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DEPARTMENT OF BIOLOGICAL SCIENCES.
GENERAL BIOLOGY 1 (BIO101) 3 UNIT

Animals Reproduction

This is the inherent property of the living organisms to continue their race by the mechanism of reproduction. The reproduction is a process by which the living beings propagate or duplicate their own kinds. The reproduction may be of the following two types:

1. Asexual reproduction
2. Sexual reproduction

Asexual Reproduction

The development of new individuals without the fusion of the male and female gametes is known as **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. The asexual reproduction is common only in lower plants and animals and it may be of following types:

A. Fission

Fission, also called binary fission, occurs in some invertebrate, multi-celled organisms. It is in some ways analogous to the process of binary fission of single-celled prokaryotic organisms. 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*.
The fission is the most widely occurring type of asexual reproduction of the protozoans and various metazoans. In this method, the nuclear and cytoplasmic contents of the cell divide or split completely into smaller-sized daughter individuals. The fission itself may be of the following types.

a. **Binary fission.** in the 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. First of all, the nucleus is followed by the division of the cytoplasm. According to the plane of fission, following types of binary fission have been recognized in the organisms.

   i. **Simple or orthodox type of binary fission.** The simple or orthodox type of binary fission occurs in the irregular shaped organism, e.g., Amoeba in which plane of division is difficult to observe.

   ii. **Transverse binary fission.** The transverse binary fission occurs in some protozoans, e.g., paramecium and some metazoans such as certain coelenterates, turbellarians and annelids. In transverse binary fission, the plane of the division is always transverse to the longitudinal axis of the body of the organisms.

   iii. **Longitudinal binary fission.** The longitudinal binary fission occurs in certain ciliates and flagellates, e.g., *Vorticella* and *Euglena* (Protozoa) and some corals (Anthozoa). In longitudinal binary fission, the nucleus and the cytoplasm divide in the longitudinal plane.

   iv. **Oblique binary fission.** The oblique binary fission occurs in most dinoflagellates. In this type of fission, the cell or body of the organism divide by the oblique division.

   v. **Strobilation.** In certain metazoan animals, a special type of transverse fission known as the strobilation occurs. In the process of strobilation, several transverse fissions occur simultaneously and giving rise to a number of individuals which often do not separate from each other immediately. The strobilation occurs in the scyphozoan (*Aurelia*), certain polychaetes and ascidians. In *Aurelia*, for instance, the strobilation occurs during the formation of Ephyra larva.

b. **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 1).

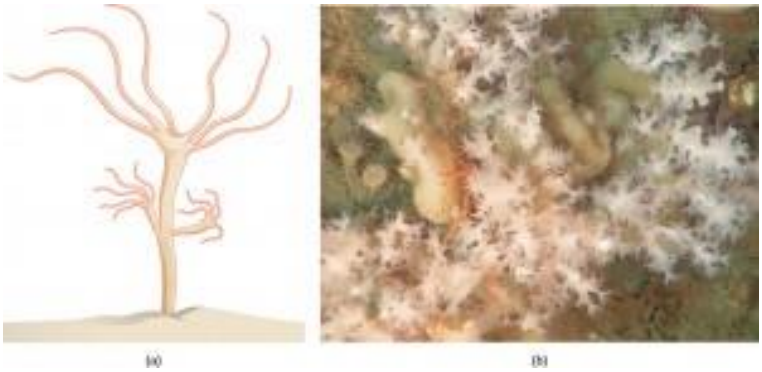


Figure 1 (a) Hydra reproduce asexually through budding: a bud forms on the tubular body of an adult hydra, develops a mouth and tentacles, and then detaches from its parent. The new hydra is fully developed and will find its own location for attachment. (b) Some coral, such as the *Lophelia pertusa* 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 2) 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 2 (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.

E. Gemmule formulation

In certain metazoan animals, the asexual reproduction is carried on by certain peculiar asexual bodies known as the **gemmules** and **statoblasts**. The gemmules occur in fresh water sponges (Family-Spongillidae) and the statoblasts occur in the bryozoans. The gemmules and the statoblasts are composed of a group of undifferentiated cells which contain stored food material. These cells are enclosed and protected by the monaxon spicules in the gemmules and by the chitinous covering in the statoblasts. Both (gemmules and statoblasts) are set free by the destruction of the parental body and they develop into a new individual in the favourable conditions.

F. Regeneration

The regeneration is a process by which the organisms develop or to regenerate their lost or worn-out parts. The regeneration is the best means of asexual reproduction in certain protozoans, sponges, coelenterates, planarians and echinoderms.

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. Sex determination, the mechanism that determines which sex an individual develops into, also can vary. In the sexual reproduction, the development of the new individual takes place by the fusion of the sex cells or male and female gametes. The sexual reproduction is the most common type of reproduction among the plants and animals. It may be of the following types:

1. **Syngamy**. The syngamy is the most common type of sexual reproduction in the plants and animals. In syngamy (Gr., *syn* = together; *gam* = marriage), the fusion of two gametes takes place completely and permanently. Following kinds of syngamy are prevalent among the living organisms:

i. **Autogamy**. In autogamy (Gr., *auto* = self; *gam* = marriage), the male and female gametes are produced by different parents and both unite to form a zygote.

ii. **Exogamy**. In exogamy (Gr., *exo* = external; *gam* = marriage), the male and female gametes are produced by different parents and both unite to form a zygote.

iii. **Hologamy**. In the lower organisms, sometimes the entire mature organisms start to act as gametes and the fusion of such mature individuals is known as **hologamy.**

iv. **Paedogamy.** Paedogamy is the sexual union of young individuals produced immediately after the division of the adult parent cell by mitosis.

v. **Merogamy.** In merogamy (Gr., *meros* = part; *gam* = marriage), the fusion of smaller-sized and morphologically different gametes (**merogametes**) takes place.

vi. **Isogamy.** In isogamy (Gr., *iso* = equal; *gam* = marriage), the fusion of morphologically and physiologically identical gametes (**isogametes**) takes place.

vii. **Anisogamy.** Some organisms produce two types of gametes. Both types of gametes differ from each other in their shape, size and behavior and are collectively known as the **anisogametes** or **heterogametes**. The male gametes are motile and small in size and known as the **microgametes**. The female gametes are passive and have comparatively large size known as the **macro-** or **megagametes**. The union of micro-band macrogametes is known as the **anisogamy** (Gr., *an* = without; *is* = equal; *gam* = marriage). The anisogamy occurs in higher animals and plants but it is customary to use the term fertilization in them instead of the anisogamy and syngamy.

viii. **Macrogamy.** the syngamy or fusion of the macrogametes is known as Macrogamy (Gr., *macro* = large; *gam* = marriage).

ix. **Microgamy.** The Microgamy (Gr., *micro* = small; *gam* = marriage) is common in certain protozoans, e.g., forminiferans and Arcella. In Microgamy the fusion of microgametes takes place.

2. **Conjugation**. The 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*.

3. **Automixis**. When the gamete nuclei of the same cell unite together to form new individuals, this phenomenon is known as the **Automixis** e.g., Paramecium.

4. **Parthenogenesis**. The parthenogenesis (Gr., *Parthenos* = virgin; *genesis* = birth) is the special type of sexual reproduction. The diploid females (workers and queens) are the result of a fertilized egg.

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 3) 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 3: Many (a) snails are hermaphrodites. When two individuals (b) mate, they can produce up to 100 eggs each.

Fertilization

The fusion of a sperm and an egg is a process called fertilization. This can occur either inside (internal fertilization) or outside (external fertilization) the body of the female. Humans provide an example of the former, whereas frog reproduction is an example of the latter.

ASSIGNMENT: Study the anatomy and physiology of human reproductive organs.

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 4).

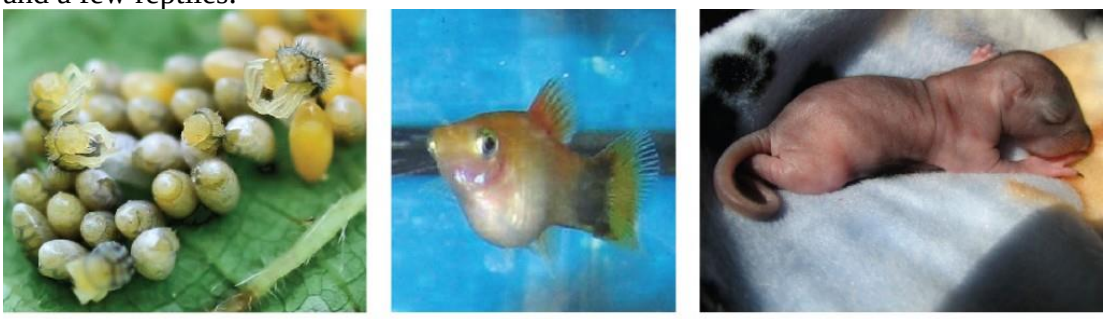
Figure 4: During sexual reproduction in toads, the male grasps the female from behind and externally fertilizes the eggs as they are deposited.

Internal Fertilization

Internal fertilization occurs most often in terrestrial animals, although some aquatic animals also use this method. 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 5 **a**). 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 5 **b**), 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 5 **c**), some cartilaginous fish, and a few reptiles.



(a) (b) (c)

Figure 5: 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.

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.

Compiled by Jummai Amos Tidi, PhD.