Lesson 25

Lesson Outline:

- The Reproductive System
  - Embryonic Origins
    - Female Reproductive System
      - Fishes
      - Tetrapods
    - Male Reproductive System
      - Fishes
      - Tetrapods

Objectives:

At the end of this lesson you should be able to:

Describe the embryonic origins of the reproductive system
Describe the phylogenetic trends seen in the design of ovaries and their ducts
Describe the significance of these trends
Describe the phylogenetic trends seen in the design of testes and their ducts
Describe the significance of these trends

References:

Chapter 15: 351-386

Reading for Next Lesson:

Chapter 15: 351-386

Reproductive System

The reproductive system consists of the gonads (the ovary and testis), their products (gametes = eggs and sperm) and the ducts that transport them.

As a rule, the gonads are located within the body in well-protected sites with ducts providing access to the outside.

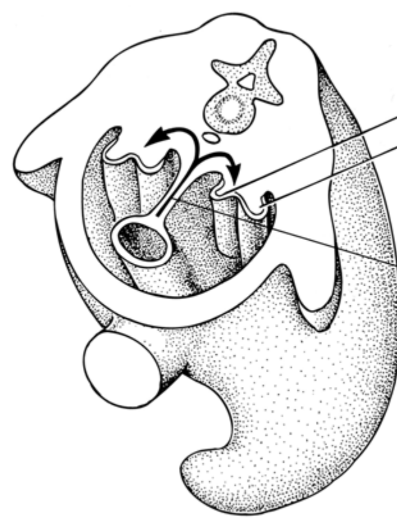
Variations in the design of the system reflect such things as:

- whether reproduction is sexual or asexual.
- whether there are separate sexes or whether there is hermaphrodism.
- whether fertilization is internal or external.
- whether the female gives rise to eggs (oviparous) or to live offspring (viviparous) or to eggs that are incubated internally and which subsequently are born alive (ovoviviparous).
- how, or whether, parents nourish the offspring.

The primary function of the system is to give rise to offspring, - to reproduce.

Embryonic Origin

The paired gonads arise from the genital ridges that originate from splanchnic mesoderm and adjacent mesenchymal cells. These ridges begin as small swellings on the dorsal wall of the coelom.



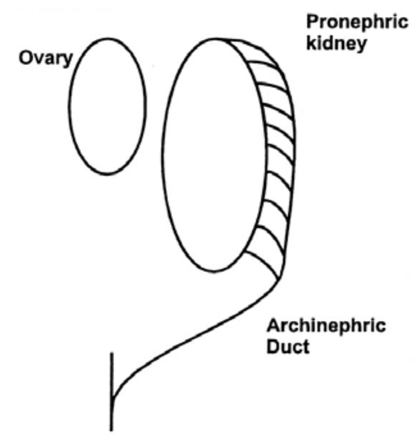
The germ cells that ultimately give rise to the sperm and eggs arise from remote sites (outside the embryo in the extraembryonic endoderm - of the yolksac and elsewhere) and migrate into the developing gonads. While all other cells of the body divide by mitosis, these are the only cells that are capable of meiosis. The fertilized egg gives rise to an organism within which only a few select cells are capable of giving rise to more fertilized eggs!

Initially the gonads are indifferent and the germ cells could turn into sperm or eggs. The factors that determine the sex of the embryo differ from species to species and are a fascinating topic of their own. Sex can be determined by as little as one gene or by as much as an entire chromosome. In many species, sex determination is linked to environmental cues - such as temperature.

The development of the ducts is highly variable between groups and we will consider these in our discussion of the phylogenetic trends.

Female Reproductive System
Fishes

In cyclostomes, females have a ***single*** large ovary. It is not served by genital ducts but releases its products (eggs) into the coelom to exit via the abdominal pores.



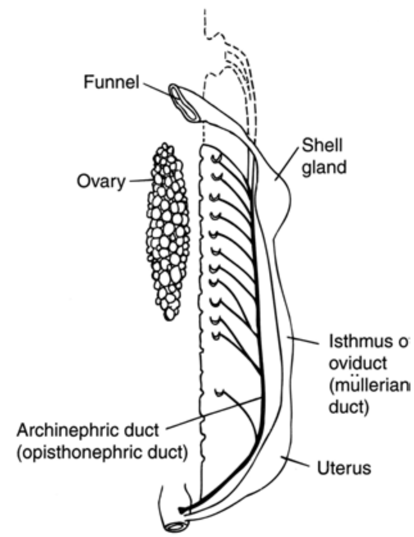
Openings between the coelom and the external environment develop secondarily as the abdominal pores to allow their escape.

In lampreys, females may release as many as 200,000 eggs during a single breeding season. Many only breed once.

The archinephric duct drains the kidney exclusively.

In elasmobranches, the ovaries are initially paired but in some species only one develops.

A second duct, the Müllerian duct (or oviduct), develops and runs parallel to the archinephric duct. In females, this becomes the oviduct. Thus in females the archinephric duct (or Wolffian duct) carries urine while the oviduct (or Müllerian duct) carries eggs.



(a) Shark

The oviduct differentiates into four regions. The extent to which these regions develop varies depending on whether fertilization is internal or external, whether the female gives rise to live young or eggs, the type of shell on the eggs, whether the live young are retained and nourished internally, and a host of other factors. The four basic parts are:

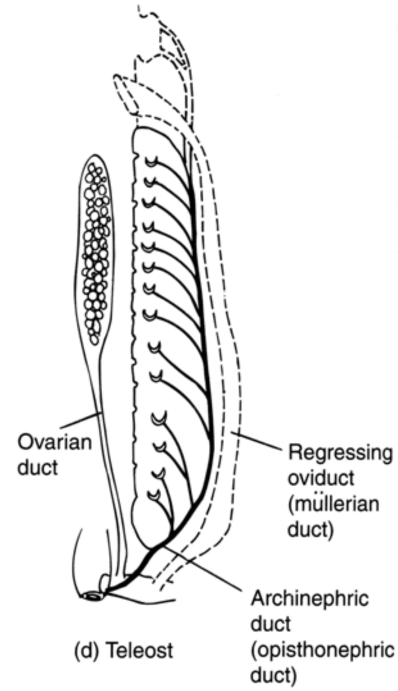
funnel - collects the eggs. The opening is the ostium.
shell gland - may store sperm (opportunistic sex).
- primary role is to secrete albumin and mucus.
In oviparous species it also produces the egg case as well (sharks have an egg case, not a shelled egg). In viviparous species it may be indistinguishable from the rest of the oviduct.
isthmus - connects the shell gland to the uterus.
uterus - nutritionally supports ovoviviparous embryos in some species.

Often the funnels of the oviducts on both sides fuse in elasmobranches.

Note: the eggs are still released into the coelom - they then migrate into the funnel of the oviduct, usually due to cilliary currents established by cells in the walls of the funnel. (This is the case in all vertebrates except teleosts).

In female bony fish, the archinephric ducts serve the kidneys and paired oviducts or ovarian ducts serve the ovaries.

In some teleosts (such as salmon) the oviducts regress and short remnants of the funnel remain in the posterior coelom. The eggs are released and fill the coelom and eventually are picked up by the short oviducts. (This is almost like a compromise between the situation seen in the cyclostomes and that seen in the elasmobranchs).



In most teleosts, new ovarian ducts develop derived from peritoneal folds that grow posteriorly and form new ducts. They are not homologous to the oviducts and appear to be unique to teleost fish.

Most teleosts lay eggs but some bear live young (ovoviviparous).

Tetrapods
In amphibians, ovaries are paired, the archinephric ducts serve the kidneys, and the oviducts serve the ovaries.

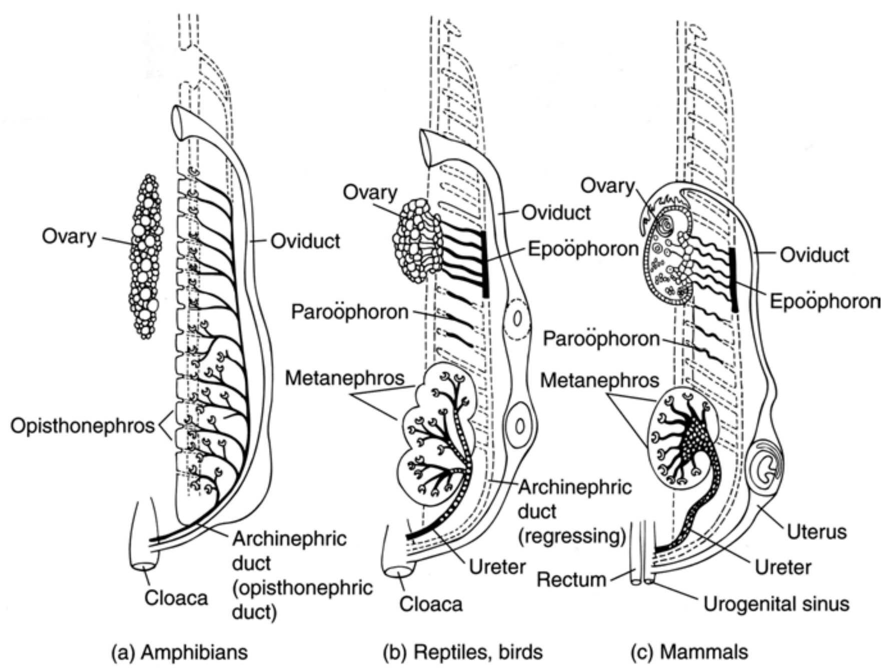
In amniotes, adults now have a metanephric kidney drained by new ducts, the ureters.

The oviducts continue to transport ova and support the embryo in transit. They often have prominent sheets of smooth muscle. In oviparous amniotes the shell gland is usually prominent. In viviparous amniotes the uterus is usually distinct (It should be obvious why!).

In most vertebrates the ovaries are paired.

The presence of a single ovary is not uncommon throughout the vertebrates, however.

Species with only one ovary are found in agnatha, chondrichthyes, osteichthyes, birds and mammals (duckbilled platypus and some bats). It is rare in reptiles and not found in amphibians.



This appears to have evolved independently many times, either through the fusion of gonads, through the regression of one gonad, through the failure of one gonad to develop, or through the failure of one gonad to become functional (which can be the right or the left in different groups).

After ovulation, eggs are released and enter the oviducts. As already mentioned, they enter the body cavity (coelom) and are drawn into the ostium of the funnel of the oviduct by ciliary currents. This is true in all vertebrates except the cyclostomes.

If fertilization is internal (more to come later), the ovum and sperm meet almost immediately in the top of the oviduct. For fertilization to be successful, sperm must be in the oviduct already before ovulation. There are a variety of strategies that have developed to ensure this (from sperm storage (up to years) to frequent sex to induced ovulation).

If fertilization is external, the smooth muscle and cilia lining the oviduct move the ova to the outside where they are fertilized. Little is added to the egg.

If fertilization is internal, in oviparous species, the oviduct adds layers of membrane or a shell to the egg. Sperm must meet the egg before a shell or thick membranes are added. In these species the shell gland is further specialized to do this.

In the uterus, shelled eggs are held until they are laid or embryos are held until their development is complete (ovoviviparous or viviparous).

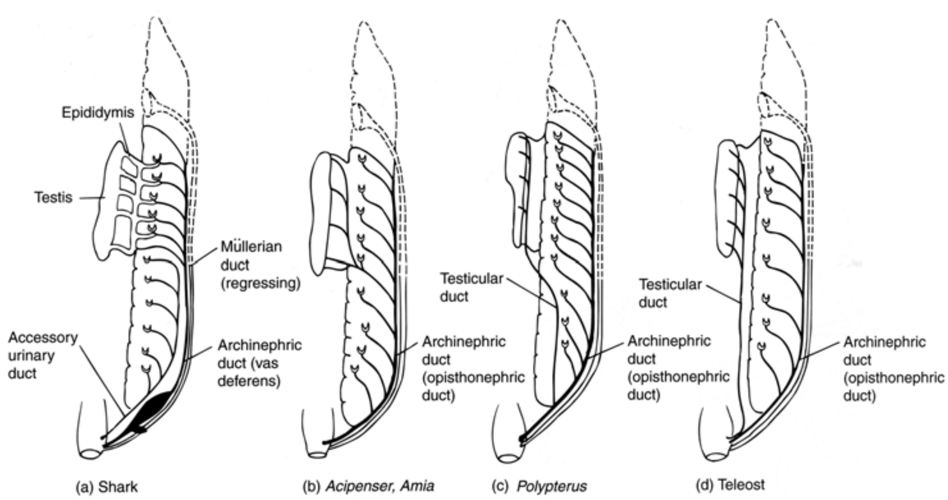
In placental mammals this is where the placenta forms.

Male Reproductive System

Fishes

In cyclostomes, males have a single large testis. As in the females, it is not served by genital ducts but releases its products (sperm) into the coelom to exit via the abdominal pores. The archinephric ducts drain the kidneys exclusively.

In elasmobranchs, in males, the Müllerian duct is rudimentary. The accessory archinephric duct services the urinary portion of the kidney. This is distinct from the archinephric duct and arises secondarily. The tubules from the anterior portion of the kidney that drain into the archinephric duct become associated with the testis and function as an epididymis storing sperm.



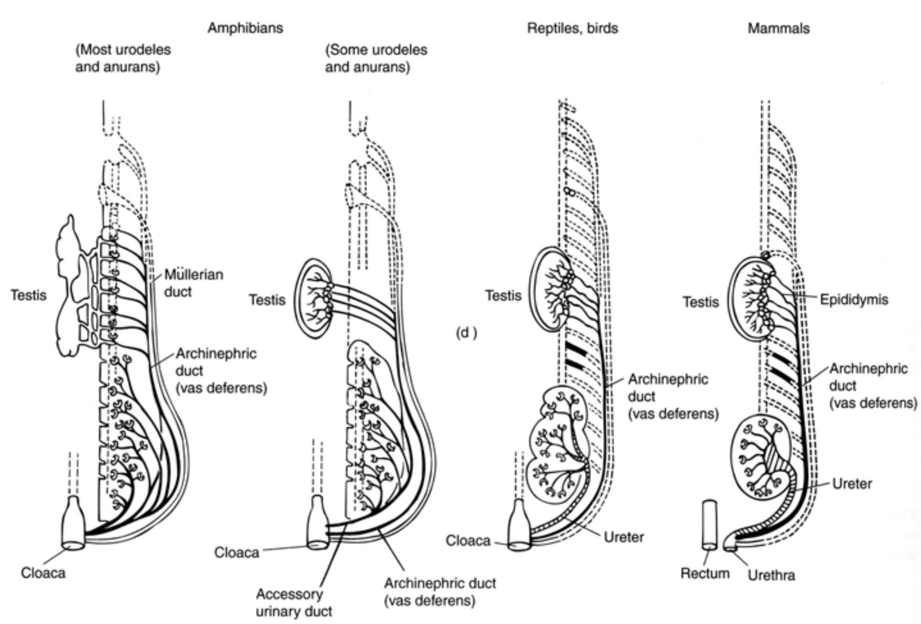
The archinephric duct is now often referred to as the vas deferens and carries some urine but mostly sperm.

In bony fish, the archinephric ducts drain the kidney and may receive sperm from the testis. The testes, however, tend to develop separate sperm ducts with separate routes. This duct is referred to as the testicular duct and is not homologous to the archinephric duct and may even establish its own opening to the exterior.
(Remember that in females, there is a unique arrangement of ducts as well - all teleosts seem to have evolved along unique paths).

In salmonids, there are no sperm ducts and sperm are released into the body cavity and exit the body through pores near the posterior part of the coelom.

Tetrapods
In amphibians, the situation is quite similar to that seen in elasmobranchs. While there are a host of variations, the posterior kidney is generally drained by accessory urinary ducts while the archinephric duct may have both urinary and reproductive functions or may be exclusively involved in sperm transport.

In male amniotes, the archinephric duct transports sperm exclusively (as the vas deferens) while the ureters now drain the metanephric kidney.



The position of the testes is generally within the abdomen. The testes of some mammals, however, descend into the scrotum, a coelomic pouch suspended outside the body but connected to the abdominal cavity by the inguinal canal.

In some mammals the testes remain within the body cavity.

In some they descend into a scrotum only during the breeding season.

In some they descend permanently into the scrotum during development.

It has been argued that the primary reason for this is that the body temperature in mammals had become very close to the upper limit before protein denaturation begins to occur. It is possible that sperm do not develop well at these high temperatures. It is cooler outside the body, the testis can be lowered and retracted by the cremasteric muscle (retracted when cold, lowered when warm) and that vascular plexus develop as a heat exchanger to cool the testes.

Arguing against this is the fact that this does not occur in all mammals and it does not occur in birds that have even higher body temperatures.