How do Organisms Reproduce

Reproduction and the Importance of Variations in DNA

Do all living organisms reproduce? Why do offspring's resemble their parents? Does reproduction always involve the participation of two parents?

Reproduction is a characteristic feature of all living organisms. It involves the creation of organelles, cells, or organisms of the same kind.

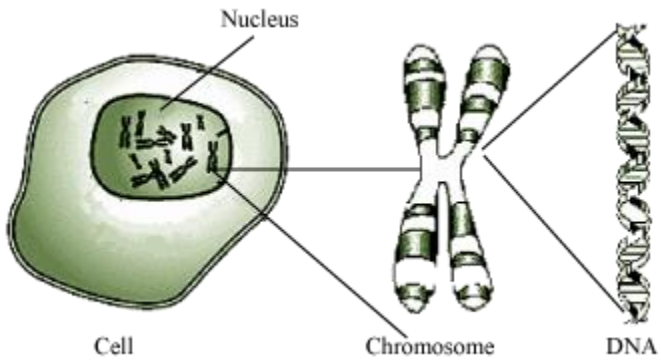
Reproduction is necessary for the survival of a particular species. During reproduction, the information for inheritance of characteristics is passed on from the parents to the offsprings in the form of **DNA**.

DNA

DNA (Deoxyribonucleic acid) is a genetic material found in the chromosomes, which are present in the nucleus of a cell. It is a chemical, which carries genetic information required by the cells to divide and produce proteins.

Genes are made up of DNA. A set of genes are responsible for the production of a specific protein. Each protein is specific for its specific function. Therefore, it is the DNA that decides the formation of the structural, enzymatic, hormonal, and other components in an organism. Genes are responsible for the physical appearance and body functions of an organism.

Therefore, it is the DNA that gets transferred from the parents to the offsprings and makes them look similar to their parents.



DNA—genetic material

Transfer of DNA

The reproducing cells produce a copy of DNA through some chemical reactions. This, in turn results in the formation of two copies of DNA. Now, these copies need to be separated from each other. The newly-formed copy of DNA cannot be simply pushed out, as it lacks an organized cellular structure. Hence, the copying of DNA always takes place with the creation of an additional cellular structure. This process is then followed by the division of a single cell to form two cells.

Do you know that larvae of the Axolotls Mexican salamander are capable of reproducing at 12 months of age?

Variations

DNA carries genetic material and passes it from the parents to the offsprings. **But are we similar to our parents in all aspects?**

Case I: An organism reproduces an offspring, which is similar to its parents in all aspects, with no changes occurring in subsequent generations.

In this situation, the offspring is adapted like its parent. It has all the characteristic features present in the parent and is well suited for that environment.

Case II: An organism reproduces an offspring similar to its parent, but a variation (like the offspring can withstand temperature changes i.e. it can survive in very high and low temperatures) has occurred, and this variation is passed to the subsequent generations.

In this situation, the offspring is similar to the parent, but is more adapted than the parent due to the variation. Therefore, it has better chances of survival than the parent.

Results of analysis: In nature, variations occur during sexual reproduction. If this variation is beneficial to the species, it is selected and remains in the population. This is because the variant species are more adapted. Therefore, they can survive better and reproduce to pass the genes to the offsprings.

Therefore, we can say that variations are important.

Let us learn the importance of variations with the help of a few examples.

1. The peppered moth (*Biston betularia*) is generally pale in colour, but some variants may be dark coloured as well. In early 1800s, the pale form of the species comprised more than 98% of the population, while a variant of this moth, the darker form comprised less than 2% of the population. The pale form was difficult for birds to see as the trees were covered with lichens. However, with the onset of industrial revolution, pollution levels increased, which resulted in a drastic decrease in the population of the lichens in that area. Also, smoke from the industries deposited over the trees. This made the pale form easily visible against the dark colour of the trees and thus, made them vulnerable. As a result, the only species of peppered moths that could survive were the dark forms, which arose as a result of variations. In this case, variations proved to be helpful. Such helpful variations are selected by nature as they help in the survival of species.

2. Due to genetic variations, a species of rabbits were produced that could run faster, escape their predators better (because of their body structure), and find food faster. As a result,

more number of faster rabbits survived as compared to the slower ones. Soon the slower rabbits got replaced by the faster rabbits. Thus, variations can also lead to evolution.

Hence, variations are important because:

- They allow the survival of a species in all conditions
- They lead to evolution

If variants are so important, then why do organisms produce similar offsprings?

Similar offsprings are produced to maintain the general body design. This needs to be done so that the organism is able to occupy the same habitat, since the organism is best adapted for that habitat. This is the reason why all fishes live only in water and all humans live only on land.

Thus, we know that variations that are beneficial to the population are passed on to the next generation. **How does nature select only beneficial variations? What happens to the variations that are not beneficial?**

Variations in nature are random. Both **positive** and **negative** variations may occur. However, only positive or beneficial variations are retained. This is because the variant species are more adapted, can survive better, and can reproduce to pass the genes to the offsprings. When a negative variation occurs, the individual is not fit and cannot survive. Therefore, it cannot pass the genes to the next generation. Thus, the negative variant is gradually lost from the gene pool.

Some Interesting Facts:

- **Do you know that identical twins are usually of the same sex and share 100% DNA? They come from one fertilized egg, which splits into two.**
- **Fraternal twins are just like normal siblings. They come from two separate eggs, fertilized by two sperms, and share 50% of their DNA.**

Importance of reproduction

Reproduction is essential for the continuation of species. Without reproduction, a particular species will not exist for a long time. Reproduction produces new individuals that resemble their parents. This is the reason why cats reproduce more cats and dogs reproduce more dogs.

Sexual Reproduction in Flowers

Reproduction in plants can be summarized in the following stages.

1. The ovule or egg is fertilized by pollen through pollination.
2. The ovules develop into seeds.
3. These seeds germinate to give rise to new plants.

Let us understand the stages and component structures involved in the process of reproduction in plants.

The male reproductive organs of flowers are **stamens** whilethe female reproductive organs are **carpels**.

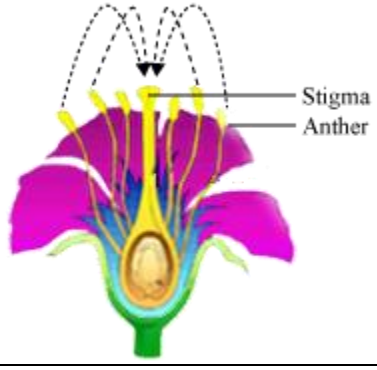
- **Male germ cells (male gametes):** The stamen (male reproductive organ) produces numerous pollen grains. The pollen contains male reproductive cells or germ cells.
- **Female germ cells (female gametes):** The carpel (female reproductive organ) consists of a style, stigma, and ovary. Inside the ovary, one or many ovules are produced. Each ovule contains one egg cell, which is the female germ cell.

The female germ cell is non-motile and is protected by the ovules and ovary.

The transfer of pollen from the anther of one flower to stigma of the same flower, or another flower in the same plant, or another flower in a different plant is called **pollination**.

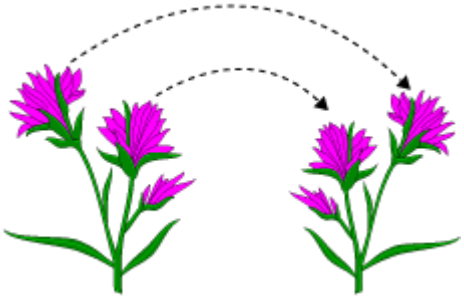
Therefore, pollination is of two types- self and cross pollination.

Self pollination: It occurs in bisexual flowers (male and female reproductive structures are present in the same flower). It is of two types:

(a) Type I	**(b) Type II**
	
It occurs within the same flower. Pollen from the anther is transferred to stigma of the same flower.	It occurs between two flowers of the same plant. Pollen from the anther of one flower is transferred to stigma of another flower in the same plant.

Cross pollination: It can occur in both unisexual (male and female reproductive structures are present in different flowers) and bisexual flowers.

In this type of pollination, pollen is transferred from the anther of one flower of one plant to stigma of another flower of another plant.



Pollinators

The transfer of pollen occurs through air, water, birds, insects such as bees, wasps, moths, snails, etc. The petals of a flower are brightly coloured or scented in order to attract insects. Some flowers even secrete nectar to attract insects such as bees.

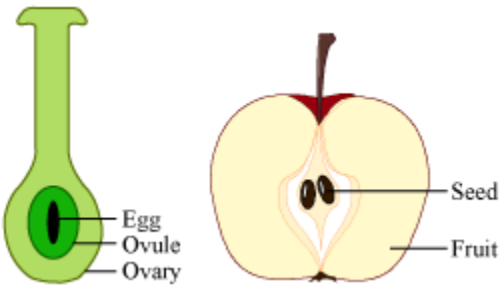
These insects and birds, which help in the transfer of the pollen to stigma, are called **pollinators**.

A zygote is formed after fertilization. This zygote divides many times to form an **embryo**.

Ovary and ovule after fertilization

The outer layers of the ovule become impervious, hard and function as a seed coat. An ovule with an embryo inside is called a **seed**.

The ovary enlarges and ripens to become a fruit. Other floral parts such as sepals, petals, stamens, style, and stigma may fall off. However, in some cases, they remain persistent in the fruit.



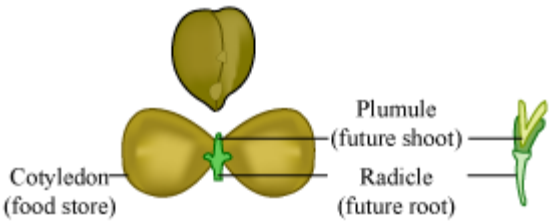
Do you know that some plants are able to produce fruits without the process of fertilization? This phenomenon is known as parthenocarpy. Parthenocarpic fruits are either seedless or contain non-viable seeds such as seedless variety of grapes and navel oranges.

Seed germination

The embryo inside a seed is inactive. It becomes active under favourable conditions and grows out of the seed coat as a seedling. This process is known as **germination**.

Favourable conditions for germination are moisture, air, and temperature.

When a seed germinates, the portion above the cotyledons, which grows into a shoot, is called a **plumule.** The portion below the cotyledons, which grows into a root, is called a **radicle**.

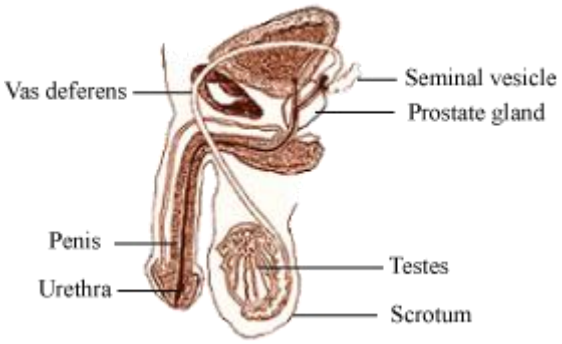


Structure of the Human Reproductive System

Structure and Functions of the Male Reproductive System

Male Reproductive System

It consists of various organs, which are involved in the production and transfer of germ cells into the female body.



The organs present in the male reproductive system consist of a pair of testes, vas deferens, prostate gland, and seminal vesicles.

Testes

They are located outside the abdominal cavity within a pouch called the **scrotum**.

The testes produce sperms. But for this they require a temperature, which is 2 – 2.5°C lower than the temperature of the rest of the body. Therefore, they are protected inside the scrotum.

The function of the testes is to produce sperms and a hormone called **testosterone**, which brings about secondary sex characteristics in boys.

Vas deferens

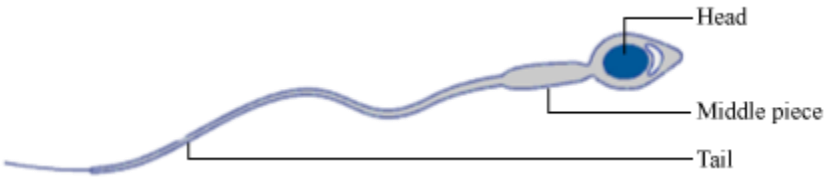
It carries the sperms from the testes to the urethra. It also receives the ducts, which bring products from the seminal vesicles and prostate glands.

Seminal vesicles and prostate glands

The fluids from these organs provide nutrients in the form of fructose, calcium, and some enzymes. The sperms produced in the testes are carried by the vas deferens. The secretions from the seminal vesicles and prostate glands lubricate the sperms. The sperms are now dispersed in a fluid, which makes their transport easier. This milky white fluid that contain mixture of sperms along with secretions from seminal vesicles and prostate glands is called **semen**. The urethra extends through the penis to an external opening and carries either urine or semen.

Structure of a sperm

It consists of a head, middle piece, and a tail.



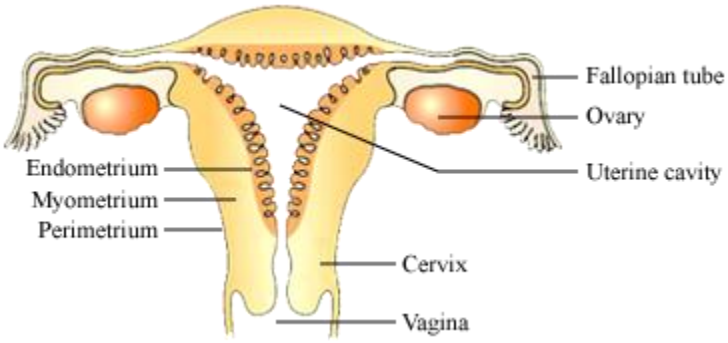
- The **head** contains a nucleus, containing the chromosomal material.
- The **middle piece** has many mitochondria to provide energy for the movement of the tail.
- The tail facilitates the movement of the sperm into the female body.

Do you know that every day around 500 million sperms mature in a normal human male? The average life span of a sperm is around 36 hours.

Structure and Functions of the Female Reproductive System

Female Reproductive System

It consists of a pair of ovaries, a pair of oviducts, uterus, and vagina.



The ovaries are located on each side of the lower abdomen. It produces thousands of eggs in the female body. It also produces a hormone called **oestrogen**, which brings about secondary sex characteristics in the female body.

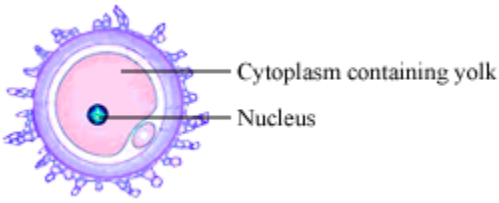
The eggs produced in the ovary start maturing on reaching puberty. One egg from each ovary grows and matures, and is carried from the ovary to the **uterus** by a thin **oviduct** or the **fallopian tube.**

Sperms from the male reproductive system enter the body of the female through the **vagina**.

Do you know that a female child at birth has around 1 -2 million potential eggs? The average life span of an egg is 12 -24 hours, after it is released from the ovary.

Structure of the ovum

It contains a single nucleus, surrounded by the cytoplasm.



We have studied the different parts of the human reproductive system. But how does reproduction take place in humans? Let us explore.

Passage of sperms inside the female body

Sperms, which are ejaculated from the male reproductive organ (penis), enter the female body through the vagina. They travel towards the fallopian tubes, where they meet the egg. The process of fusion of the sperm and ovum is called **fertilization**. Fertilization takes place in the fallopian tubes.

During fertilization, the haploid nucleus of the sperm and ovum fuse to form a zygote. This zygote divides to form an embryo.

Menstrual cycle

The ovary releases one egg every month. The uterus also prepares itself every month to receive a fertilized egg. The inner uterus lining (endometrium) becomes thick and is supplied with blood to nourish the embryo.

If the egg is not fertilized, then the uterus lining is not required. Hence, it breaks down and is released in the form of blood and mucous through the vagina.

This process lasts for 2-8 days. This cycle occurs every month and is known as **menstruation**. Hence, the menstrual cycle is the reproductive cycle in the female body. It begins with the onset of puberty.

Development of secondary sex characteristics

Growth of beard may vary among different individuals (males). While some have a thick growth, others may have a very sparse growth.

This is because each individual matures at a different pace. This pace is determined by the individual's biological clock.

But, why do such changes occur at a certain age and not gradually since childhood?

Development into an adult or reaching maturity is essential for reproduction. The period of life where changes set in for the development of a young individual into an adult is called **puberty**. During puberty, many changes occur that allow an individual to attain sexual maturity as the sex organs become well developed, and the body becomes capable of reproduction.

Therefore, **puberty** is a period during which body changes such as growth of beard, hair growth in armpits, appearance of pimples, development of breasts etc. occur in a child's body. With the onset of puberty, the body becomes capable of reproduction.

Time of occurrence of puberty

Puberty occurs when the body is ready to change.

- **For girls:** Puberty can start anywhere between the ages 8 and 13. However, the age of puberty may vary in different individuals.
- **For boys:** Puberty in boy's starts somewhat later than girls. It occurs between 9.5 and 14 years.

What controls the occurrence of puberty?

When a child reaches the age of puberty, the pituitary gland in the brain secretes a hormone called **follicle-stimulating** hormone. This hormone acts as a signal to the reproductive organs (the testes in males and ovaries in females). In response to this signal, the reproductive organs produce hormones that cause changes in the male and female body. These changes are referred to as **secondary sex characteristics**.

Secondary sex characteristics in boys

- Under the influence of hormones, the larynx develops prominently. The vocal cord become longer and thicker in boys, causing the voice to become hoarse.
- Growth of hair in other areas of skin like underarms, face, hands, and legs.
- Enlargement of the testicles followed by penis.
- Testes grow and start producing sperms.

Secondary sex characteristics in girls

- Development of breasts, darkening of skin around nipples (present at the tip of breasts).
- Growth of hair in other areas of skin like underarms, face, hands, and legs.
- Increase in the size of uterus and ovary.
- Beginning of the menstrual cycle.

However, some body changes are common to both boys and girls.

These common changes are:

- Growth of pubic hair
- Growth of the reproductive organs
- Secretions of sebum (oil) from the skin, which results in pimples

Puberty or sexual maturation should not be confused with adolescence. Adolescence is the period between the beginning of puberty and adulthood. An Adolescent experiences not only physical growth, but changes in emotional, psychological, and social status as well.

Fertilization and Embryo Development

Do you know what fertilization is?

Fertilization is the process of the union of an egg and sperm. Let us study how fertilization takes place.

Whom does the new individual resemble – the father or the mother? The new individual shows characteristics of both, the father and the mother.

Fertilization takes place inside the body in dogs, cats, and human beings. This type of fertilization is known as **internal fertilization**.

But do you know that in some animals, fertilization takes place outside the body of the organism?

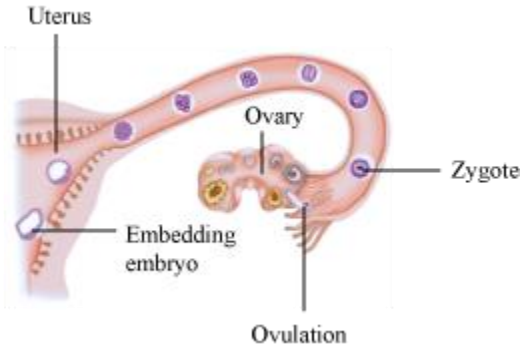
In animals such as frog and fish, the process of fertilization takes place outside the body. This type of fertilization is known as **external fertilization**. In external fertilization, both the male and the female release their gametes in water. The gametes then fuse in water and result in the formation of a zygote, which develops into a new individual.

Do you know how eggs of animals, in which external fertilization occurs, are protected?

Eggs of animals such as frogs are covered with jelly, which holds all the eggs together and also protects the eggs from the external environment.

You know that the process of fertilization leads to the formation of a zygote. **But what happens to this zygote afterwards? How does it give rise to a new individual?** Let us explore.

The zygote formed after fertilization divides repeatedly to form a mass of cells known as the **embryo**. The cells of the embryo start dividing into groups, which leads to the formation of future tissues and organs of the baby.



Development of an embryo inside the female body

The zygote formed after fertilization in the fallopian tubes is implanted in the uterus. The uterus is also known as the womb. Here, the zygote divides to form an embryo, which develops into a foetus.

How is the embryo attached in the uterus?

The uterus is a sac-like structure which opens into the vagina. The wall of the uterus has three layers of tissues:

1. The outer-thin layer is known as the **perimetrium**.

2. The middle layer is thick and is made up of smooth muscles. It is known as the **myometrium**. These muscles contract strongly during the delivery of a baby.

3. The inner layer lines the uterine cavity, which has many glands and is known as the **endometrium**. It thickens every month and is supplied with blood to nourish the embryo. It undergoes cyclic changes during the menstrual cycle.

Therefore, the zygote in the uterus or womb divides many times to form an embryo. This leads to pregnancy.

Within a span of some months, the embryo starts developing limbs, hands, and legs and begins to resemble a miniature human being. When all the body parts of an embryo can be recognised it is known as a **foetus**. The full term of development of an embryo into a fully developed foetus is known as **gestation**. In humans, the gestation period is of about 280 days. When the foetus is fully developed, the mother gives birth to the baby. During child birth the baby is pushed out of the female's body through vagina by powerful contractions of uterus muscles.

The process discussed above explains the development of an embryo in humans.

But what about the process of embryo development in animals, which lay eggs like birds?

In hens, after fertilization, when the egg travels through the oviduct, it gets covered with various protective layers, including the shell.

The hen lays eggs, and it takes around three weeks for the embryo to develop into a chick.

You must have seen hens sitting on their eggs. A hen does this to keep the egg warm and to maintain a proper temperature for the growth of the embryo inside the egg.

Do you know that the heart of an embryo starts beating when the embryo is 23 days old?

Natural Vegetative Propagation

Vegetative propagation

It is the plant's ability to reproduce by producing new plants from vegetative plant parts such as roots, stem, and leaves.

Vegetative propagation is classified into two types:

- Vegetative propagation
  - Natural
  - Artificial

Natural vegetative propagation

It is a process involving structural modification of stems, roots, or leaves of plants.

- Natural vegetative propagation
  - propagation by leaves
  - propagation by stems
  - propagation by roots

Propagation by leaves: In *Bryophyllum,* the leaf allows the development of many shoot buds. These buds form roots at their base. When these plantlets break and fall from the parent leaf on the ground, a new plant is formed.

Propagation by shoots: In a potato plant, the stem is modified to store food. This modified stem is called the **tuber**. Since it is a modified stem, it has many auxiliary buds over its surface called eyes.Each of these buds, when planted in soil, can develop into a new plant.

Propagation by roots: Roots are modified to store foods in sweet potato, asparagus, carrot, turnip, etc. When these get detached from the parent plant, they form a new plant.

Advantages of Natural Methods of Vegetative Propagation

- The plants (like banana, seedless grapes, rose, etc) that can not produce viable seeds can reproduce with the help of vegetative propagation.
- To get genetically identical copies of a plant in order to preserve the selected varieties, vegetative propagation is useful.
- It is a rapid, easier, and less expensive method of reproduction.
- Vegetative propagation is suitable for the plants with small number of seeds or higher periods of seed dormancy.

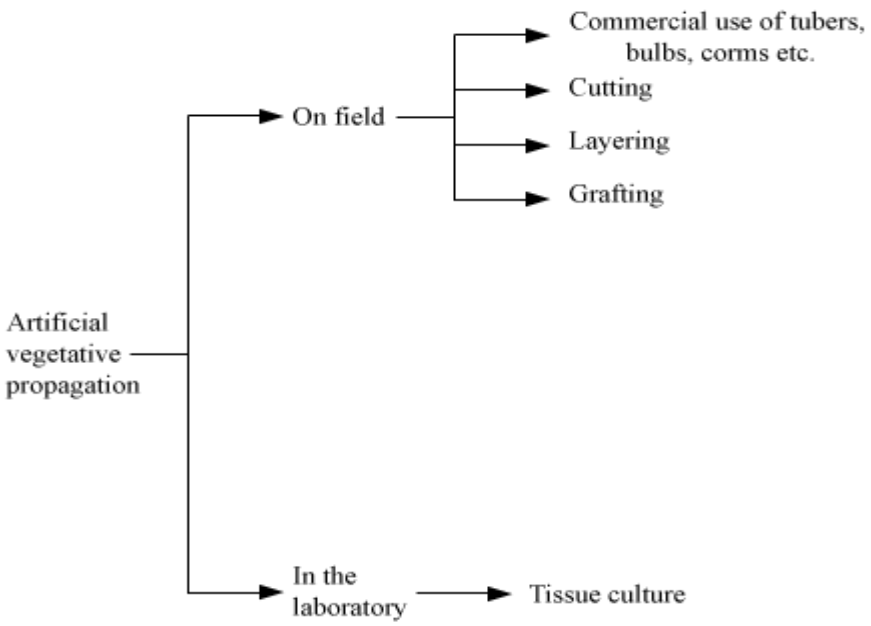
Disadvantages of Vegetative Propagation

- No genetic variability is introduced in the vegetatively propagated plants. Generation after generation same varieties are produced.
- Since all plants are genetically alike, hence all of them suffer from same diseases.
- The plants loose their vigour and undesirable characters are transmitted from generation to generation.

Artificial Vegetative Propagation

Artificial Vegetative Propagation

This process is used commercially for improving the yield, quality, and disease resistance of plants and their products.



Types of artificial vegetative propagation

Cutting

It refers to the formation of a complete plant from the regenerated pieces of roots, stem etc.

Examples: Rose, sugarcane, money plant etc.

Stem cutting

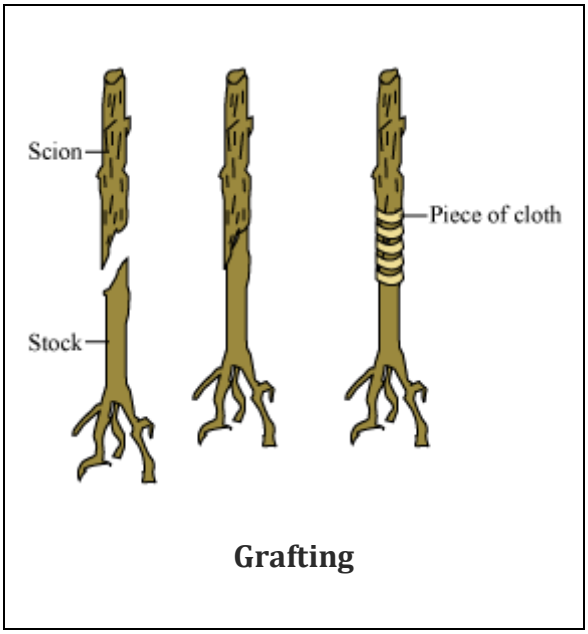
Stem cutting – in this short length of stem of plants are removed and placed in suitable conditions to develop roots. Sometimes root cutting has to be placed in rooting hormone to stimulate rooting

Root cutting – in this method root cuttings are put in damp soil to produce anew plant.

Grafting

In this method, a stem cutting from the desired plant (scion) is inserted on a rooted plant (stock) which is resistant to diseases. These are bound firmly with the help of tape or cloth so that they have vascular continuity.

Examples: Rose, mango, citrus etc.



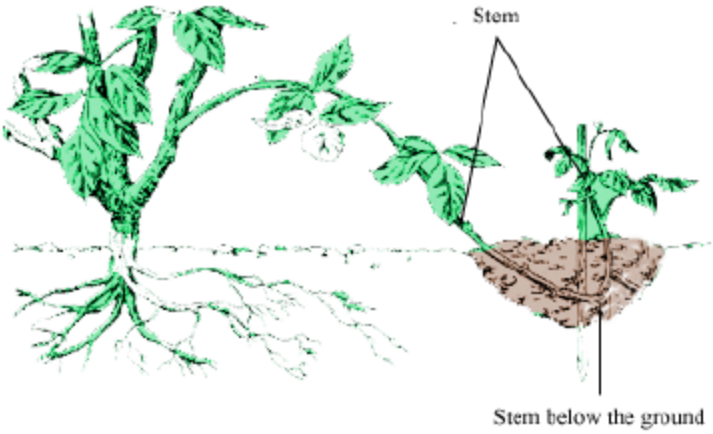
Grafting

Bud grafting – In this scion of a dormant bud are grafted on to the disease resistant stock. The scions of good coloured roses are grafted on to the stocks of wild rose to produce a better rose variety.

Layering

In this method, the branch of a plant is bent and covered with moist soil called mound. After a few days, roots arise from the underground portion. These separate from the parent plant and grow independently.

Examples: Jasmine, strawberry, bougainvillea etc.



Layering

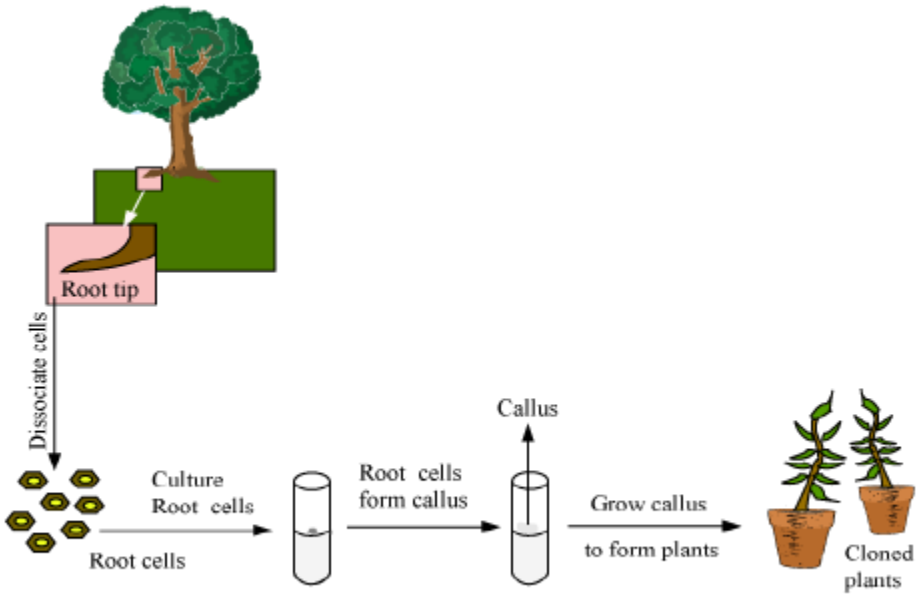
Layering is of two types – air layering and mound layering

Mound layering – the stem is bent so that node lies beneath the soil. The growing tip remains above the soil. Adventitious roots grow at the node which is cut from the parent plant and grown as in jasmine and strawberry.

Air layering – in this method plants having thick branches that can not be bent are propagated. The stem of such plants are girdled, covered with a moist cotton and is kept in a polythene bag. When adventitious roots start appearing, the branch is cut and planted.

Tissue Culture

In this method, the cells of a plant tissue are taken under sterile conditions. These cells are kept in test tubes containing culture medium, which allows these cells to grow fast and form an unorganized mass of cells called callus. This callus is transferred into another medium containing proper growth hormones for differentiation and organ formation. As a result, small plantlets are formed in the test tubes. These can be later placed in soil where they can grow into mature plants. This technique is called **micro-propagation.**



Tissue culture

Asexual Reproduction in Animals

Methods of Asexual Reproduction

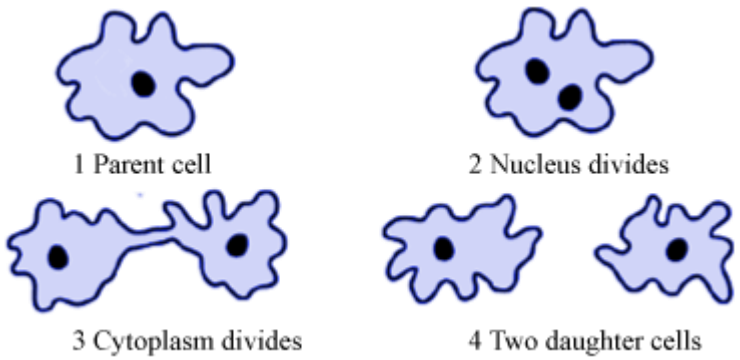
Fission

It occurs in single-celled organisms, belonging to the kingdom Protista and Monera. It is further divided into two types:

Fission [Binary fission
Multiple fission

Binary fission

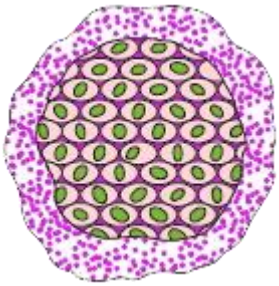
In binary fission, the single cell divides into halves. A few organisms that divide by binary fission are bacteria and *Amoeba*. In this process, the nucleus of Amoeba first divides to form two daughter nuclei. Later the body of Amoeba splits into two halves, each half receiving its own nucleus. This leads to the formation of the two daughter amoebae.



In *Amoeba*, cell division or splitting of cells can take place in any plane. Binary fission can also occur in one particular axis. For example, *Leishmania* (a parasitic flagellated protozoan), which causes *kala azar* in humans, divides only longitudinally.

Leishmania has whip-like flagella at one end of the cell. Cell division occurs in relation to these flagella.

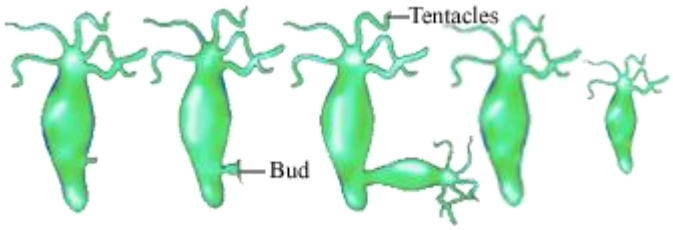
Multiple fission: In multiple fission, a single cell divides into many daughter cells simultaneously. Examples:*Plasmodium and Amoeba*



Budding

It involves the formation of a new individual from a protrusion called the **bud**. It is very common in plants, yeasts, and lower level animals such as *Hydra*.

In *Hydra,* the cells divide rapidly at a specific site and develop as an outgrowth called a **bud**. These buds, while attached to the parent plant, develop into small individuals. When this individual becomes large enough, it detaches itself from the parent body to exist as an independent individual.



Regeneration
This mode of asexual reproduction takes place in some invertebrates belonging to the animal kingdom. Individual body parts of these animals have the ability to grow into new organisms.

Let us discuss how this process takes place in *Planaria*.

Do you know that lizards can regenerate their lost tails? When a predator attacks, the lizard breaks off its tail. This is done to distract the predator so that it eats the tail, and the lizard escapes. Later, the lizard regenerates its lost tail.

Spore Formation
Some organisms like *Rhizopus* (fungi) reproduce with the help of spores. They are produced in sporangia (blob like structures) attached to thread like structures called hyphae. These spores are capable of giving rise to new individuals. They are covered by thick walls which provide them protection until they come in contact with a moist surface and begin to grow.

Reproductive Health

Do you know that some diseases are sexually transmitted, and can spread from one person to another while having sex? What are these sexually transmitted diseases? Let us explore.

A Sexually transmitted disease (STD) is a disease that gets transferred from one person to another through sexual contact. Some common sexually transmitted diseases are herpes, HIV-AIDS, syphilis, gonorrhoea etc. Gonorrhoea and syphilis are bacterial infections, while HIV-AIDS and warts are viral infections.

Sexual act not only leads to the transfer of sexually transmitted diseases, but also leads to unwanted pregnancies. **What measures can be taken to prevent the spread of sexually transmitted diseases and unwanted pregnancies?** The answer to this question lies in the method of contraception.

Contraception is the process where different methods are used to prevent pregnancy. They interfere with processes such as fertilization, implantation of an embryo, ovulation etc. Thus, these methods help in birth control.

Contraception not only prevents pregnancies, but also prevents sexually transmitted diseases.

Contraceptive methods can be broadly divided into the following types:

- Contraceptive methods
  - Natural method
  - Barrier method
  - Oral contraceptives
  - Implants and surgical methods

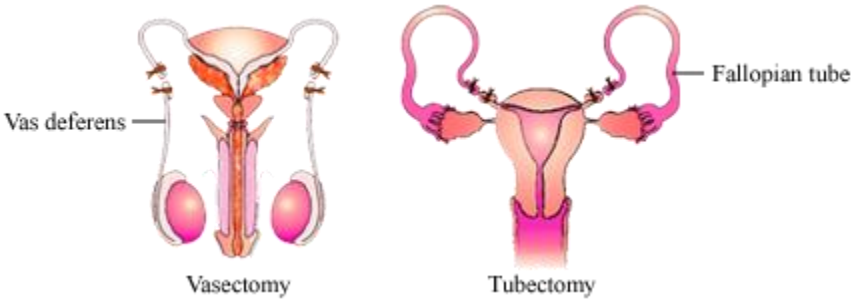
(i) Natural methods: In this method, sexual act is avoided from day 10th to 17th of the menstrual cycle since during this period ovulation is expected. Therefore, the chances of fertilization are very high.

(ii) Barrier methods: In this method, the fertilization of ovum and sperm is prevented with the help of barriers. Barriers are available for both males and females. Condoms act as barriers. They are made of a thin rubber, which is used to cover the penis and vagina in males and females respectively.

(iii) Oral contraceptives: In this method, tablets or drugs are taken orally. These contain small doses of hormones, which prevent the release of eggs and prevent fertilization.

(iv) Implants and surgical methods: Contraceptive devices such as the loop or Copper-T rods are placed in the uterus to prevent pregnancies. However, they can cause side effects in the uterus.

Some surgical methods can also be used to block the gamete transfer. It includes the blocking of vas deferens to prevent the transfer of sperms by a process known as **vasectomy.** Similarly, the fallopian tubes in the female body can be blocked by surgery to prevent the egg from reaching the uterus. This process is known as **tubectomy**.



Surgical methods are safe, if the surgery is performed properly.

Surgery can also be performed during unwanted pregnancies. However, these methods are misused by people for illegal sex-selective abortion of female foetuses, which has lead to a rapid decline in the female-male sex ratio.

A healthy society needs a balance between the female-male sex ratio. Therefore, the process of prenatal sex-determination has been prohibited by the law in our country.

Some interesting facts:

- **Do you know that our population was around 350 million at the time of independence? The recent data (July 2007) suggests that our population is more than one billion (1,129,866) now.**
- **India is the second largest country (after China) to cross the one billion mark**

Board question(s) related to this lesson: