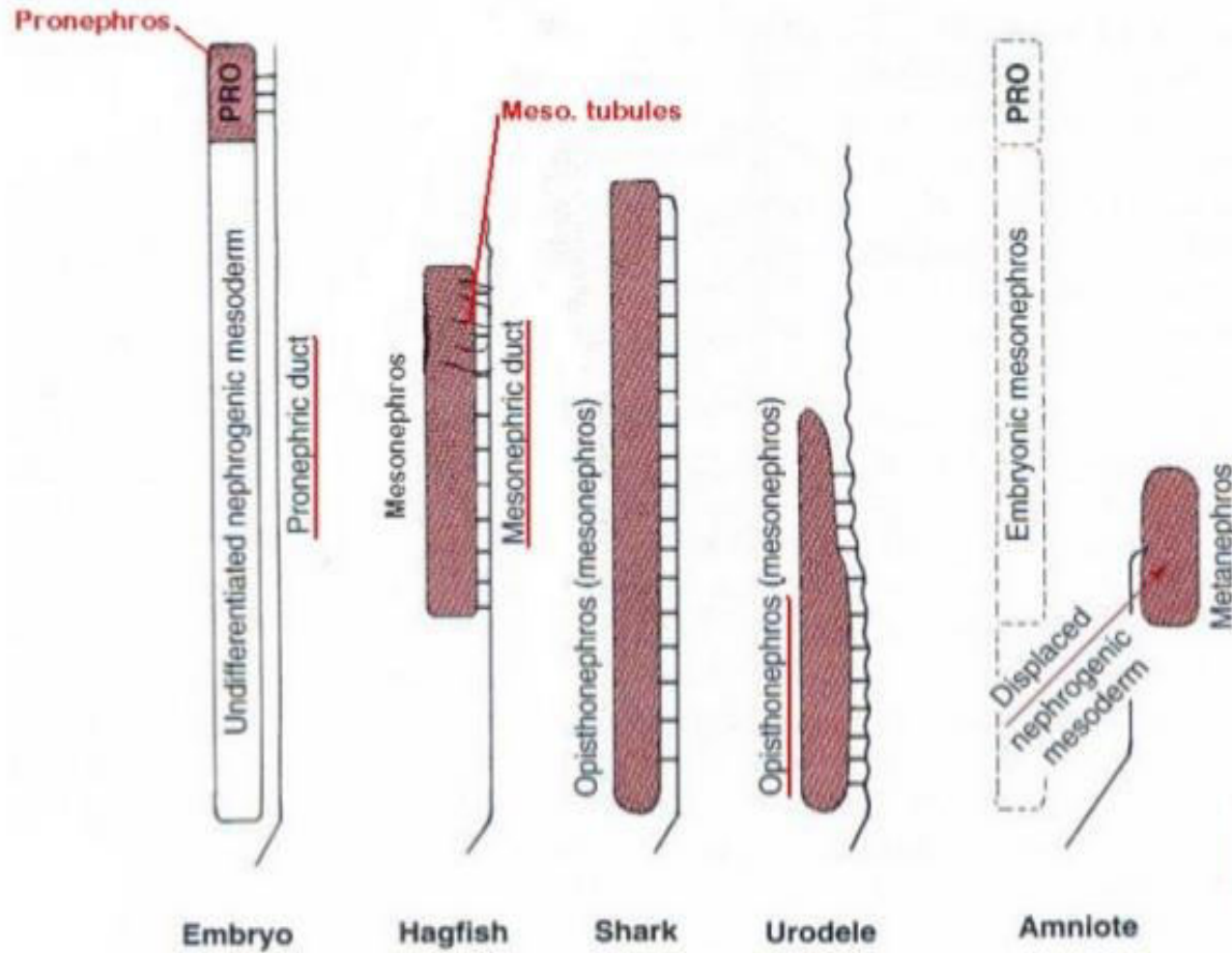
Fig. 48.4. A plan of pronephros, mesonephros, and metanephros.



THE ANAMNIOTE KIDNEY: *OPISTHONEPHROS*

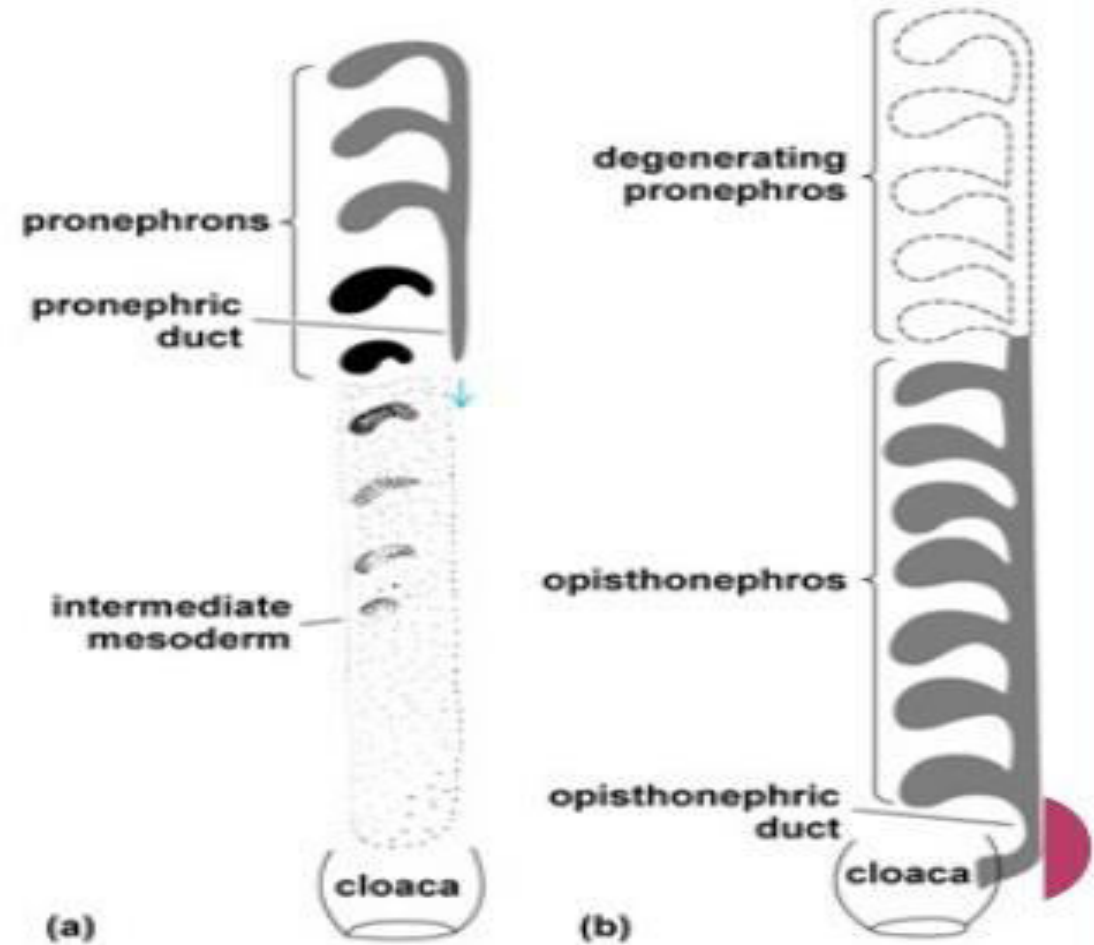
- The kidney mass caudal to pronephric region
 - Functional adult kidney of lampreys, most fishes and amphibians
 - Drained by mesonephric (archinephric) duct
 - Mesonephros similar to opisthonephros but mesonephros is the structure that appears during embryonic development in reptiles, birds, and mammals.
 - When it serves as an adult kidney, it is sometimes called **opisthonephros**.
 - In sharks and caecilians, the kidney is opisthonephros, i.e., mesonephric tubules extend posteriorly throughout the length of the coelom.
- 

FATE OF NEPHROGENIC MESODERM (RED)



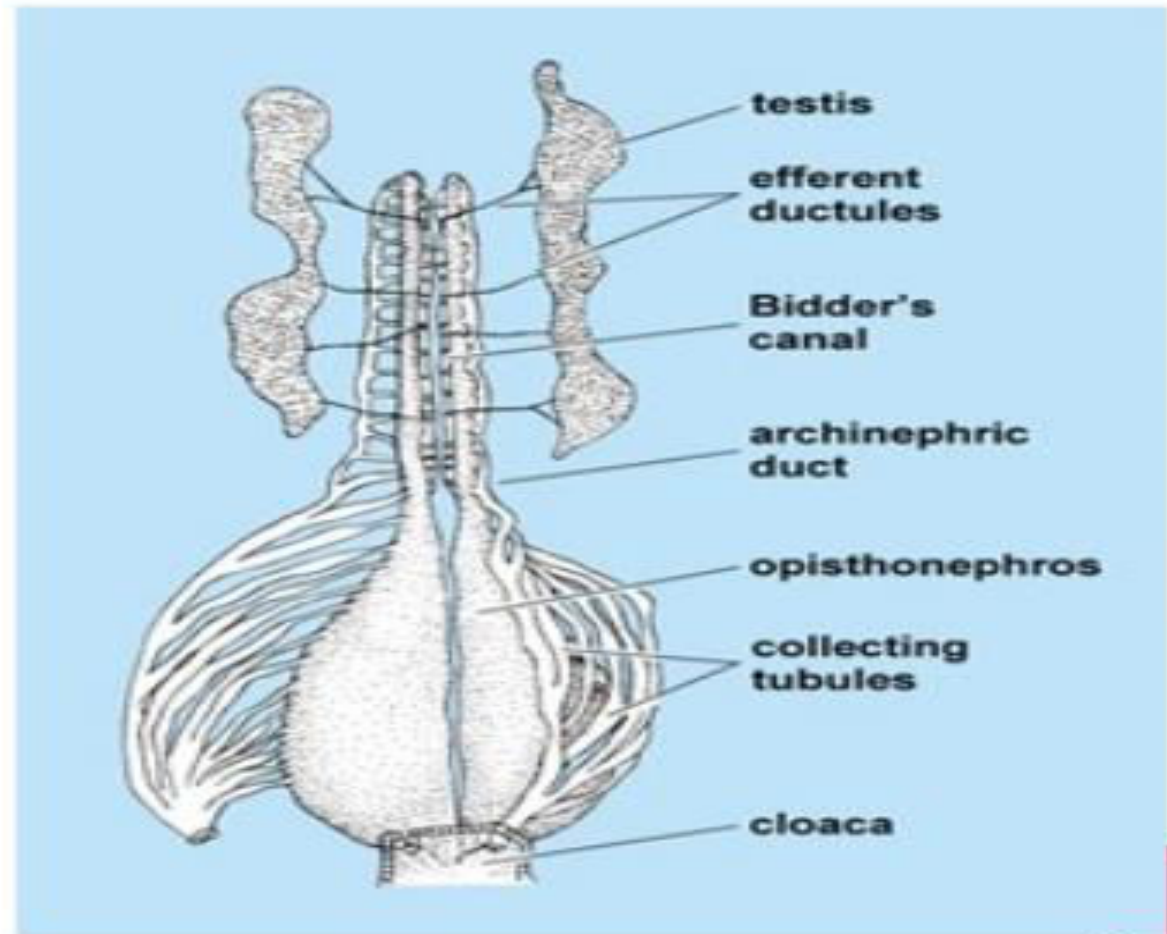
THE ANAMNIOTE KIDNEY: *OPISTHONEPHROS*

- It is different from pronephros because it lacks segmental tubules that is exhibited by the pronephros.
- Kidney tubules and coelom are rarely connected.
- Renal corpuscles with internal glomeruli are typically present.



THE ANAMNIOTE KIDNEY: *OPISTHONEPHROS*

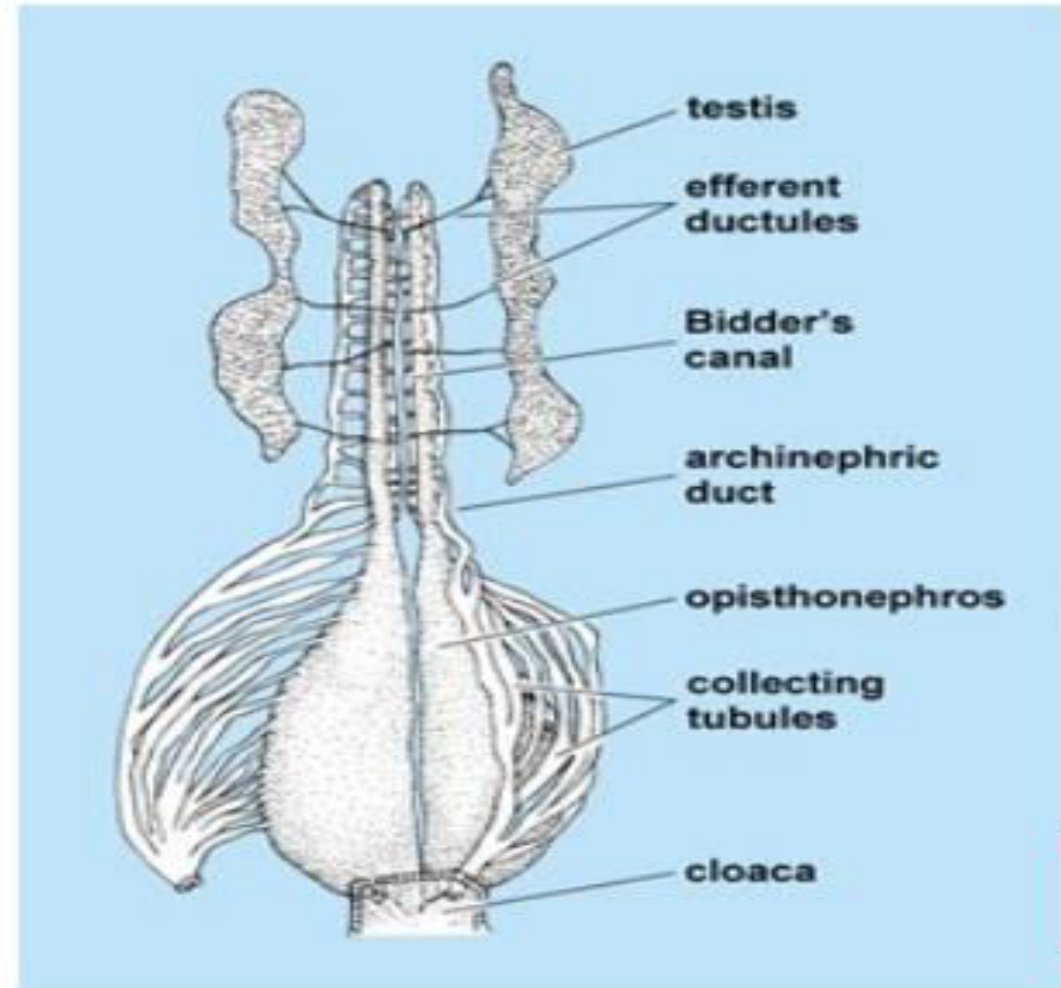
- An opisthonephric tubule has a narrow neck adjacent to the renal corpuscle.
- Neck is followed by the:
 - **collecting portions**, which joins the archinephric duct and;
 - **secretory part**, which forms the proximal and distal convoluted tubules.



Urogenital organs of male salamander,

THE ANAMNIOTE KIDNEY: OPISTHONEPHROS

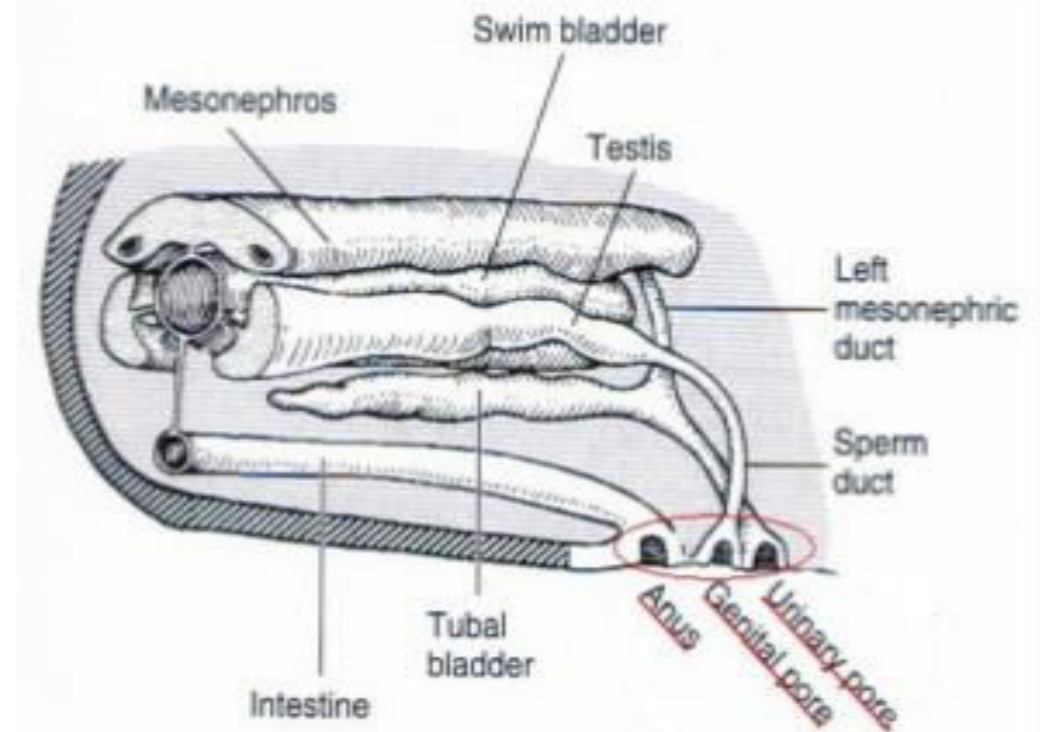
- Ureter-like duct is formed by the union of collecting ends of several collecting tubules.
- This may open into the archinephric duct or may connect independently with the cloaca.



THE ANAMNIOTE KIDNEY: OPISTHONEPHROS

Opisthonephric kidneys of fishes

- Males have longer kidneys than females.
- *Efferent ductules* connect the testes with the archinephric duct.
- Archinephric duct becomes the ductus deferens which serve for sperm transport.
- Female fishes have the posterior ends of their archinephric ducts enter a common **urinary sinus** inside a small **urinary papilla**.



THE ANAMNIOTE KIDNEY: OPISTHONEPHROS

- Urinary papilla enters the cloaca in sharks.
- It opens directly to the outside in fishes without cloaca.
- Seminal vesicles and sperm sacs may develop for the temporary storage of spermatozoa.

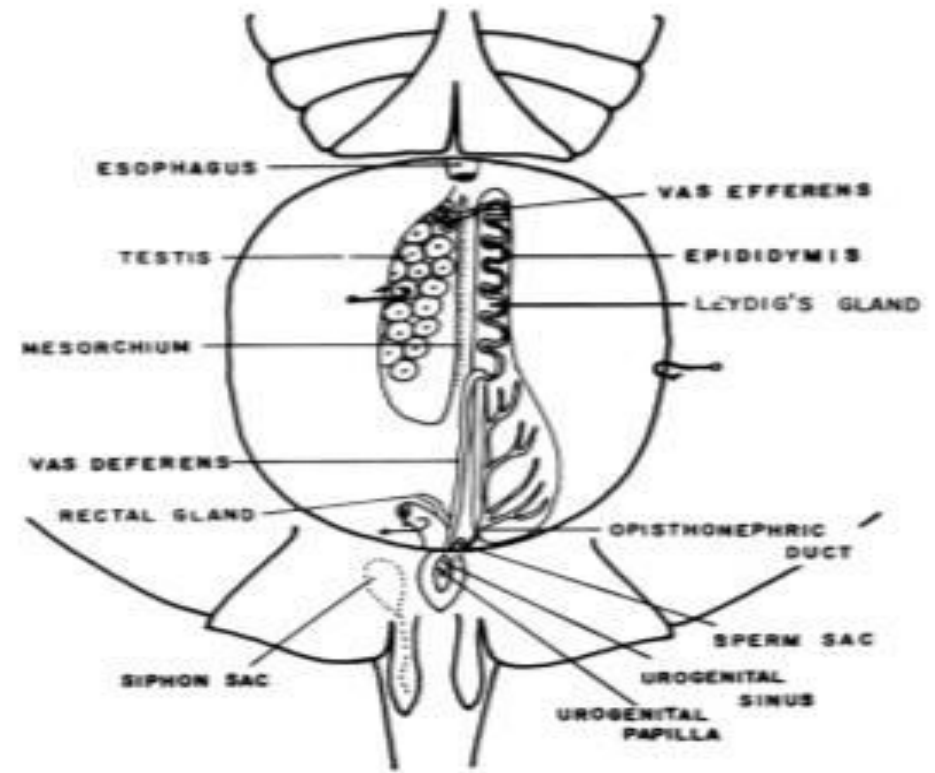
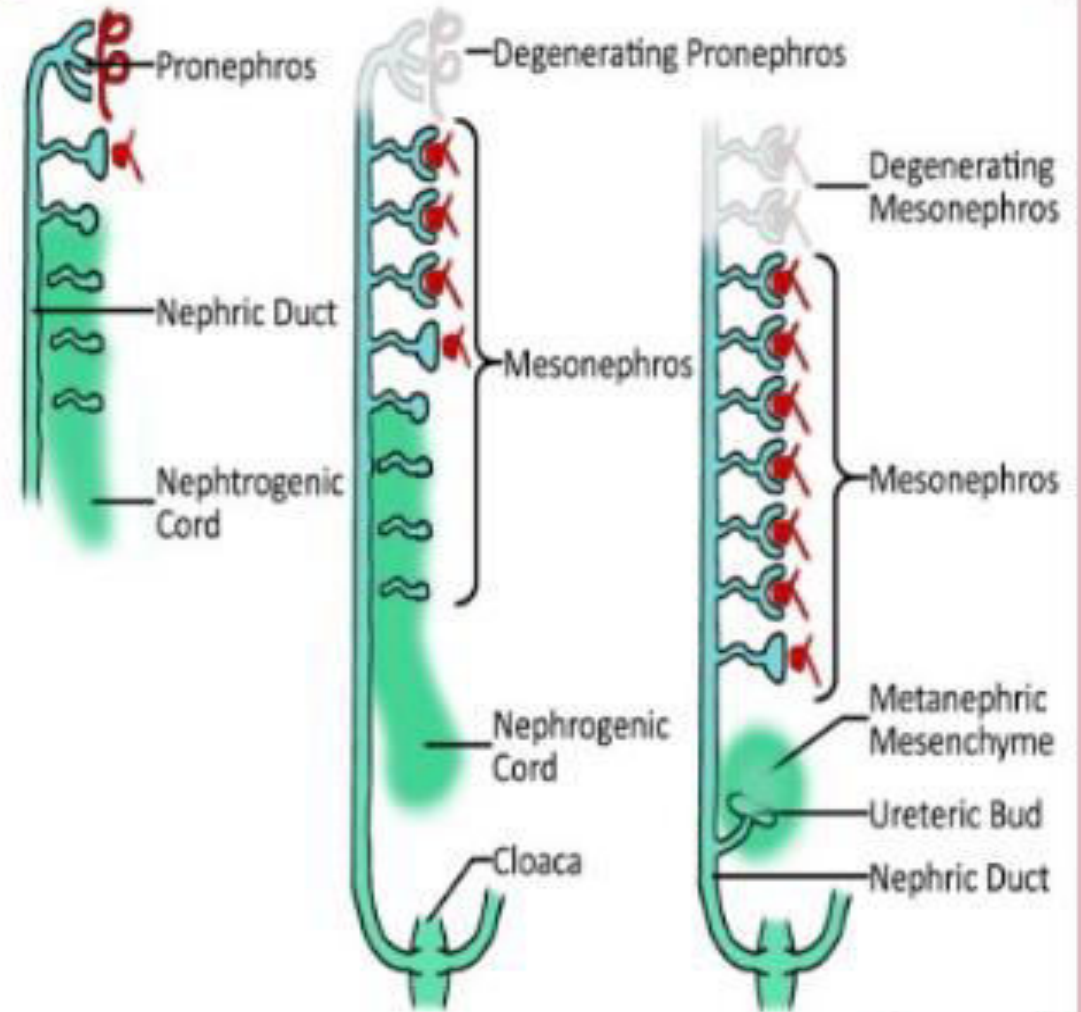


FIGURE 10. Urogenital system of male round stingray. Rectum and left testis moved to animal's side.

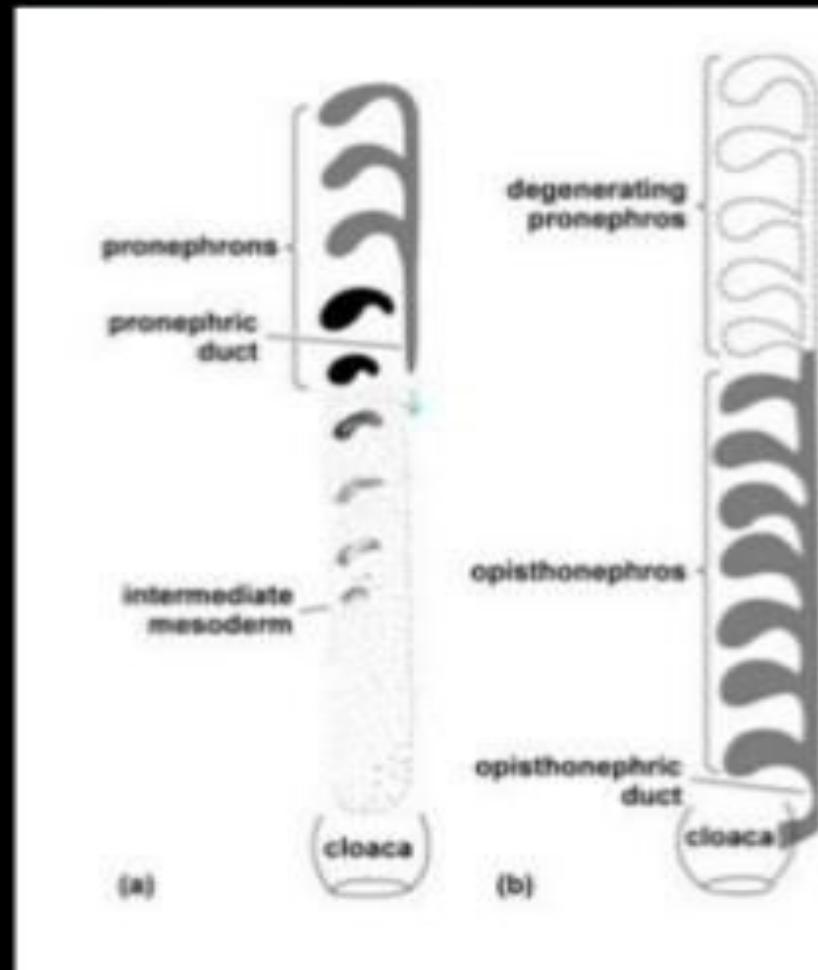


THE AMNIOTE KIDNEY

- **Mesonephros** develops as the embryonic kidney in reptiles, birds, & mammals
- It is sometimes called the **Wolffian body** and the mesonephric duct is called the **Wolffian duct**.
- It functions for a short time after hatching or birth



MESONEPHROS



- Develops from middle part of intermediate mesoderm.
- Form soon after degradation of pronephros.
- Mesonephros is functionally better than pronephros
- bcoz mesonephric tubules are numerous in number.
- They develop internal glomeruli.

In tailed amphibians the kidneys are rather elongate structures as in elasmobranchs.

But in anurans there is a tendency for these structures to be short and compact.

Renal corpuscles are large to assist in the elimination of water and, thus, prevent excessive dilution of the body fluids.

Most marine fishes other than elasmobranchs, have the renal corpuscles very small so as to reduce water loss.

The renal corpuscles are much larger in freshwater fishes than in marine species.

Elasmobranchs, unlike most marine fishes, have large renal corpuscles.

In some amphibians the archinephric duct is both genital and excretory in nature in the male, whereas in others the archinephric duct serves only for the transport of sperms, and the kidney is drained by a new duct, somewhat comparable to the ureter of higher vertebrates.

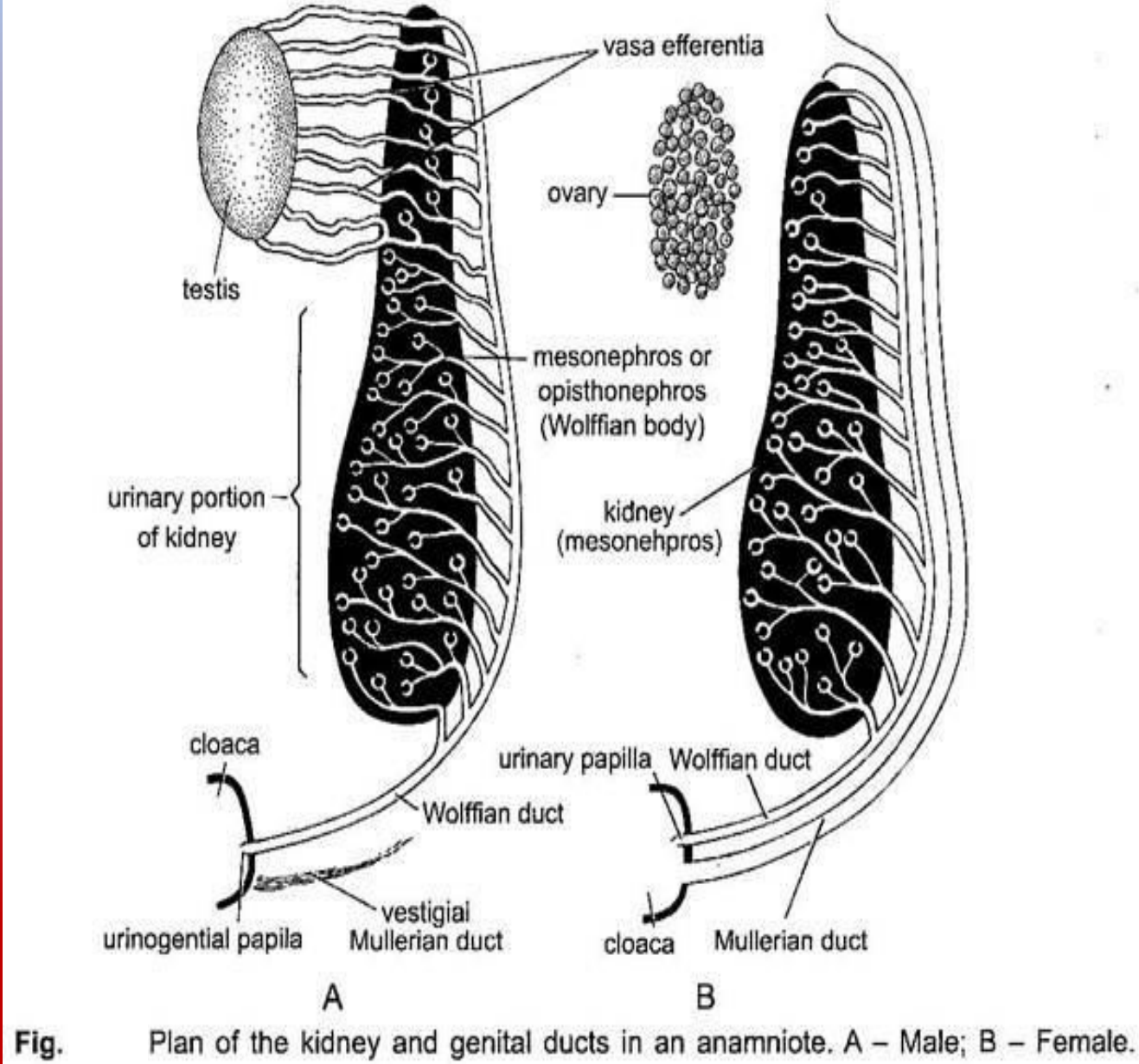
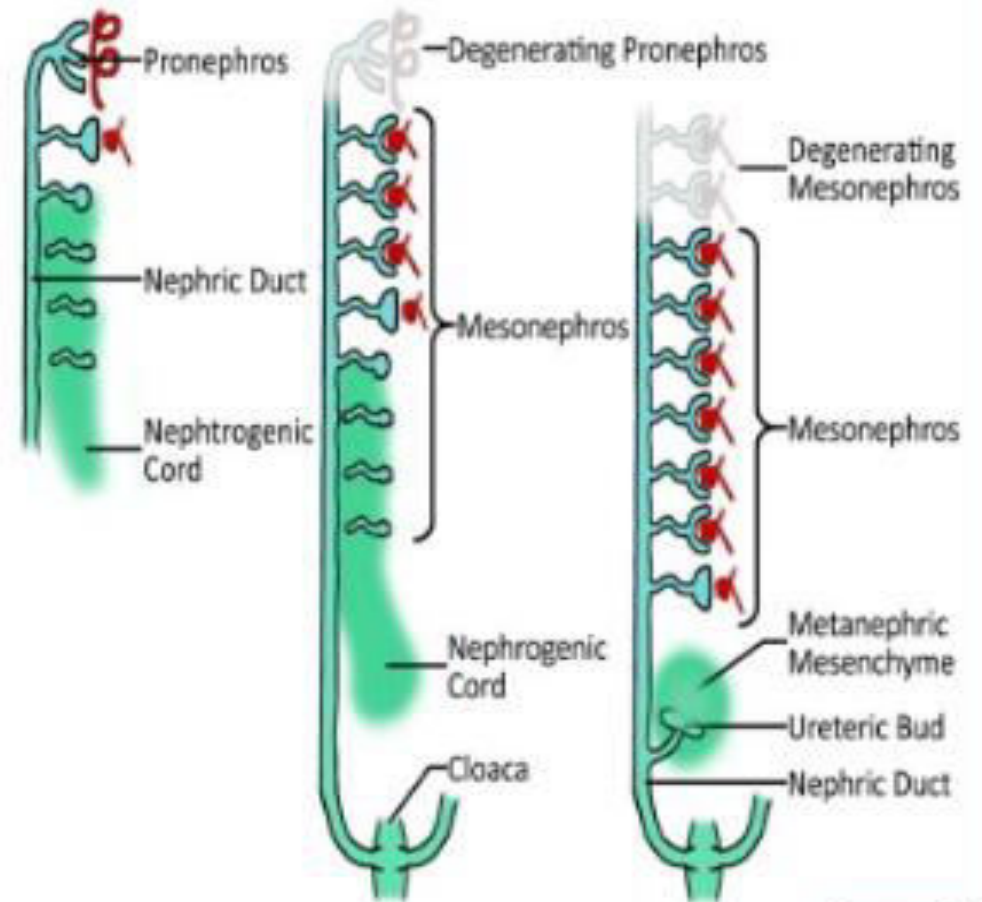


Fig. Plan of the kidney and genital ducts in an anamniote. A – Male; B – Female.

THE AMNIOTE KIDNEY: METANEPHROS

- Arise posterior to the mesonephros.
- **Nephron** is the functional unit.
- Each nephron is composed of **renal corpuscles**, **secretory tubules**, and **collecting tubules**.
- Differentiation of metanephros begins when a metanephric **bud** sprouts from posterior end of the mesonephric duct.
- **Nephrogenic mesoderm** surrounds the bud.



THE AMNIOTE KIDNEY: METANEPHROS

- Bud grows anteriorly together with the metanephric **blastema**, and eventually gives rise to **metanephric duct** or **ureter**, and **pelvis** of the kidney.
New Excretory Duct
- Fingerlike outgrowths from the pelvis invade the kidney blastema and become collecting tubules.
- S-shaped tubules are organizing within the blastema.
 - One end grows toward and encapsulates a **glomerulus** to form a renal corpuscle.
 - The other end grows toward and empties into a **collecting tubule**.



- **Metanephric has a double origin, a tubular outgrowth arises from the base of mesonephric duct near the cloaca and it grows anteriorly and dorsally and eventually the metanephric tubules open into it.**
- **Its distal end dilates to form the pelvis which divides several times to form collecting tubules, while its proximal part becomes the ureter or metanephric duct.**
- **The nephrotome gives rise to metanephric uriniferous tubules of which there are thousands with no segmental arrangement.**
- **The metanephric tubules become long and much coiled and have glomeruli enclosed in Bowman's capsules but they lack peritoneal funnels so that all connection with the coelom is lost.**
- **The metanephric tubules are much convoluted, and a thin U-shaped loop of Henle is formed in between proximal and distal convolutions of the tubule.**

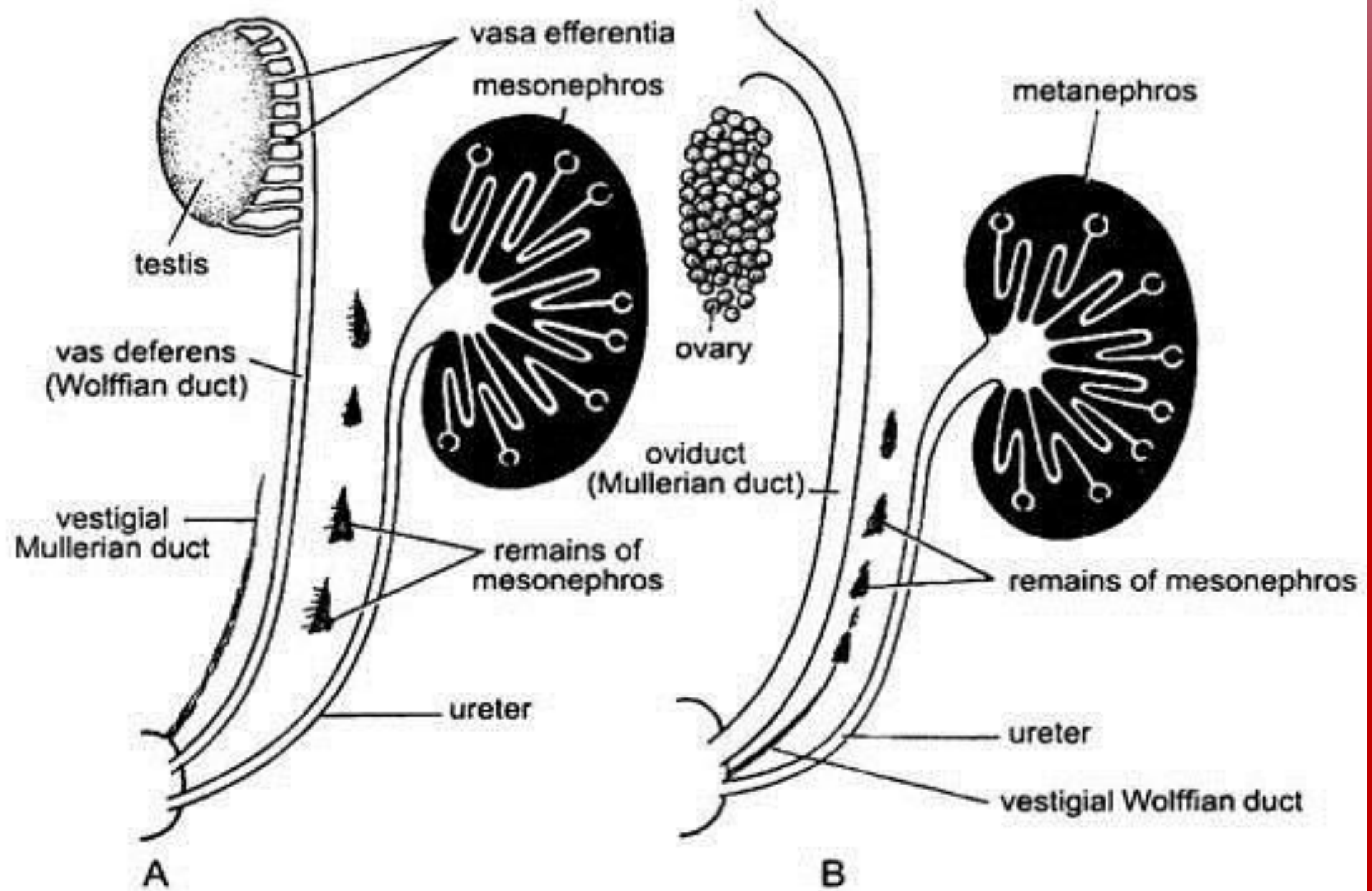
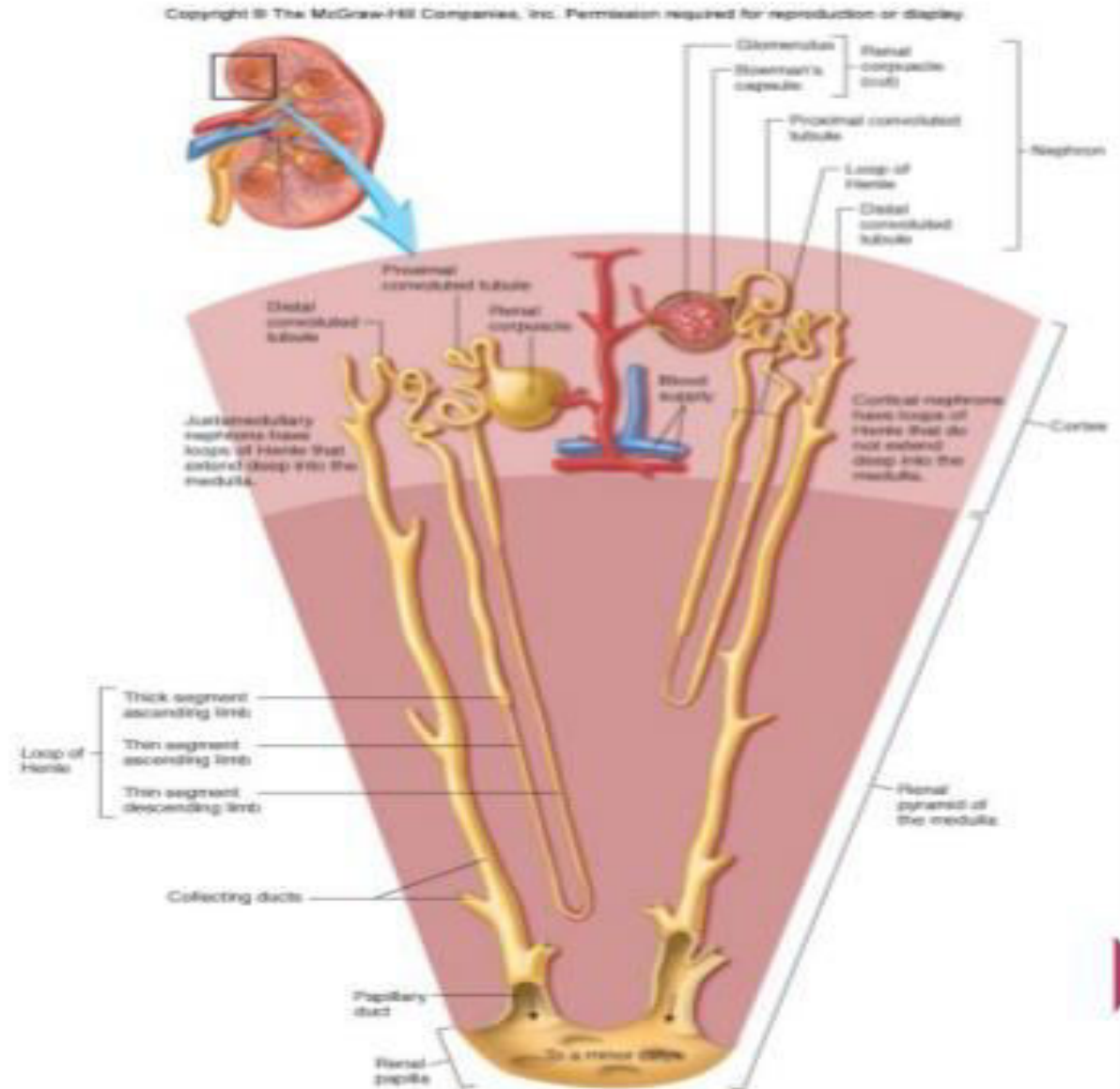


Fig. Plan of the kidney and genital ducts in an amniote A–Male; B–Female.

THE AMNIOTE KIDNEY

○ Each **kidney tubule** of mammals is composed of the following parts:

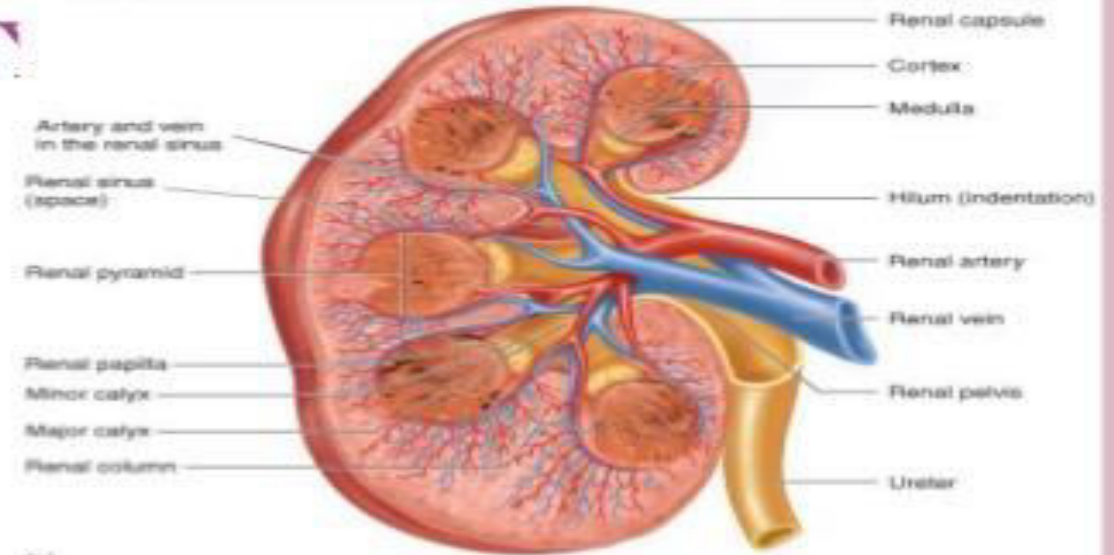
- **Proximal convoluted tubule**
- **Loop of Henle with ascending and descending portions**
- **Distal convoluted tubule.**



THE AMNIOTE KIDNEY

- **Capsule** is a connective tissue that surrounds the kidney.
- **Cortex** is the outer kidney substance containing renal corpuscles.
- **Medulla** is the inner substance which contains the loops of Henle and common collecting tubules
- **Renal pyramids** are the conical aggregated loops and collecting tubules.
- **Renal papilla** is a blunt tip of each renal pyramid that project into a funnel-shaped outpocketing, the **calyx** of the pelvis.

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(a)



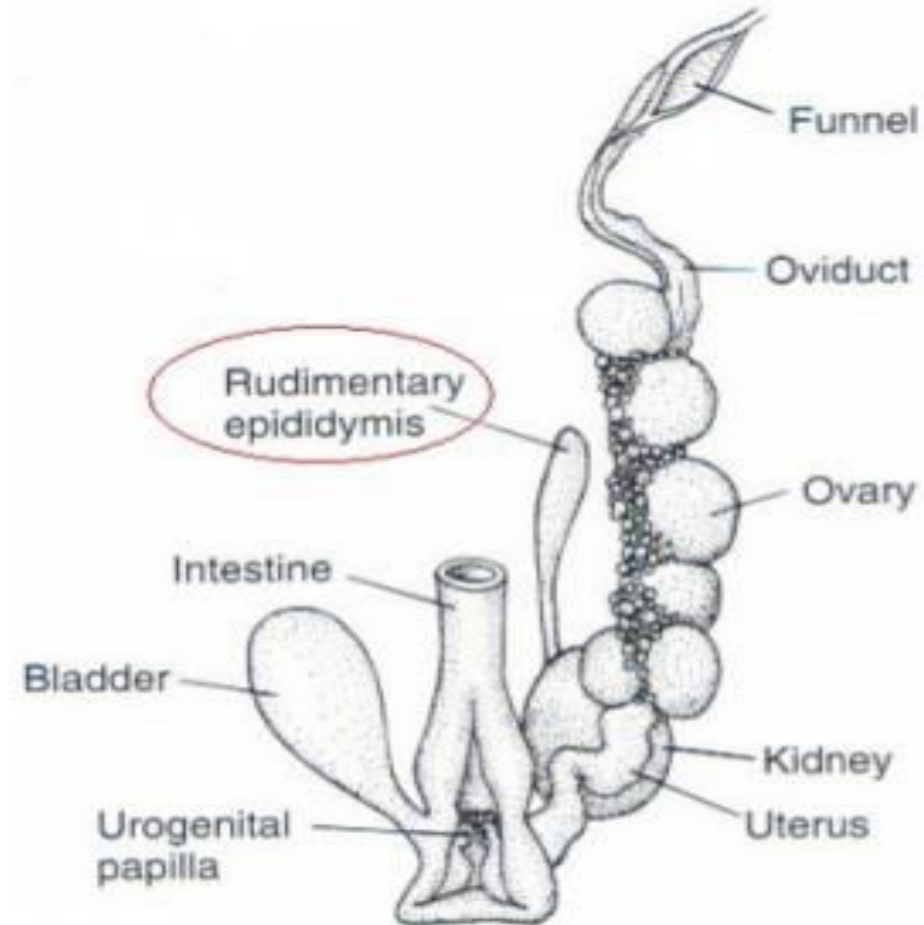
(b)

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COMPARATIVE ANATOMY OF THE METANEPHROS

Reptiles

- Kidneys restricted to the posterior half of the abdominal cavity and confined to the pelvic region.
- Generally small and compact, with lobulated surface.

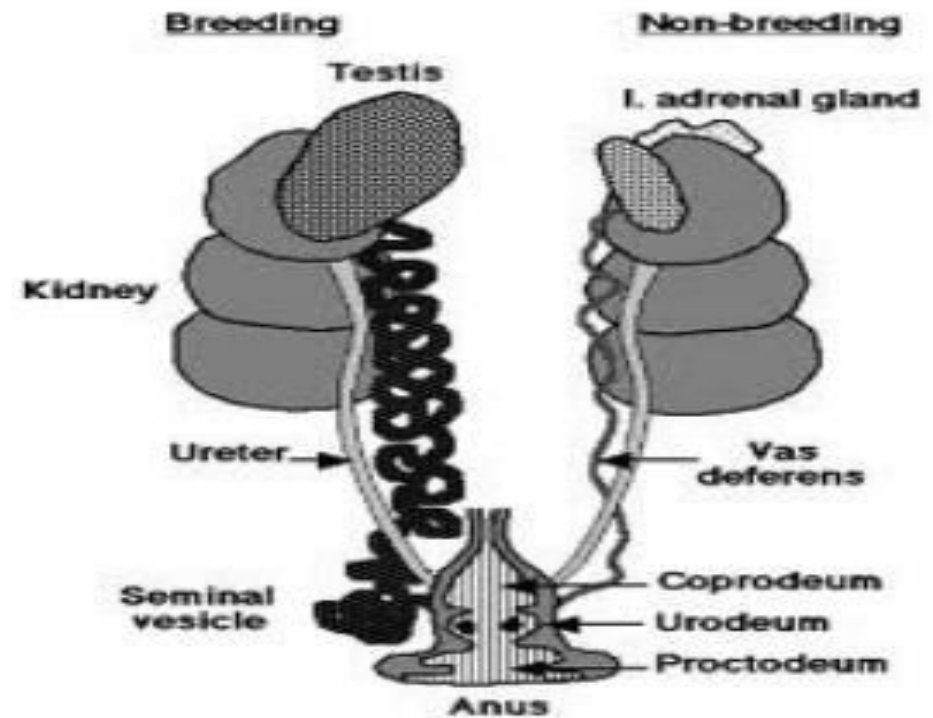


Urogenital system of female sphenodon

COMPARATIVE ANATOMY OF THE METANEPHROS

Birds

- Kidneys located in the pelvic region of the body cavity, with the posterior ends usually united.
- Lobed structures with short ureters which open into the cloaca.



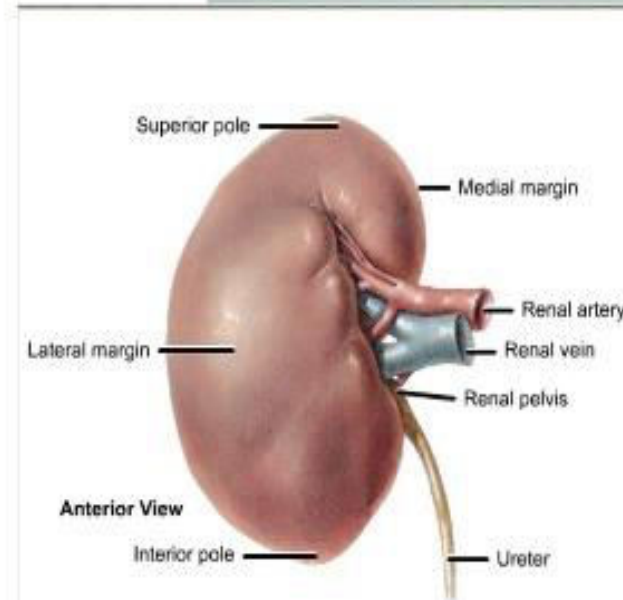
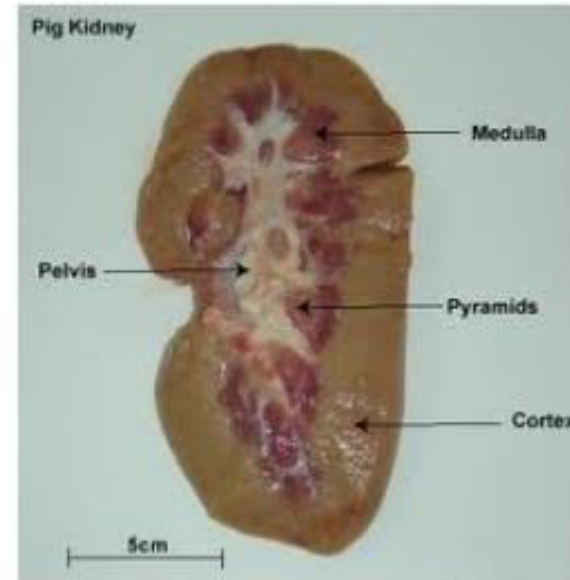
Male bird's urogenital system



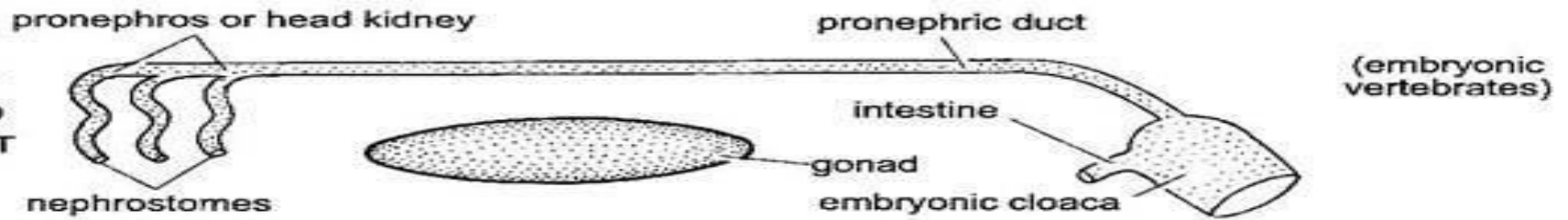
COMPARATIVE ANATOMY OF THE METANEPHROS

Mammalian kidney

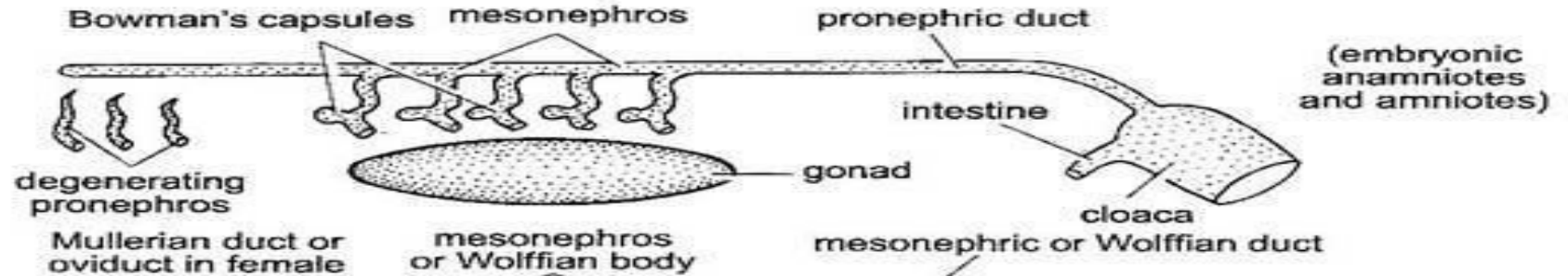
- Compact, bean-shaped organ attached to the body wall.
- **Ureter** leaves the hilum or hilus.
- **Hilum** is also the part where blood vessels and nerves enter and leave the kidney.



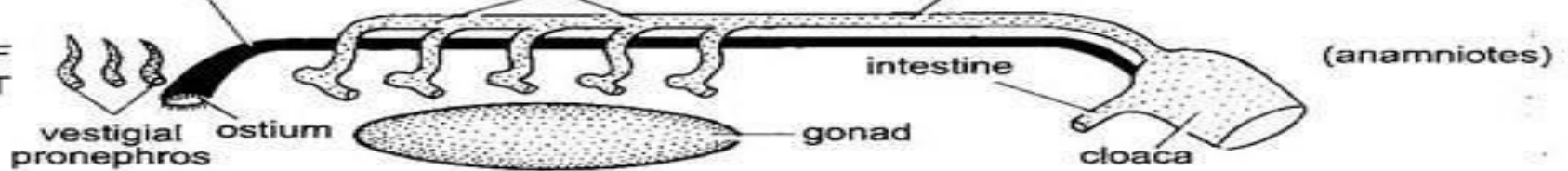
DEVELOPMENT OF PRONEPHROS AND PRONEPHRIC DUCT



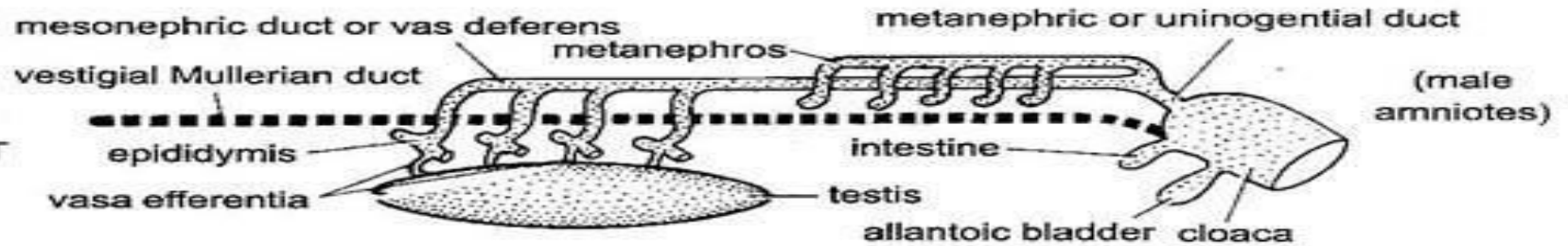
ATROPHY OF PRONEPHROS AND DEVELOPMENT OF MESONEPHROS



DIFFERENTIATION OF MESONEPHRIC DUCT



DEVELOPMENT OF METANEPHROS AND METANEPHRIC DUCT



DEVELOPMENT OF METANEPHROS AND METANEPHRIC DUCT

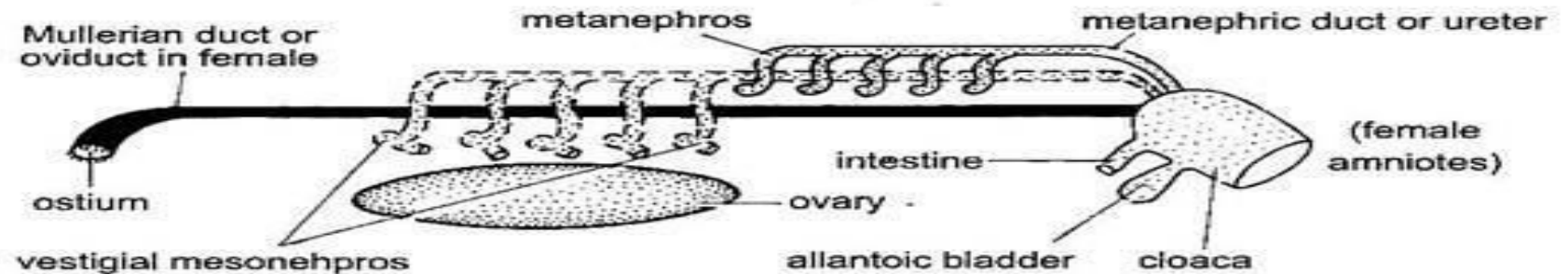



Fig. Evolution of kidney in vertebrates.

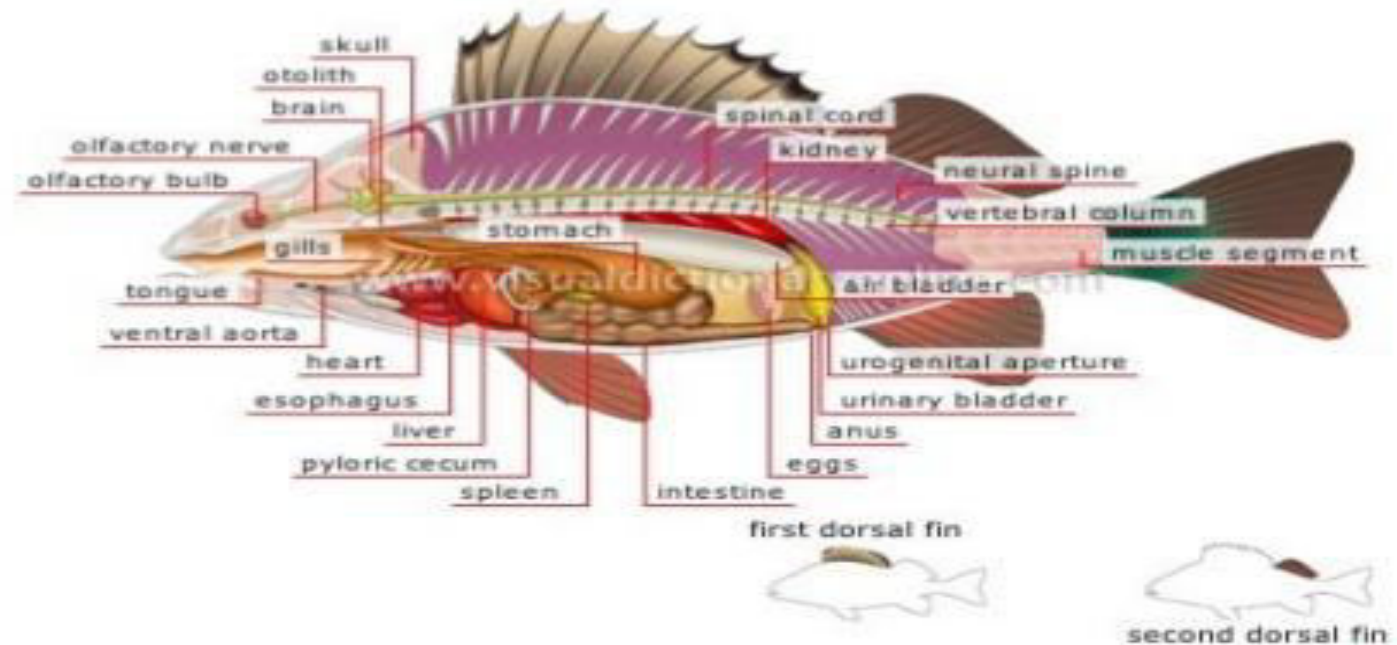
URINARY BLADDER

- Embryonic origin: ventral cloacal wall and portion of the allantois.
 - Function: temporary storage of urine before disposal or voiding
 - It may serve as a reservoir of water in terrestrial vertebrates.
 - Water, reabsorbed from the bladder results from the action of an antidiuretic hormone.
 - This is important to prevent dehydration.
 - In some lower vertebrates, it may serve as recovery sites for some ions that are scarce in their niche.
- Urinary bladders are found in all vertebrates except agnathans, snakes, crocodilians, some lizards, & birds (except ostriches).
 - Fish - bladders are terminal enlargements of the mesonephric ducts called **TUBAL BLADDERS**.
 - Amphibians through Mammals - bladders arise as evaginations of ventral wall of the cloaca.
- 

URINARY BLADDER: FISHES

TUBAL BLADDERS.

- It is an insignificant enlargement of the conjoined posterior ends of the urinary ducts.
- Not significant because fishes are immersed in water.
- Many marine fishes can extract fresh water from sea water by drinking sea water and quickly excreting the salts.



URINARY BLADDER

Cloacal Bladder

Amphibians

- Large and thin walled
- It connects with the cloaca a short distance beyond the openings of the archinephric ducts.



URINARY BLADDER

- **Crocodylians, snakes, some lizards, and birds** do not have urinary bladder.

Birds

- Absence in birds reduces the energy requirements for flight.
- Urinary wastes, mainly in the form of uric acid are eliminated via the cloaca along with the feces.

Turtles

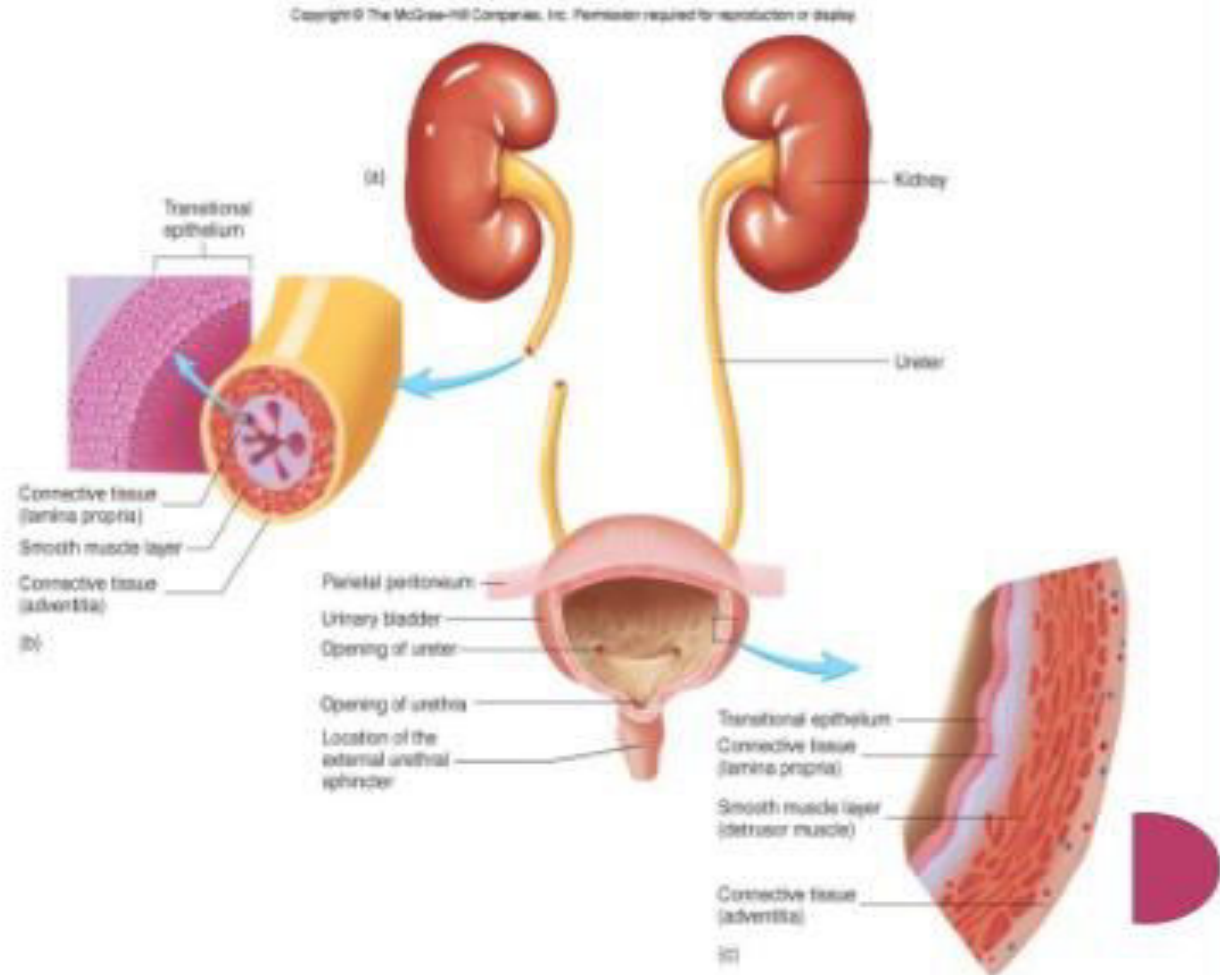
- With a pair of accessory urinary bladders which is connected with the cloaca, and functions as accessory organs for respiration
- These may be filled with water in females, which is used to soften the ground in preparing a nest.



URINARY BLADDER

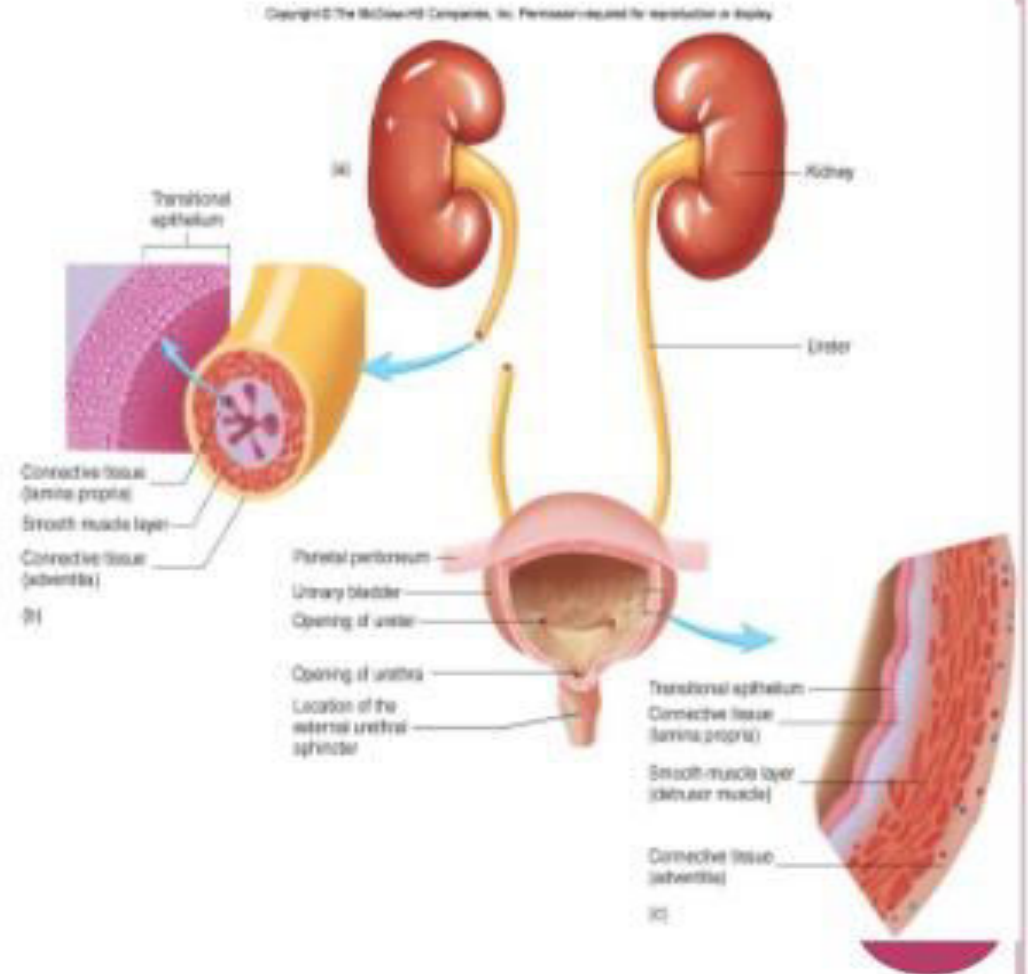
Mammals

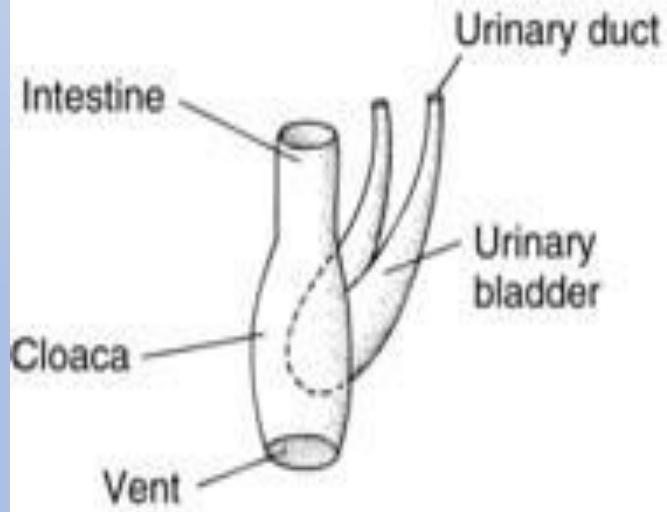
- Present in all mammals.
- It is muscular and connects to the outside by the urethra
- Lower ends of ureters opens directly into the bladder on its posterior dorsal surface.



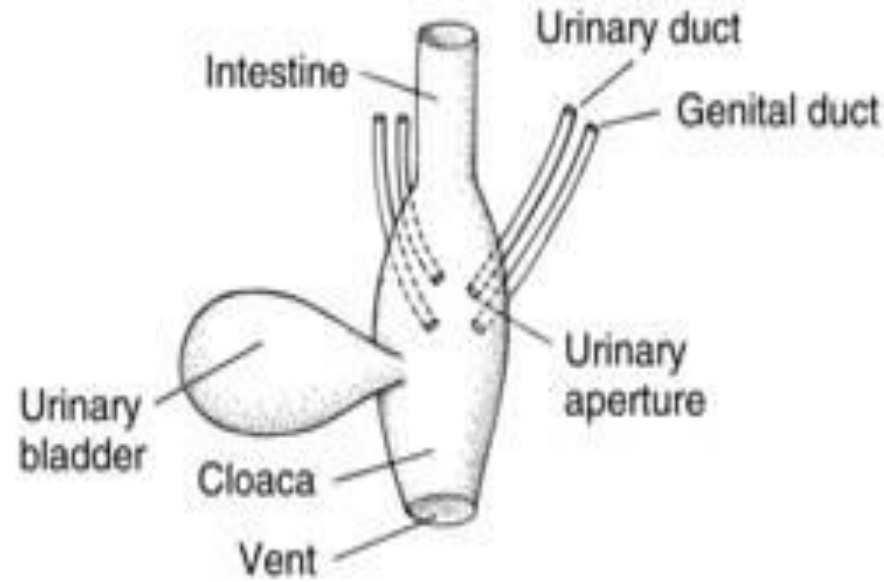
URINARY BLADDER

- Much of the muscles of the bladder continues down into the urethra.
- In males, the urethra is longer and passes through the penis and open at the tip through the **external urethral orifice** or **meatus**.
- Female rats and mice have their urethra that opens independently to the outside, passing through the clitoris.
- In other mammals, the urethra enters a **urogenital sinus** or **vestibule**.

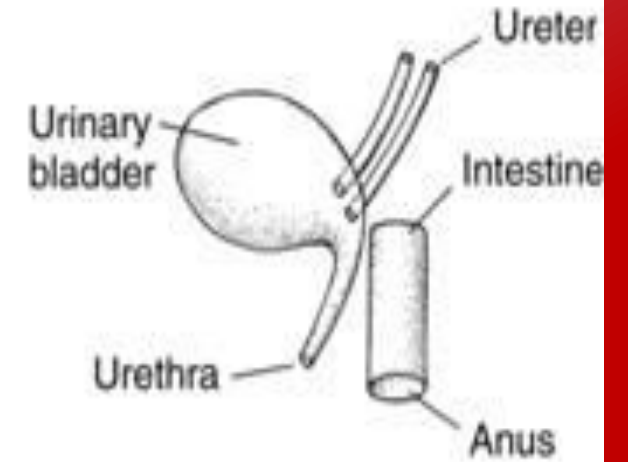




(a) Embryonic teleost



(b) Amphibian, reptile



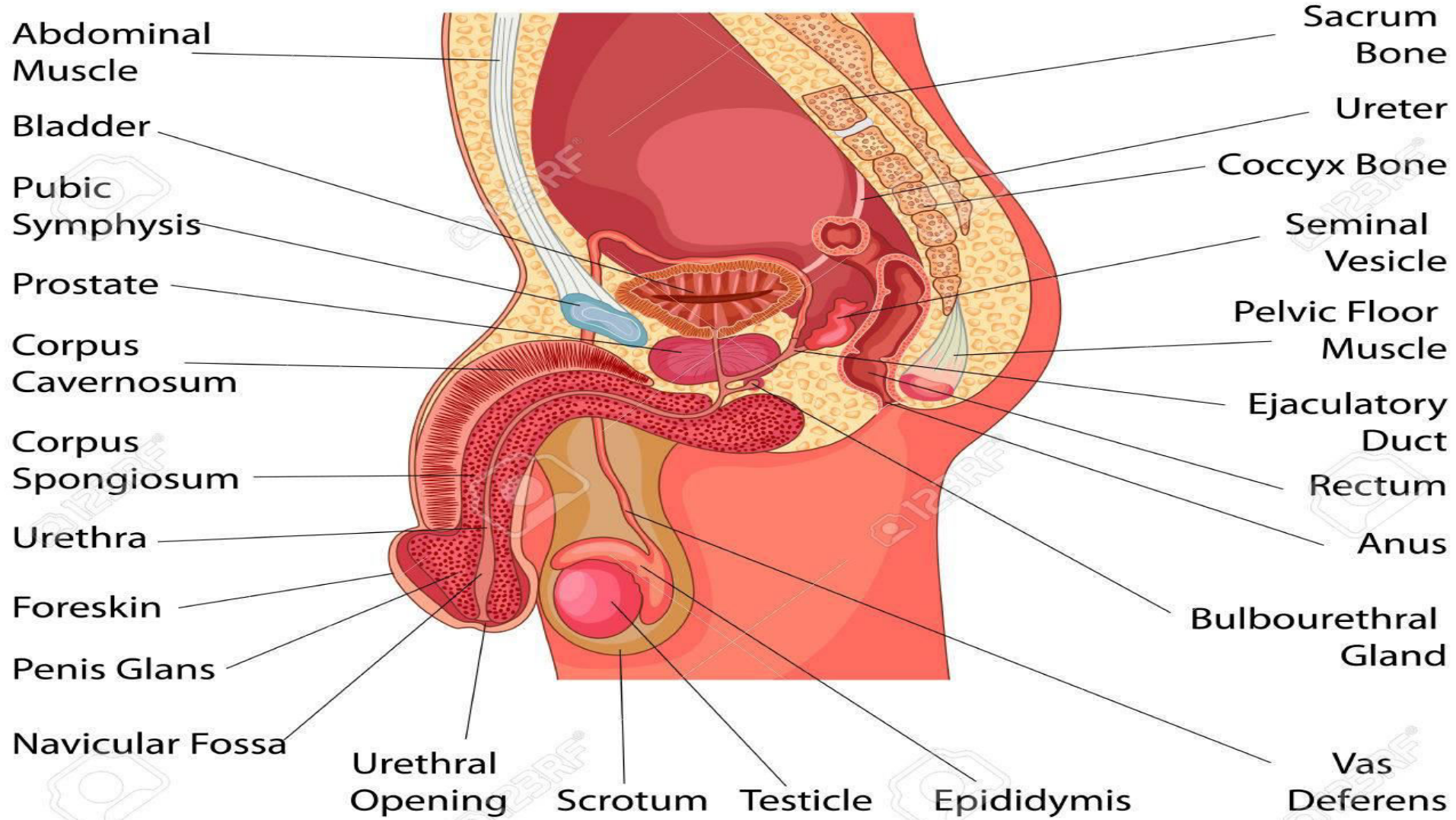
(c) Eutherian mammal

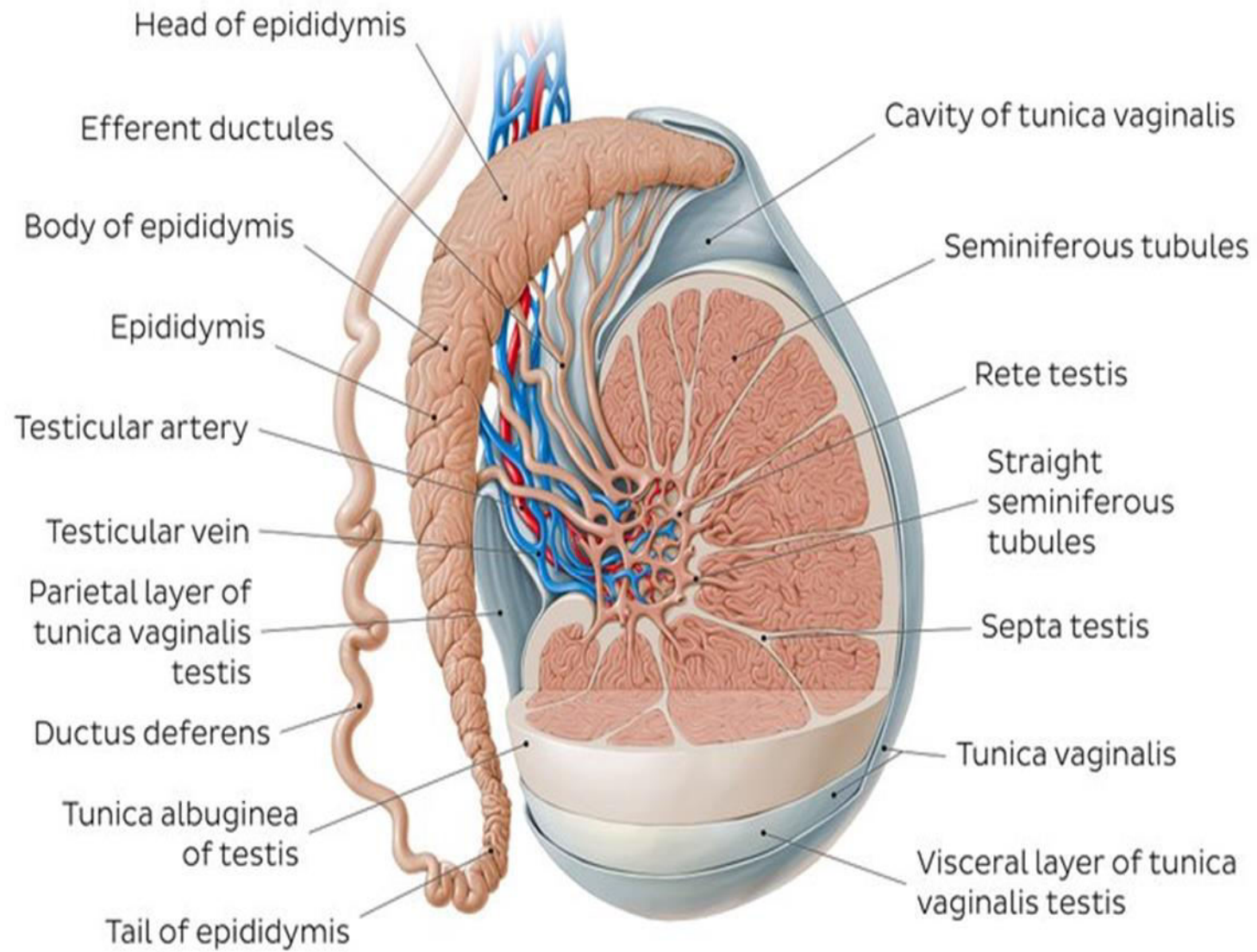
Fig- Evolution of the Urinary Bladder

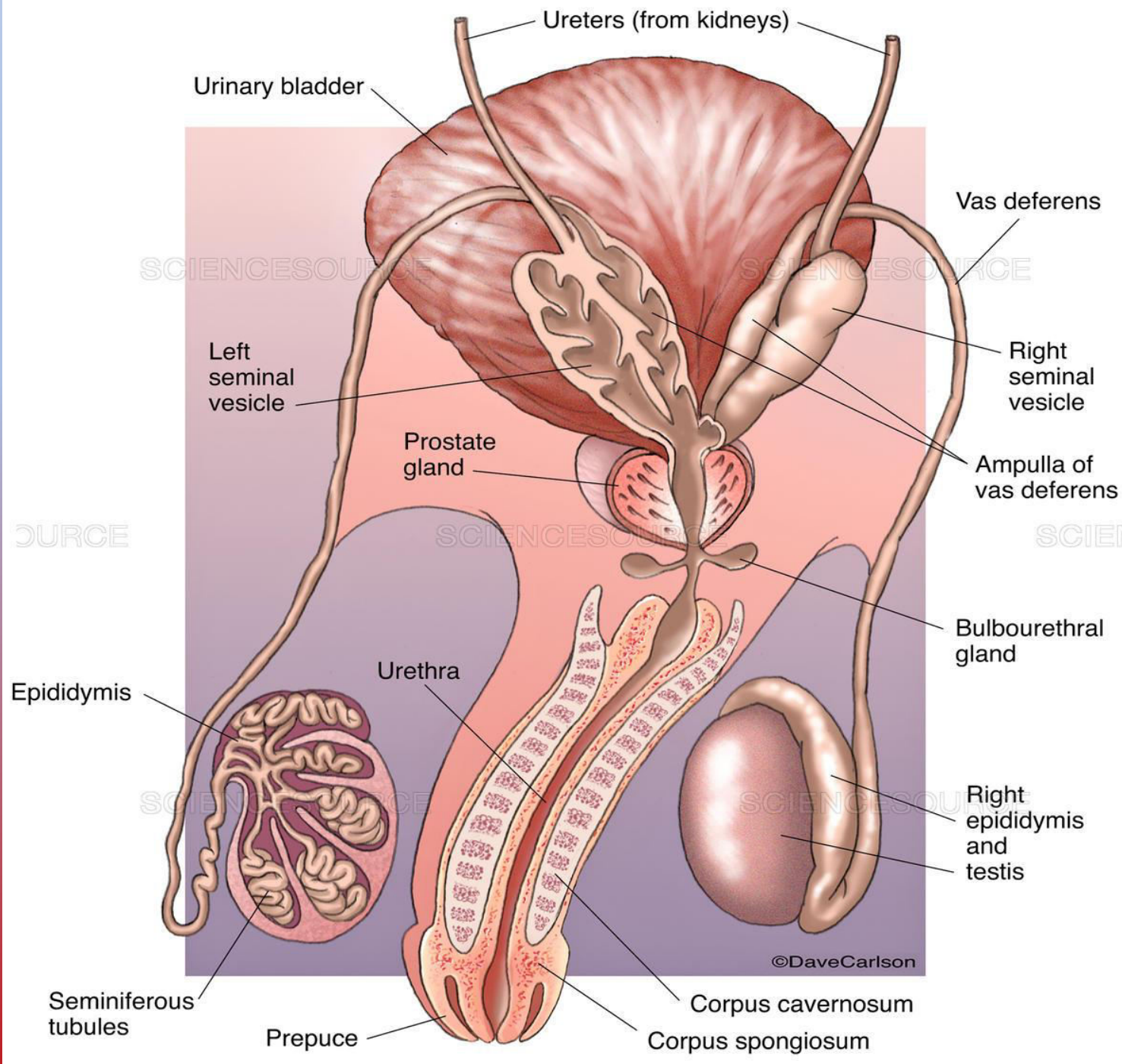
GENITAL SYSTEM

- Vertebrates exhibit sexual reproduction.
- Sexes are separate with exception of few hagfishes and few bony fishes.
- Male gonads.....Testes produces sperms
- Female gonadsOvariesproduces ova
- Gonads originate as a pair of genital ridges.
- Generally 1 pair of gonad are present but some vertebrates have single gonad.

Male Reproductive System







Embryonic Development

Gonads and Gametes

- The paired gonads arise from the genital ridge, initially a thickening in the splanchnic mesoderm to which adjacent mesenchyme cells contribute

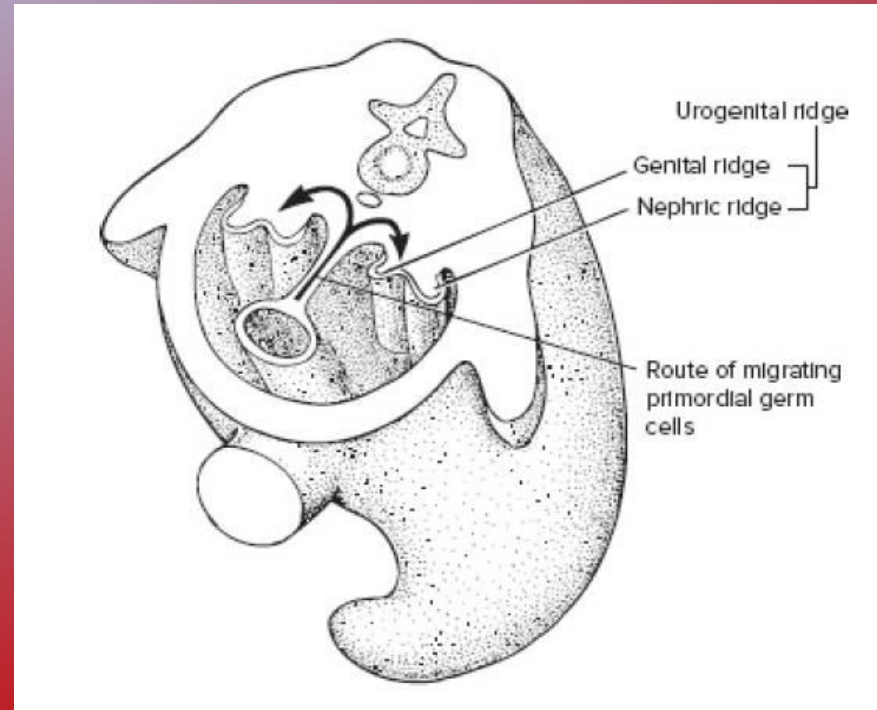


FIGURE Urogenital ridge. In the posterior part of the developing embryo, paired urogenital ridges arise within the roof of the coelom. The medial ridges are the genital ridges and give rise to the gonads. The lateral nephric ridges give rise to the kidney and its ducts. Primordial germ cells that develop into eggs or sperm arise outside the gonads, migrate to them, and colonize the early gonad rudiments.

- The gonad shows neither unique male nor female characters at this early stage, it is termed an **indifferent gonad**.
- The gonads of both sexes initially contain germ cells, the future sperm or eggs.
- Germ cells themselves do not arise in the genital ridge nor even in the adjacent mesoderm.
- They do not arise in the embryo at all.
- They first debut in remote sites outside the embryo in the extraembryonic endoderm.
- From the extraembryonic endoderm, they undergo a journey that takes them eventually to the indifferent gonad, where they take up a permanent residence.
- In females, germ cells establish residence in the cortex.
- In males, arriving germ cells establish residence in the medulla, which develops into the seminiferous tubule.

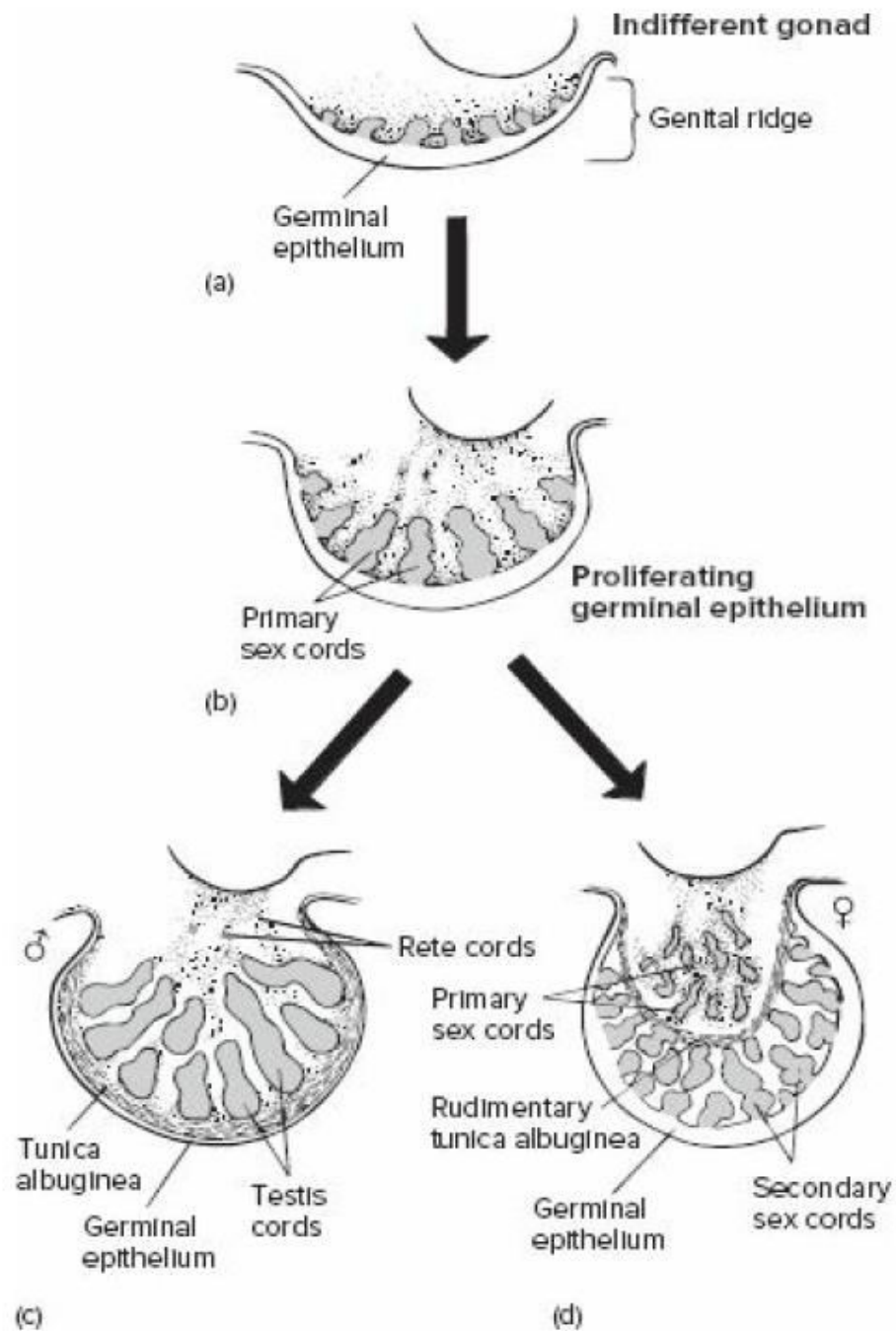


FIGURE Embryonic formation of the gonad. (a,b) Thickening of the genital ridge and inward movement of adjacent mesenchymal cells give rise to a swelling, the genital ridge, from the roof of the coelom. Because this early developmental stage is similar in both sexes, it is referred to as the indifferent gonad, which includes cortex and medulla. Primordial germ cells arriving from distant locations outside the embryo usually take up residence in the indifferent gonad. (c) In males, the medulla enlarges to become the testis cords that will form the seminiferous tubules. (d) In females, the cortex expands, forming secondary sex cords that house the follicles.

Reproductive Tracts

- Parts of the embryonic urinary system are salvaged by or shared with the genital system.
- In female mammals, the mesonephric duct (wolffian duct) drains the embryonic mesonephros, but it regresses later in development when the metanephros and its ureter become the kidney of the adult.
- A second parallel **Müllerian duct** arises next to the embryonic mesonephric duct before it regresses.
- The Müllerian duct forms the oviduct, uterus, and vagina.
- A few mesonephric tubules may persist as the **Paroöphoron** and **Epoöphoron**.
- In male mammals, the mesonephric duct becomes the vas deferens.
- Mesonephric tubules and some of the associated ducts contribute to the epididymis.

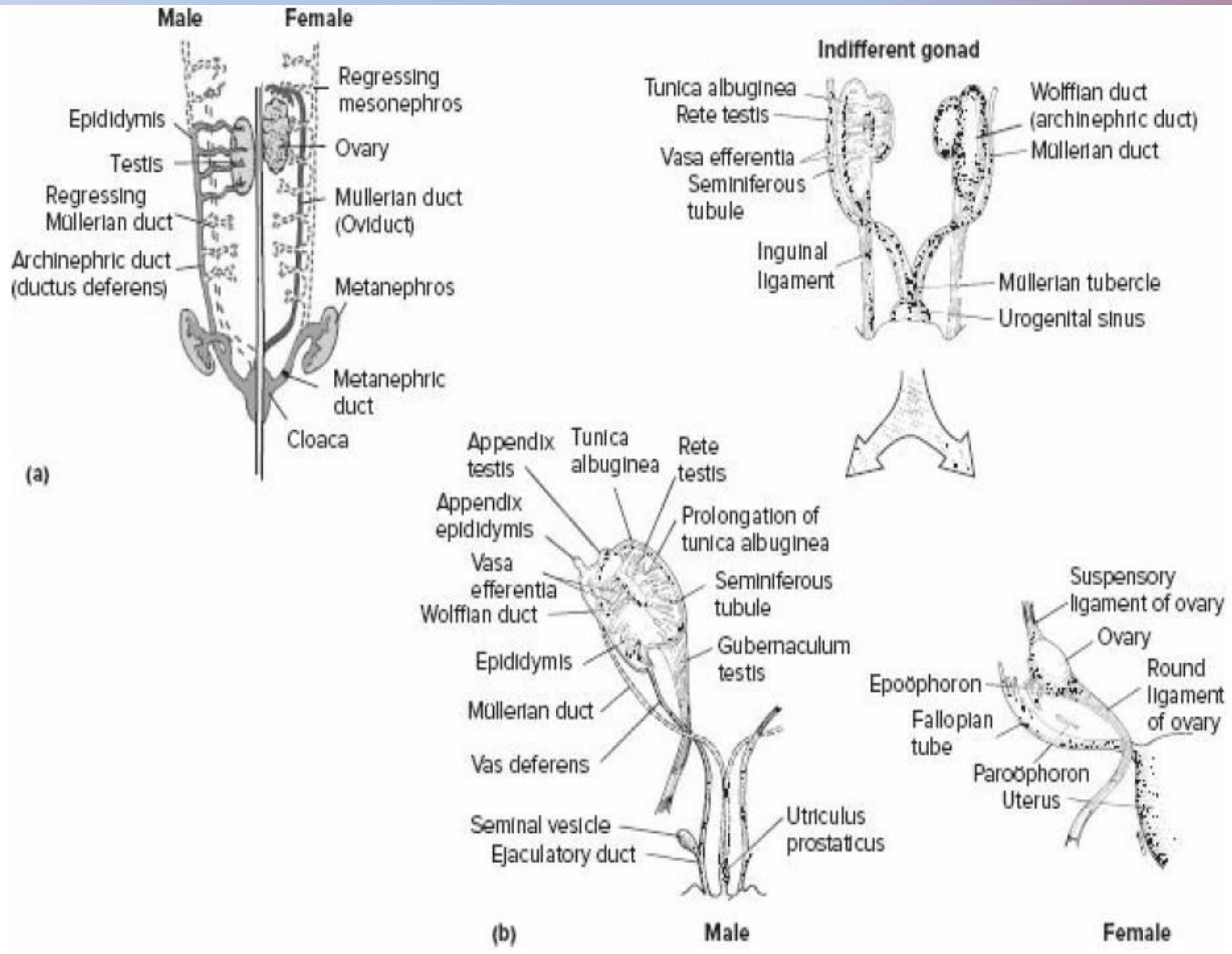


FIGURE:
Duct derivatives male and female
(a) The Müllerian and Archinephric ducts have different fates in females and male.
(b) Embryonic formation of the male and female genital systems in mammals.

Male Ducts

- Except in CYCLOSTOMES, sperms are released in a closed system of ducts.
- **Deferent ducts** carries either the sperm or both sperm and urine.
- CHONDRICHTHYANS have paired deferent ducts that convey ONLY SPERM.
- Several PRIMITIVE RAYFINNED FISHES and SOME DIPNOANS pass sperm into the anterior end of deferent duct which convey both sperm and urine.
- All AMPHIBIANS have deferent ducts, some species convey ONLY SPERM and in others BOTH sperm and urine.
- Deferent ducts of AMNIOTES carry ONLY SPERM.

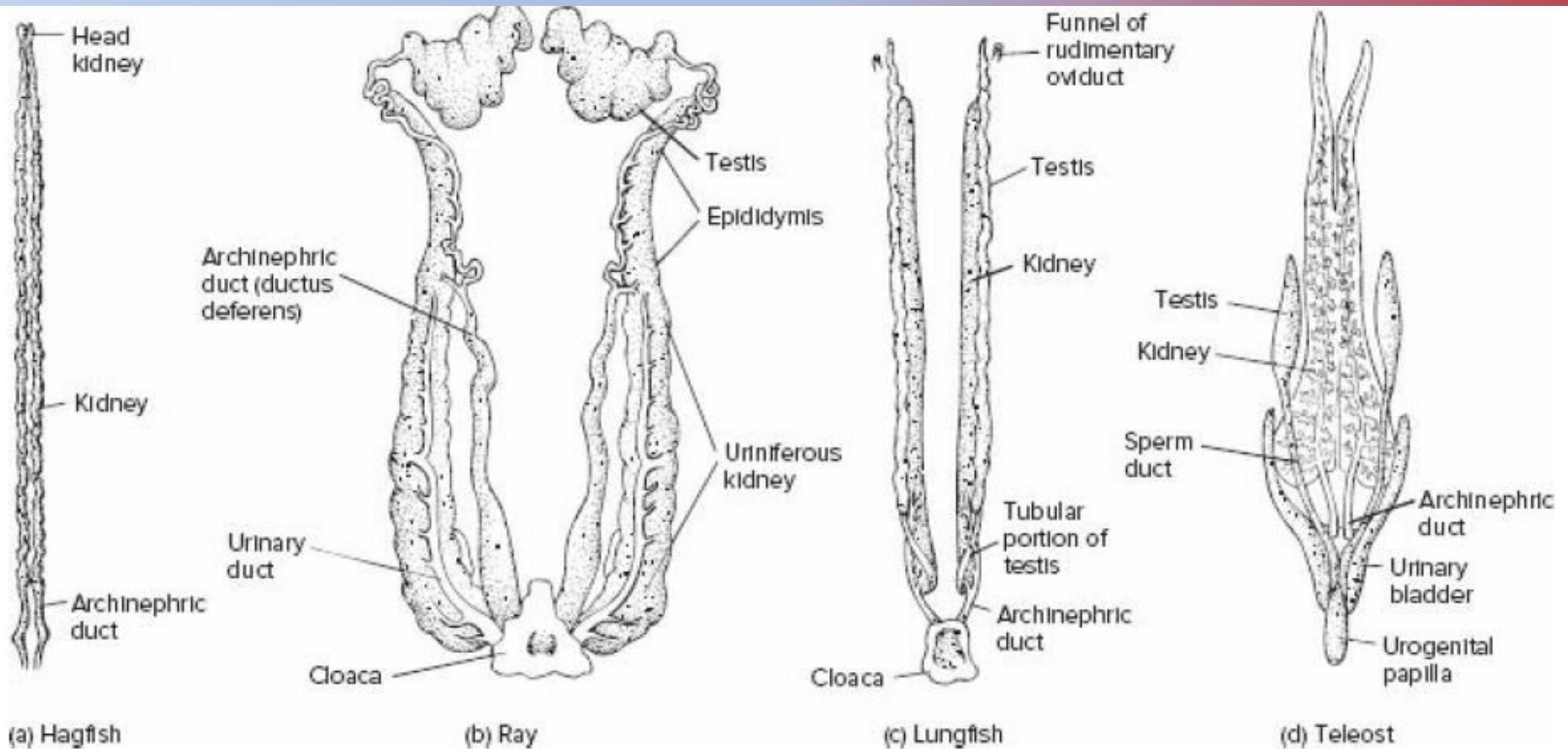


FIGURE: Urogenital systems of male fishes. (a) Hagfish, *Bdellostoma*. The single testis of the hagfish hangs in the dorsal body wall between the kidneys. (b) Elasmobranch, *Torpedo*. (c) Lungfish, *Protopterus*. (d) Teleost, sea horse *Hippocampus*.

- **The accessory urinary ducts, distinct from the archinephric ducts, are usually present to service the posterior uriniferous kidney.**
- **In bony fishes, the archinephric ducts drain the kidneys and may receive sperm from the testes.**
- **However, the testes tend to develop separate sperm ducts and routes of exit.**
- **In most teleosts, this separate duct system forms a testicular duct, which is not homologous to the archinephric duct and may even establish its own opening to the exterior.**

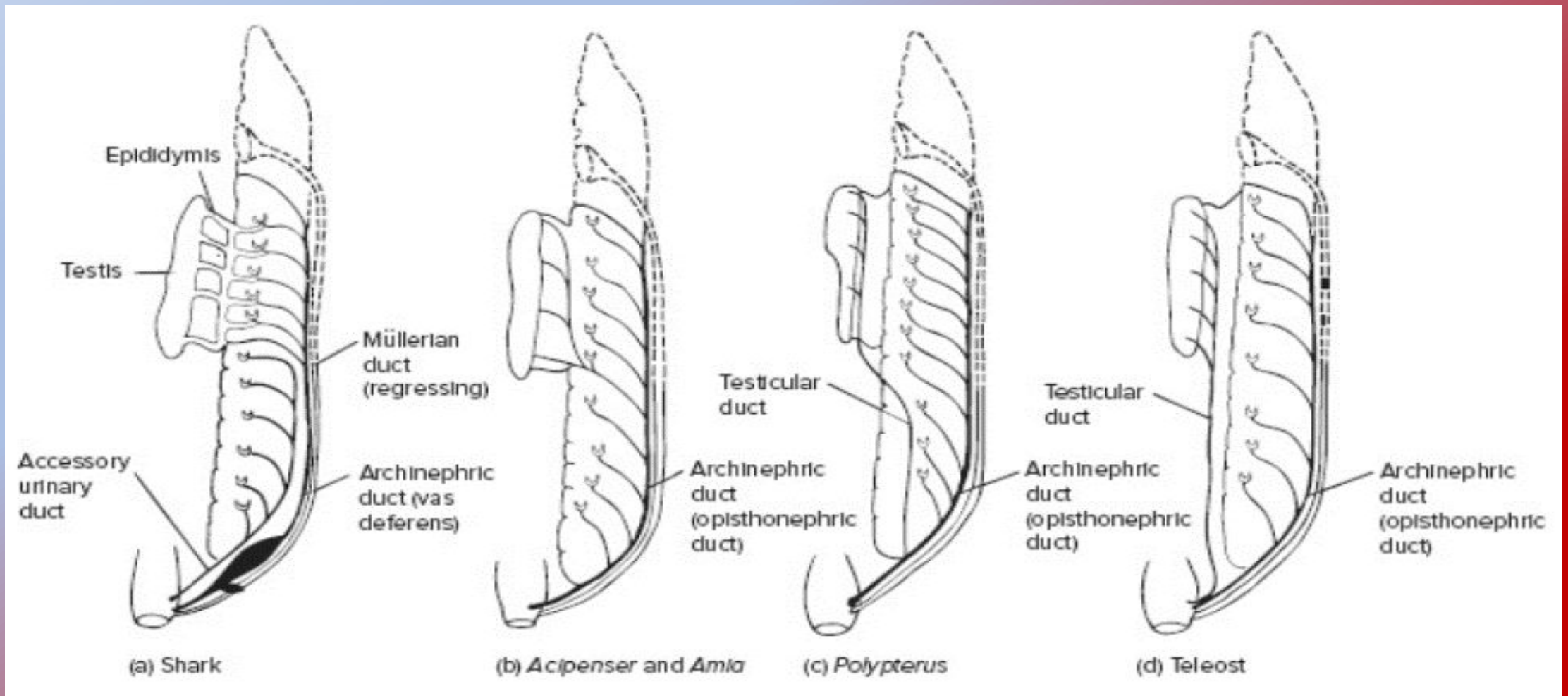


FIGURE: Urogenital ducts of male fishes. (a) Shark. (b) Sturgeon and bowfin. (c) Bichir. (d) Teleost.

In sharks, an accessory urinary duct develops to drain the kidney, and the archinephric duct is concerned with sperm transport. In other groups, additional ducts that develop to drain the testis sometimes join the archinephric duct. In teleosts, these exit independently.

- In *Necturus*, the archinephric ducts transport both sperm from the testes and urine from the uriniferous kidneys.
- In salamander families, new accessory urinary ducts service the caudal kidneys, and sperm are transported from the testes through tiny ducts in the cranial kidneys to the archinephric ducts (vas deferens) to be stored.

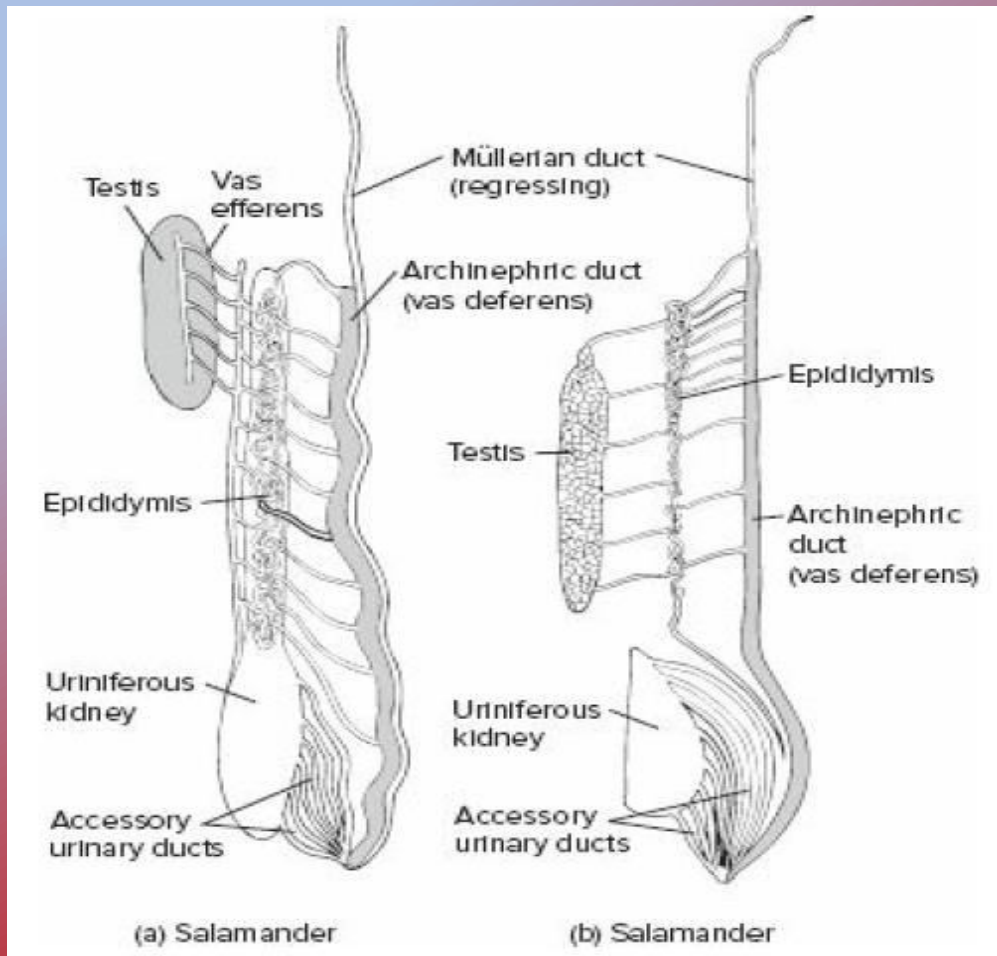


FIGURE: Urogenital systems of male amphibians.
(a) Salamander, *Ambystoma*.
(b) Salamander, *Gyrinophilus*.

- In all frogs and a few species of salamanders, tiny ducts that reach directly from the testes to the archinephric ducts bypass the anterior part of the kidneys.
- In some adult amphibians, the archinephric ducts may have both reproductive and excretory roles.
- In other species, these ducts may be involved exclusively in sperm transport, and new accessory urinary ducts may drain the opisthonephros.
- In male amniotes, the archinephric duct (vas deferens) transports sperm exclusively.

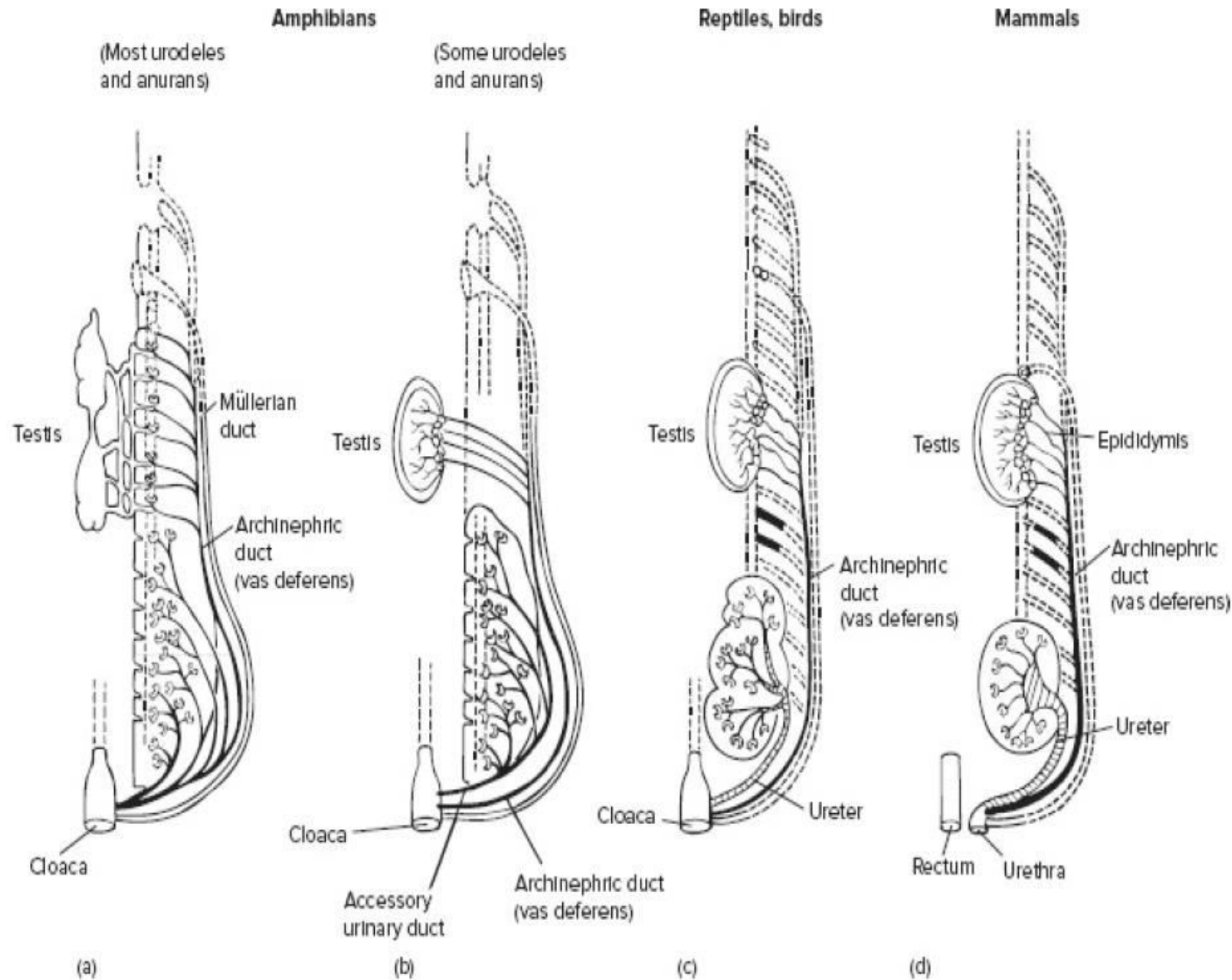
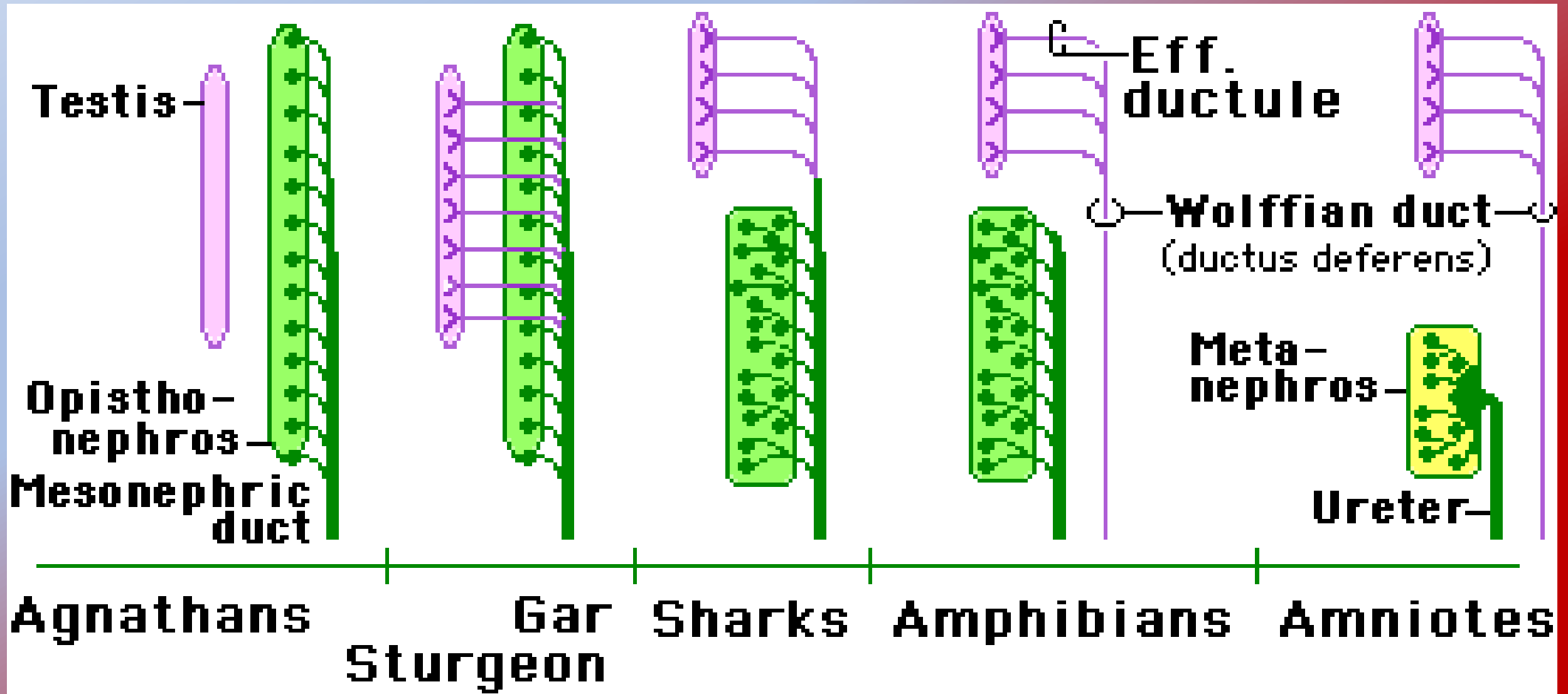


FIGURE: Urogenital ducts of tetrapod males.
(a) Most urodeles and most anurans (adults).
(b) Some urodeles and some anurans (adults).
(c) Reptiles and birds.
(d) Mammals.



Male Urogenital Relations

Female Reproductive System

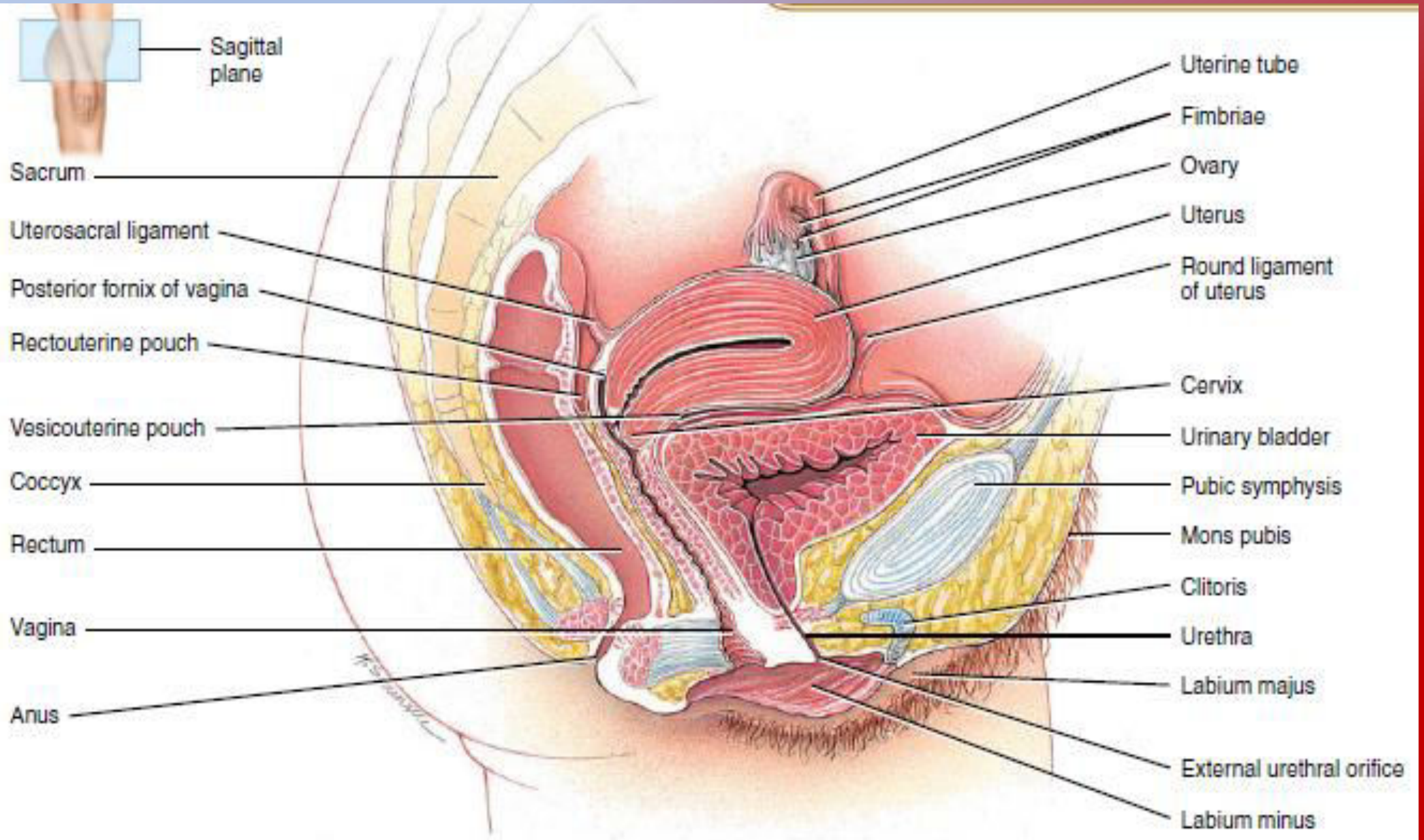
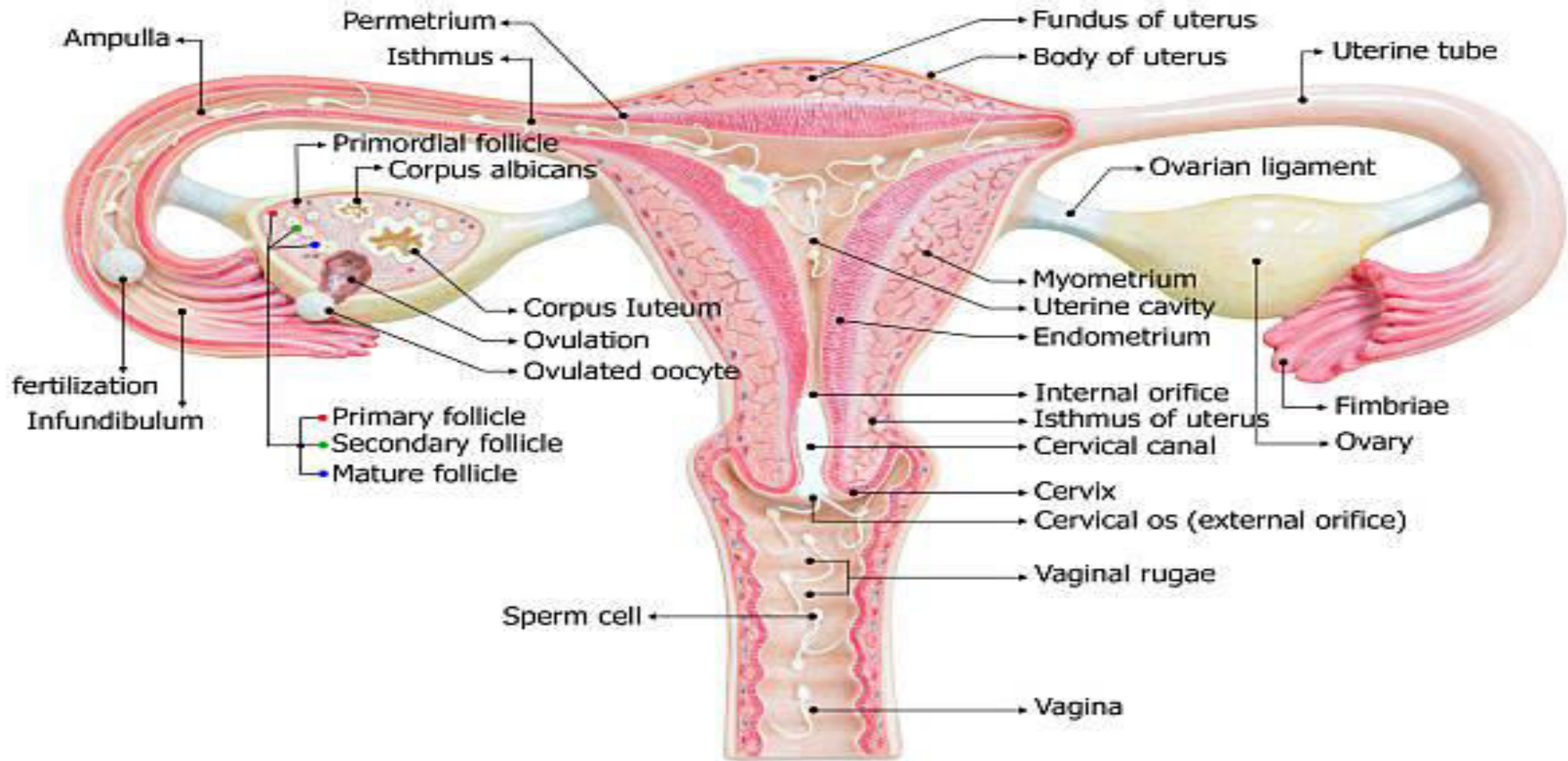
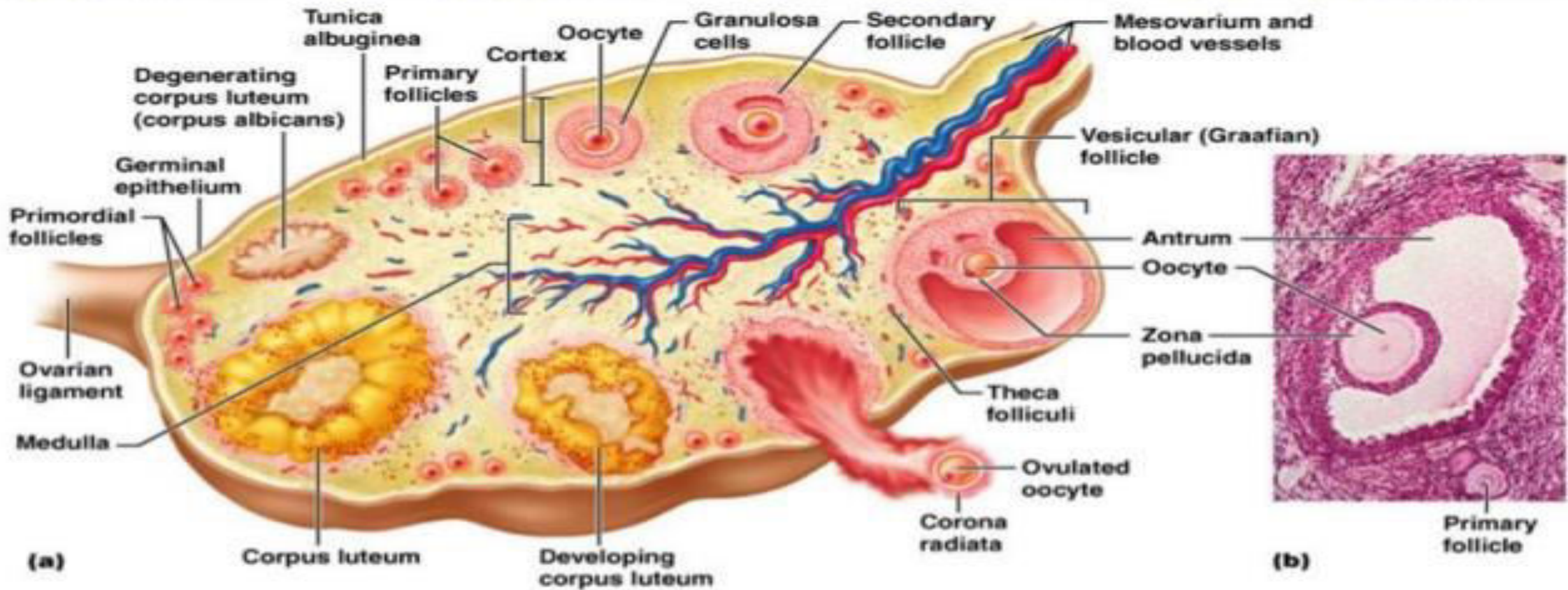


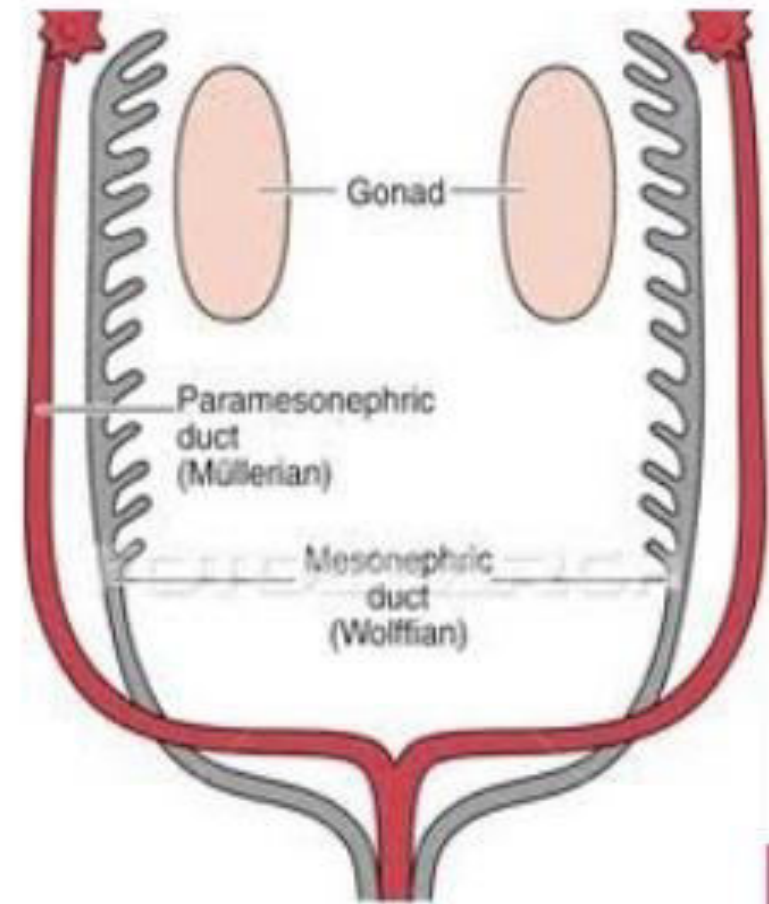
Diagram of Female Reproductive System





OVIDUCTS

- Modifications of the Mullerian ducts, which degenerates in the males.
- Differentiates into regions .
- Posterior portion expands to become the **uterus**.
- Serves as temporary storage site for eggs or a place where the young develops.



- Cyclostome ovaries lack ducts. Instead, eggs are shed into the coelom.
- From the coelom, they reach the cloaca (in lampreys) or anus (in hagfishes) through secondary pores.
- The archinephric ducts drain the kidneys exclusively.

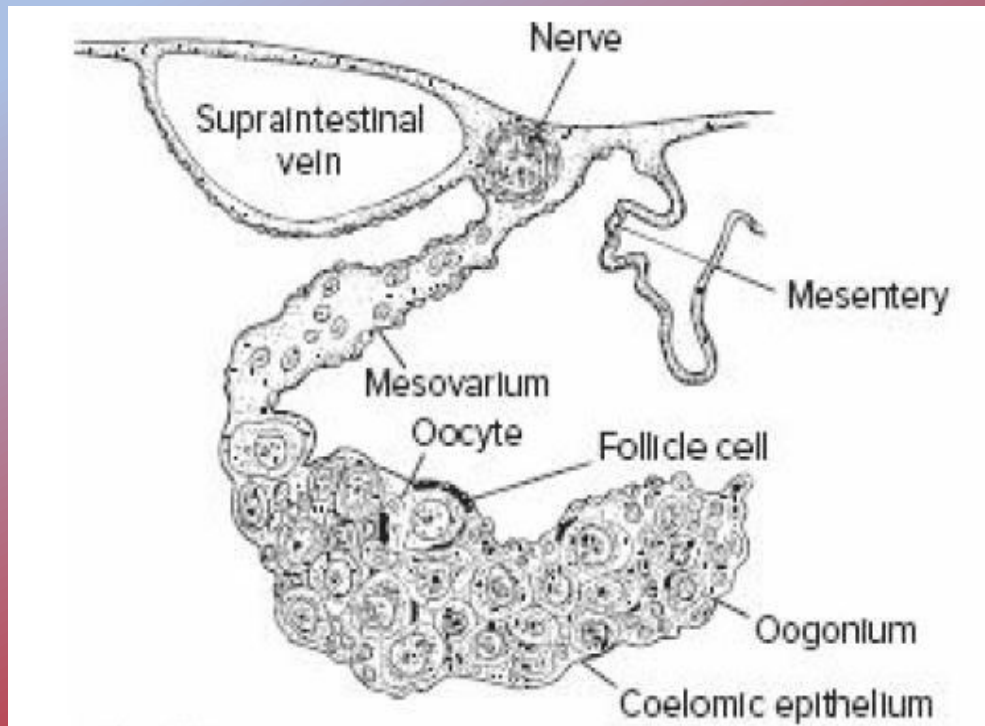


FIGURE: Hagfish Ovary.

- In elasmobranchs, The Müllerian duct, or oviduct, differentiates into four regions: funnel, shell gland, isthmus, and uterus
- In many teleosts, the oviducts regress entirely, leaving egg transport to new ovarian ducts.
- It is not homologous to the oviducts (Müllerian ducts) of other vertebrates.
- Instead, they are derived from **peritoneal folds** that embrace each ovary and have grown posteriorly to form new ducts.

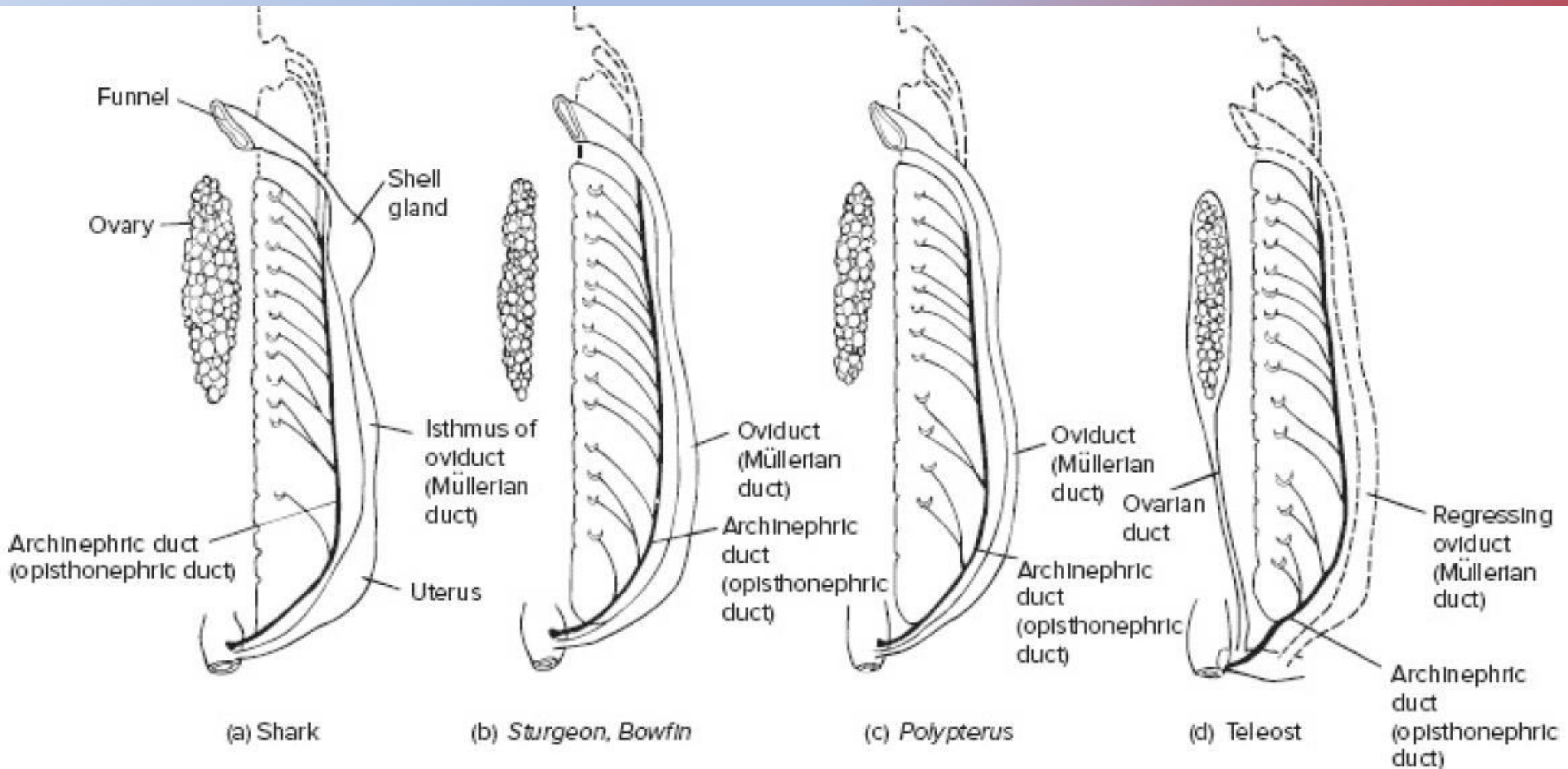


FIGURE: Oviducts of female fishes. (a) Shark. (b) Sturgeon and bowfin. (c) Bichir. (d) Teleost.

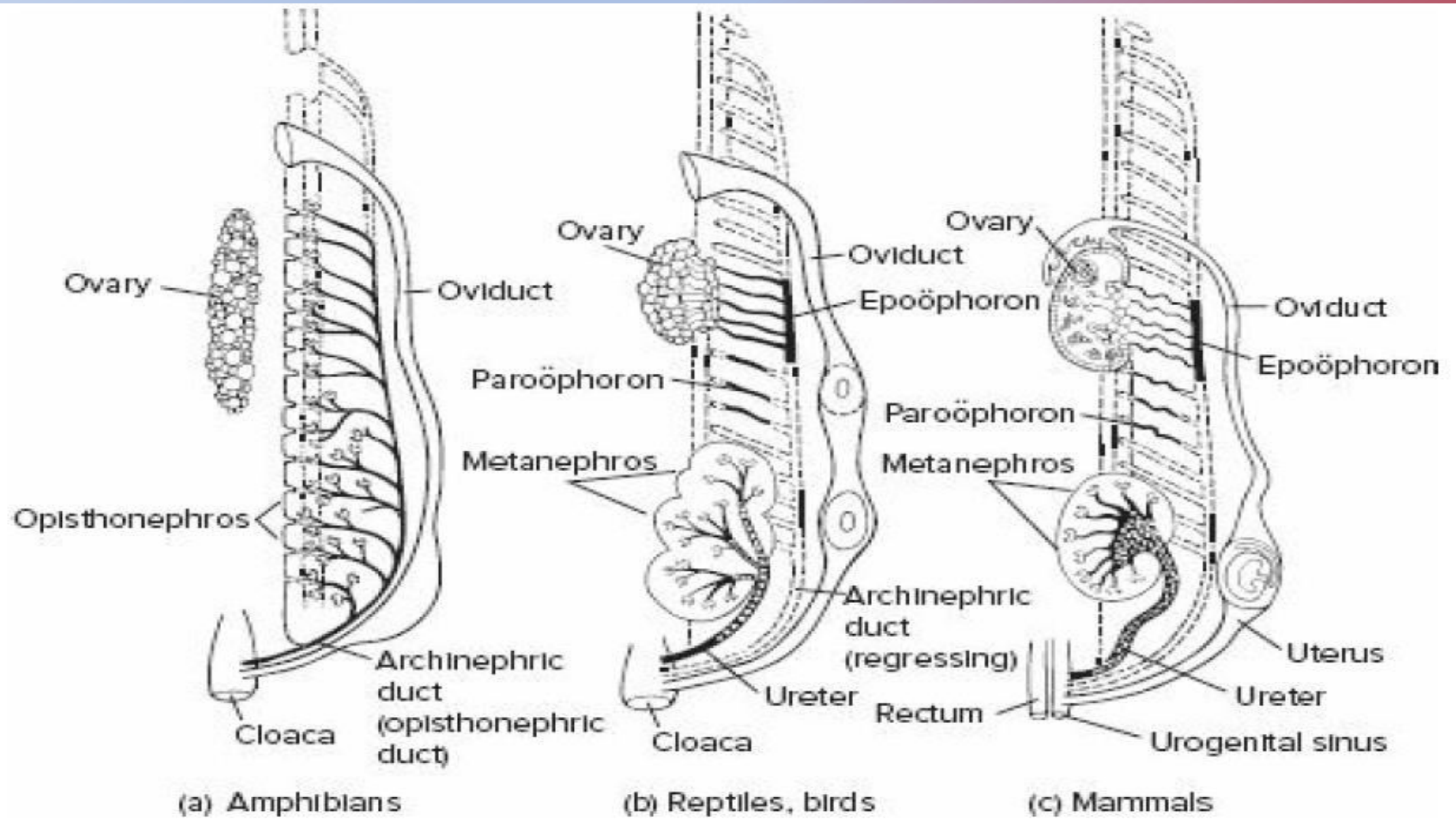
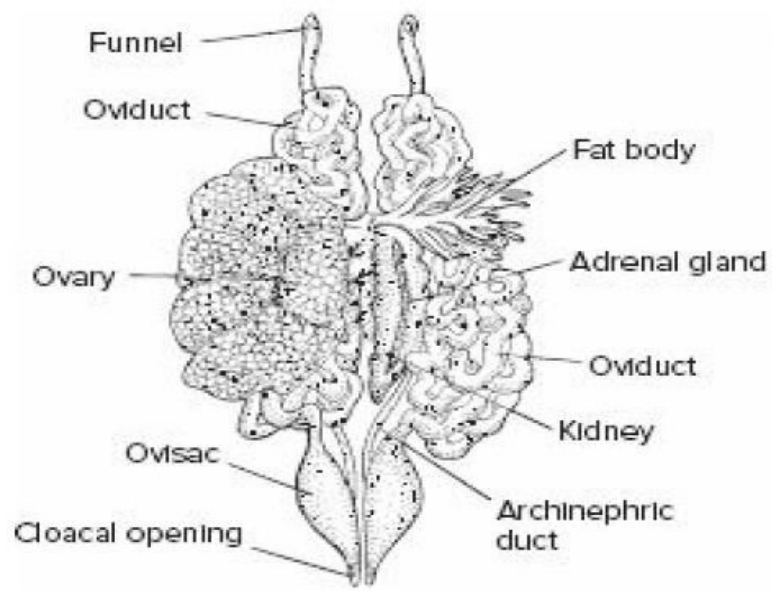
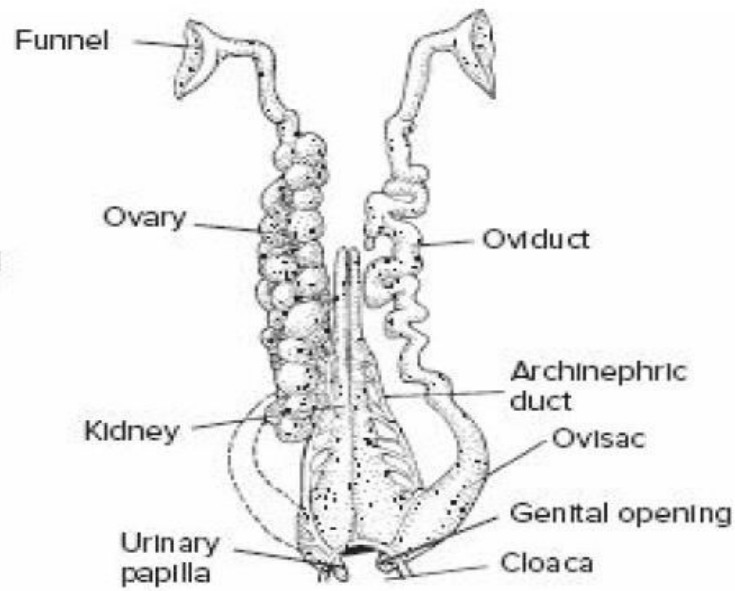


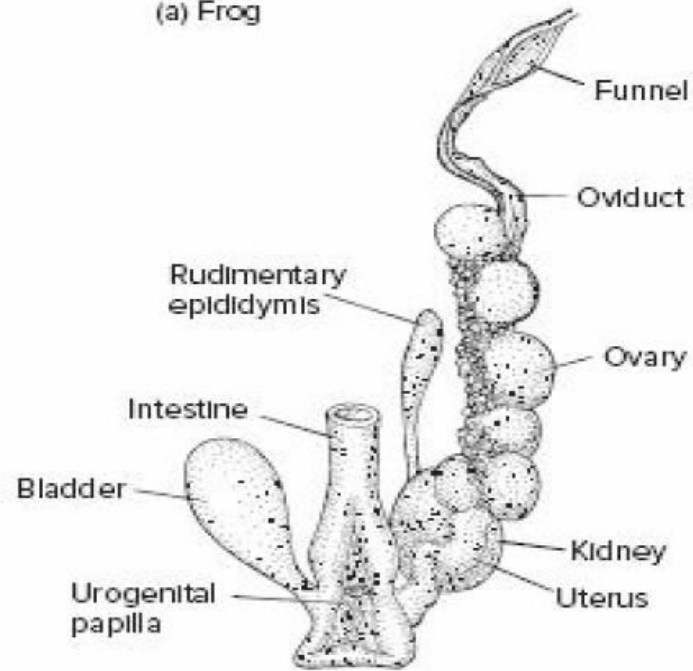
FIGURE: Urogenital anatomy of tetrapod females.



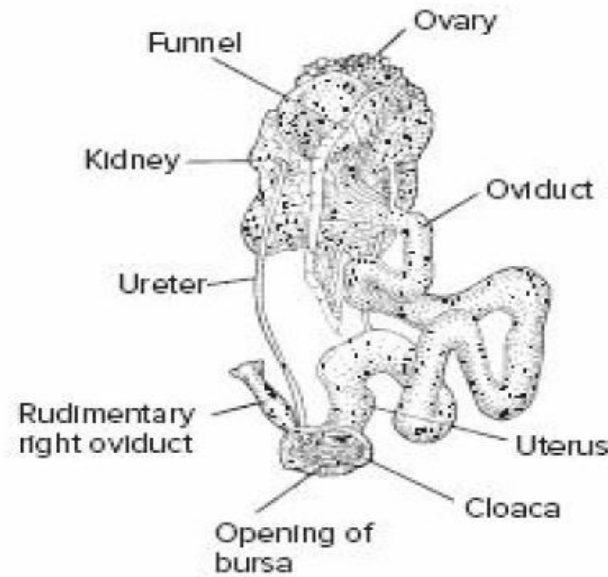
(a) Frog



(b) Salamander

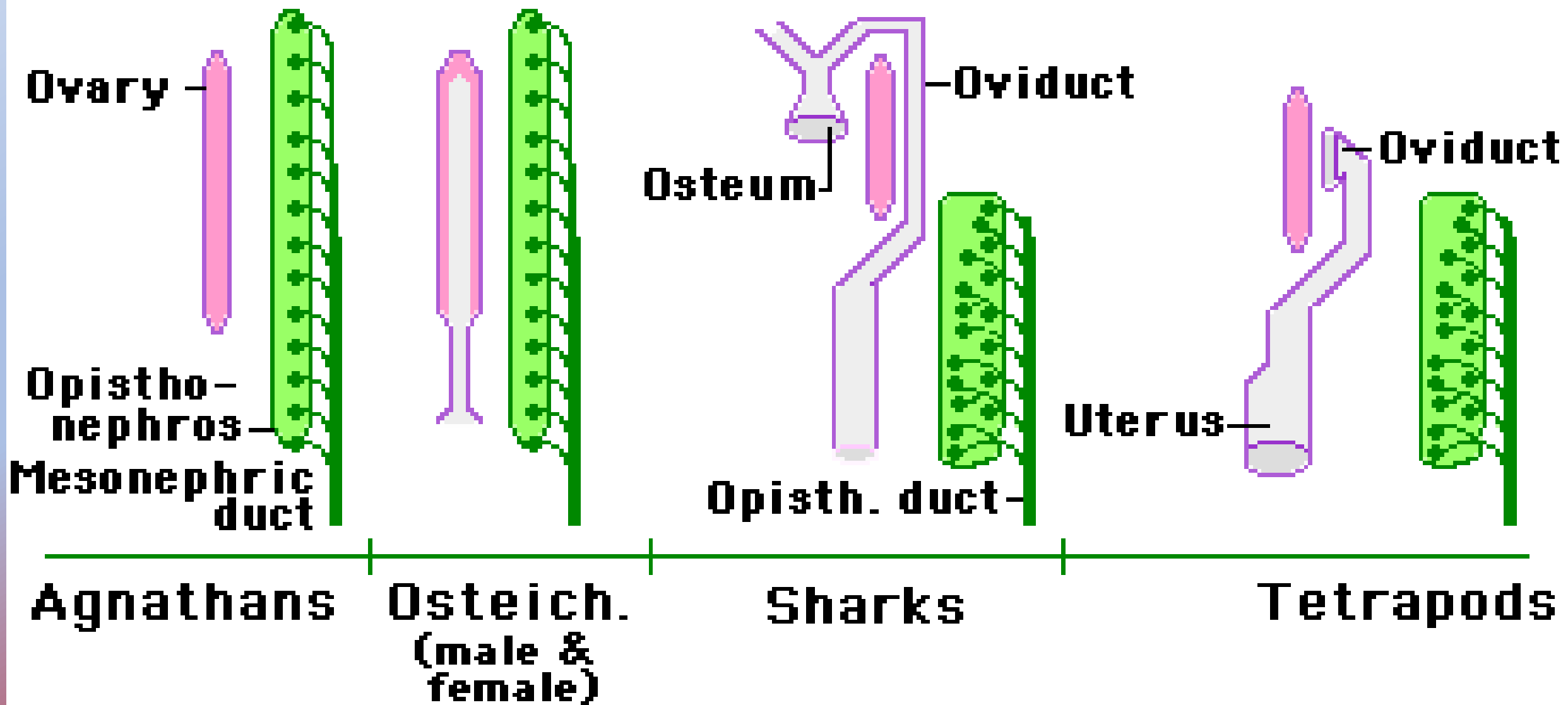


(c) Reptile



(d) Bird

FIGURE: Urogenital systems of tetrapod females, ventral views.



Female Urogenital Relations

THANK YOU