

CHAPTER 11

Reproductive Systems in Vertebrates

PERFORMANCE OBJECTIVES

At the end of this chapter, students should be able to:

- identify the various parts of the male and female reproductive systems.
- describe the structures and functions of the male and female reproductive organs of vertebrates.
- draw and label diagrams of male and female reproductive systems in mammals.
- draw, label and describe the structures of male and female gametes (sperm and ovum).
- distinguish between male and female reproductive organs in mammals.
- distinguish between eggs of vertebrates.
- compare reproduction in fish, bird, toad, reptile and mammals.

INTRODUCTION

The reproductive system is the system that plays essential roles in the reproductive process. The reproductive systems are well developed in vertebrates. Basically, the reproductive systems of vertebrates are made up of organs known as gonads and associated with these are glands and ducts. The gonads are responsible for the reproduction of gametes, which are essential for reproduction. In addition, they also produce hormones required for the purpose of reproduction. The male gonad, testes, produces sperm cells (spermatozoa or sperm), whereas the female gonad, ovaries, produces eggs or ova.

REPRODUCTIVE SYSTEMS IN FISHES

BONY FISHES: A typical example of bony fish is the Tilapia, whereas shark is an example of cartilaginous fish. The major reproductive system of bony fishes consists of the two elongated testes suspended in the abdominal region. The testes join posteriorly into a simple duct, which open at the genital opening (cloaca) Figure 11.1.

In the female bony fish, the ovaries are contained in a sac-like structure suspended in the abdominal region. The ovaries are connected in a single duct, which leads to the genital opening.

SUGGESTED PRACTICALS

ACTIVITY 1

Examine and draw a dissected vertebrate. Indicate the male and female reproductive organs.

CARTILAGINOUS FISH: In the cartilaginous fish (e.g., shark), the male reproductive system consists of the testes, vasa efferentia, vas deferens, urinogenital papilla, clasper and other inclusions

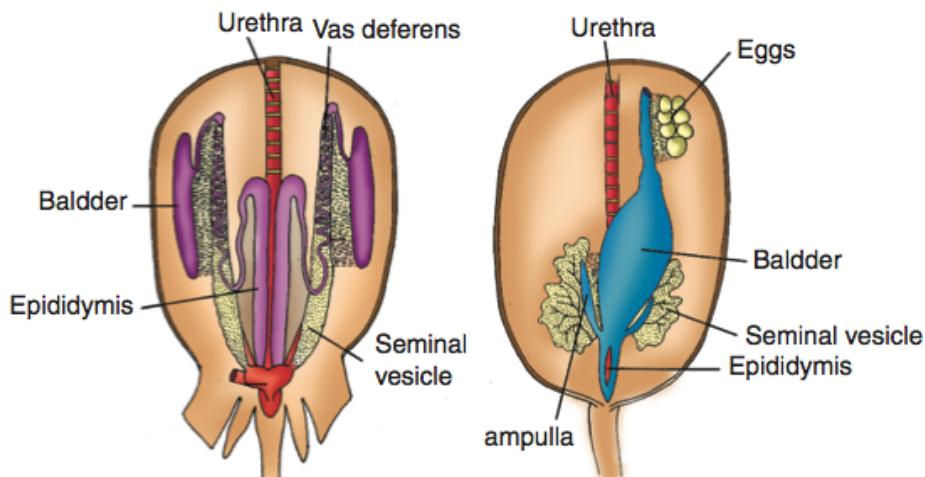
that enhance reproduction. The testes are normally long cylindrical organs. Each testis is made of so many separate swellings within which the sperm cells are formed. The sperm cells formed pass through many ducts known as vasa efferentia located in the anterior region of the testis. The sperm enters the vas deferens from the vasa efferentia. The seminal vesicle stores the sperms from where it is released in the process of copulation. The siphon

is a muscular sac found on the ventral side beneath the skin, and it communicates with the two grooved claspers by small channels. These pairs of claspers are similar to the pairs in higher vertebrates.

ACTIVITY 2

Compare the male reproductive system with that of the female in Activity 1.

The female reproductive system comprises of the right and left ovaries. The eggs in various stages of development can be seen in the ovaries. There is a pair of oviducts, and along the length of each oviduct is a swollen portion known as the oviduct gland. The shark pushes its clasper into the oviducts of the female shark during mating and squeezes out the seminal fluid, which



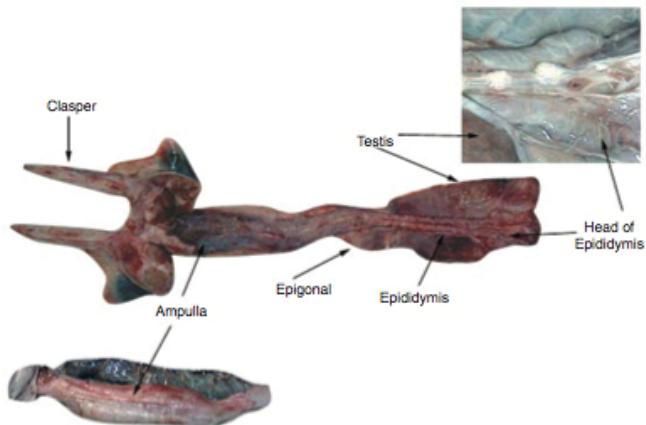
▲ Figure 11.1 Reproductive system of (A) Male skate fish and (B) Female skate fish

contains sperm cells, from the urinogenital papilla into the clasper groove while the siphon produces a current of water that washes the sperm cells from the clasper grooves into the oviduct.

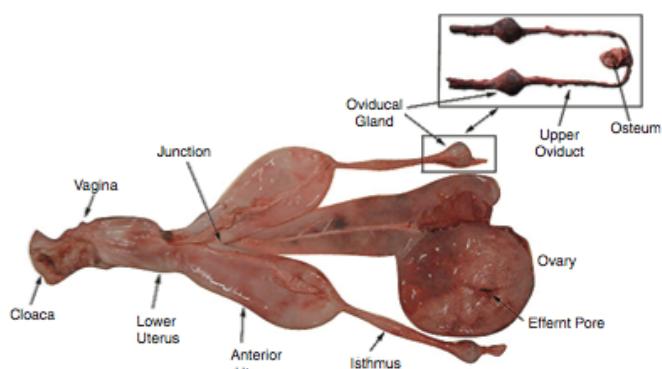
REPRODUCTIVE SYSTEMS IN REPTILES

In a typical reptile (e.g., Agama Lizard), two ovoid testes are located in the abdominal region. Tiny vessels emerge from the testes where the sperm cells are led to the epididymis. These vessels are known as vasa efferentia. Each epididymis passes over the ventral side of the kidney on its side and opens into the posterior chamber near the two protrusible penes (Figure 11.4A). Two rudimentary and cylindrical hemipenes emerge from the cloacal chamber.

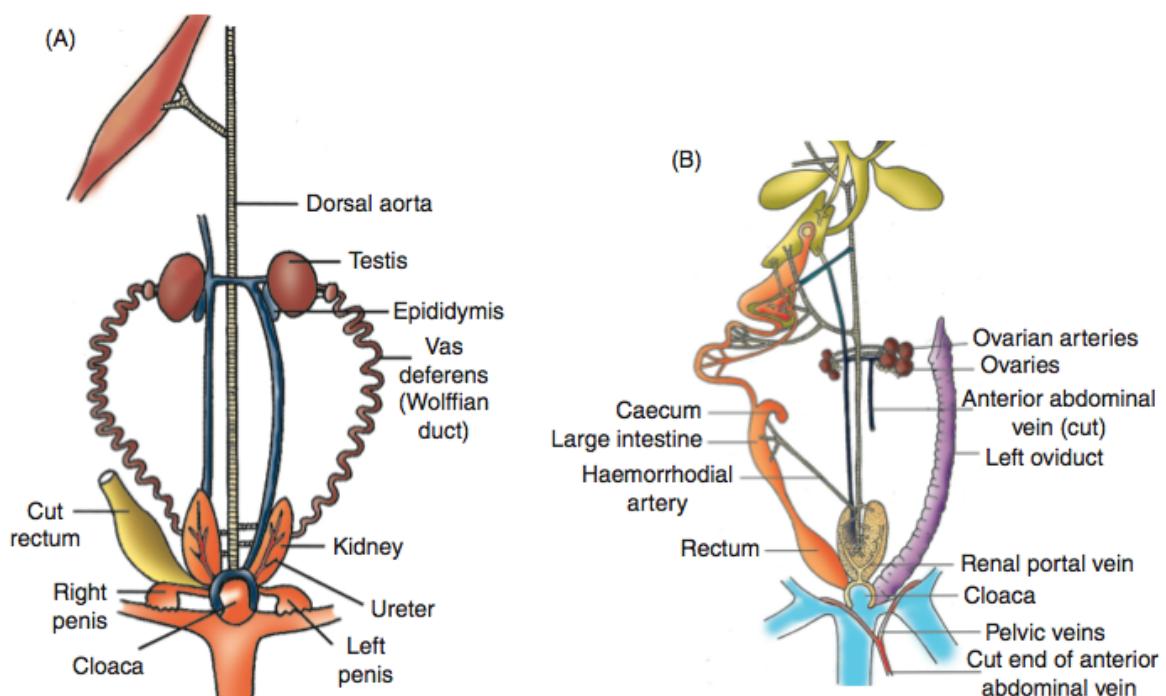
In the female lizard the ovaries are located at the two sides of the abdomen with the right ovary anterior to the left (Figure 11.4B). The oviducts open into the cloaca. The eggs are released into the abdominal space from where they are moved on by the action of cilia into the wide opening of each oviduct.



▲ FIGURE 11.2 Structure of the male reproductive system in shark



▲ FIGURE 11.3 Structure of the female reproductive system in shark



▲ FIGURE 11.4 (A) Structure of the male reproductive system of Agama Lizard (B) Structure of the female reproductive system of Agama Lizard

During mating, the male penis penetrates through the female cloaca into the opening of the

oviduct while the seminal fluid that contains the sperm is released into the oviduct.

SUGGESTED PRACTICALS

ACTIVITY 3

Dissect the female Agama Lizard showing clearly the reproductive organs.

REPRODUCTIVE SYSTEM IN BIRDS

MALE BIRDS: The cock has a pair of testes near the kidneys. A sperm duct runs down from each testis and opens into the cloaca. A cock lacks penis. Therefore, sperm cells accumulate at the wide posterior end of the sperm duct. During mating, sperm cells are transferred from the

male into the female as the cloacae come in contact.

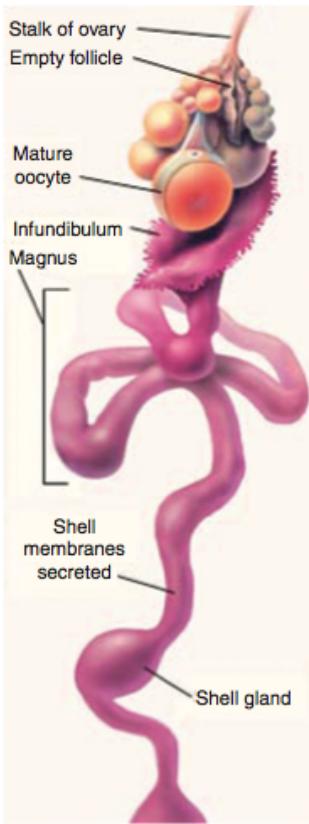
FEMALE BIRDS

The typical adult female birds (e.g., pigeon) possess only the left ovary, which is located anterior to the kidney. Follicle of different sizes is found in the ovary (see Figure 11.5). The left oviduct is large with a wide mouth, thick-walled funnel and a coiled duct that leads into urodeum. The absence of one oviduct (right oviduct) could be as a result of the large size of the egg.

SUGGESTED PRACTICALS

ACTIVITY 4

Dissect a male bird (pigeon) indicating the urinogenital system.



▲ FIGURE 11.5 Female reproductive system of bird

THE MAMMALIAN REPRODUCTIVE SYSTEM

MALE REPRODUCTIVE SYSTEM: This reproductive system consists of the following organs (Figure 11.6):

(i) The Testes: They are two ovoid structures situated in the scrotal sac. The testes are external in most mammals (e.g., man, goat, etc.). In humans, the testes are suspended in the posterior end of the abdominal cavity and would have descended into the scrotum at birth. They require temperature range of below 35°C to function effectively. The testes contain coiled tubules called seminiferous tubules. These contain actively dividing cells that produce sperm cells.

The seminiferous tubules continue and emerge into a spongy structure called the epididymis on top of the testes. This structure stores sperm produced in the testes. The testes also produce testosterone, a sex hormone responsible for the development of male secondary sexual characteristics, e.g., growth of hairs in the private areas and the arm pits.

(ii) Vas deferens: This is also known as the sperm duct. It is a continuation of the epididymis. It serves as the pathway through which sperm cells run from the epididymis and opens to the urethra.

(iii) Penis: This is a sensitive urinogenital organ. It consists of spongy erectile tissue. Blood flows into the dilated erectile tissue when stimulated. The flow of blood into the tissue contributes to its turgidity, hence the erection of the penis on stimulation. The penis is covered with a sensitive skin called the glans penis and a retractable foreskin called prepuce. This can be surgically removed during circumcision.

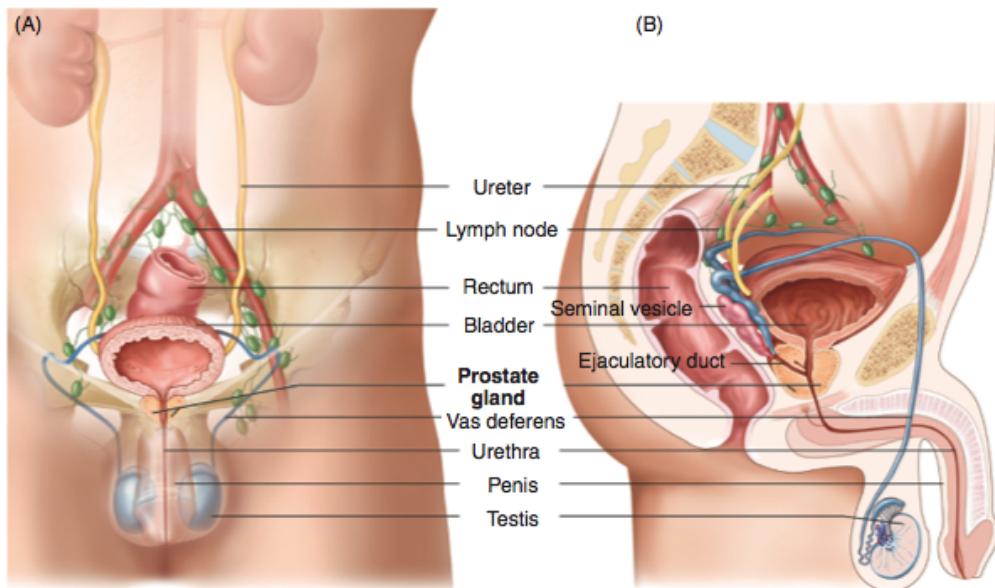
The male reproductive system also consists of certain other accessories and glands whose secretions play important roles in reproduction. These include the prostate gland, whose

secretion helps to energise and transport the sperm, and the Cowperâ€™s gland, whose secretion helps to normalise the alkaline concentration of the sperm so as to neutralise acidic matters along the wall of the urethra.

Note: The mixture of sperm and these secretions is known as semen.

FEMALE REPRODUCTIVE SYSTEM: The female reproductive system consists of the following organs (Figure 11.9):

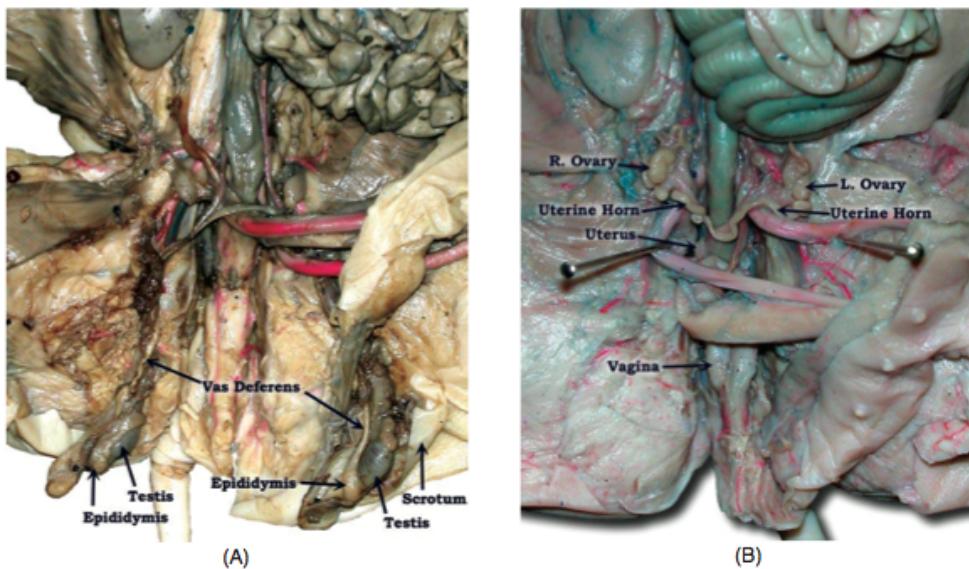
(i) Ovary: The female mammal has two ovaries each located below the kidneys on both sides. The ovaries contain several thousands of potential eggs called primary oocytes. They are covered by a layer called germinal epithelium. The ovaries produce the female gamete, i.e., ovum (plural - ova). Matured ovum is secreted approximately once in every 28 days. The shedding of a mature egg is known as â€˜ovulationâ€™.



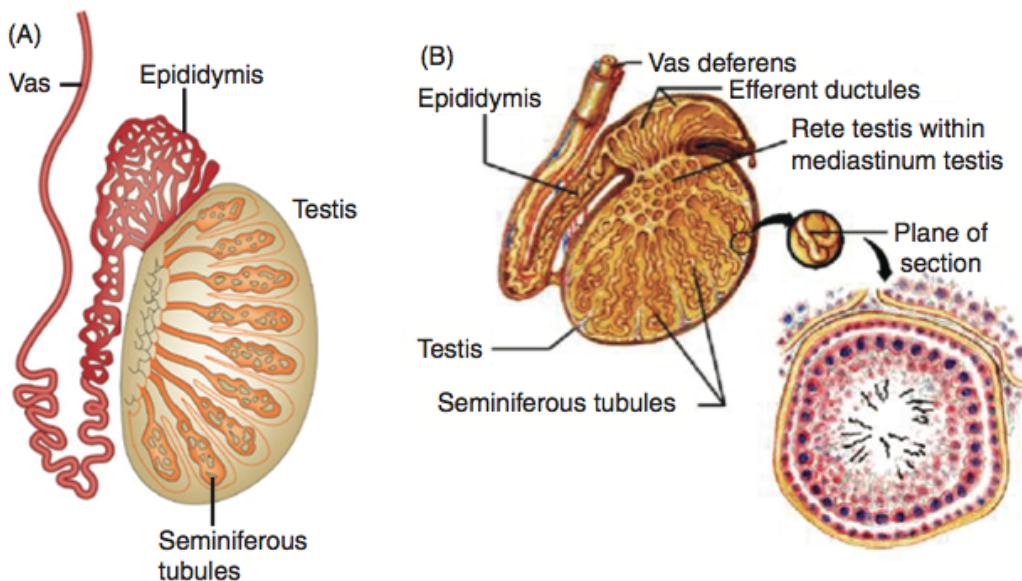
▲ FIGURE 11.6 Human male reproductive organs (A) front view and (B) side view

(ii) Oviduct: The released egg is received by a funnel-shaped structure known as fallopian funnel, which opens to the oviduct or fallopian tube, the pathway for the passage of ovum. Fertilisation occurs in this structure. The oviduct opens to the uterus.

(iii) Uterus (womb): This is a muscular structure usually a pair in the rat, with one connected to each fallopian tube; it may be single, as in human. It is connected to the exterior through the vagina. It has a glandular lining membrane for nourishing the embryo in the early stages of development. It also has smooth muscles in its wall, which greatly increases in number during pregnancy. Its contraction ultimately expels the foetus and its placenta.



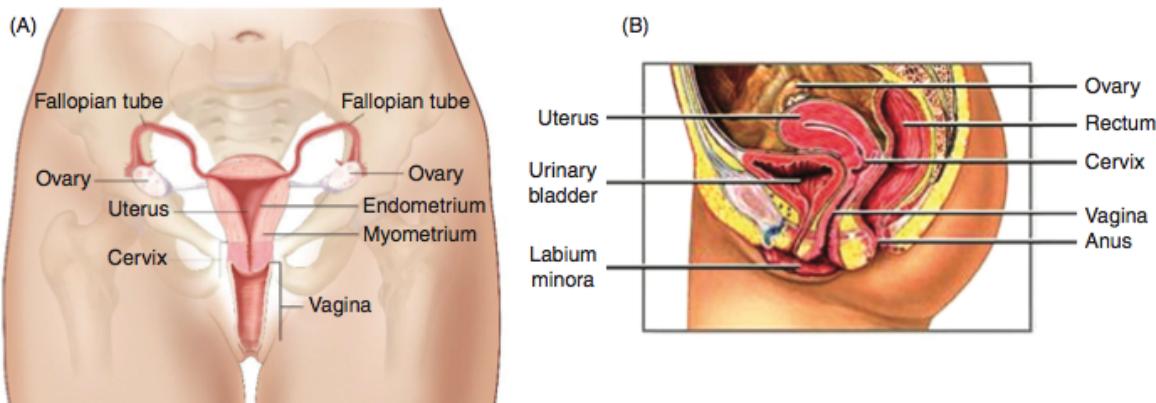
▲ FIGURE 11.7 Structure of male and female reproductive system of a mammal (guinea pig)



▲ FIGURE 11.8 (A) Longitudinal section of a testis and (B) diagrammatic representation of the arrangement of tubules in the testis

- (iv) Cervix: This lies at the ventral end of the uterus. It closes after fertilisation to avoid further entrance of sperm and foreign bodies.
- (v) Vagina: This part serves as the receptor of sperm cell ejaculated by the male. It opens posteriorly to the vulva. There is a film of connective tissue that covers the vaginal opening called hymen. This tissue can be easily removed by sexual activities or physical exercises.
- (vi) Clitoris: This is a rod-like rudimentary structure that is analogous to the penis in the male. It is sensitive and erectile and does not play a serious role in reproduction other than arousal.

Note: The urinary and reproductive passages of human females are separate and they open separately to the exterior in external genitalia called vulva. Hence, urinogenital organs are present in all mammals, except in female humans.



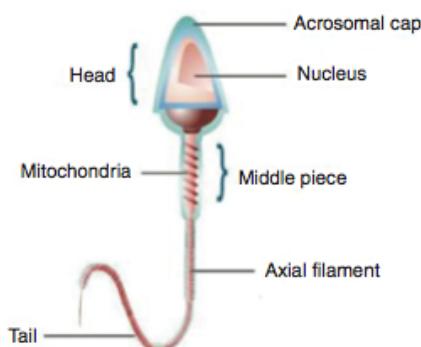
▲ FIGURE 11.9 (A) Front view and (B) side view of the human female reproductive system

STRUCTURE OF MAMMALIAN GAMETES

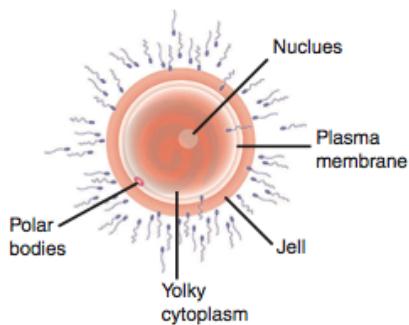
The mammalian gametes (Figures 11.10 and 11.11) are the male gametes called sperm cell (spermatozoon) and the female gametes called eggs or ova. Each gamete is unicellular.

MALE GAMETE

The human male gamete (Figure 11.10) is shaped like a tadpole and consists of a head (about 3 micrometers wide) with a nucleus and a tail or flagellum. The whole sperm, including the tail, with which it moves inside the seminal fluid is about 60 micrometres long. A sperm cell is microscopic and is usually smaller than an egg (ovum) (Figure 11.11).



▲ FIGURE 11.10 Structure of a human sperm cell



▲ FIGURE 11.11 A generalised mammalian egg (ovum)

FEMALE GAMETES: The human female gametes are also microscopic but are larger than the sperm cell. Each ovum is about 0.1 mm in diameter. It consists of the cytoplasm, a nucleus in the centre, granules and yolk droplets (Figure 11.11). The yolk provides a source

of nourishment for the embryo, at least, in its early stages of development.

The ovum's cytoplasm is surrounded by two membranes. The inner one is the plasma membrane, whereas the outer one is the vitelline membrane. The ovum is bounded on the outside by a jelly coat of variable thickness made up by glycoprotein. The nuclei of the sperm cell and ovum contain chromosomes, which are thread-like materials that carry genes. The genes are responsible for passing on the parent's characteristics to the offspring.

SIMILARITIES IN MAMMALIAN REPRODUCTIVE SYSTEMS

The male and female mammalian reproductive systems are similar in the following ways:

- (i) Both have gonads or sex organs (testes and ovaries).
- (ii) Gametes are produced by their gonads.
- (iii) Both systems have external openings.
- (iv) Their gonads act as ductless (endocrine) glands.
- (v) Both systems combine to allow internal fertilisation

Table 11.1 displays the differences between the mammalian male and female reproductive organs.

TABLE 11.1 Differences in Mammalian Male and Female Reproductive Organs

MALE REPRODUCTIVE ORGAN	FEMALE REPRODUCTIVE ORGAN
Testes are in scrotal sacs outside the body	Ovaries are located inside the body
Epididymis present	Epididymis absent
Sperm produced by testes	Eggs produced by ovaries
Sperm cells pass out through the urethra	Ova pass into the oviducts where they are fertilised
Sperm ducts present	Sperm ducts absent
Seminal vesicle present	Seminal vesicle absent

MALE REPRODUCTIVE ORGAN	FEMALE REPRODUCTIVE ORGAN
Prostate gland present	Prostate gland absent
Cowper's gland present	Cowper's gland absent
Penis present	Penis absent
Oviducts absent	Oviducts present
Uterus absent	present
Vagina absent	Vagina present
Cervix absent	Cervix present
Vulva absent	Vulva present

COMPARISON OF REPRODUCTION IN FISHES, REPTILES AND MAMMALS

All vertebrates begin their lives as a result of fusion of male and female gametes (a sperm cell and an egg or ovum). This process is called fertilisation.

In most fishes and amphibians, fertilisation is external. In reptiles, birds and mammals, fertilisation is internal. Consequently, there is always some type of coition (mating) before fertilisation can occur. In all vertebrates, some courtship behaviour always precedes mating prior to fertilisation.

Most fishes and amphibians lay their eggs (without shells) in water (oviparity) where they are fertilised. Most reptiles also lay eggs (ovi-parity), which have shells that may be soft and leathery (e.g., lizards and snakes) or hard (e.g., crocodiles). All reptiles lay their eggs on land. Some fishes, amphibians and reptiles and most mammals are viviparous (they do not lay eggs but give birth to well-developed young ones alive). Some fishes (e.g., guppy) are said to be oviparous (lay eggs, which hatch within them). A few mammals in Australia (e.g., the duck-billed platypus and monotreme) are oviparous.

Many fishes experience a very high mortality rate from their eggs to the young ones (called fries). To compensate for such losses, the fishes lay large numbers of eggs (over one million) every breeding season.

There is a relatively high mortality rate of tadpoles as against those that mature to young frogs and toads. To compensate for this, most amphibians lay hundreds of eggs at once during breeding season.

Reptiles lay fewer eggs. For example, the female Agama Lizard lays about 20–70 eggs at a time. The rate of mortality among reptiles is perhaps higher among their eggs than among their young ones. This is because young reptiles are well developed and able to fend for themselves by the time they are hatched.

The number of eggs laid by birds varies from species to species. The pigeon lays either one or two eggs per breeding season, whereas the domestic fowl can lay about 15 eggs. Most chicks are blind, naked and helpless when they are hatched. For about two weeks, such young birds remain in the nest where they are fed by their parents. This is the time that most of them (about 75%) are preyed on by predators like the hawk.

TABLE 11.2 Comparison of reproduction in vertebrates

TYPE OF VERTEBRATE	TIME OF BREEDING	MODE OF FERTILIZATION	NO. OF EGGS LAID	MODE OF GROWTH	PARENTAL CARE
Fishes	Seasonal	External	Millions	Mostly oviparous	Mostly none
Amphibians	Seasonal	External	Hundreds	Mostly oviparous	None
Reptiles	Seasonal	Internal	Many	Mostly oviparous	None except Nile crocodiles
Birds	Seasonal	Internal	Few	Oviparous	Occurs for a short time
Mammals	Seasonal except in humans	Internal	None except in monotremes	Mostly viviparous	Occurs for a long time

Most fishes, all amphibians and most reptiles do not show parental care for their eggs or young ones. Although birds and mammals produce few offspring at a time, they protect and take care of them to a great extent. Parental care is most highly developed among mammals,

which protect and feed their young ones until they can fend for themselves. Generally, vertebrates that show external fertilisation – fishes, amphibians – produce more eggs and experience higher mortality rates among their eggs and young ones than reptiles, birds and mammals, which show internal fertilisation.

STRUCTURAL DIFFERENCES IN THE EGGS OF VERTEBRATES

The fish eggs are very small and appear like mass of sand grains in freshly killed fish. The eggs contain the young fish and are enclosed in egg case or membrane.

The amphibian, e.g., toad or frog, eggs are also small spheres, which consist of semiliquid cytoplasm containing a nucleus surrounded by a tough black egg membrane. The toad's egg is black on the upper surface and yellowish white on the under surface because the protoplasm of the egg is full of yolk granules abundant in the lower part of the egg; thus, black surface floats uppermost. It has a thin coat round it. This absorbs water and swells to form the jelly or albumen. This jelly protects the egg and separates them resulting in a bead-like structure.

Reptile, e.g., Agama lizard, eggs is cream coloured. It has soft but tough leathery shell. It absorbs water from the surrounding soil and increases in size or volume.

Bird's egg is the largest single animal cell. It has a porous shell, which allows exchange of gases with the egg and its environment. The egg possesses two membranes enclosing the albumen. This is evident where the air space is found as the two separate enclosing air. The albumen contains the yolk inside in which the germinal disc or embryo occupies the innermost core.

SUGGESTED PRACTICALS

Comparison of mammalian reproductive organs.

- Examine a male and a female rat dissected by your teacher.
- Draw and label the reproductive organs of the male and female rats.
- State one difference you observe in the structures of the two specimens.

Observation of mammalian sperm cells

- Your teacher will obtain a male rat and kill it for dissection. He should cut open its scrotal sac and cut the testes and suck up a little of the milky fluid into a pipette.
- Put two drops of the fluid on a slide and a drop of salt solution. Put on a cover slip.
- Observe under the microscope using low power and then high power.
- Can you observe any sperm cells? Which structures shown in Figure 11.10 can you see?
- Are the sperms moving? If not suggest some reasons for this.

CHAPTER SUMMARY

â- The reproductive organs of a male mammal consists of two testes, epididymis, sperm ducts, vasa efferentia, seminal vesicles, a prostate gland, a Cowper's gland, a penis and one urethra.

â- The reproductive organs of a female mammal consist of two ovaries, oviducts, uterus (in female humans), cervix, vagina and vulva.

â- The mammalian male and female gametes, the sperm cells and eggs (ova) are unicellular and microscopic.

â- The sperm consists of a head with nucleus and a tail with which it moves in the seminal

i-,uid.

- â- The ovum is larger than a sperm and consists of the cytoplasm, a nucleus, granules and yolk droplets, which nourish the embryo
- â- The male and female mammalian reproductive organs are similar in some ways; both have sex organs, produce gametes, have external openings and the organs favour internal fertilisation.
- â- The male and female mammalian reproductive organs are different in many ways.

REVISION QUESTIONS

OBJECTIVE QUESTIONS

Choose the correct options to the following questions.

1. Which of the following structures is absent in the reproductive system of a male mammal?
a. Testes b. Claspers c. Prostate gland d. Sperm ducts
2. Sperm cells in mammals are stored in the
a. epididymis. b. testes. c. scrotum. d. seminal vesicle.
3. The female of all of the following organisms has two ovaries except that of a
a. frog. b. toad. c. bird.
4. One of the following vertebrates has the largest egg?
a. Reptile b. Bird c. Toad
5. Which of the vertebrates listed below is mostly viviparous?
a. Amphibians b. Mammals c. Fishes d. Reptiles

ESSAY QUESTIONS

1. By means of labelled diagrams, show the structures of the reproductive organs of a male and female mammal.
2. State the functions of each of the following mammalian reproductive organs:
(a) Scrotum (b) Testes (c) Vas deferens (d) Prostate gland (e) Uterus (f) Fallopian tube
3. By means of labelled diagrams, describe the structures of the mammalian sperm cell and ovum.
4. State four similarities and eight differences between the reproductive organs of male and female mammals.
5. Briefly discuss the structural differences in eggs of vertebrates.