FEDERAL UNIVERSITY OF WUKARI
FACULTY OF PURE AND APPLIED SCIENCES
DEPARTMENT OF BIOLOGICAL SCIENCES
GENERAL BIOLOGY 1 (BIO101) 3 CREDIT UNIT

Animals Reproduction

Do you recall the processes of digestion, circulation and respiration which you have studied in your secondary school? Reproduction is the process by which new individuals are produced by the parents. It ensures that a plant or animal species does not disappears from the earth. This process is very important in maintaining stability in the ecosystem and for the continuation of life on earth. Imagine what would have happened if organisms had not reproduced, all the species would have become extinct. You will realize that reproduction is very important as it ensures the continuation of similar kinds of individuals, generation after generation.

Some animals produce offspring through asexual reproduction while other animals produce offspring through sexual reproduction. Both methods have advantages and disadvantages. **Asexual reproduction** produces offspring that are genetically identical to the parent because the offspring are all clones of the original parent. A single individual can produce offspring asexually and large numbers of offspring can be produced quickly; these are two advantages that asexually reproducing organisms have over sexually reproducing organisms. In a stable or predictable environment, asexual reproduction is an effective means of reproduction because all the offspring will be adapted to that environment. In an **unstable** or **unpredictable environment**, species that reproduce asexually may be at a **disadvantage** because all the offspring are **genetically identical** and may not be **adapted to different conditions.**

During **sexual reproduction**, the **genetic material** of **two individuals** is **combined** to **produce genetically** diverse offspring that **differ from their parents**. The genetic diversity of sexually produced offspring is thought to give sexually reproducing individuals' **greater fitness** because more of their offspring may **survive** and **reproduce** in an **unpredictable** or **changing environment**. Species that reproduce sexually (and have separate sexes) must maintain two different types of individuals, males and females. Only half the population (females) can produce the offspring, so fewer offspring will be produced when compared to asexual reproduction. This is a disadvantage of sexual reproduction compared to asexual reproduction.

1. Asexual Reproduction

Asexual reproduction occurs in prokaryotic microorganisms (bacteria and archaea) and in many eukaryotic, single-celled and multi-celled organisms. There are several ways that animals reproduce asexually, the details of which vary among individual species.

a. Fission

Fission is the splitting of a unicellular organism into two or more separate daughter cells. The term fission is applied to instances in which an organism appears to split itself into two parts and, if necessary, regenerate the missing parts of each new organism. For example, species of turbellarian flatworms commonly called the planarians, such as *Dugesia dorotocephala*, are able to separate

their bodies into head and tail regions and then regenerate the missing half in each of the two new organisms. Sea anemones (Cnidaria), such as species of the genus *Anthopleura* (Figure1), will divide along the oral-aboral axis, and sea cucumbers (Echinodermata) of the genus *Holothuria*, will divide into two halves across the oral-aboral axis and regenerate the other half in each of the resulting individuals.

Figure 1: Sea Anemone

i. **Binary fission**, the animal body splits or divides in such a plane that two equal and identical halves are produced. It is most common in protozoans but it also occurs in certain lower metazoans, some invertebrate, multi-celled organisms. First of all, the nucleus is followed by the division of the cytoplasm.

ii. **Multiple fission.** In the multiple fission, the nucleus of the cell divides very rapidly into many nuclei. Each daughter nucleus in later stage is surrounded by the little mass of the cytoplasm and forms the asexually reproducing body such as schizogont, gamont, spore, etc. The multiple fission occurs in most algae, fungi and some protozoans, e.g., *Amoeba*, *plasmodium* and *monocystis*, etc.

b. Budding

Budding is a form of asexual reproduction that results from the outgrowth of a part of the body leading to a separation of the "bud" from the original organism and the formation of two individuals, one smaller than the other. Budding occurs commonly in some invertebrate animals such as hydras and corals. In hydras, a bud forms that develops into an adult and breaks away from the main body (Figure 2).

Figure 2 (a) Hydra reproduce asexually through budding: a bud forms on the tubular body of an adult hydra, develops a mouth and tentacles, and then detaches from its parent. The new hydra is fully developed and will find its own location for attachment. (b) Some coral, such as the Lophelia pertusa shown here, can reproduce through budding. Part a: This shows a hydra, which has a stalk-

like body with tentacles growing out the top. A smaller hydra is budding from the side of the stalk. Part b: This photo shows branching white coral polyps.

c. Fragmentation

Fragmentation is the breaking of an individual into parts followed by regeneration. If the animal is capable of fragmentation, and the parts are big enough, a separate individual will regrow from each part. Fragmentation may occur through accidental damage, damage from predators, or as a natural form of reproduction. Reproduction through fragmentation is observed in sponges, some cnidarians, turbellarians, echinoderms, and annelids. In some sea stars, a new individual can be regenerated from a broken arm and a piece of the central disc. This sea star (Figure 3) is in the process of growing a complete sea star from an arm that has been cut off. Fisheries workers have been known to try to kill the sea stars eating their clam or oyster beds by cutting them in half and throwing them back into the ocean. Unfortunately for the workers, the two parts can each regenerate a new half, resulting in twice as many sea stars to prey upon the oysters and clams.

Figure 3 (a) Linckia multifora is a species of sea star that can reproduce asexually via fragmentation. In this process, (b) an arm that has been shed grows into a new sea star.

d. Parthenogenesis

Parthenogenesis is a form of asexual reproduction in which an egg develops into an individual without being fertilized. The resulting offspring can be either haploid or diploid, depending on the process in the species. Parthenogenesis occurs in invertebrates such as water fleas, rotifers, aphids, stick insects, and ants, wasps, and bees. Ants, bees, and wasps use parthenogenesis to produce haploid males (drones). The diploid females (workers and queens) are the result of a fertilized egg. Some vertebrate animals—such as certain reptiles, amphibians, and fish—also reproduce through parthenogenesis. Parthenogenesis has been observed in species in which the sexes were separated in terrestrial or marine zoos. Two female Komodo dragons, a hammerhead shark, and a blacktop shark have produced parthenogenic young when the females have been isolated from males. It is possible that the asexual reproduction observed occurred in response to unusual circumstances and would normally not occur.

2. Sexual Reproduction

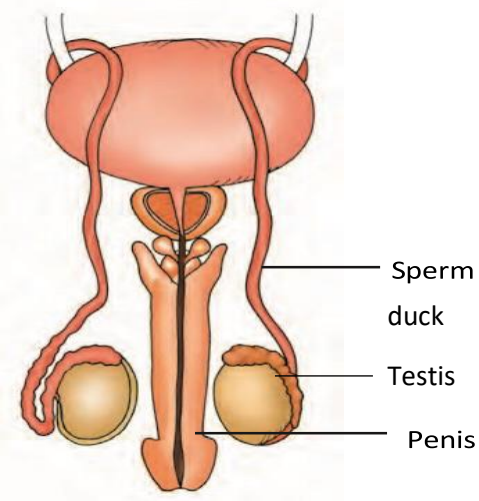
In animals, males and females have different reproductive parts or organs. The reproductive parts in animals produce gametes that fuse to form a zygote. It is the zygote which develops into a new individual. This type of reproduction beginning from the fusion of male and female gametes is called sexual reproduction.

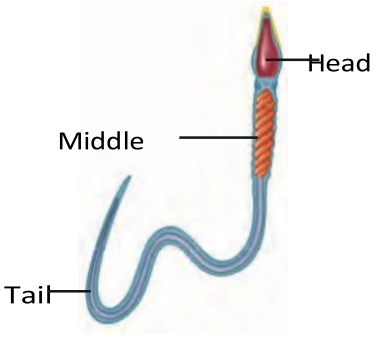
Sexual reproduction is the combination of reproductive cells from two individuals to form genetically unique offspring. The nature of the individuals that produce the two kinds of gametes can vary, having for example separate sexes or both sexes in each individual.
The sexual reproduction may be of the following types:

i. **Syngamy** is the most common type of sexual reproduction in plants and animals. In syngamy (Gr., *syn* = together; *gam* = marriage), the fusion of two gametes takes place completely and permanently.
ii. **Conjugation** is temporary union of the two individuals of same species. During the union, both individuals known as **conjugants** exchange certain amount of nuclear (DNA) materials and after these conjugants are separated. The conjugation is most common among the ciliates, e.g., *Paramecium*.
iii. **Automixis** is when the gamete nuclei of the same cell unite together to form new individuals, this phenomenon is known as the **Automixis** e.g., Paramecium.

Let us find out the reproductive parts in humans and study the process of reproduction in them.

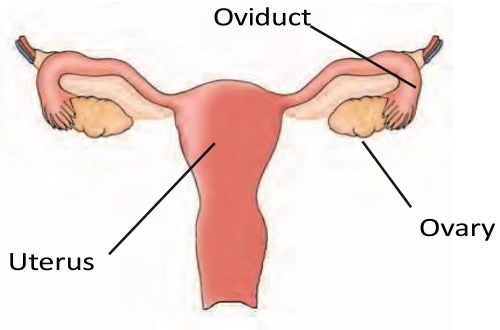
Male Reproductive Organs
The male reproductive organs include a pair of testes (singular, testis), two sperm ducts and a penis (Figure 4a). The testes produce the male gametes called sperms. Millions of sperms are produced by the testes. Look at Figure 4b which shows the picture of a sperm. Though sperms are very small in size, each has a head, a middle piece and a tail. Does it appear to be a single cell? Indeed, each sperm is a single cell with all the usual cell components.





4a: Two sperm duct and penis *4b: Human sperm*

The female reproductive organs are a pair of ovaries, oviducts (fallopian tubes) and the uterus. The ovary produces female gametes called ova (eggs). In human beings, a single matured egg is released into the oviduct by one of the ovaries every month. Uterus is the part where development of the baby takes place. Like the sperm, an egg is also a single cell.



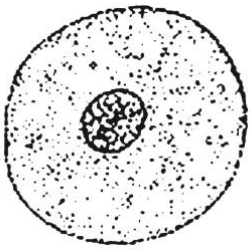
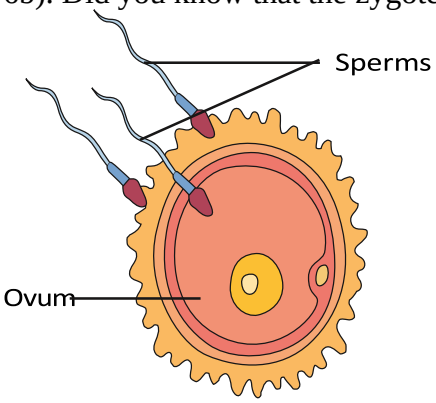


Figure.5a Female reproductive organs

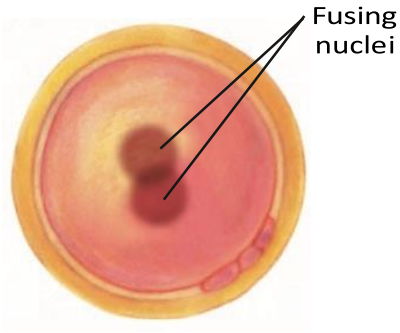
Figure 5b: Human Ovum

Fertilization

The first step in the process of reproduction is the fusion of a sperm and an ovum. When sperms come in contact with an egg, one of the sperms may fuse with the egg. Such fusion of the egg and the sperm is called fertilization (Figure 6a). During fertilization, the nuclei of the sperm and the egg fuse to form a single nucleus. This results in the formation of a fertilized egg or zygote (Figure 6b). Did you know that the zygote is the beginning of a new individual?



6a: Fertilisation



6b: zygote

The process of fertilization is the meeting of an egg cell from the mother and a sperm cell from the father. So, the new individual inherits some characteristics from the mother and some from the father. Look at your brother or sister. See if you can recognize some characters in them similar to those of your mother or your father.

Fertilization which takes place inside the female body is called **internal fertilization**. Internal fertilization occurs in many animals including humans, cows, dogs and hens.

You will be surprised to know that in many animals' fertilization takes place outside the body of the female. In these animals, fertilization takes place in water. Let us find out how this happens.

During spring or rainy season, frogs and toads move to ponds and slow flowing streams. When the male and female come together in water, the female lays hundreds of eggs. Unlike hen's egg, frog's egg is not covered by a shell and it is comparatively very delicate. A layer of jelly holds the eggs together and provides protection to the eggs (Figure 7).

Figure. 7: Eggs of frog

As the eggs are laid, the male deposits sperms over them. Each sperm swims randomly in water with the help of its long tail. The sperms come in contact with the eggs. This results in fertilization. This type of fertilization in which the fusion of a male and a female gamete takes place outside the body of the female is called **external fertilization.** It is very common in aquatic animals such as fish, starfish, etc.

Types of Fertilization

1. External Fertilization

External fertilization usually occurs in aquatic environments where both eggs and sperm are released into the water. After the sperm reaches the egg, fertilization takes place. Most external fertilization happens during the process of spawning where one or several females release their eggs and the male(s) release sperm in the same area, at the same time. The spawning may be triggered by environmental signals, such as water temperature or the length of daylight. Nearly all fish spawn, as do crustaceans (such as crabs and shrimp), mollusks (such as oysters), squid, and echinoderms (such as sea urchins and sea cucumbers). Frogs, corals, mayflies, and mosquitoes also spawn (Figure 8).

Figure 8 During sexual reproduction in toads, the male grasps the female from behind and externally fertilizes the eggs as they are deposited.

2. Internal Fertilization

Internal fertilization occurs most often in terrestrial animals, although some aquatic animals also use this method examples are; salmon, horseshoe and damselfish. Internal fertilization may occur by the male directly depositing sperm in the female during mating. It may also occur by the male depositing sperm in the environment, usually in a protective structure, which a female picks up to deposit the sperm in her reproductive tract. There are **three ways** that offspring are produced following internal fertilization.

In **oviparity**, fertilized eggs are laid outside the female's body and develop there, receiving nourishment from the yolk that is a part of the egg (Figure 9a). This occurs in some bony fish, some reptiles, a few cartilaginous fish, some amphibians, a few mammals, and all birds. Most non-avian reptiles and insects produce leathery eggs, while birds and some turtles produce eggs with high concentrations of calcium carbonate in the shell, making them hard. Chicken eggs are an example of a hard shell. The eggs of the egg-laying mammals such as the platypus and echidna are leathery.
In **ovoviparity**, fertilized eggs are retained in the female, and the embryo obtains its nourishment from the egg's yolk. The eggs are retained in the female's body until they hatch inside of her, or she lays the eggs right before they hatch. This process helps protect the eggs until hatching. This occurs in some bony fish (like the platyfish *Xiphophorus maculatus*, Figure 9b), some sharks, lizards, some snakes (garter snake *Thamnophis sirtalis*), some vipers, and some invertebrate animals (Madagascar hissing cockroach *Gromphadorhina portentosa*).

In **viviparity** the young are born alive. They obtain their nourishment from the female and are born in varying states of maturity. This occurs in most mammals (Figure 9c), some cartilaginous fish, and a few reptiles.

Figure 9 In (a) oviparity, young develop in eggs outside the female body, as with these Harmonia axydridis beetles hatching. Some aquatic animals, like this (b) pregnant Xiphophorus maculatus are ovoviparous, with the egg developing inside the female and nutrition supplied primarily from the yolk. In mammals, nutrition is supported by the placenta, as was the case with this (c) newborn squirrel.

Development of Embryo
Fertilization results in the formation of zygote which begins to develop into an embryo. The zygote divides repeatedly to give rise to a ball of cells. The cells then begin to form groups that develop into different tissues and organs of the body. This developing structure is termed an embryo. The embryo gets embedded in the wall of the uterus for further development.
The embryo continues to develop in the uterus. It gradually develops body parts such as hands, legs, head, eyes, ears etc. The stage of the embryo in which all the body parts can be identified is called a foetus. When the development of the foetus is complete, the mother gives birth to the baby.

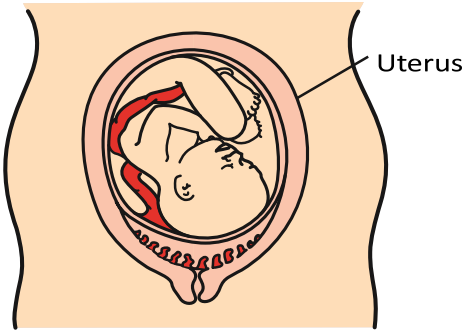


Figure 10: Foetus in the uterus

Internal fertilization takes place in hens also. But, do hens give birth to babies like human beings and cows? You know that they do not. Then, how are chicks born? Let us find out.
Soon after fertilization, the zygote divides repeatedly and travels down the oviduct. As it travels down, many protective layers are formed around it. The hard shell that you see in a hen's egg is one such protective layer.

After the hard shell is formed around the developing embryo, the hen finally lays the egg. The embryo takes about 3 weeks to develop into a chick. You must have seen the hen sitting on the eggs to provide sufficient warmth. Did you know that development of the chick takes egg place inside the egg shell during this period? After the chick is completely developed it bursts open the egg shell.
In animals which undergo external fertilization, development of the embryo takes place outside the female body. The embryos continue to grow within their egg coverings. After the embryo develop, the eggs hatch.

Young Ones to Adults
The new individuals which are born or hatched from the eggs continue to grow till they become adults. In some animals, the young ones may look very different from the adults. Recall the life cycle of the silkworm (**egg → larva or caterpillar → pupa → adult**). Frog is another such example.
Observe the different stages of frog starting from the egg to the adult stage. We find that there are **three distinct** stages, that is, **egg → tadpole (larva) → adult**. Don't the tadpoles look so different from the adults? Can you imagine that these tadpoles would someday become frogs? Similarly, the caterpillar or the pupa of silkworm looks very different from the adult moth. The features that are present in the adult are not found in these young ones. Then what happens to the tadpoles or caterpillars thereafter?
You must have seen a beautiful moth emerging out of the cocoon. In the case of tadpoles, they transform into adults capable of jumping and swimming. The transformation of the larva into an adult through drastic changes is called metamorphosis. What about the changes that we observe in our body as we grow?
Do you think we too undergo metamorphosis? In human beings, body parts similar to those present in the adults are present from the time of birth.

Hermaphroditism

Hermaphroditism occurs in animals in which one individual has both male and female reproductive systems. Invertebrates such as earthworms, slugs, tapeworms, and snails (Figure 11) are often hermaphroditic. Hermaphrodites may self-fertilize, but typically they will mate with another of their species, fertilizing each other and both producing offspring. Self-fertilization is more common in animals that have limited mobility or are not motile, such as barnacles and clams. Many species have specific mechanisms in place to prevent self-fertilization, because it is an extreme form of inbreeding and usually produces fewer fit offspring.

Figure 11: Many (a) snails are hermaphrodites. When two individuals (b) mate, they can produce up to 100 eggs each.

Sex Determination

Mammalian sex is determined genetically by the combination of X and Y chromosomes. Individuals homozygous for X (XX) are female and heterozygous individuals (XY) are male. In mammals, the presence of a Y chromosome causes the development of male characteristics and its absence results in female characteristics. The XY system is also found in some insects and plants. Bird sex determination is dependent on the combination of Z and W chromosomes. Homozygous for Z (ZZ) results in a male and heterozygous (ZW) result in a female. Notice that this system is the opposite of the mammalian system because in birds the female is the sex with the different sex chromosomes. The W appears to be essential in determining the sex of the individual, similar to the Y chromosome in mammals. Some fish, crustaceans, insects (such as butterflies and moths), and reptiles use the ZW system.

More complicated chromosomal sex determining systems also exist. For example, some swordtail fish have three sex chromosomes in a population.

The sex of some other species is not determined by chromosomes, but by some aspect of the environment. Sex determination in alligators, some turtles, and tuataras, for example, is dependent on the temperature during the middle third of egg development. This is referred to as **environmental sex determination,** or more specifically, as temperature-dependent sex determination. In many turtles, cooler temperatures during egg incubation produce males and warm temperatures produce females, while in many other species of turtles, the reverse is true. In some crocodiles and some turtles, moderate temperatures produce males and both warm and cool temperatures produce females.

Individuals of some species change their sex during their lives, switching from one to the other. If the individual is female first, it is termed **protogyny** or "first female," if it is male first, it is termed **protandry** or "first male." Oysters are born male, grow in size, and become female and lay eggs. The wrasses, a family of reef fishes, are all sequential hermaphrodites. Some of these species live

in closely coordinated schools with a dominant male and a large number of smaller females. If the male dies, a female increases in size, changes sex, and becomes the new dominant male.

Importance of Reproduction

1. To maintain balance between birth and death rate.
2. The new individuals replace the old and dying population.
3. It also helps in increasing the number of species in the ecosystem.
4. The genes are transmitted from the parent to offspring.
5. It leads to evolution of species.
6. Variation in species and their ability to survive in different environments is the result of reproduction.

The main Environmental Factors Influencing Animal Reproduction

1. Temperature
2. Nutrition
3. Amount and distribution of rainfall
4. Social interactions among individuals within the same population
5. Predator-prey interaction
6. Parasite and pathogen (diseases)
7. Solar radiation etc.

Compiled by Jummai Amos Tidi, PhD.