4 Heredity

Observe the picture given below and answer the following questions.

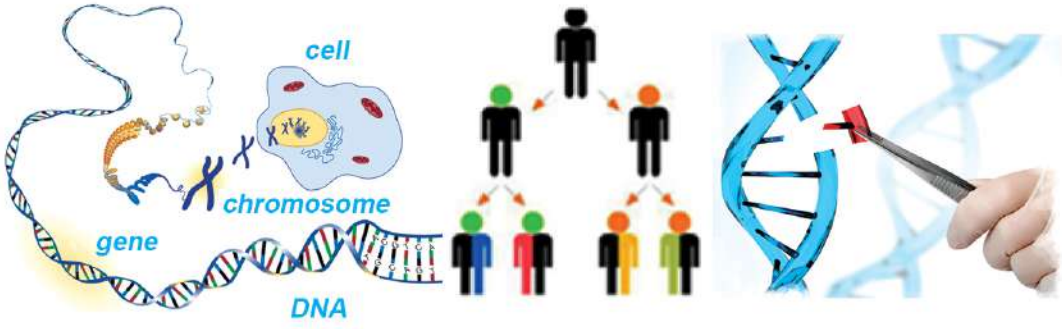


Figure 4.1 Gene, Sex determination, Genetic Technology

i. What are the lines in the nucleus of the cell in the picture above?

ii. What is the secret behind the offspring of living beings resembling their parents?

iii. How does the transmission of parental characters from one generation to another take place in organisms?

iv. How is the number of cells increased in an organism?

v. In the picture above, why is a small fragment of DNA being removed and another piece added?

All living things do not live forever. When organisms become mature, they produce offspring like themselves. In all organisms, characters are passed on from the previous generation to the next generation, so the offspring of all organisms resemble their parents. Chromosomes found in the nucleus of the organism are responsible for this. During cell division, chromosomes replicate and divide to pass into daughter cells. Parental characteristics are transmitted to offspring, and the influence of several other factors, including the environment contributes to the variation in organisms of the same species. Chromosomes determine the characteristics of living beings. The characteristics of living beings depend upon the number of chromosomes and millions of

genes present in the chromosomes in an organism. Sex chromosomes have the main role in the determination of sex. Genes present in the chromosome determine the physical characteristics of a living being and also help in the transmission of such characteristics to the next generation. The branch of biology that deals with the study of genes is called genetics.

Mendel founded various laws regarding genetics which made it easier to perform various experiments in this field. Nowadays, various technologies have been developed in genetics. These are proven to be effective in various research works and the daily lives of human beings. The development of genetic engineering has made the reproduction of various animals through artificial means and the development of various hybrid animals possible.

4.1 Cell division

Observe the picture given below and discuss:

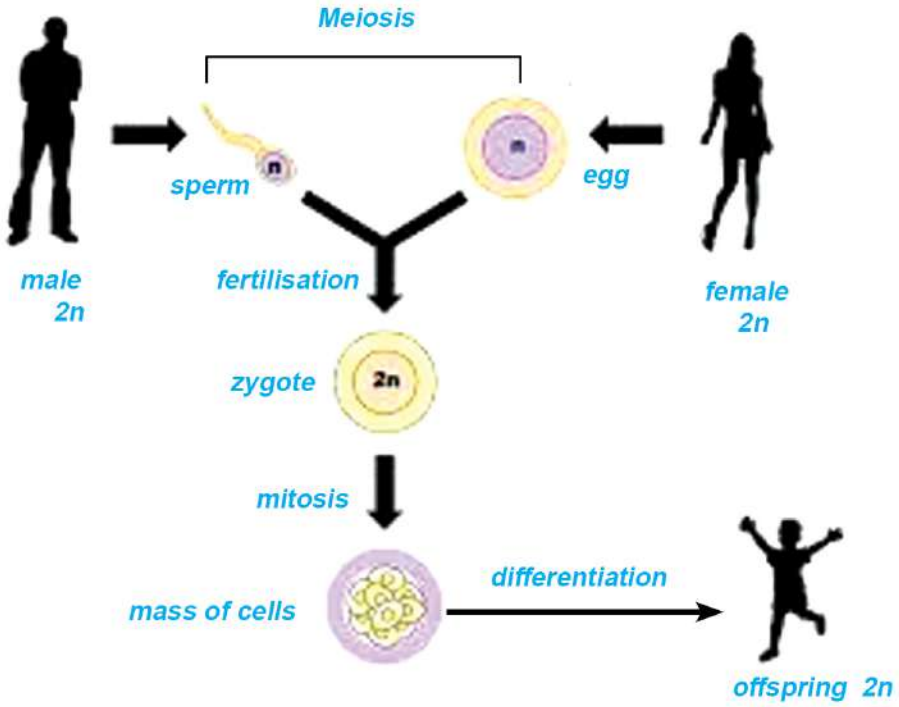


Figure 4.2 Cell division for the growth and development of living beings

Questions for discussion

i. How does the body heal wounds when abody part is injured?

ii. How does a single-cell zygote develop into a giant body?

iii. Are new somatic cells and gametes produced in our body in the same way?

iv. What is the difference between gametes and somatic cells?

It is assumed that prokaryotic cells evolved into eukaryotic cells and unicellular eukaryotic cells slowly evolved into multicellular organisms over time. At the time of sexual reproduction, cells in the male and female reproductive organs undergo meiosis cell division to form gametes. Male and female gametes formed in this way, fuse during mating or copulation to form a zygote. Zygote is single-celled. It gets divided by repeated mitosis cell division to develop into a complete body, which is the combined form of numerous cells. Both mitosis and meiosis cell division are complete in two phases; karyokinesis and cytokinesis. The division of the nucleus is called karyokinesis, followed by the division of cytoplasm along with the cell membrane, which is called cytokinesis. Two daughter cells are formed from a mother cell in a mitosis cell division and four daughter cells are formed in a meiosis cell division. Daughter cells formed at the end of meiosis are gametes, whereas cells formed at the end of mitosis are somatic or vegetative cells.

A. Mitosis cell division

Activity 4.1 The study of mitotic cell division

Objective: To prepare and study the model of mitotic cell division

Materials required: Clay of various colours, woolen thread pieces of different colours, cardboard

Method

i. Take cardboard. Make a shape of a cell on it by using any coloured clay.

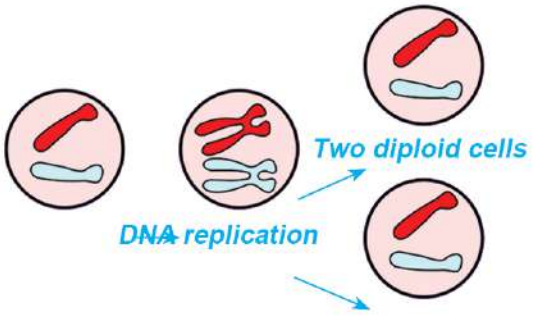


Figure 4.3 Model of mitotic cell division

ii. Use two different coloured threads to represent chromosomes.

iii. Make another cell and show DNA replication as shown in the figure.

iv. Now, show that two separate cells have an equal number of chromosomes, as given in the figure.

v. Paste the prepared mitotic cell division model on the board and discuss it in class. Take the number of cells, number of chromosomes, etc. into consideration while discussing.

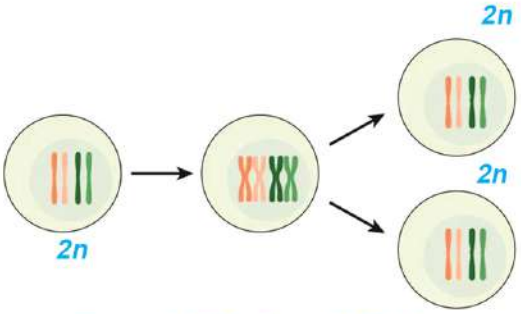


Figure 4.4 Mitotic cell division

Mitotic cell division occurs in all cells of the body except reproductive cells. A cell divides into two daughter cells during mitotic cell division. This type of cell division mainly occurs for the growth, development, and repairing of the tissue of the body. In our body, except for gamete, each cell is diploid containing two sets of chromosomes in which one set is paternal and another set is maternal. Such cells are represented by 2n. Before cell division, DNA in the chromosomes of the nucleus of a cell is replicated and forms two identical copies. At the end of cell division, two identical daughtercells are formed, each havinga copy of the DNA. This is how genetic characteristics found in mother cell are established in daughter cells. So, there is no change in the number of chromosomes in the daughter cells formed by mitotic cell division. Hence, this type of cell division is also called equational division.

Significance of mitotic cell division

a. Mitosis plays a key role in physical growth, as the number of cells with the same genetic makeup increases during cell division.

b. It helps regenerate cells in injured areas, returning them to their original state.

c. It helps in the asexual reproduction of some plants and invertebrates.

d. It maintains genetic stability.

B. Meiotic cell division

Activity 4.2 The study of meiotic cell division

Objective: To prepare and study a model of meiosis cell division.

Material required: Different coloured clay, gum, chart paper, or thermocol sheet.

Method

i. Take a cardboard or thermocol sheet. Make a shape of a cell on it using any coloured clay.

ii. Use different coloured clay to make chromosomes.

iii. Make another cell and show DNA replication as shown in the figure.

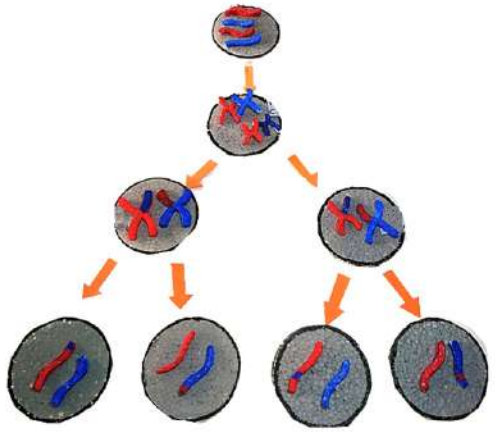


Figure 4.5 Model of meiosis cell division

iv. Make two separate cells with halfof the number of chromosomes and paste them.

v. Now make four cells and make an equal number of chromosomes in each cell as shown in the picture.

vi. Paste the prepared meiotic cell division model on the board and discuss it in class. Consider new numbers of cells, changes in chromosome numbers, etc. while discussing it.

This type of cell division is only confined to the mother cells of major reproductive organs, i.e., the testis and ovary. In this cell division, one diploid mother cell divides to form four haploid daughter cells or gametes. A haploid cell is a cell in which the chromosome number is reduced to half that of the mother cell. In meiosis, there is a slight variation in the genetic makeup of the daughter cells produced from the mother cell. This cell division completes in two phases.

During the first phase, an exchange of genetic materials occurs between two non-sister chromosomes through crossing over,and due to this phenomenon; the genetic makeup of each chromosome

changes. Afterward, they become separate and get organized into two haploid nuclei. So, karyokinesis is the division of a nucleus into two. Then, it is followed by cytokinesis to form two haploid cells. In the second phase, mitotic cell division of these haploid cells occurs, first through karyokinesis and then cytokinesis. Finally, four cells are formed at the end of meiotic cell division. Variation in the genetic makeupof these cells is found due to crossing over in the first phase of meiosis. This division is also called reductional cell division because chromosome number is reduced to half in the daughter cells. Meiotic cell division occurs in the testes of adult males and ovaries of adult females to form gametes needed for sexual reproduction. During sexual reproduction, the male gamete fuses with the female gamete to form a diploid zygote.The mitosis cell division of the zygote forms the whole body of an organism.

Question to think

Why are the face, body structure, and behaviours of the children born from the same parents not exactly the same?

Significance of meiotic cell division

1. Meiotic cell division plays amain role in the sexual reproduction of organisms.
2. It helps in evolution by bringing variation.
3. It helps to repair chromosomal disorders.

Activity 4.3

Make a list of differences between mitosis and meiosis on a chart paper or prepare Power Point slides and present them in the class.

Objective: To study the differences between mitotic and meiotic cell divisions

Materials required: Chart paper, different colours

Based on the information obtained above and by observing the activity 4.2 and 4.1, write the differences between mitosis and meiosis. Also, you can prepare Power Point slides for presentation.

4.2 Deoxyribonucleic acid (DNA)

DNA is a long thread-like structure found inside the cell, carrying genetic information. DNA is found in the cytoplasm of prokaryotic cells and the chromosome of the nucleus of eukaryotic cells. DNA of viruses is covered by a capsid, a protein coat. In DNA, a single unit formed by the combination of a nitrogen base, and deoxyribose sugar is called a nucleoside, while a single unit formed by the combination of a nitrogen base, deoxyribose sugar, and phosphate ion is called a nucleotide. Such nucleotides are the structural unit of DNA. The sequence of nucleotides is different among individuals. So, qualities are also different among them. DNA consists of two antiparallel strands. Four types of nitrogen bases found in DNA are adenine, guanine, cytosine, and thymine. Adenine is linked with thymine by making a double bond, but guanine is linked with cytosine by making a triple bond. DNA carries hereditary information or characters in an organism. A small segment of DNA that represents/codes the particular character of an organism is called a gene. Millions of such genes are found in a chromosome. During cell division, hereditary information is transmitted by DNA from the mother cell to daughter cells, which helps in the transmission of characters from one generation to another. Transcription occurs in DNA to form RNA, which helps to synthesize protein.

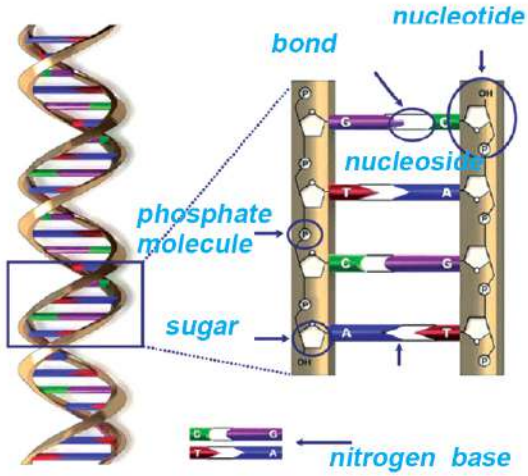


Figure 4.6 Structure of DNA

Project work: Formation of a DNA model

Construct a DNA model with the help of materials found in your locality and present it to the class.

4.3 Ribonucleic acid (RNA)

RNA is a polynucleotide where each nucleotide is formed by the

combination of a nitrogen base, ribose sugar, and phosphate. RNA is single-stranded. It is generally found in the cytoplasm and also found in chromosomes in some amount. RNA is enclosed within a capsid in viruses. It serves as genetic material in them. Four types of nitrogen bases found in RNA are adenine, guanine, cytosine, and uracil. Adenine is linked with uracil by a double bond, but guanine is linked with cytosine by a triple bond. There are three types of RNA which are Messenger RNA (m-RNA), transfer RNA (t-RNA), and ribosomal RNA (r-RNA). The main function of RNA is to synthesize proteins.

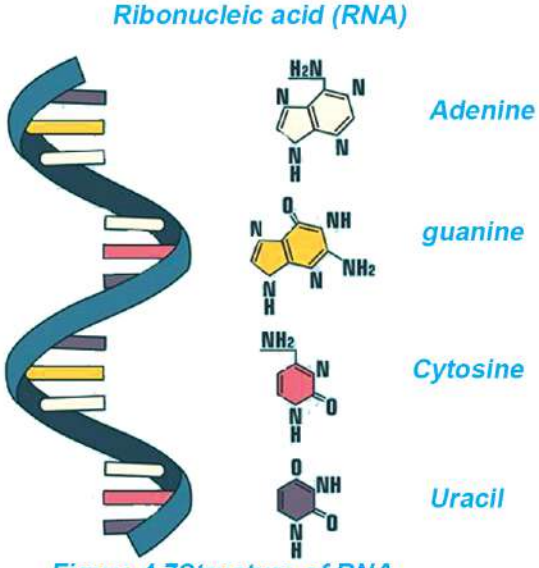


Figure 4.7Structure of RNA

Activity 4.4

Objective: To differentiate DNA and RNA

Materials required:

Models or pictures of DNA and RNA

Method:

i. Thoroughly observe the model of DNA and RNA.

ii. Identify nitrogen bases and sugar molecules found in DNA and RNA both and fill up the given table.

Basis of difference	DNA	RNA
Nitrogen bases		
Sugar		
Function		
location		

4.4 Chromosome

Observe the picture given below and discuss the following question.

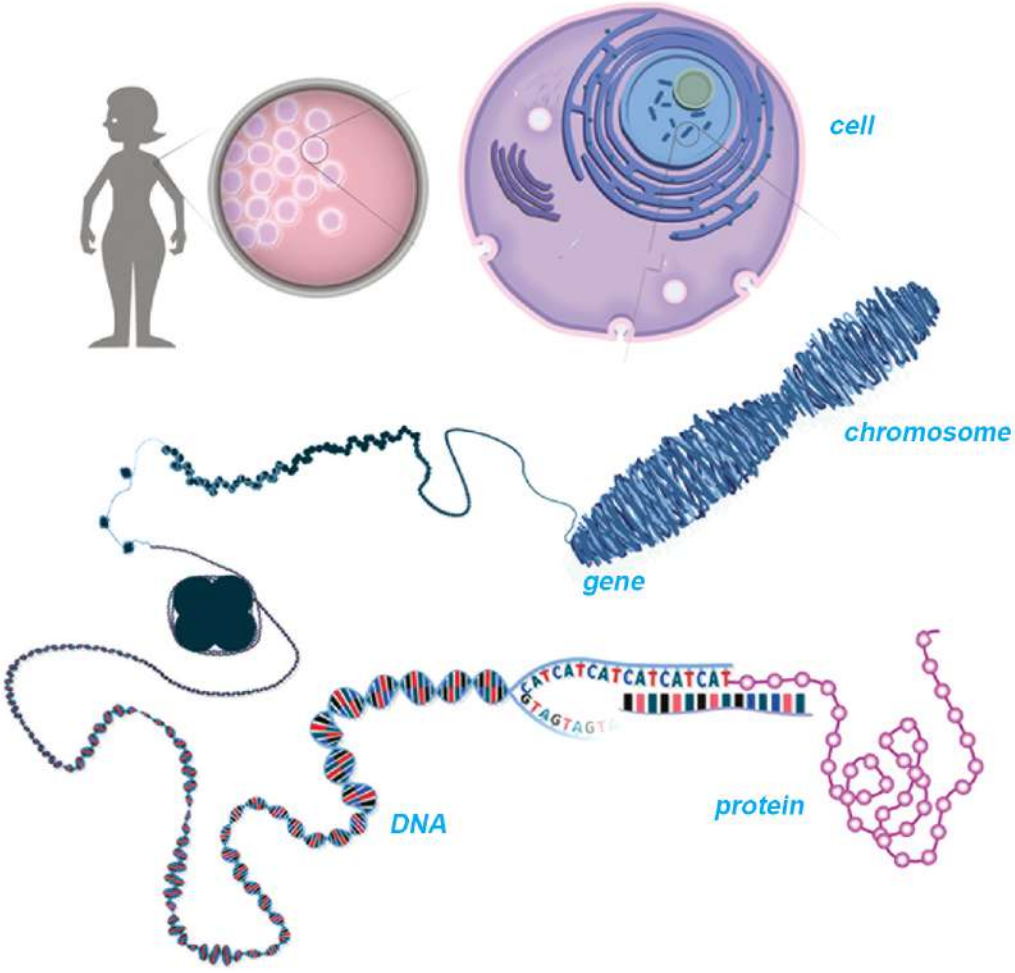


Figure 4.8 Cells, Chromosome, and Gene location

i. Where are chromosomes found in the body?

ii. What is a chromosome made of up?

iii. What is the role of genes in a living being's body?

iv. Do all living beings possess chromosomes?

When we observe the plant cell and animal cell through a powerful microscope, we can see a network of minute fibers inside the nucleus. These fibres are called chromatin fibres. During cell division, these fibres become short and thickened and also prominent, which are called a chromosome. Each Chromosome is made up of DNA and histone protein, and numerous genes are found in a chromosome. Each gene represents a particular character of an individual. A small fragment of DNA in the chromosome is a gene. The chromosome has mainly two parts: chromatid and centromere. Chromatids are the two arms of the chromosome. Sister chromatids are the identical copies found in the replicated chromosome. The knot-like structure of the chromosome where two chromatids are connected is called the centromere.

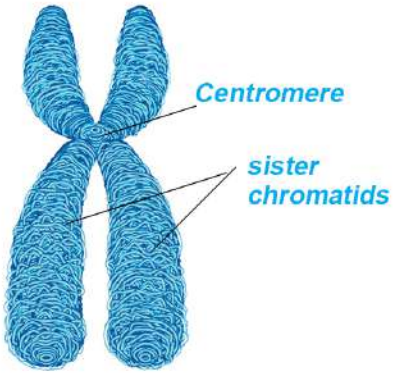


Figure 4.9 Structure of chromosome

Gene

The smallest fragment of DNA in a chromosome which codes or represents a specific character of an organism is called a gene. There are millions of genes in a chromosome. Genes help in the transmission of hereditary characteristics from parents to offspring. Genes also help in evolution by processes like mutation and genetic recombination.

Types of chromosomes

Chromosomes are of two types based on their function. They are somatic chromosomes or autosomes and sex chromosomes.

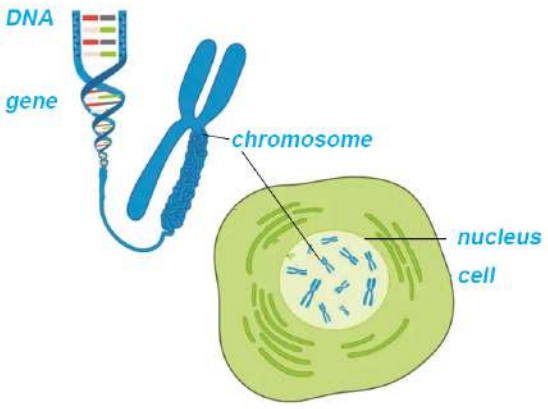


Figure 4.10 Location of gene

Project work 4.1 Construction of human karyotype model

Materials required: Different coloured clay, cardboard or thermocol, gum, chart or picture of human karyotype

Method

i. Make a model of 22 pairs of somatic chromosomes and the single paired sex chromosome found in either males or females by using different coloured clay, after observing the chart or picture of the human karyotype.

ii. Now, paste these chromosome models serially on the cardboard or thermocol.

iii. Present the karyotype model that you prepared in class and discuss the somatic chromosomes and sex chromosomes.

a. Somatic chromosomes

The chromosomes that determine the physical characteristics of an individual are called somatic chromosomes. In a pair of somatic chromosomes, each member has the same morphology. So, these chromosomes are also called autosomes.

b. Sex chromosomes

The chromosomes that determine the sex of an individual are called sex chromosomes. The structure of each member of a pair of sex chromosomes is different. So, these chromosomes are called heterosomes.

Number of chromosomes

In a particular organism, the number of chromosomes is constant. But the chromosome number varies from species to species. For example,human beings have 46 chromosomes, but gorillas have 48 chromosomes in a cell of their body. The number of chromosomes is generally expressed in pairs. For example, human beings have 23 pairs of chromosomes

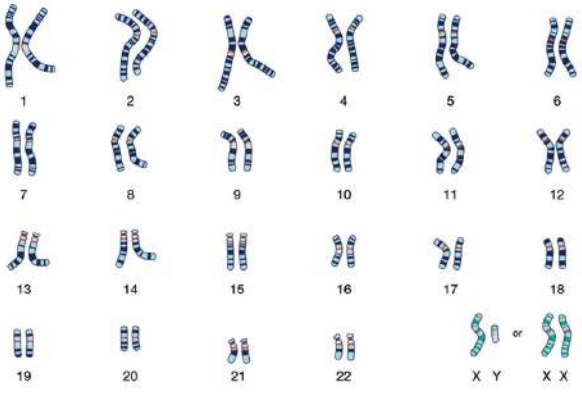


Figure 4.11 Number of chromosomes in humans

in a cell. The purpose of mentioning it like this is that among the 23 pairs, one set of 23 chromosomes belongs to the father, and the remaining set of 23 chromosomes belongs to the mother.

Generally, two sets of chromosomes are found in a somatic cell called diploid (2n). One set of chromosomes is found in a gamete called haploid (n). For example, a human somatic cell contains 46 (2×23) chromosomes, which is diploid. Human gametes, either sperm or ovum, contain 23(1×23) chromosomes, which is haploid.

Role of sex chromosomes in the determination of sex in humans

Project work 4.2 Constructing Modelof sex determination in humans

Materials required: Clay of various colours, cardboard or thermocol, gum, chart, or picture showing the process of sex determination

Method

i. Observe the human sex determination chart or picture and use different coloured clay to make X chromosome and Y chromosome.

ii. Paste the X and Y chromosomes on the cardboard or thermocol sheet according to the required number of sex determination processes and name them.

iii. Present the prepared model in class and discuss the role of sex chromosomes in determiningthe sex of an organism.

Genes present in the chromosome determine the characteristics of living beings. Similarly, the process of separation of male and female sexes due to the genes present in the sex chromosomes of an organism is called sex determination. Sex chromosomes determine the sex of the fetus.

There are a total of 23 pairsof chromosomes in the body cells of humans. Among them, 22 pairs are autosomes, and one pair is a sex chromosome or heterosome. The cell of a male individual contains one pair of sex chromosomes called XY, but the cell of a female

individual contains XX sex chromosomes. During the reproductive phase, meiotic cell division takes place in the diploid ($2n=2\times23$) germ cells (found in testes and ovaries) of males and females to produce haploid gametes ($n=23$) respectively. The mother cell of the male reproductive organ (testis) consists of 44+XY chromosomes. This cell gets divided through meiosis to form sperm having either 22+X or 22+Y chromosomes. Similarly, the mother cell of the female reproductive organ (ovary) consists of 44+XX chromosomes. This cell also gets divided through meiosis to form an ovum having only 22+X chromosomes. During sexual intercourse or copulation, if a sperm having 22+X chromosomes fuses with the ovum with 22+X chromosomes, then the future child will be a female or daughter (44+XX). Similarly, if a sperm having 22+Y chromosomes fuses with the ovum with 22+X chromosomes, then the future child will be a male or son (44+XY). The probability of getting a son or daughter is 50% in fertilization since 50% of male sperm have X-sex chromosomes, and 50 % have Y-sex chromosomes.

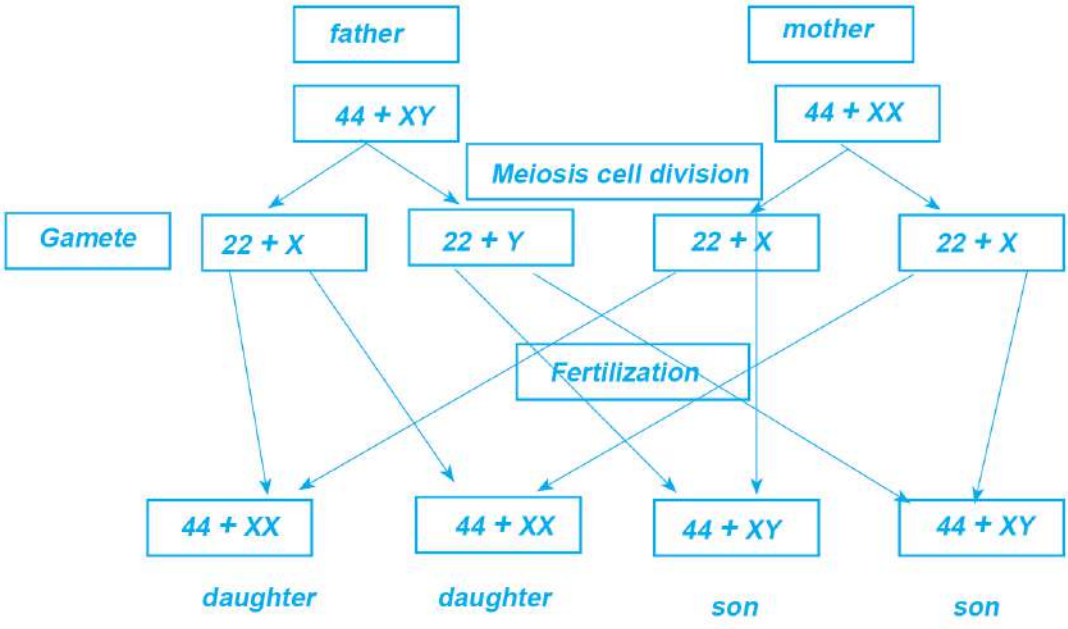


Figure 4.13 Sex determination chart

Exercise

1. Choose the correct option for the given questions.

a. How many pairs of sex chromosomes are found in the human cell?

i. 1 pair
ii. 22 pairs
iii. 23 pairs
iv. 46 pairs

b. What is a chromosome made up of?

i. DNA and RNA
ii. DNA and carbohydrate
iii. DNA and protein
iv. RNA and protein

c. What is the main function of sex chromosomes?

i. To determine physical characteristics
ii. To determine sex
iii. To increase immunity
iv. To determine the structure of the eye

d. What is the smallest unit of the chromosome that helps in the transmission of hereditary characteristics?

i. DNA
ii. Chromatid
iii. Centromere
iv. Gene

e. Which of the following statements is correct for mitotic cell division?

i. Four cells are formed at the time of cell division.
ii. Haploid cells are formed at the end of cell division.
iii. It has the main role to form gametes.
iv. This cell division helps to repair tissue.

f. A technician working in a radiotherapy laboratory was tested after a long time of marriage when there was no childbirth. After the test, it was found that his child production capacity was reduced because he worked in high-intensity

radiation for a long time. Which part of the cell is affected in this case?

i. DNA ii. RNA

iii. Cytoplasm iv. Nucleus

g. If there is no DNA transcription in a cell, which process is affected?

i. Photosynthesis ii. Protein synthesis

iii. Sexual reproduction iv. Cell division

h. If a nucleotide is destructed during DNA replication, what happens to the organism?

i. Genetic disorder occurs

ii. It brings a problem in cell division

iii. It brings a problem in reproduction.

iv. The chromosome doesnot function.

i. Which of the following indicates the set of chromosomes in a cell of a woman?

i. 44+XY ii. 44+XX

iii. 22+XY iv. 22+XY

j. Which of the following statements is true?

i. Ovum contains only a Y chromosome and sperm contains an X chromosome.

ii. Ovum contains only an X chromosome and sperm contains a Y chromosome.

iii. Ovum contains only an X chromosome and sperm contains either an X or Y chromosome.

iv. Ovum and sperm both contain X and Y-chromosomes.

2. Write differences:

a. Autosome and sex chromosome

b. Mitosis and meiosis

c. DNA and RNA

d. Haploid and Diploid

3. Give reason:

a. Offspring have the same characteristics as their parents.

b. The male has a main role in the determination of sex.

c. Though males have both X and Y sex chromosomes, some of them have only male or only female kids.

d. Meiotic cell division is also called reductional cell division.

e. Mitotic cell division is also called equational cell division.

f. Sexual reproduction is impossible without meiotic cell division.

g. Meiotic cell division brings variation.

4. Answer the following question.

a. What is a gene?

b. What is a chromosome? Clarify the role of chromosomes in the body of living beings.

c. Explain the importance of mitotic cell division in the growth and development of the body.

d. Explain the role of mitosis and meiosis in the reproduction of organisms.

e. What will happen if meiotic cell division doesnot occur in the reproductive cell of an organism? Explain.

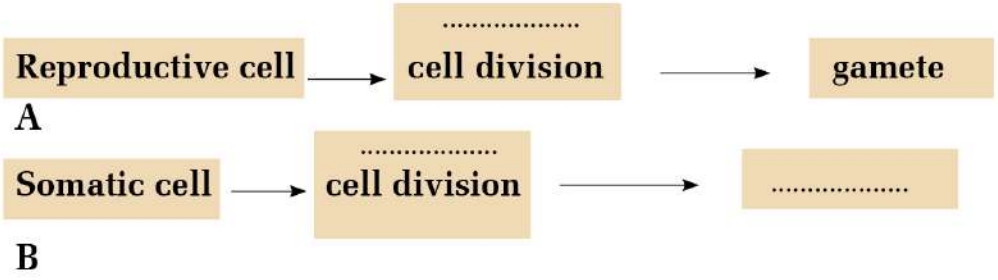
f. Clearly explain the role of genes in the transmission of hereditary characteristics in organisms.

g. How is sex determined in humans? Explain with a chart.

h. A woman is pregnant. What is her probability of giving birth to a daughter? Write in percent.

i. A couple gave birth to only a son. Does it mean that the testes of those male-produced spermshave Y-chromosomes only?

j. Complete the concept maps 'a' and 'b'. Write the differences between these processes.



4.8 Genetics and genetic technology

Heredity and Mendelism

All living beings can produce offspring like themselves. Due to this reason, they continue their generation by giving birth to their young ones. Offspring inherit the characters of the previous generations. Although the organisms may look the same, they have some qualities that differ from each other. Parental characteristics are transmitted to the offspring in both sexual and asexual reproduction. These traits are transmitted from one generation to another because of the genes present in the chromosomes of the nucleus of a cell. Each gene carries a specific characteristic of an organism and hence it is responsible for transmitting the qualities of the father and mother to their children. The phenomenon in which parental characters are transferred to their young ones is called heredity, and such characters are called hereditary characters.

Activity 4.5 The study of various types of peas

Material required: Various types of pea seeds, a chart showing dominant and recessive characters based on Mendel's experiment, chart paper, gum

Method:

i. Collect various types of pea seeds found in your locality. Sort them into different groups on the basis of their characters like shape, size, and colour.

ii. Discuss these characteristics on the basis of Mendel's experiment chart. Based on the discussion, differentiate these characters into dominant and recessive characters.

iii. Paste these seeds on the chart paper and also mention characters to present in the class.

Conclusion:

The branch of biology that deals with the study of genes, heredity, and variation is called genetics. Genetic engineering, medical genetics, etc., are sub-branches of genetics. Gregor Johann Mendel was the first scientist to propose the laws of genetics through various researches.

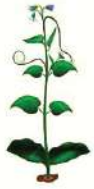
	Flower color	Seed shape	Seed color	Pod color	Pod shape	Plant height	Flower position
DOMINANT	 Purple	 Round	 Yellow	 Green	 Inflated	 Tall	 Axial
RECESSIVE	 White	 Wrinkled	 Green	 Yellow	 Constricted	 Short	 Terminal

Figure 4.13 Dominant and recessive characters in pea plant

Mendel was born on 22 July 1822 in Austria and is also called the father of genetics. He carried out many experiments on the pea plants grown in his garden to prove that hereditary characters transmit from parents to offspring. While doing experiments, he considered seven pairs of contrasting characters in the pea plant, which are:

- Height of plant: Tall (TT) and dwarf (tt)
- Position of flower: Axial (AA) and terminal (aa)
- Colour of pod: Green (GG) and yellow (gg)
- Shape of pod: Inflated (II) and constricted (ii)
- Shape of seed: Round (RR) and wrinkled (rr)
- Colour of flower: purple (RR) and white (rr)
- Colour of seed: yellow (YY) and green (yy)

Mendel selected pea plants for his research due to the following reasons:

1. Pea plants are bisexual and their flowers are closed, making them naturally self-pollinating plants.
2. Cross-pollination can be done if necessary.
3. Their life cycle is short, and offspring can be produced faster.
4. They have many pairs of contrasting characters.
5. Many seeds can be produced at once, and due to this, many offspring can be produced.
6. They are easy to cultivate.

Method of Mendel experiment

Mendel studied seven pairs of pure and hybrid traits found in pea plants separately and classified each offspring according to the trait. He selected pure tall pea plants and pure dwarf pea plants and carried out pollination between them to study the heredity. Seeds obtained from that pollination were grown, which were called first filial generation. All the plants of first filial generation were tall. He performed experiments using the remaining pairs of contrasting characters too. He found similar type of results, i.e., only one character was expressed in each of the first filial generations. When two pea plants, each having a pair of contrasting characters, were pollinated, the character expressed in the first filial generation was called the dominant character. The character which was hidden in first filial generation was termed recessive character.

Mendel carried out self-pollination between the hybrids produced in first filial generation. After self-pollination, the offspring obtained in the second filial generation were both tall and dwarf. Among them, 75% were tall and 25% were dwarf. Furthermore, while self-pollinating the pure tall progeny of the second filial generation, all the offspring were pure tall pea plants. Self-pollination between pure dwarf plants of the second generation produced only pure dwarf offspring. Similarly, self-pollination of hybrid offspring of the second filial generation yielded 75% tall and 25% dwarf pea plants, which is presented in the chart given below:

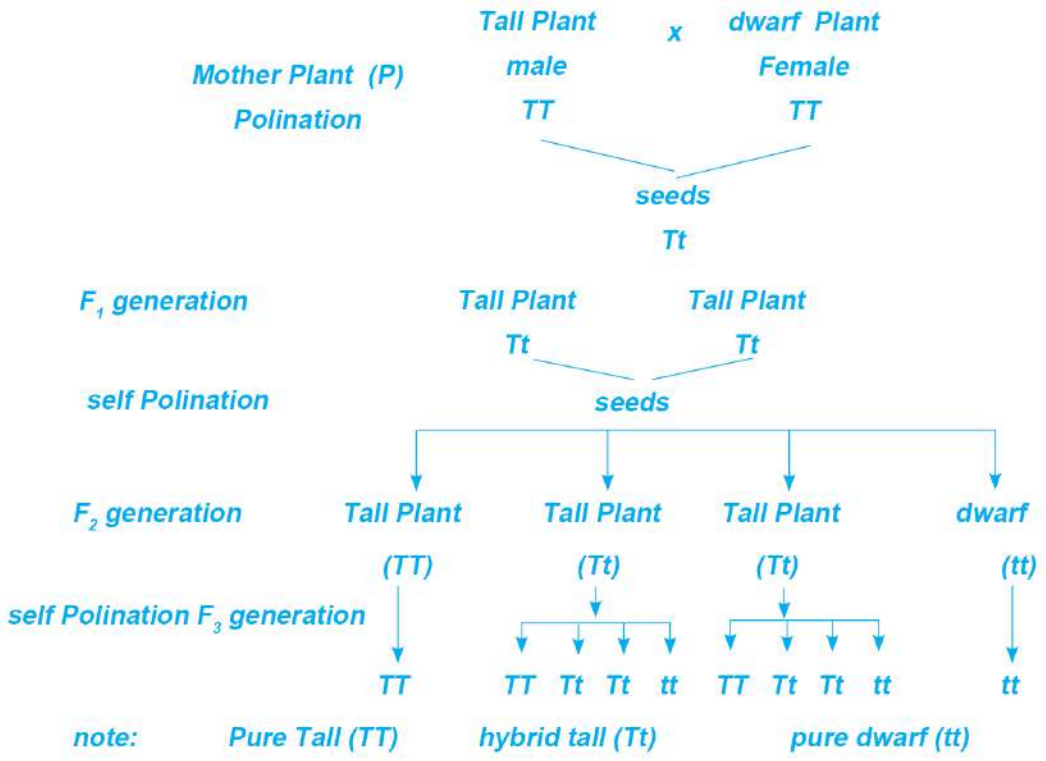


Figure 4.14

Monohybrid cross between tall plant and dwarf pea plant (upto F3 generation)

Results of Mendel's experiment

a. Tall plants were produced from pure tall plants.

b. Tall and dwarf plants were produced in a ratio 3:1 from hybrid tall plants.

c. Dwarf plants were produced from pure dwarf plants.

Phenotypic ratio and genotypic ratios in Mendel's experiment

Phenotypic characters are the character seen externally in an organism. Similarly, Genetic constitution or genetic makeup of an organism is called genotypic character.

Phenotypic ratio is Tall: dwarf = 3:1

Genotypic ratio is pure tall: hybrid tall: pure dwarf = 1:2:1

Monohybrid cross and dihybrid cross

When a cross is made between two pure plants or organisms considering a pair of contrasting characters, then it is called a monohybrid cross. Example: 100% hybrid plants were produced in a cross pollination between a pure tall pea plant and a pure dwarf pea plant in first filial generation.

Similarly, when a cross is made between two pure plants or organisms considering two pairs of contrasting characters, this cross is called dihybrid cross.

Activities 4.6 Prepare a chart of monohybrid cross according to Mendel's experiment up to F2 generation and discuss it in the class.

Laws of Mendel

1. Law of dominance
2. Law of purity of gametes or law of segregation
3. Law of independent assortment

Law of dominance

According to Mendel's law of dominance, when a cross is made between two pure individuals having a pair of contrasting characters, only one character is expressed externally in F1 generation which is called the dominant character. Hence, the character or trait which is expressed externally in F1 generation is called the dominant character and the character which remains hidden in F1 generation is called the recessive character.

In Mendel's experiment, a cross pollination between pure tall pea plant and pure dwarf pea plant

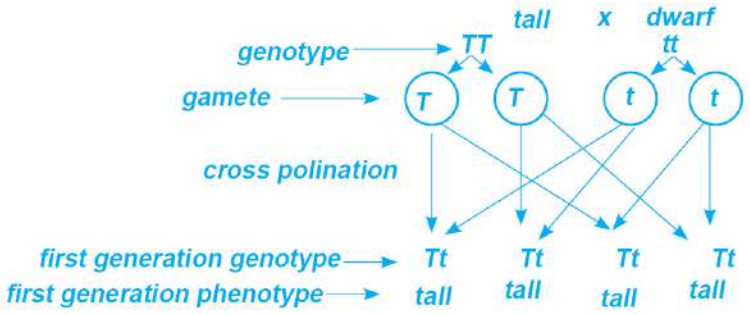


Figure 4.15 Chart showing Mendel's law of dominance

produces all the hybrid offspring in F1 generation in which all are externally tall indicating tall character is dominant and dwarf as a recessive character.

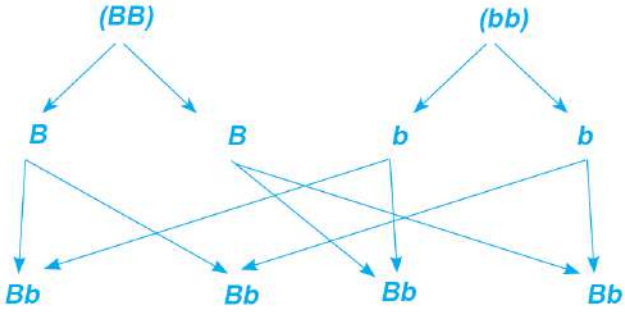


Figure 4.16 Cross breeding of pure black guinea pig and pure white guinea pig

Mendel's law of dominance can also be studied by crossing guinea pigs. When black guinea pigs (BB) are crossed with white guinea pig (bb), then hybrid black guinea pigs are produced in the F1 generation. Here, black colour is the dominant character, and white is the recessive character.

Law of purity of Gametes

Although two different characters coexist in the hybrid of the first generation, they remain pure without losing their originality. In the formation of gametes in the hybrid, during meiosis cell division, the genes of the pure or hybrid allele in the mother cell are separated and only pure characters enter each gamete. It means gametes formed are pure. This law is called the purity of gametes.

For example, when self-pollination is performed among the progeny obtained in the first filial generation, the genes of the hybrid alleles separate, and hence tall and dwarf plants are produced in the second generation. The ratio of tall and dwarf plants is 3:1.

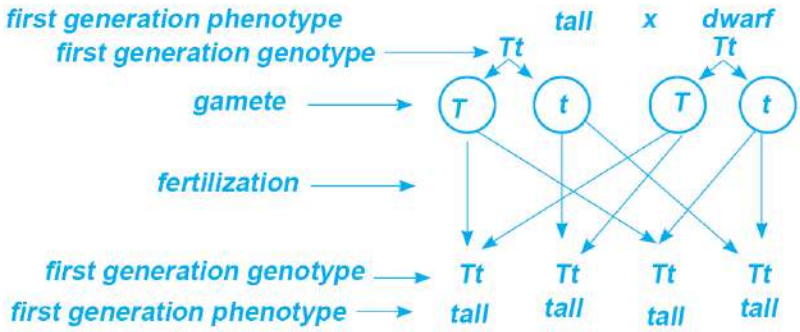


Figure 4.17: Second generation produced from self-pollination between hybrids of first generation

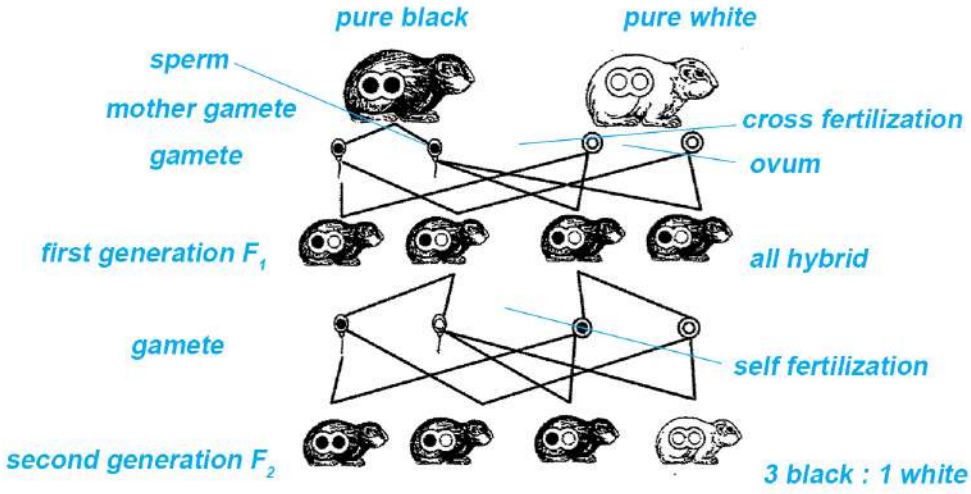


Figure 4.18 Second generation produced by self-breeding of hybrid black guinea pig

Similarly, when the hybrids offspring obtained by crossing the pure black guinea pig and pure white guinea pig were crossed together, 75% black and 25% white guinea pigs were produced. In this case, phenotypic ratio of black and white was 3:1, and the genotypic ratio was 1:2:1 (pure black: hybrid black: pure white).

Genetic technology

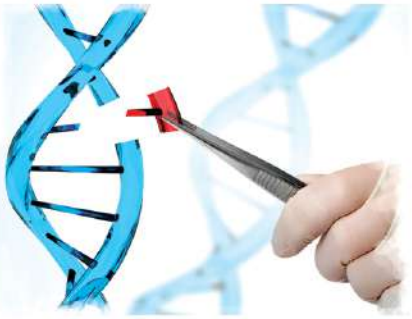


Figure 4.19 A fragment of DNA of an organism is added to the DNA of another organism

Currently, the world has advanced a lot in the field of technology, and genetic technology is one of them. This technology helps to develop new qualities by making various changes in DNA easily and quickly. In this technology, modification in the genetic material or gene is carried out. Nowadays scientists have been able to find out: what genes are, their function, and how they can be altered by adding, deleting, and substituting DNA. Genes are found in all organisms, and they are transferred from one generation to another. Genes have coded instructions that are used to synthesize proteins and to transmit hereditary characters.

Genetic technology is the process of modifying genes by understanding genetic expression, taking advantage of natural genetic variation, and transferring genes to new organisms. Among the various technologies, genetic engineering is the process that alters the DNA structure of an organism using laboratory-based techniques. It is also called genetic modification. In this process, a new trait is developed by changing a single nitrogen base pair (A-T or C-G), deleting or adding a gene in the DNA. Gene variants created through genetic engineering can be passed from one generation to the next. Identifying genes and their functions is an important application of genetic technology. Genetic technology has an important place in biotechnology and molecular biology. It has made it possible to change and regulate plant characteristics by using DNA sequencing information in its structure, function, process, etc. At present, genetic technology based on molecular markers, transgenic technology and gene expression has been widely used in agricultural production, which has shown great potential to improve agricultural yield and quality, reduce losses caused by various biotic and abiotic factors, and improve the reproductive capacity of organisms. These modern DNA technologies with high potential and need are the important ways to guarantee the sustainable development of agriculture. Nowadays, DNA technology is mostly used in the field of forensic science. This technology is used to investigate various criminal cases called DNA test.

Role of DNA testing in various investigations

The use of DNA testing technology has made it easier to investigate various criminal cases and identify the guilty. DNA testing is mostly used for criminal investigations and paternity testing. As a scientific method, it is effective in establishing facts, but DNA testing is a complex and highly sensitive task. Even a simple error can lead to significant inaccuracies. Therefore, to make DNA testing reliable, fair, and effective, special attention is required during the collection and transportation of samples. Samples should also be protected from contamination.

Project work

Use the internet to find out the application of DNA testing in various fields and prepare a Power Point slide. Present it in the class and discuss.

Selective breeding

Since ancient times, people have been selecting and breeding plants and animals with good qualities for agricultural products they want. In this way, selective breeding is the process of selecting animals and plants with the best qualities and interbreeding them to produce offspring with desired characters. The main purpose of selective breeding is to introduce the desired traits in an organism and establish those traits in the future offspring. This method involves selecting and breeding the mother and father, or both, to produce desired plants and animals. Selective breeding emphasizes natural reproduction using the gene variation occurring naturally in organisms. However, some people criticize it because, during selective breeding, some natural qualities may disappear, or it can mutate and undesirable qualities may appear in animals. For example, if we reject dwarf animals and breed only tall animals, the offspring inherits the gene for tall. If this process is repeated for many generations, the tallness trait will be established in future generations while the quality of being dwarf or short will disappear.

Project work

Use the internet or inquire your elders about selective breeding in various organisms and make a short report on it. Then discuss it in class.

Disadvantages of selective breeding

1. Usually, selective breeding increases the population of plants and animals having similar genetic traits.
2. There is a chance of spreading infectious diseases genetically.
3. In this method, breeding between very closely related species is done, so offspring are more likely to suffer congenital genetic problems.
4. Selective breeding is also called artificial selection because it involves human interferences.
5. Selective breeding inhibits some naturally occurring genetic traits and can affect biodiversity, making it possible for species to become extinct in the future due to some bad traits.

Method of selective breeding

Various techniques can be adopted in selective breeding. Some techniques are mentioned below:

Inbreeding

Inbreeding is done to establish the population of organisms with predictable traits. In this method, closely related animals are allowed to interbreed. If inbreeding is done continuously, genetically alike offspring will be produced. Organisms produced in this way are described as purebred or inbred. Examples of purebred animals are Siamese cat and Labrador Retriever dogs.

Figure 4.20 Siamese cat and Labrador Retriever dog

Line breeding

It is also a type of inbreeding. In this method, breeding is done between more distant relatives to get animals with desired characteristics. This reduces the rate of becoming purebred. It also reduces the risk of ill health that can sometimes be seen on purebred animals.

Self-pollination

Most plants have both male and female reproductive organs in the same body. They are able to self-pollinate. Only some qualities of plants grown from the seeds produced from self-pollination are identical to mother plant, but not all. This is because of gene reshuffle during sexual reproduction. This method helps to produce genetically identical plants.

Cross breeding

This method involves breeding two unrelated individuals. Generally, this type of breeding is done between two different species of same genus. This is often used to produce progeny with desired traits from two different individuals. This method is suitable to produce offspring which display the characteristics of interest by crossing two purebred organisms. Offspring produced by cross breeding are called hybrids.

The main purpose of cross breeding is to enhance the quality of the hybrid. Qualities of the hybrid are not transferred to all subsequent generations.

Some organisms produced from cross breeding

Liger

The hybrid animal obtained by crossing the male lion and female tiger is called liger. It is a most known hybrid animal. It is larger than its parents. It generally behaves like the lion.

Tigon

The hybrid animal obtained by crossing the male tiger and female lion is called Tigon. Tigon is smaller than the Liger, and it is smaller than either of its parents. It resembles tiger but most qualities such as roaring and socialization are like that of a lion.

Figure 4.21 Liger

Tigon

Beefalo

Beefalo is a hybrid produced by the cross between a buffalo (American Bison) and a bull. They are different from other hybrids and they can reproduce.

Figure 4.22 Beefalo

Zebroid

The hybrid animal obtained by crossing the zebra and horse is called zebroid. They cannot reproduce.

Figure 4.23 Zebroid

Mule

The hybrid animal produced by cross breeding of a donkey and a horse is called mule. It can carry load like the donkey and run like the horse. It is also sterile.

Figure 4.24 Mule

Pomato

Pomato is the plant produced by crossing potato and tomato. In this plant, tomato is produced in stem above the soil and potato is produced underground.

Figure 4.25 Pomato

Activity 4.7

In addition to the examples mentioned above, prepare a list of animals produced by selective breeding that you have seen or heard, or search on the internet and discuss in the class.

Advantage of cross breeding

Cross breeding can be carried out in both the plants and animals. By this method new varieties of an organism can be produced. Farmers are benefitted by this technique. Some advantages of cross breeding are given below:

1. This method combines the desirable qualities of two organisms from different breeds, varieties, or species.
2. Human beings can produce organisms with desired characters.
3. Cross breeding provides the opportunity to make full use of a wide range of genetic material.
4. Animals that exhibit better quality than the parent animal can be developed.
5. Immunity, strength, age, vigour, etc.of an organism can be improved by this method.

6. Crop production can be increased from plants produced throught his method.

Disadvantages of cross breeding

1. If there is no proper understanding and management of cross breeding techniques, problems may arise in breeding policy in the future.
2. The price of products obtained from cross breeding is lower compared to that of the products obtained from purebred. So, farmers cannot earn as much as expected.
3. There is a limitation in the sale of animals produced by cross breeding in the export market.
4. As the external and genetic characteristics of the hybrid go on changing, the chance of extinction of purebreds increases.
5. In this breeding, natural traits of parent are not completely transferred to their progeny; hence such traits may disappear gradually.

Artificial insemination

Nowadays, because of the development of various technologies, fertilization is possible without mating between male and female organisms. The practice of producing offspring of advanced variety has greatly increased nowadays which is by collecting semen from the male located at far distant and inseminating into the body of the female organisms. Thus, artificial insemination (AI) is the technique of collecting semen from advanced breeds of male and allowing them to enter the female reproductive tract at the right time through the use of equipment. Offspring produced by this technique are found to be as normal as those produced by natural mating. In this process, healthy sperm is collected from the male and allowed to pass into the uterus of a healthy female for fertilization at the appropriate time using artificial means.

The first scientific research on artificial insemination of domestic animals was carried out in dogs in 1784 by the Italian scientist Lazzaro spallanzani.

His experiment confirmed that fertility resides in the microscopic sperms that float in semen, not in the liquid part of the semen. The main objective of artificial insemination is to produce a large number of advanced offspring by transmitting the sperm of an advanced breed of male to a female ready for conception.With this technique, the farmers in animal husbandry can avoid the trouble of rearing expensive males with special qualities. This also helps to strengthen farmers' economic status. Currently, artificial insemination is in practice instead of natural mating in many animals, such as cows, buffaloes, goats, sheep, etc. This is a subsidiary method of reproduction that is now practiced worldwide. This type of breeding is a useful technique to improve genetic quality in animal husbandry.

Advantage of artificial insemination

Artificial insemination has many advantages compared to natural mating. Some of them are listed below:

1. There is no need of rearing male for breeding, which saves expenses of rearing.
2. It helps to control the infection and spread of disease during mating.
3. After collecting semen from the male, it is tested and fertility is checked to ensure the fertility of the male.
4. Collected special semen can be used even after the death of the male.
5. Collected semen can be easily transported over long distances for fertilization.
6. This method helps to prevent injury to the female or male at the time of fertilization.
7. This method increases the rate of fertilization.
8. It helps to keep a good record of reproduction.

Disadvantage of artificial insemination

1. It needs well-trained manpower and special equipment.

2. It requires more time than natural breeding.

3. Reproduction may nottake place, or there might be a chance of infection if the equipment isnot properly sanitized during artificial insemination.

In vitro fertilization (IVF)

A case study:

A 38-years-old woman and her 42-years-old husband have been trying to conceive for the past five years. Test of infertility did not show any cause for this. Regular ovulation cycle is normal in her body. Her reproductive tract is also normal, as shown by Hysterosalpingography (a special X-ray of internal female reproductive organ). Her husband's sperm count is also normal. They are disappointed because they still donot have a child. In this situation, the doctor advised them to adopt invitro fertilization (IVF) method. Do you know about invitro fertilization? Search on the internet or inquire with elders about it and discuss in class.

Let us know

Lesle Brown, a woman who lived in Manchester, England, had suffered for many years due to the blockage in her fallopian tubes. To solve it, she underwent the experimental IVF procedure in November 1977. For this, a matured ovum was taken out from her ovary and fused in a dish in the laboratory with her husband's sperm to form an embryo. Then, the embryo was transplanted into her uterus after a few days. British gynaecologist Patrick Steptoe and scientist Robert Edwards had been doing research on IVF a decade earlier. When the media found out about Brown's conception, she faced intense investigation. Then, Lesle Brown gave birth to her daughter by caesarean section on 25th July 1978. Her daughter's name is Louise Joy Brown, who is the first child in the world to be borne by invitro fertilization.

In Nepal, IVF technology began in 2004 in Om hospital through the establishment of an IVF centre. On March 3, 2005, Rajendra Tamang and Sandhya Tamang gave birth to a baby named Om Mani Tamang as Nepal' s first test-tube baby through this process.

IVF is the most effective method of assisted reproductive technology. This method is a complex series of procedures to help couples with reduced fertility and genetic problems. IVF is a method of conception that differs from normal sexual intercourse. The child born through the process of IVF is physically and mentally normal. The characteristics of the child born from IVF may or may not match those of his parents, as this procedure can be done using a couple's own ovum and sperm, or if a couple has problems with ovum and sperm production, an egg and sperm from a known or unknown donor can also be used. In IVF, a mature ovum from the ovary of female is taken and stored in a petridish and fused with the sperm of the male in a sophisticated laboratory. The fertilized ovum is then transferred to the female's womb (uterus) after a few days. It takes about three weeks for a complete cycle. But it may take more time depending upon the nature of the problem. The embryo grows in woman's uterus as in normal pregnancy.

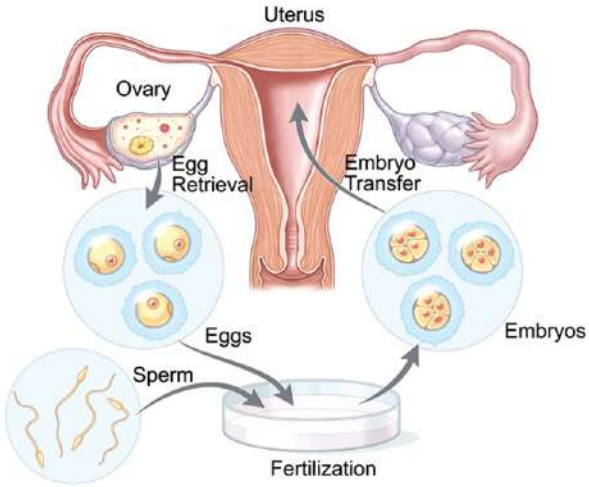


Figure 4.26 Method of In Vitro fertilization

Advantage of IVF

1. IVF is the best method of conception for those couples who are unable to conceive due to various problems related to conception.

2. It allows conception by using a couple's own sperm and ovum or by the use of donor's sperm and ovum.

3. It is more successful than other assisted reproductive techniques.

4. It is helpful to solve the problem related to various chromo-

somal disordersin the child.

5. Infertility and genetic problems can besolved by this technique.
6. It increases fertility and reduces the risk of miscarriage.
7. It increases the chance of having a healthy child.

Disadvantage of IVF

1. There is no guarantee of a successful IVF cycle. It may not be successful and may take more than one cycle.
2. There may be various side effects associated withthe use of IVF.
3. The problem of multiple births at the same time can also occur.
4. Adopting this technique may cause emotional stress in the couple.
5. There is a chance that the embryo might be implanted outside the uterus.
6. It is an expensive method.
7. There is also a chance of pre-mature birth of a baby with low weight.

Exercise

1. Choose the correct option for the following questions.

a. What plant did Mendel use for his experiment?

i. Pea ii. Gram

iii. Maize iv. Bean

b. Which of the following is the genotypic ratio for Monohybrid cross?

i. 1:2 ii. 3:1

iii. 1:2:1 iv. 9:2:3:1

c. What is the term for a characteristic that is passed down from generation to generation?

i. Dominant character ii. Recessive character

iii. Hereditary character iv. Imported character

d. A white-skinned child was born to a dark-skinned parent. What is the reason for this?

i. The parent was hybrid

ii. Both the father and mother have pure black characters

iii. White colour is dominant

iv. Black colour is recessive

e. In order to produce good meat, farmers look for Boer goats and cross them with local goats. What kind of breeding method is this?

i. Artificial insemination ii. Selective breeding

iii. IVF iv. Natural selection

f. Ramit has produced a new plant by crossing an orange plant and a lemon plant.What type of plant is this?

i. Advanced variety plant ii. Pure plant

iii. Hybrid plant iv. Artificial plant

g. Roshani is a student from Himalayan region. A mule is reared in her home for transportation of the goods. But the mule is getting older, and her family members are considering getting a new mule. In this situation, she asked her father how amule gives birth to a child. Which of the following is the correct answer given by her father?

i. Mules produce offspring naturally

ii. There is inbreeding in mule.

iii. Mule cannot produce offspring naturally

iv. Mules produce offspring by AI.

2. Differentiate:

i. Dominant and recessive characters

ii. Phenotype and genotype

iii. Inbreeding and crossbreeding

iv. Artificial insemination and invitro fertilization

v. Tigon and Liger

3. Give reason:

a. Children look like their parents, but not exactly the same.

b. Mendel selected pea plants for his experiment.

c. When tall pea plants and dwarf pea plants are cross-pollinated, tall plants are produced in the first filial generation.

d. When self-breeding is done between hybrids, different types of offspring are produced.

e. DNA testing is a reliable technique for criminal investigation.

f. Genetic engineering involves the detailed study of DNA.

g. Offspring produced by cross-breeding may be sterile.

h. Special attention should be given while collecting samples for DNA testing.

4. Answer the following question:

a. What is genetics?

b. What is DNA testing? For what purposes is it used?

c. Give some examples of genetic technology.

d. Mention the importance of DNA in genetic technology.

e. Explain the importance of genetic engineering.

f. What is monohybrid cross? Show in the filial chart, the result obtained by cross pollinating first and then self-pollinating of a red flowering pea plant and white flowering pea plant.

g. Explain with an example that Mendel's experiment can be done not only in plants but also in animals.

h. Explain the Mendel's law of dominance and purity of gametes.

i. Round seeded pea plant and wrinkle seeded pea plant arecross-pollinated first and then the offspring obtained were self-pollinated again. The result of the second filial generation is shown in the table below. Now answer the following questions:

	R	r
R	RR	Rr
R	Rr	rr

i. What is the ratio of plants showing dominant and recessive characters?

ii. Write the genotypic and phenotypic ratio of this generation.

iii. Among them, which plant is purely round-seeded? Why?

j. When a cross is made between a black guinea pig and a white guinea pig, the offspring of first filial generation were all black. Explain why white guinea pigs did not appear in this generation?

k. A teenage girl who has lost her mental balance became the victim of rape and gave birth to a child. How can the father of the child be detected?

l. The district animal development centre conducted a camp to fertilize many cows at once. Which technique did that organization adopt at that time? Explain this technique in brief.

m. Is genetic engineering a boon or a bane for the present era? Give your arguments.

n. How has AI technology helped to bring happiness to the farmer? Explain.

o. IVF is proved to be a boon for childless couples. Justify this statement.