10th – How do Organisms Reproduce I

Reproduction is one of the fundamental attributes of a living organism, through which it is able to produce more of its own kind. Through this process, new individuals are produced, that grow and reproduce again, thus increasing the population of a species. How do we ascertain whether two organisms belong to the same species or not? Consider the example of a common urban crow and a black jungle crow. You may think they belong to the same species because they resemble each other. Actually, however, they belong to two different species because they cannot interbreed. A species is defined as a group of organisms (plants or animals) that can interbreed to produce fertile offspring. Compared to life processes like nutrition, respiration, etc., reproduction may appear to be a waste of energy as it is not essential for the survival of an individual. But it is an important function of a living being as it helps an organism to perpetuate its own kind. Reproduction is essential for the:

1. Continuity of life, from the time of its origin (millions of years ago)
2. Addition of new species
3. Replacement of dead organisms
4. Transfer of variation from one generation to another.

Organisms Produce Similar Offspring: Organisms produce similar offspring, but not exact copies of themselves. The offspring have similar body structures and similar genetic blueprints (DNA) in their cells. It is present in the nucleus of a cell in the form of a condensed structure called as chromosome.

At the cellular level, reproduction involves first making a copy of its DNA and creating the cellular apparatus for the new cell. Then the nucleus divides and separates the two copies of DNA. Finally, the cytoplasm divides and separates the cellular apparatus. Thus, a cell divides to produce two new similar cells. DNA carries information for making proteins. Any change, or error, in the copying of the DNA sequence will change the structure of the protein formed. This altered protein may change the basic body design. If this protein happens to be an enzyme then the biochemical reaction it catalyzes will also be affected. Errors in the copying of DNA cause variation (change) in the offspring. Due to this tendency for variation, organisms do not create exact copies during reproduction.

Importance of Variation: Reproduction involves the replication of DNA. If the replication is exact, the body design and features of the organism are maintained across generations. Thus reproduction provides stability to the populations of a species. But reproduction also provides variation. Variation refers to the differences found in the morphological and physiological feature of an organism. Variation is important for the survival of a species over a period of time, but it may bring advantages and/or disadvantages to the organisms in which it occurs. All organisms are exposed to certain environmental conditions. They adapt to cope with even slight changes in the environment.

Any drastic change in the environment, like extreme temperature change, varying water level, an earthquake or a meteorite hit, may take a heavy toll on organisms that are unable to cope with its effects. Variation gives some individuals in a population the ability to cope with changes that others cannot withstand. Suppose, there is a sudden drop in environmental temperature. As a result, some organisms will die due to severe cold. But some of them that have developed the ability to cope with extreme cold will survive and reproduce. This ability comes from variation caused by changes in the DNA.

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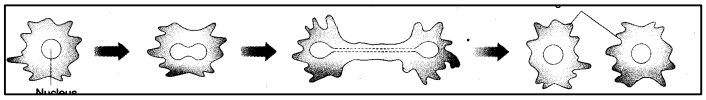
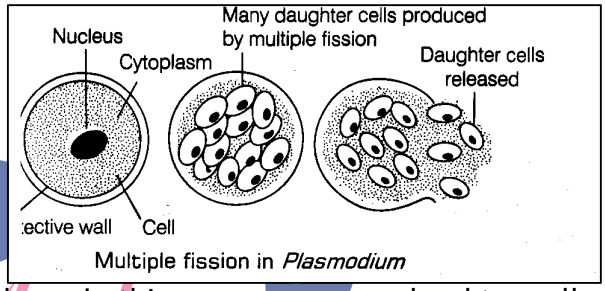
Reproduction in living organisms takes place by two general methods: asexual and sexual.

Asexual Reproduction: The type of reproduction that takes place without the process of gamete (sex cell) formation is called asexual reproduction. This process is very common in unicellular organisms and is said to be the simplest type of reproduction e.g. binary fission in amoeba, budding in hydra, spore formation in Rhizopus and fungus, vegetative propagation in flowering plants like rose etc. This type of reproduction takes place commonly in lower plants and animals, where the body is not very complex. There are different forms of asexual reproduction.

1. **Binary Fission:** it is the type of fission in which the parent organism divides into two identical daughter organisms with a definite orientation. At first nucleus divides amitotically (i.e. without spindle formation or appearance of chromosomes) into two, followed by the division of the cytoplasm and finally splitting of the parent to two daughter cells. Binary fission can be seen in organisms such as Amoeba, Paramecium, Euglena, etc. Some unicellular organisms show more organisation of their bodies as seen in Leishmania, (causative agent of kala-azar) which has a whip like structure at one end of the cell. In such organisms, binary fission occurs in a definite orientation in relation to

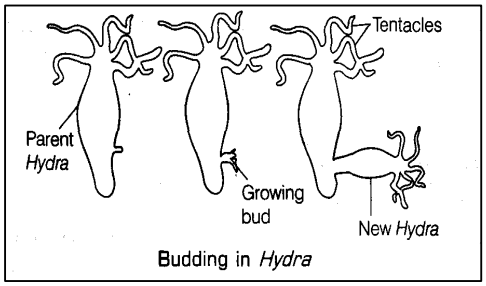


2. **Multiple Fission:** it is the type fission in which the parent organism divides into many identical daughter organisms at the same time. In this, the nucleus of the cell splits repeatedly to form many smaller nuclei called daughter nuclei surrounded by a little bit of cytoplasm and thin membrane around them. In this way, many new daughter cells are formed from a parent cell within a protective wall (cyst). Under favourable conditions, the cyst bursts and the daughter cells are released each forming a new organism. Multiple fission can be seen in organisms, such as Plasmodium (malarial parasite), Monocystis, etc.



Multiple fission in *Plasmodium*

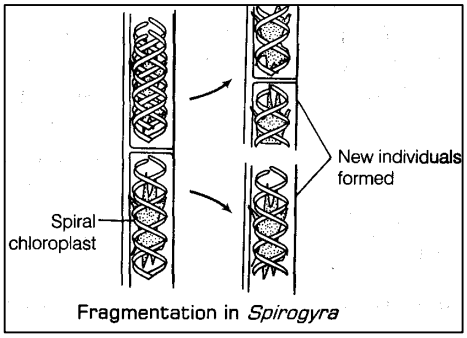
3. **Budding:** Sometimes new individuals develop from the body wall of the parent as bulblike projections called buds. The buds may be unicellular or multicellular depending upon the type of parent organism. The buds finally separate to form new individuals. Budding occurs in yeast, Hydra and sponges.



Budding in *Hydra*

4. **Fragmentation:** Obtain some pond water. You may see green filamentous structures floating in it. Take some of these structures on a slide. Put a drop of glycerine on them and cover them with a coverslip. Observe under a microscope. The green filamentous structures you see are an alga named Spirogyra, which grows in ponds, ditches and springs. Each filament has a single row of cylindrical cells. Each cell has spiral bands of chloroplasts. When a Spirogyra filament breaks into pieces, each piece grows into a new filament by cell division. This process is fragmentation. During this process

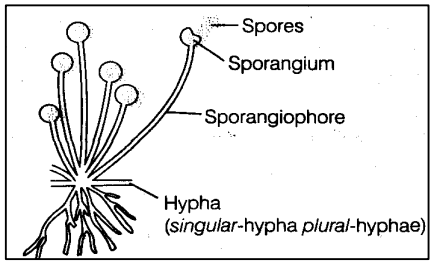
the body of an individual breaks up into two or more parts and each part develops into a complete organism. Some animals like sponges, Hydra and flatworms (Planaria) also reproduce by a similar method known as regeneration. If they are cut into pieces, each piece can regenerate into an entire individual.



Fragmentation in *Spirogyra*

In complex organisms all cells are not similar. The cells are organized into tissues and tissues into organs. The different organs are placed at definite positions. If such an organism breaks off at any point, the broken part cannot grow into a complete organism with all organs.

5. Spore Formation: Spores are asexual reproductive bodies enclosed in a thick-walled structure called sporangium, which can tide over unfavourable conditions such as extreme heat, dryness, acidity, and so on. Spore formation is a common method of asexual reproduction in many lower forms of life such as algae, bacteria and fungi. Under favourable conditions, the spores are released by the breaking of the thick wall of the sporangium. The spores then germinate into new individuals. In fungi, sporangia burst and release spores. By this method of asexual reproduction, organisms can overcome unfavourable conditions. We have seen thread like projections called **hyphae** developing on the bread, if a moist bead is kept in open for a few days. This is because the spores of Rhizopus present in the air settle down on the bread and germinate to form a new Rhizopus colony. Some fungi, e.g., Rhizopus and Mucor reproduce by producing spores.



6. Vegetative Propagation in Plants: It is a type of asexual plant reproduction in which, new plants are obtained from a part of the parent plant without the involvement of its reproductive organs. Under favourable conditions, various structures take part in this type of reproduction on its own known as natural vegetative propagation, in which plant parts like root, stem and leaves develop into new plants. The property of vegetative propagation is used in cutting, layering and grafting, which are known as methods of artificial vegetative propagation employed in order to grow many plants like sugarcane, roses, grapes, etc., by farmers. Organs of some plants are used for vegetative propagation, e.g.

Tuber of potato Bulb of onion Adventitious roots of dahlia
Rhizome of ginger Leaf buds of Byophyllum

The vegetative parts of a plant such as the root, stem, leaf, etc., can produce new plants. Vegetative propagation is common in plants like orchids, ornamental plants and grasses. Plants such as banana, rose, jasmine, etc., which do not produce seeds, can be grown by vegetative methods. The new plants are genetically similar to and bear the characteristics of the parent plant. In some plants like Dahlia, sweet potato, etc., the adventitious roots become swollen due to storage of food. Adventitious buds are also present on them. When roots bearing such buds are planted in the soil, new plants are produced as a result of vegetative propagation.

Some plants produce subaerial stems which develop as lateral branches from the mother plant and give rise to a new plant after getting detached from the mother plant. For example, in runners such as grasses the stem grows along the surface of the soil and produces roots where it touches the ground to give rise to a new plant. In some plants the underground stem gets modified for storage of food, and under favourable conditions it produces shoots and gives rise to a new plant. Such stems include rhizomes, tubers, bulbs and corms.

Natural Vegetative Propagation

Method	*Details of Method*
By roots	In some plants like dahlia, sweet potato, etc., the adventitious roots are used for vegetative propagation.
By stems	Runners, suckers, bulbs, tubers, etc., reproduce by means of stems.
By leaves	Some plants like *Bryophyllum* bear buds on leaves which on coming in contact with the soil, develops into a small plant under favourable conditions.

The fleshy leaves of Bryophyllum bear adventitious buds in the notches along the leaf margin. These buds develop into small plants (plantlets) under favourable conditions. These plantlets can be easily separated to grow as independent plants.

Artificial modes of vegetative propagation: Farmers, gardeners and horticulturists have developed various artificial methods of vegetative propagation, like grafting, layering, cutting and tissue culture for growing plants in gardens and nurseries. Cutting is a very simple method of propagation in which a piece of the parent plant's stem with nodes and internodes is placed in moist soil. This grows into a new plant. In grafting the cutting of a plant is attached to the stem of a rooted plant. The attached cutting becomes a part of the rooted plant, draws nutrition from it and grows roots at the joint. Now if it is separated, it grows into a new plant. In layering, one or more branches of the parent plant are bent close to the ground and covered with moist soil. The covered portions grow roots and develop into new plants.

Artificial Vegetative Propagation

Method	*Details of Method*
Cutting	Pieces of stem removed by cutting and placed in the soil often form a root system and develop into a new plant. Chemicals may be used to encourage root growth. Ornamental plants like rose, jasmine are grown through this method.
Grafting	Piece of one plant without roots (scion) can be attached to the part with root (stock) of another plant. Many apple varieties, lemon, grapes, mango, pear, etc. are grown through this method.
Layering	The defoliated part of branch is covered with soil. After a few days, this part develops roots. The method is used to grow plants like jasmine and grape.

Advantages of vegetative propagation are:

- Maintains genetic stability as the plants produced are genetically similar to the parent plant and have all its characteristics.
- It is a quick method.
- This method is easier and cheaper than collecting seeds.
- Plants raised by vegetative propagation can bear flowers and fruits earlier than those produced by seeds.
- It also makes possible the propagation of plants such as banana, orange, rose and jasmine, which have less capacity to produce seeds.

Disadvantages of vegetative propagation are:

- The plantlets obtained by vegetative propagation are difficult to transport than seeds.
- They can get easily damaged during storage.

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• They are more likely to carry disease as disease of parent plant is transferred to the daughter plant.
• There is no genetic variation, so there is less adaptability to the environment.

Tissue Culture: Tissue culture involves maintaining of tissues or organs (in case of plant tissue culture isolated cells or small pieces of plant tissues are used) under sterile in vitro conditions in nutrient cultures to grow into new disease-free plants. This technique is also known as in vitro micropropagation because it takes place in a laboratory and the plants are transferred from the labs to the soil.

Plant tissue culture is widely used for the rapid multiplication of plant species with superior qualities. In this method, small pieces are cut from the plant like flower buds, stem tissue, growing tips, leaves, etc., (known as explants). These a then transferred to an artificial medium where they divide rapidly to form a callus (undifferentiated mass of cells). This callus is then transferred to fresh medium containing hormones for growth and differentiation, where it subsequently develops into plantlets.

After this, the developed plantlets are placed in the soil to grow into a mature plant. Various advantages of tissue culture are given below:

1. It is possible to produce large number of plants from a single parent in a disease-free environment.
2. Rapid production of ornamental plants like carnations, orchids, dahlia, etc., is possible.

Q1. Amoeba is considered as immortal due to its reproductive strategy. Justify
Q2. Why can some multicellular organisms not divide cell by cell?
Q3. Name the kind of organisms that reproduce by spore formation. How is this method of reproduction advantageous for that organism?
Q4. How is binary fission different from multiple fission?

A Summary of Modes of Asexual Reproduction

Asexual Reproduction

- Rapid mode of multiplication including only one parent.
- New individuals produced are genetically identical to parents (i.e. clone).
- Depends on body design of organisms.

Fission — Parent organism splits or divides into two or more daughter cells.
- **Binary Fission** — Parent organism divides into two identical daughter organisms with definite orientation. e.g. *Amoeba*
- **Multiple Fission** — Parent organism divides into many identical daughter organisms. e.g. *Plasmodium*

Fragmentation — Organism breaks into two or more small pieces. e.g. *Spirogyra.*

Regeneration — A single segment of an organism can give rise to new individuals. e.g. *Hydra.*

Budding — A bud is formed which develops as an outgrowth and detaches to grow into a new individual.

Vegetative Propagation — New plants are obtained from parent plant part.
- **Natural** — By roots, stems, leaves, e.g. runners, sweet potato, etc.
- **Artificial** — Cutting, grafting layering, e.g. rose, apple, etc.

Tissue Culture — (*In vitro* micropropagation) Maintains tissue or organs under sterile *in vitro* conditions to grow disease-free plants. e.g. ornamental plants like orchids.

Spore Formation — Living cells or spores have the ability to germinate and give rise to a new colony.

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