
Reproduction

Objectives

After going through this lesson, the learners will be able to understand the following:

- Reproduction
- Types of reproduction
- Asexual reproduction
- Types of asexual reproduction
- Cloning

Content Outline

- Introduction
- Life Span
- Asexual Reproduction
- Types of Asexual Reproduction
- Cloning
- Advantages and Disadvantages of asexual reproduction
- Summary

Introduction

Biology, in essence, is the story of life on earth. While individual organisms die without fail, species continue to live through millions of years unless threatened by natural or anthropogenic extinction. There is a large diversity of living organisms on the earth. The plants and animals are main living organisms. All organisms differ in their form and structure. Some plants are small, still others are large. Some animals exist on land, some others live in water. Some plants are grown in pots, some are large trees.

All organisms grow and after a definite period of life, they perish. Before death the organisms try to continue their species. The organisms produce the individuals like themselves. The process by which the species is continued is called reproduction.

Life Span

Each and every organism can live only for a certain period of time. The period from birth to the natural death of an organism represents its life span. Lifespan of a Butterfly is about 1-2

weeks, Crow is about 15 years, and Parrot is 140 years. The life span of Crocodile is about 60 years and that of Tortoise is 100-150 years. Can you find out the life span of Elephant, Dog, Cow, Horse, Fruit fly and a Banyan tree and arrange them as per their age. Isn't it both interesting and intriguing to note that it may be as short as a few days (sometimes adults may last even for a few min as in case of Mayfly) or as long as a few thousand years? Between these two extremes are the life spans of most other living organisms. You may note that life spans of organisms are not necessarily correlated with their sizes; the size of a crow and parrot are not very different yet their life spans show a wide difference. Similarly, a mango tree has a much shorter life span as compared to a Peepal tree.

Every organism has a specific average lifespan. It means every organism grows and lives for a particular length of time. Lifespan may range from one day to 4000 years.



Butterfly



Crow



Parrot



Crocodile



Tortoise



Elephant



Dog



Cow



Horse



Fruit fly



Banyan Tree



Mango Tree



Peepal Tree

Lifespan depends upon four stages:

- i. **Juvenility:** This represents the stage when an organism develops the capacity to reproduce.
- ii. **Maturity:** In this stage reproduction starts..
- iii. **Ageing and senescence:** Progressive deterioration in the body of a living being is called ageing. The terminal irreversible stage of aging is known as senescence.
- iv. **Death:** In death, there is permanent cessation of all vital activities. Lifespan of a Mayfly is only one day. Houseflies have a lifespan of 1-4 months. Lions live for about 25 years. Insects live for a few months.



May fly



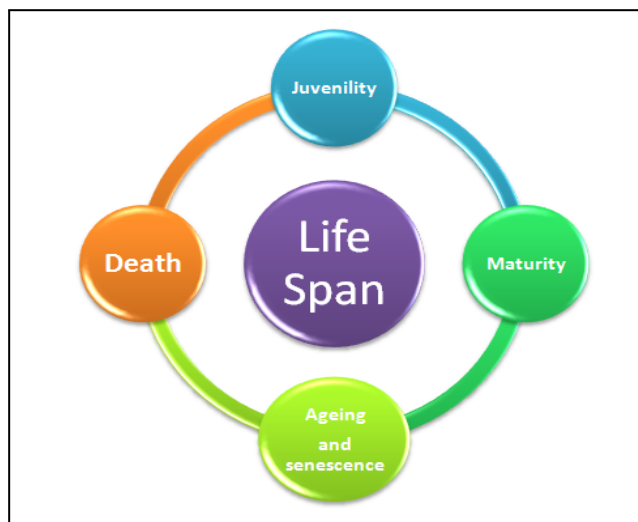
House fly



Lion

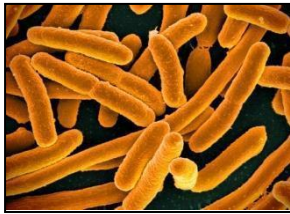


Insects



Whatever be the life span, death of every individual organism is a certainty, meaning no individual is immortal, except single-celled organisms. Why do we say there is no natural death in single-celled organisms? Given this reality, have you ever wondered how vast

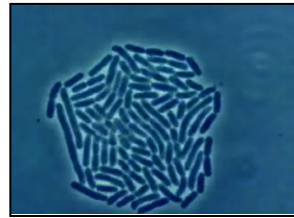
numbers of plant and animal species have existed on earth for several thousands of years? There must be some processes in living organisms that ensure this continuity. Yes, we are talking about reproduction, something that we take for granted.



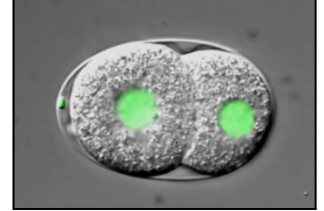
Single cell organisms



Organism diversity



Bacteria Multiplying



Sexual Reproduction

Reproduction becomes a vital process without which species cannot survive for long. Each individual leaves its progeny by asexual or sexual means. Sexual mode of reproduction enables creation of new variants, so that survival advantage is enhanced. This unit examines the general principles underlying reproductive processes in living organisms and then explains the details of this process in flowering plants and humans as easy to relate representative examples.

All organ systems, except the reproductive systems, help the organism to remain alive under different conditions of environment. Reproduction is defined as a biological process in which an organism gives rise to young ones (offspring) similar to itself. The offspring grow, mature and in turn produce new offspring. Thus, there is a cycle of birth, growth and death. Reproduction enables the continuity of the species, generation after generation.

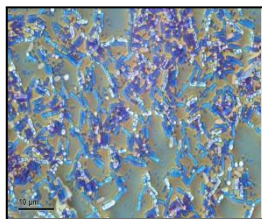
There is a large diversity in the biological world and each organism has evolved its own mechanism to multiply and produce offspring. The organism's habitat, its internal physiology and several other factors are collectively responsible for how it reproduces. Based on whether there is participation of one organism or two in the process of reproduction, it is of two types. When offspring is produced by a single parent with or without the involvement of gamete formation, the reproduction is asexual. When two parents (opposite sex) participate in the reproductive process and also involve fusion of male and female gametes, it is called sexual reproduction.



Diversity of Organisms

Asexual Reproduction

Asexual reproduction is a type of reproduction by which offspring arise from a single organism, and inherit the genes of that parent only; it does not involve the fusion of gametes and almost never changes the number of chromosomes. Asexual reproduction is the primary form of reproduction for single-celled organism as the archaeobacteria, eubacteria, and protists. Many plants both simple and higher, and fungi reproduce asexually as well.



Archaeobacteria



Eubacteria



Protist



Bryophyllum



Fungi

Any reproductive process that does not involve meiosis or syngamy is said to be asexual, or vegetative. The absence of syngamy means that such an event can occur in the sporophyte generation or the gametophyte stage. Because of the lack of new genetic material, an organism clones itself through this process and makes genetically identical organisms. This can be advantageous in some circumstances, but deleterious in others, depending on how the makeup of the plant suits its ecosystem. There are a few major ways in which plants asexually reproduce in their life cycles to secure future generations.

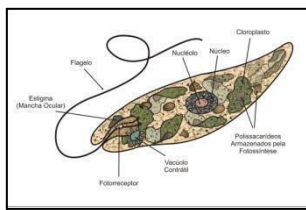
In this method, a single individual (parent) is capable of producing offspring. As a result, the offspring that are produced are not only identical to one another but are also exact copies of their parents. Are these offspring likely to be genetically identical or different? The term clone is used to describe such morphologically and genetically similar individuals.

Types of Asexual Reproduction

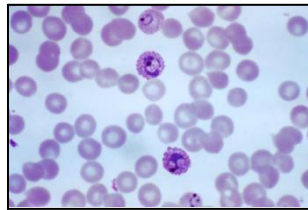
Asexual reproduction includes Fission, Budding, Vegetative reproduction, sporogenesis, Fragmentation and Agamogenesis (Parthenogenesis and Apomixis).

Fission

Fission is the division of a cell or a body into two or more parts and the regeneration of those parts into *separate* cells (bodies, populations, or species). Fission may be Binary fission or Multiple fission. **Binary fission** ("division in half") is a kind of asexual reproduction. It is the most common form of reproduction in prokaryotes and occurs in some single-celled eukaryotes. **Multiple fission** at the cellular level occurs in many protists, e.g. in sporozoans and algae. The nucleus of the parent cell divides several times by mitosis, producing several nuclei. The cytoplasm then separates, creating multiple daughter cells.



Euglena (Protists)



Sporozoans



Algae

Budding

Budding is a form of asexual reproduction in which a new organism develops from an outgrowth or bud due to cell division at one particular site and is unequal. The new organism remains attached as it grows, separating from the parent organism only when it is mature, leaving behind scar tissue. Since the reproduction is asexual, the newly created organism is a clone and is genetically identical to the parent organism.

Organisms such as hydra use regenerative cells for reproduction in the process of budding. In hydra, a bud develops as an outgrowth due to repeated cell division at one specific site. These buds develop into tiny individuals and, when fully mature, detach from the parent body and become new independent individuals. In yeast also small buds are produced which initially remain attached to the parent cell and then replaced into new yeast individuals. Sometimes they remain attached and form a colony.

Vegetative reproduction

Vegetative reproduction also known as **vegetative propagation** or **vegetative multiplication** or **vegetative cloning**, is a form of asexual reproduction in plants. It is a process by which new organisms arise without production of seeds or spores. It can occur naturally or be induced by horticulturists. The structures used to give rise to new offspring are called vegetative propagation.

Vegetative reproduction includes:

- a. **Runners:** **Runners** are stems that grow horizontally above the ground. They have nodes where buds are formed. These buds grow into a new plant. eg. Strawberry runners.
- b. **Bulb:** A modified shoot, a **bulb** is a short stem with fleshy leaves or leaf bases that function as food storage organs during dormancy. A bulb's leaf bases, also known as scales, generally do not support leaves, but contain food reserves to enable the plant to survive adverse weather conditions. At the center of the bulb is a vegetative growing point or an unexpanded flowering shoot. The base is formed by a stem, and plant growth occurs from this basal plate. Roots emerge from the underside of the base, and new stems and leaves from the upper side e.g. Onion, garlic etc.
- c. **Corm:** A **corm** also known as **bulbo-tuber**, or **bulbotuber** is a short, vertical, swollen underground plant stem that serves as a storage organ used by some plants to survive winter or other adverse conditions such as summer drought and heat. Corms are not made up of leaves, but a vertical swollen compact stem, and as such are solid. The corm is protected by a tunic of old leaf petioles e.g. Colocasia.
- d. **Rhizome:** The **rhizome** is a modified underground stem serving as an organ of vegetative reproduction, e. g. *Polypodium* (polypody), Iris, Couch Grass and Nettles. If a rhizome is separated into pieces, each piece may be able to give rise to a new plant. The plant uses the rhizome to store starches, proteins, and other nutrients.
- e. **Tubers:** a tuber is a short, thick, round stem that is a part of certain plants (such as the potato), that grows underground, and that can produce a new plant. **Tubers** are enlarged structures in some plant species used as storage organs for nutrients. They are used for the plant's perennation (survival of the winter or dry months), to provide energy and nutrients for regrowth during the next growing season, and as a means of asexual reproduction. They may be stem tubers as Potato or Root tubers as Sweet Potatoes.

Spore

A **spore** is a unit of asexual reproduction that may be adapted for dispersal and for survival, often for extended periods of time, in unfavorable conditions. Spores form part of the life cycles of many plants, algae, fungi and protozoa.

Fragmentation

A form of asexual reproduction wherein a parent organism breaks into fragments, each capable of growing independently into a new organism. Fragmentation, also known as splitting, as a method of reproduction is seen in many organisms such as filamentous cyanobacteria, moulds, lichens, many plants, and animals such as sponges, acoelomate flatworms, some annelid worms and sea stars.

Agamogenesis

Agamogenesis is any form of reproduction that does not involve a male gamete. Examples are parthenogenesis and apomixis.

- a. **Parthenogenesis: Parthenogenesis** is a type of asexual reproduction in which the offspring develops from unfertilized eggs. It is particularly common amongst arthropods and rotifers and can also be found in some species of fish, amphibians, birds, and reptiles, but not in mammals. Parthenogenetic development also occurs in some plant species, such as roses and orange trees.

- b. **Apomixis:** The development of an embryo without the occurrence of fertilization, especially in plants. Apomixis is an asexual mode of seed formation that produces clonal progeny with a maternal genotype. It primarily influences reproductive events in the ovule of the flower. Apomixis (asexual seed formation) is the result of a plant gaining the ability to bypass the most fundamental aspects of sexual reproduction: meiosis and fertilization.



Runners

Bulb of Onion



Corm



Rhizome

Tubers



Spores



Fragmentation

Parthenogenesis in Frog

Let us see how widespread asexual reproduction is, among different groups of organisms. Asexual reproduction is common among single-celled organisms, and in plants and animals with relatively simple organisations. In Protists and Monerans, the organism or the parent cell divides into two to give rise to new individuals. Thus, in these organisms cell division is itself a mode of reproduction. Many single-celled organisms reproduce by binary fission, where a cell divides into two halves and each rapidly grows into an adult (e.g., Amoeba, Paramecium). In yeast, the division is unequal and small buds are produced that remain attached initially to the parent cell which eventually gets separated and mature into new yeast organisms (cells). Members of the Kingdom Fungi and simple plants such as algae reproduce through special asexual reproductive structures. The most common of these structures are

zoospores that usually are microscopic motile structures. Other common asexual reproductive structures are conidia (*Penicillium*), buds (*Hydra*) and gemmules (sponge).

The most common form of asexual reproduction in plants is called vegetative propagation that includes Bulb, Corm, Rhizome, Stolon, Runner, and Tubers.

In Animal kingdom, asexual reproduction occurs only in relatively unspecialised animals. Members of the animal phylum Cnidaria can undergo budding (e.g. *Hydra*). Another form of asexual reproduction seen in animals like Platyhelminthes is fragmentation.

Cloning of Animals

Cloning is the production of many genetically identical copies of an individual by asexual reproduction. It may occur naturally, but techniques have been developed which allow the process to be carried out artificially. The first successful cloning of a vertebrate was carried out in the late 1960s by Dr J. Gurdon at Oxford University.

The process doesn't naturally occurs in vertebrates but, by taking a cell from the intestine or skin of a frog and introducing its nucleus into an egg cell whose own nucleus had been destroyed by ultraviolet radiation, he was able to grow tadpole, which inturn grew into a frog identical to the parent from which the nucleus was transplanted. Research in Scotland in 1996 led to the successful cloning of a sheep, Dolly from a cell taken from parent's udder.

You must have heard about the scourge of the water bodies or about the 'terror of Bengal'. This is nothing but the aquatic plant 'water hyacinth' which is one of the most invasive weeds found growing wherever there is standing water. It drains oxygen from the water, which leads to death of fishes. You may find it interesting to know that this plant was introduced in India because of its beautiful flowers and shape of leaves. Since it can propagate vegetatively at a phenomenal rate and spread all over the water body in a short period of time, it is very difficult to get rid of them. Are you aware how plants like potato, sugarcane, banana, ginger, dahlia are cultivated? Have you seen small plants emerging from the buds (called eyes) of the potato tuber, from the rhizomes of banana and ginger? When you carefully try to determine the site of origin of the new plantlets in the plants listed above, you will notice that they invariably arise from the nodes present in the modified stems of these plants. When the nodes come in contact with damp soil or water, they produce roots and new plants. Similarly, adventitious buds arise from the notches present at margins of leaves of *Bryophyllum*. This ability is fully exploited by gardeners and farmers for commercial propagation of such plants. It is interesting to note that asexual reproduction is the common method of reproduction in organisms that have a relatively simple organisation, like algae and fungi and that they shift

to sexual method of reproduction just before the onset of adverse conditions. Find out how sexual reproduction enables these organisms to survive during unfavourable conditions? Why is sexual reproduction favoured under such conditions?

Asexual (vegetative) as well as sexual modes of reproduction are exhibited by the higher plants. On the other hand, only sexual mode of reproduction is present in most of the animals.

Advantages and Disadvantages of Asexual Reproduction

Asexual reproduction can be advantageous and/or disadvantageous. One positive aspect is that it can create individuals rapidly and in large quantities. Secondly, bypassing the sexual process can help a plant in times of dryness since motile sperm require water to fertilize the egg. Another advantage lies in the fact that plants with the desired characteristics can be cloned for economic reasons (agriculture). However, if something goes wrong, such as the occurrence of a fatal mutation, the whole society of clones can be terminated. For this reason, farmers are careful in determining how to propagate their vegetation. Secondly, they do not show variation.

(<http://www.ucmp.berkeley.edu/glossary/gloss6/asexual.html>)

Advantages:

- i. Only one parent is required:** Finding a mate can be very difficult for organisms that are in desolate environments, like the deep ocean. Asexual reproduction takes the need to find a mate away, allowing these organisms to multiply.
- ii. Genetically identical offspring:** If an organism is well adapted to its environment, the fact that the offspring are genetically identical may be an advantage. Successful combinations of genes are preserved.
- iii. Dispersal and spread:** The methods of asexual reproduction often enable dispersal of species. For example *Penicillium* and *Mucor* are common moulds which spread rapidly by means of asexually produced spores which are light and easily dispersed by air currents. This enables the fungi to find fresh sources of food. Plants that produce rhizomes, such as sea couch grass in sand dunes, bracken, and *Spartina* (cordgrass) in mud flats, spread rapidly by this means.
- iv. Rapid multiplication:** Bacteria can divide as often as once every 20 minutes allowing numbers to build up very rapidly. Many parasites rely on one or more asexual stages where rapid multiplication compensates for large losses at other stages in the life cycle. The malarial parasite, tapeworm and liver fluke are good examples.

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- v. **Better chance of survival will be at hand:** With a large number of organisms, species would still survive even when conditions change and the number of predators varies.

Disadvantages:

- i. **No Diversity:** Since the traits of only one parent are passed on, all of the offspring are exactly identical. This results in loss of diversity among the population of these organisms.
- ii. **Prone to Extinction:** All of the same traits also mean all of the same weaknesses. Parasites and other predators that have evolved to kill just one of the organisms can eliminate the entire population.
- iii. **It risks issues on inheritance:** Often, it requires a single asexual parent, from which the chromosomes and genes are copied. This means the genetic mutations or defects which could be bred out in asexual reproduction would be present in the offspring with no exception.
- iv. **There might be the risk of food and space competition:** Some asexual reproduction methods are producing offspring that are just close together, so there is a big possibility that they would compete for food and space.
- v. **There might be problems with crowding:** asexually reproducing organisms would usually lead to the struggle for existence and overcrowding within the community.

Summary

Reproduction enables a species to live generation after generation. Reproduction in organisms can be broadly classified into asexual and sexual reproduction. Asexual reproduction does not involve the formation or fusion of gametes. It is common in organisms that have a relatively simple organisation such as the fungi, algae and some invertebrate animals. The offspring formed by asexual reproduction are identical and are referred to as clones. Zoospores, conidia, etc., are the most common asexual structures formed in several algae and fungi.

Budding and gemmule formation are the common asexual methods seen in animals. Prokaryotes and unicellular organisms reproduce asexually by cell division or binary fission of the parent cell. In several aquatic and terrestrial species of angiosperms, structures such as

runners, rhizomes, suckers, tubers, offsets, etc., are capable of giving rise to new offspring. This method of asexual reproduction is generally referred to as vegetative propagation. Asexual reproduction is fairly distinct from sexual reproduction in a way that it does not need two parents and special cells to reproduce, which means that it does not require special mechanisms that combine sex cells and allow fertilization. It simply uses mitosis, which results in copying the parent organism. Most plants are thought to undergo this type of reproduction, but you need to know that there are also animals that reproduce asexually.