Biology

Standard X

Part 1

Government of Kerala
Department of General Education

Prepared by

State Council of Educational Research
and Training (SCERT), Kerala

2025

THE NATIONAL ANTHEM

Jana-gana-mana adhinayaka, jaya he
Bharatha-bhagya-vidhata
Punjab-Sindh-Gujarat-Maratha
Dravida-Utkala-Banga
Vindhya-Himachala-Yamuna-Ganga
Uchchala-Jaladhi-taranga
Tava subha name jage,
Tava subha asisa mage,
Gahe tava jaya gatha
Jana-gana-mangala-dayaka jaya he
Bharatha-bhagya-vidhata
Jaya he, jaya he, jaya he,
Jaya jaya jaya, jaya he.

PLEDGE

India is my country. All Indians are my brothers and sisters.

I love my country, and I am proud of its rich and varied heritage. I shall always strive to be worthy of it.

I shall give my parents, teachers and all elders, respect and treat everyone with courtesy.

To my country and my people, I pledge my devotion. In their well-being and prosperity alone, lies my happiness.

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Dear friends,

Learning science will help one to know about the world around us, also to indulge in the process of knowledge creation through self experiences. Scientific knowledge which is constantly updating, is the sum total of knowledge acquired till date. Science can also be termed as a specified method to know about one's surroundings and to make modifications inaccordance with one's favourable conditions.

The construction of scientific knowledge is done through various activities, and in this way the students get the opportunity to create knowledge through learning activities. The production and application of knowledge is also a social process. The learning experiences facilitated in this textbook is through considering all these things in the forefront.

In the chapter of genetics , you will find out innovations and discoveries in the field of genetics that unlocks the secrets of life, as well as the various possibilities of genetic technology will open up. These discoveries will lead you to the process of evolution, which explains the origin and relationships of species, and to the different levels of evolution.

Knowledge gained by humans from various realms of genetics provide strength to technologies such as gene editing. The factor that helped humans for that was their developed brain . This textbook provides you the opportunity to learn and comprehend more about the senses and the nervous system.

You should be able to logically analyse and to draw conclusions out of the knowledge gained in this way. Let it be recalled that science is meant to be renewed.

With love and regards,

Dr. Jayaprakash R.K.
Director
SCERT Kerala

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Contents

Icons used in this textbook for convenience

Activities

Let's Assess

Extended Activities

Let's Find

Further reading

Evaluation not required

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a [1]**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

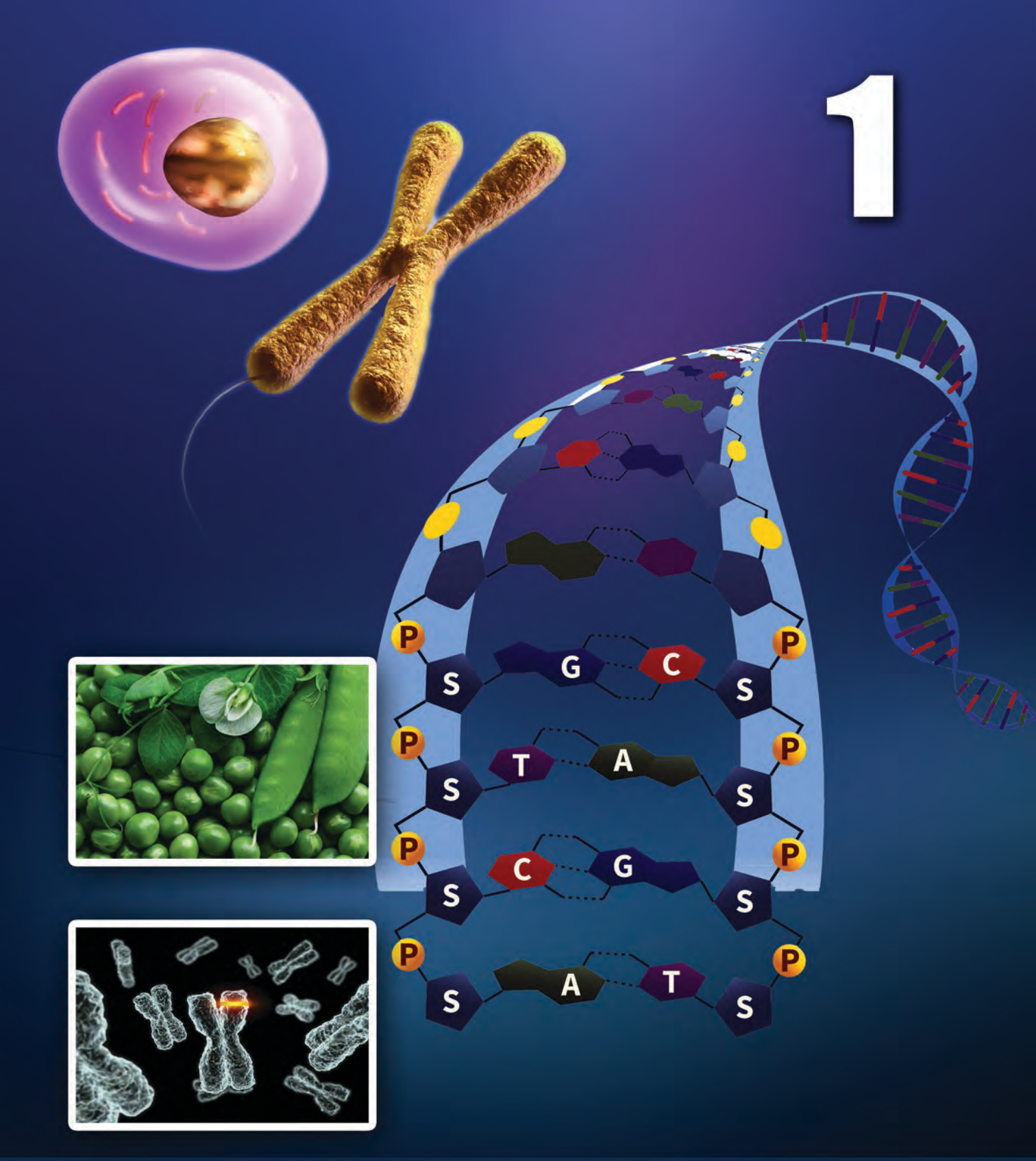
EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the [2][unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

---

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)



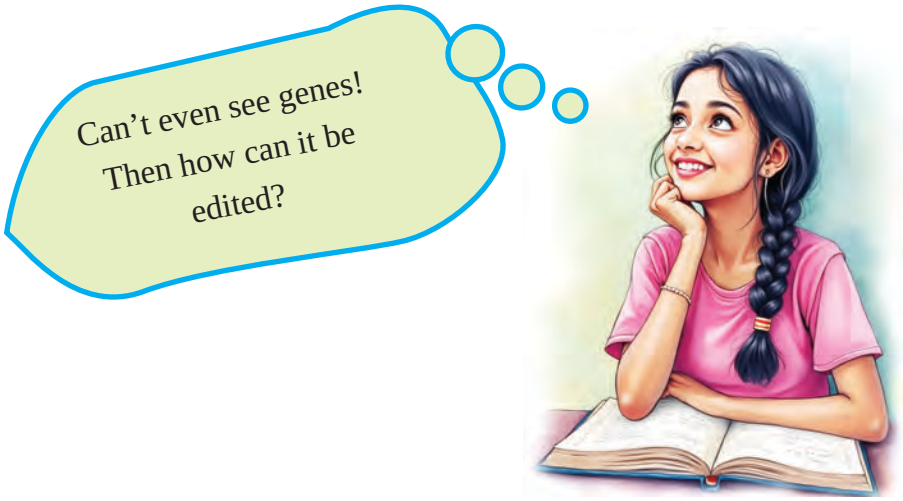
Genetics of Life

The Nobel Prize in Chemistry for developing methodology of Gene Editing

Jennifer A Doudna Emmanuelle Charpentier

The Nobel Prize of 2020 in Chemistry was shared by Emmanuelle Charpentier and Jennifer A Doudna for their contributions in the field of gene editing. The award is for the discovery of a technology called CRISPR-Cas 9, a gene editing process which can bring desirable changes in the genes in DNA. This discovery is expected to make revolutionary advances in genetic disease therapy and treatment of cancer. It can also be used to develop crops that are resistant to pests and diseases.

You have read the extract related to the technology which can bring revolutionary changes in the treatment of diseases and other fields.



Didn't you too have this doubt?

A deeper understanding of DNA (Deoxyribonucleic acid) and genes paved the way for gene editing.

Let us understand the location and ultra structure of DNA and gene.

Observe illustration 1.1 and make notes on the location of DNA.

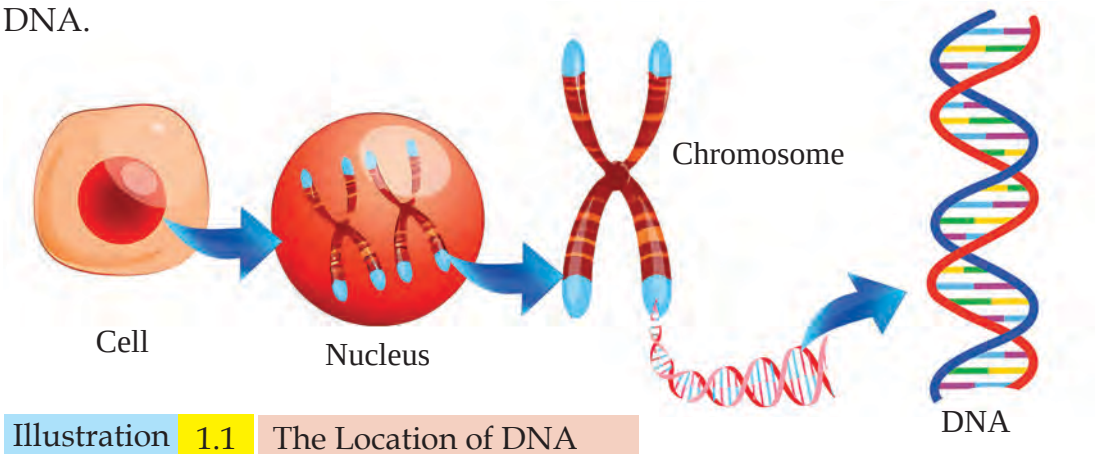


Illustration 1.1 The Location of DNA

You have understood the location of DNA. Discovery of the structure of the nucleic acid DNA was one of the greatest leaps in the field of biological studies.

Structure of DNA

In 1953, James Watson along with Francis Crick had presented the double helical model of DNA. They proposed the structure of DNA based on the X-ray diffraction studies conducted by Rosalind Franklin and Maurice Wilkins. The crucial information that led to this discovery was obtained from the famous 'Photo 51', an X-ray diffraction image of DNA taken by Rosalind Franklin. Rosalind Franklin passed away at the age of 37 in 1958. James Watson, Francis Crick and Maurice Wilkins were awarded the Nobel Prize in Medicine in 1962 for their contributions on the discovery of the double helix model of DNA.

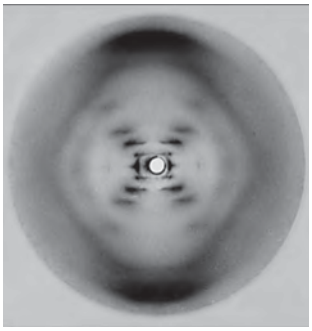
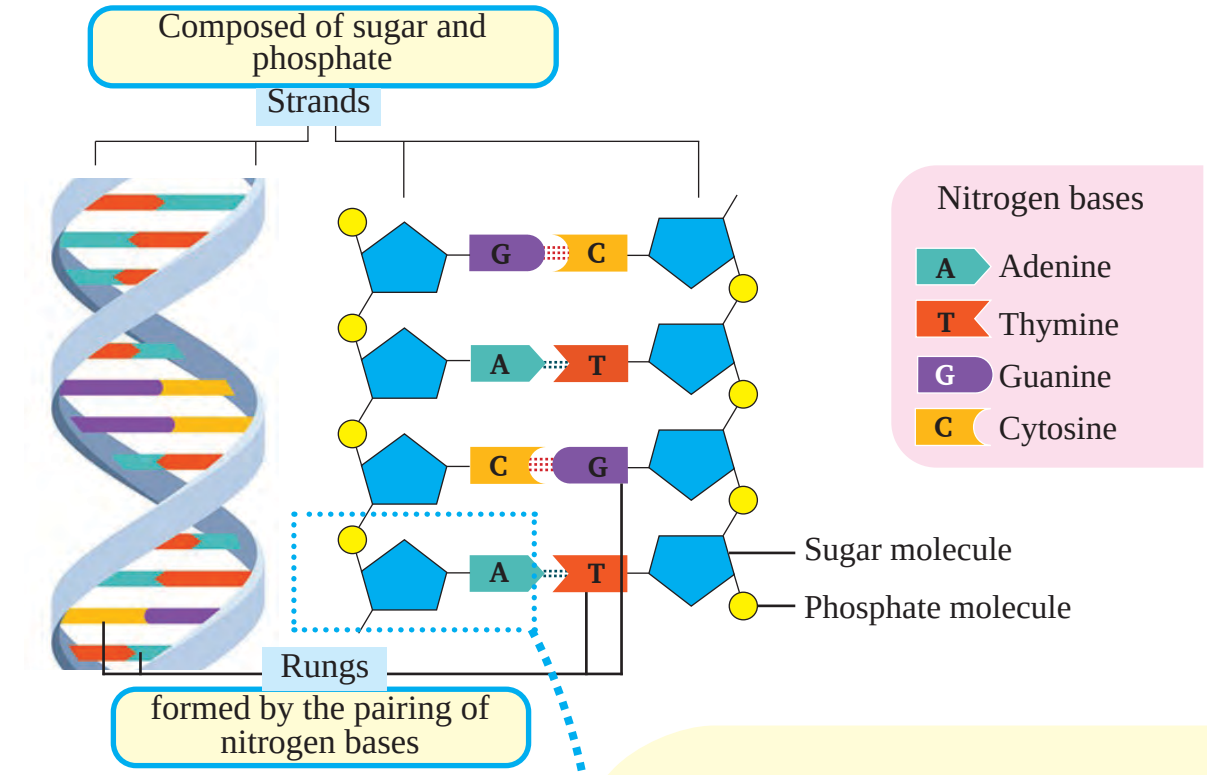


Photo 51

Rosalind Franklin 1920-1958 | Maurice Wilkins 1916-2004 | Francis Crick 1916-2004 | James Watson 1928

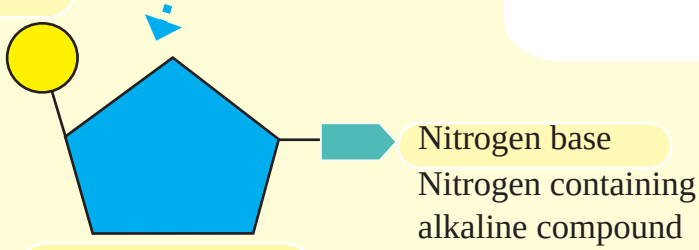
Analyse the illustration 1.2 to gain an understanding on the structure of DNA and complete the work sheet 1.1.



Double helix model of DNA

Nucleotide

The basic building block of DNA Each nucleotide is composed of a deoxyribose sugar, a phosphate group, and a nitrogen base.



Participates in the formation of bonds that link nucleotides together

Illustration 1.2 Structure of DNA

Worksheet

1. Number of strands in DNA	
2. Molecules used to make strands	
3. Molecules used to make rungs	
4. Different types of nitrogen bases	
5. Formation of rungs	
6. Mode of nitrogen base pairing	
7. Molecules in a nucleotide	

Worksheet 1.1 The structure of DNA

Prepare the double helix model of DNA by using locally available waste materials and display it in class.

How does normal sugar differ from a sugar molecule in DNA? Find out.

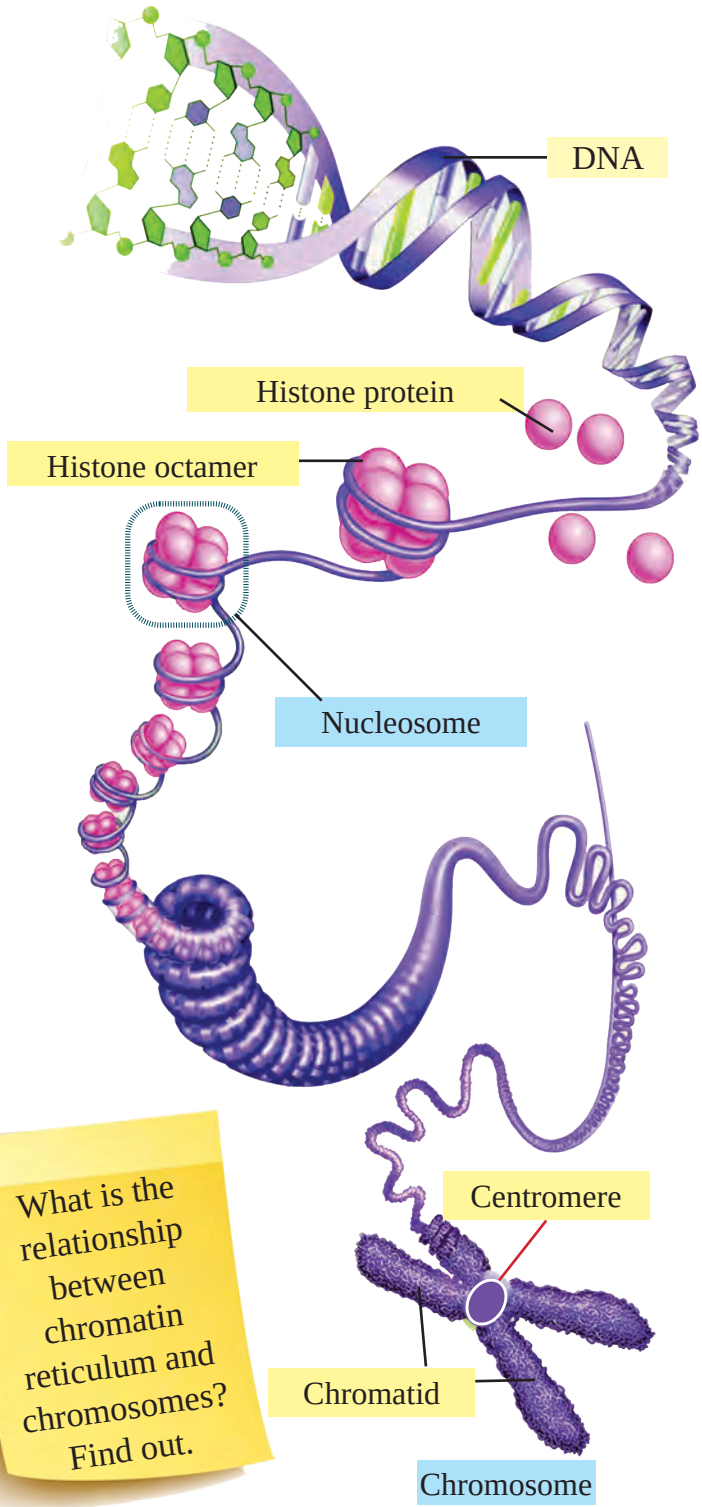
Size of DNA

The DNA in each chromosome is about 2 inches (5cm) long. If DNA from 46 chromosomes of a human cell joins together, it would be around 6 feet in length (2m). The human body is made up of trillions (one lakh crore) of cells. If the DNAs of all the cells joins together, it would be about 67 billion (one billion = 100 crore) miles in length. It is capable enough to wrap around the Earth over two million times!

How does such a larger DNA fit into the chromosomes of tiny cells?

Haven't you listened to the child's doubt?

Analyse the illustration 1.3 and description based on the indicators and find the answer to the child's doubt.



What is the relationship between chromatin reticulum and chromosomes? Find out.

Chromosome

DNA and histone proteins are the primary components of a chromosome. Eight histone proteins join together to form a histone octamer. DNA strands wind around this **octamer** to form a structure called **nucleosome**. The chromosomes are formed by packing and coiling numerous nucleosomes and recoiling the chains of nucleosomes. **Chromatids** are the parts of a chromosome which are connected by means of centromere.

Indicators

- Building blocks of chromosomes
- Histone and nucleosome
- Formation of chromosome
- Chromatid, centromere

Illustration 1.3 The structure of chromosome

Each species possess a specific number of chromosomes. How many chromosomes do humans have? How do they appear? Analyse the illustration 1.4 based on the indicators, understand human chromosomes and prepare notes.

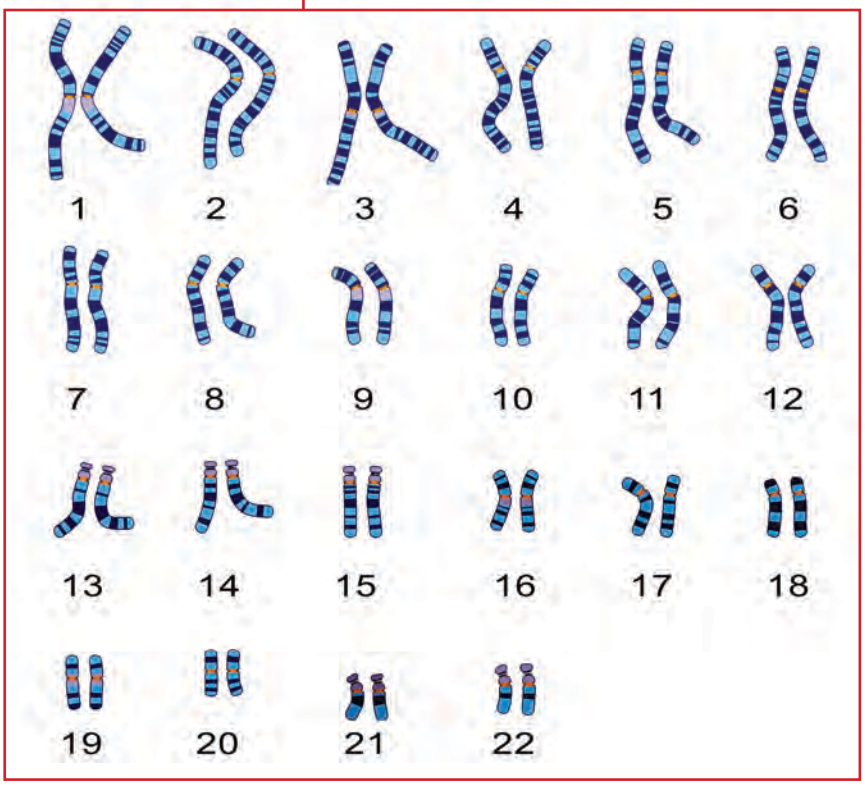
Human Chromosomes

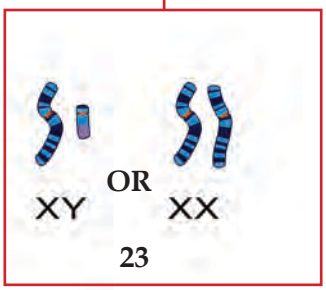
Somatic chromosomes

These are chromosomes that control physical characteristics. There are twenty two pairs of somatic chromosomes. A pair of identical chromosomes together form a homologous chromosome. One of these is inherited from the mother and the other from the father.

Sex Chromosomes

These are the chromosomes which are involved in sex determination. They are of two types. X chromosome and Y chromosome. The Y chromosome is comparatively smaller than that of the X chromosome. The SRY gene on the Y chromosome is responsible for the development of testis in the embryo.





Why are chromosomes seen in pairs? Find out.

Illustration 1.4 Human chromosomes

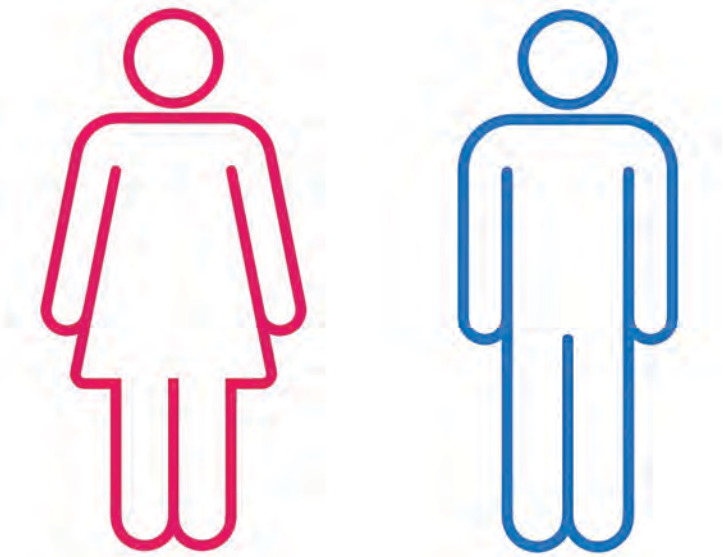
Are there multiple organisms with the same number of chromosomes? Find out.

Indicators

- Different types of chromosomes
- Somatic chromosomes and their functions
- Homologous chromosomes
- Sex chromosomes and their function

Prepare a table including the chromosome number of various organisms that are seen in your surroundings and display it in class.

Pay attention to the given genetic constitution of a female and a male and complete table 1.1. Analyse the information in the table and draw inferences of chromosomal similarities and differences between a female and a male.



44 + XX

44 + XY

	Genetic constitution	Total Number of chromosomes	Number of somatic chromosomes	Number and type of sex chromosomes
Female				
Male				

Table 1.1 Human Chromosomes

Different genetic constitutions

Though, 44+XX and 44+XY are considered as normal genetic constitutions, many different kinds of genetic constitutions are seen in humans. These variant genetic constitutions influence the physical and mental development of the individuals. Gender determination is a complex process which not only depends upon genetic constitution, but also on other factors. Some examples for variant genetic constitutions:

- 44+X0: Females with only one X chromosome. They have the condition called Turner syndrome.
- 44+XXX: Females with three X chromosomes. They have triple-X syndrome.
- 44+XXY: Males with two X chromosomes and one Y chromosome. They have Klinefelter syndrome.
- 44+XYY: Males with one X chromosome and two Y chromosomes. They have XYY syndrome.

Gender determination may become complex in individuals with these genetic constitutions mentioned above. For example, females with Turner syndrome may have female sex organs. However, they may not develop female sexual characteristics at the beginning of their adolescence. Males with Klinefelter syndrome may have male sex organs, but they may also exhibit female characteristics.

The Y chromosome of the father is important in sex determination. Why? Find out.

You have understood that genes provide instructions as to how our body should function. Where are these genes found? How do they perform? Analyse illustration 1.5, their description and prepare notes out of it.

Gene

Gene is a specific sequence of nucleotides in DNA. Proteins, which are synthesised according to the instructions of genes, are responsible for the formation of characteristic features and for controlling metabolic activities.

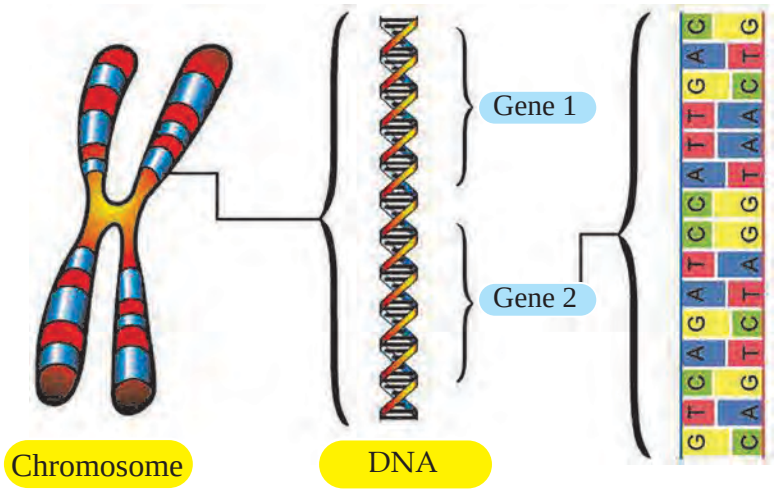


Illustration 1.5 Genes

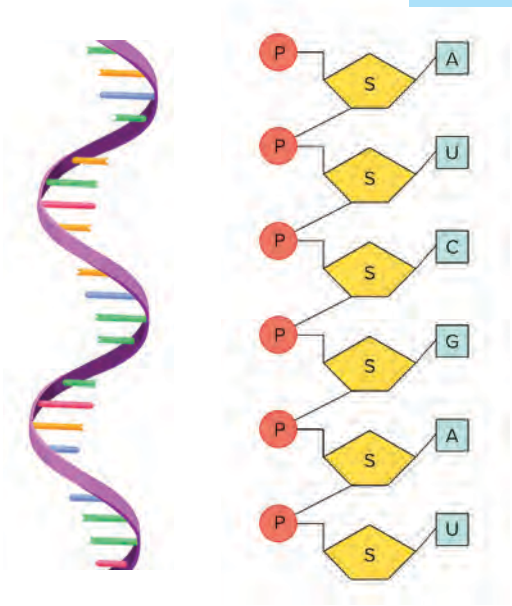


Illustration 1.6 Structure of RNA

The nucleic acid RNA also plays a crucial role in the synthesis of proteins.

Analyse illustration 1.6 and the description to understand the structure and characteristic features of RNA.

RNA (Ribonucleic acid)

RNA is another type of nucleic acid, similar to DNA. They are also made up of nucleotides. Each of the nucleotide contains a ribose sugar, a phosphate group, and a nitrogenous base. The nitrogen bases in RNA are Adenine, Guanine, Uracil, and Cytosine. Most of the RNAs have a single strand.

Didn't you understand the structure of RNA? Compare this with the structure of DNA and complete the table 1.2.

	Number of strands	Type of sugar molecule	Nitrogen bases
DNA			
RNA			

Table 1.2 DNA, RNA Comparison

Protein Synthesis

Have you understood that the proteins are synthesised as a result of the action of genes? Prepare a note on various stages of protein synthesis by analysing the illustration 1.7 and the description based on the indicators.

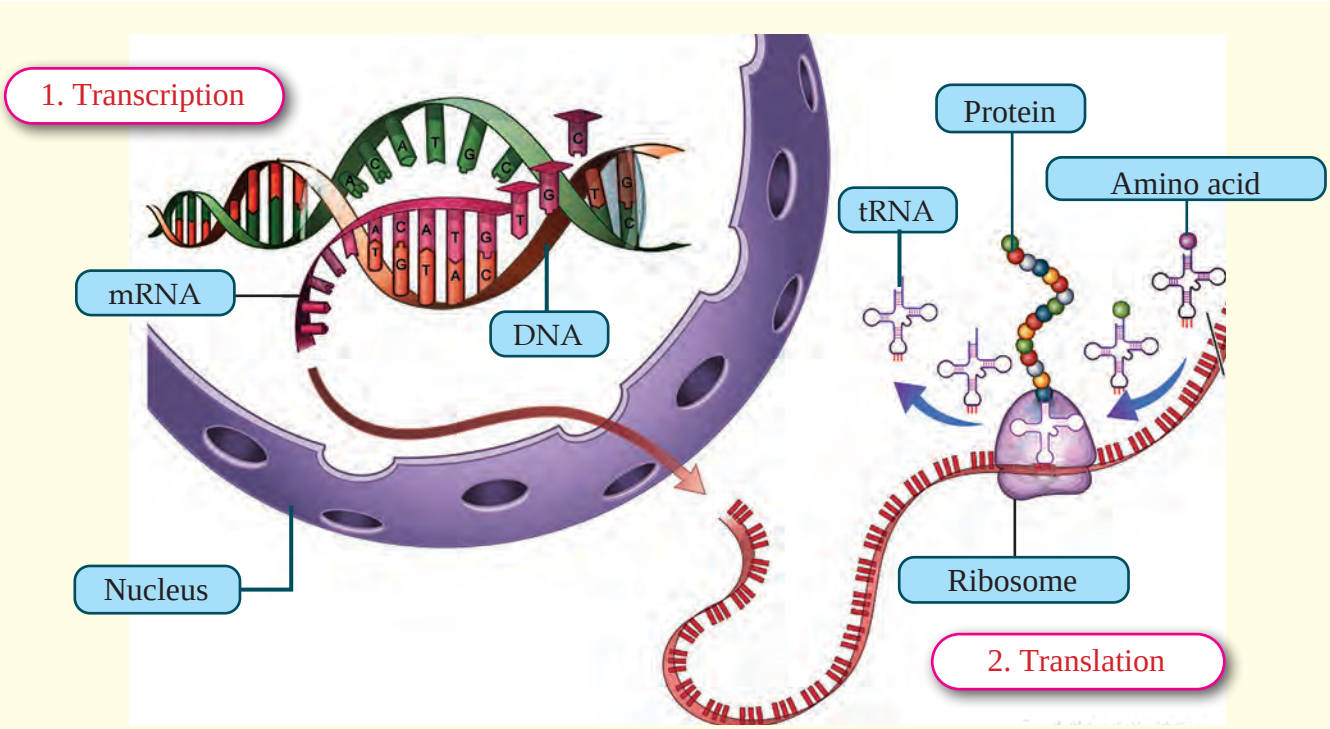


Illustration 1.7 Protein Synthesis

1. Transcription

mRNA is formed from a specific nucleotide sequence (gene) in DNA with the help of various enzymes. The mRNA contains messages for protein synthesis.

2. Translation

tRNAs (transfer RNA) carry specific amino acids to the ribosome based on message in the mRNA that has reached the ribosome from the nucleus. The rRNAs (ribosomal RNA), which are part of ribosomes combine amino acids to make protein.

Indicators

- Stages of Protein Synthesis
- Processes take place in the nucleus
- Processes take place in the cytoplasm

Prepare a flow chart that shows the various stages of protein synthesis and display it in the classroom.

Various RNAs involved in protein synthesis are given in the illustration 1.8. Complete it by including their name and function.

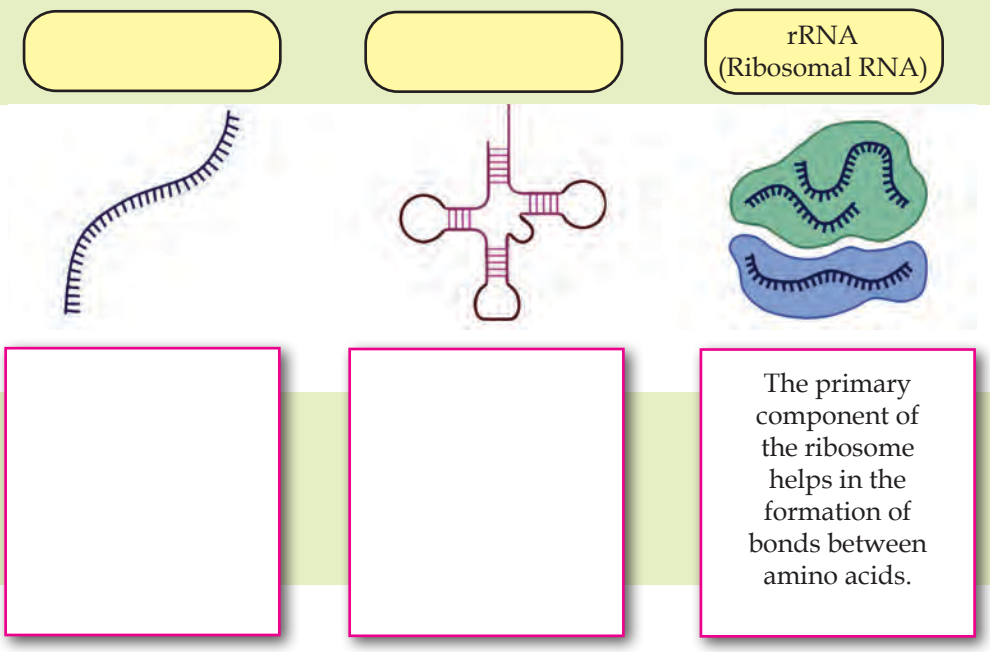


Illustration 1.8 Different types of RNAs

To understand how proteins, which are synthesised according to the direction of genes, influence the characteristic features of organisms, observe the pictures given and find out the similarities and differences between parents and offsprings.

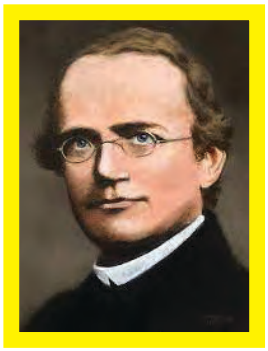
Similarities and Differences in Characters

Some characteristics of parents are also found in their children. Isn't it also common to see certain characters in children which differ from their parents?

Heredity refers to the transmission of characteristics from parents to their offspring. Variations are characters expressed in offspring, that differ from their parents. Genes inherited from parents are responsible for both heredity and variations.

The historical path that led science to the discovery of genes is pivotal. Analyse the given description to get a deeper understanding.

Mendel Museum of Masaryk University in Brno



Gregor Johann Mendel
1822-1884

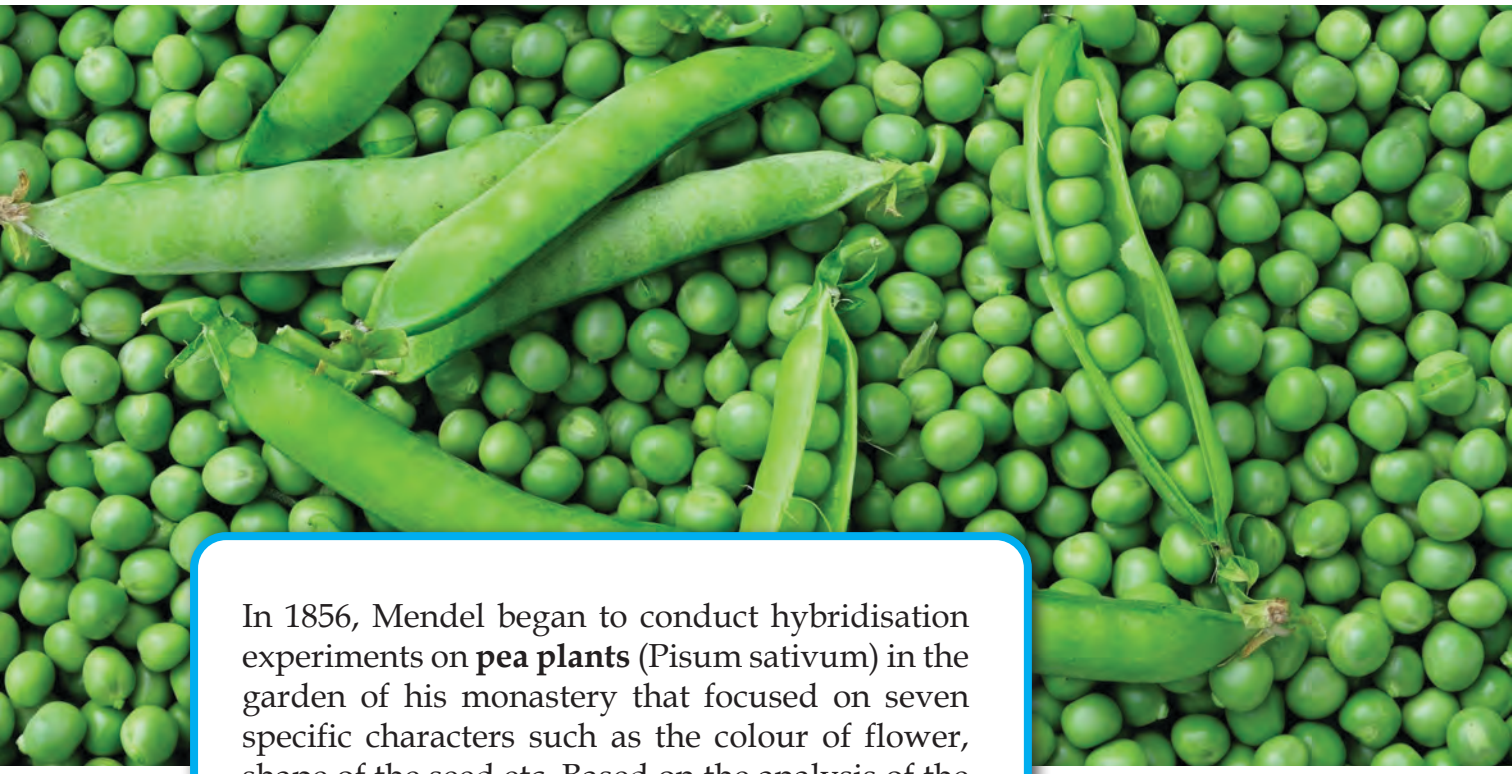
Genetics in the Garden

Genetics is the branch of science that deals with genes, heredity, and variation. Gregor Johann Mendel's experiments on pea plants (Pisum sativum) and the conclusions he drew out of hybridisation experiments laid the foundation for the field of genetics. Therefore, he is considered as the father of genetics.

Know the scientists

Gregor Johann Mendel

Gregor Johann Mendel was born on 20 July, 1822, at Hyncice a small village of Northern Moravia, which is now known as Czech Republic. After joining the Augustinian monastery at Brno, he became a priest in 1847. Between 1851 and 1853, he attended the University of Vienna where he studied Physics, Mathematics, and Natural sciences, and learned statistical methods to analyse data scientifically.



In 1856, Mendel began to conduct hybridisation experiments on **pea plants** (Pisum sativum) in the garden of his monastery that focused on seven specific characters such as the colour of flower, shape of the seed etc. Based on the analysis of the experimental result, he explained that a pair of factors controls each character and represented those factors using symbols. These factors are now known to be genes. Gregor Mendel's conclusions are known as the **Laws of Inheritance**. These laws provide the fundamental genetic framework to understand heredity and variation.

In 1865, he presented his findings in the Natural History Society at Brno. The following year, he published a thesis titled 'Experiments on Plant Hybridisation.' However, the scientific community of that time largely ignored Mendel's discoveries. Gregor Mendel passed away in 1884.

In 1900, sixteen years after his death, botanists Hugo de Vries, Carl Correns, and Erich von Tschermak recognised the significance of Mendel's research. With this, Mendel's findings were accepted as the foundation of the science of genetics. Genetics has grown into the most extensive branch of science through numerous contributions of various scientists.

Hugo de Vries

Carl Correns

Erich Von Tschermak

Mendel's Experiments

Mendel initially conducted hybridisation experiments by considering a single pair of contrasting traits. This is known as a monohybrid cross. The hybridisation experiment conducted considering the trait of the height is depicted in the illustration 1.9. Analyse it based on the indicators, and form inferences.

Parental plants

Tall

X

Dwarf

Tall

First generation (F_1)

He hypothesised that there must be certain factors within the seed that control traits. To find out what might have happened to the factor responsible for dwarfness, he self-pollinated the plants obtained in the first generation to produce a second generation of plants.

Second generation (F_2)

1064 plants

787 Tall

277 Dwarf

The ratio between the traits is approximately 3:1

Illustration 1.9 Monohybrid Cross

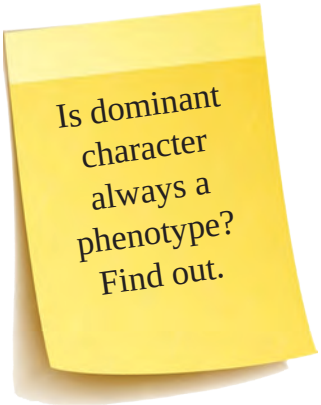
Indicators

- The characters considered and their traits
- Dominant and recessive traits in the first generation
- Importance of self-pollination
- Traits in the second generation

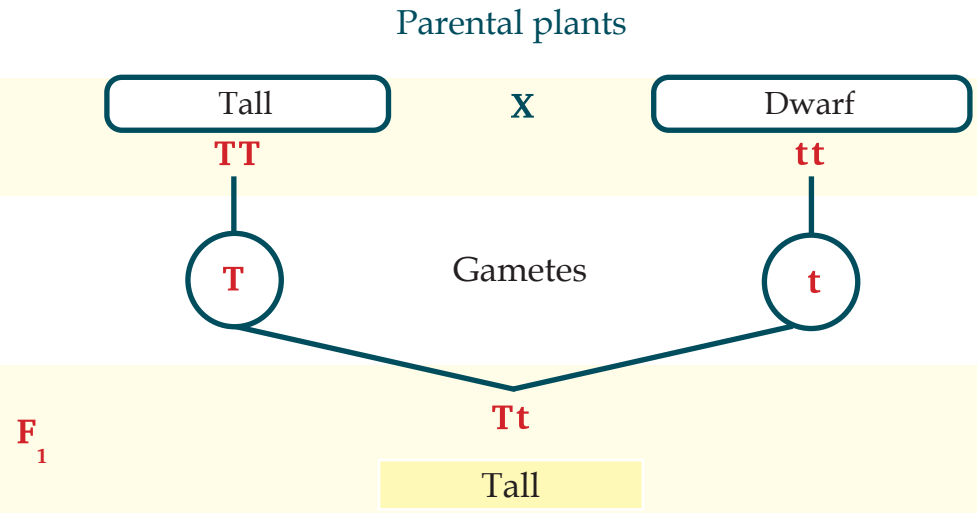
While conducting hybridisation experiments based on the contrasting traits of six other characteristics in pea plants, Mendel obtained results similar to the first experiment.

Factors

Gregor Mendel hypothesised that characters from parents are passed on to offsprings through certain factors that are transmitted through gametes. It was only after Mendel's period that, these factors were discovered to be genes that are located in chromosomes in the nucleus. A gene that determines a character can have different forms. These different forms of genes are called alleles. A gene usually has two alleles. The hybridisation experiment shown in illustration 1.9, the different alleles that determine the character of height are represented by ***T*** and ***t***. The allele ***T*** represents tall and the allele ***t*** represents dwarf. The observable characteristics of an organism are called phenotype, and the genetic constitution responsible for these characteristics are called genotype.



Observe the illustration 1.10 of the hybridisation experiment where the factors controlling the traits are represented using symbols. Complete the illustration, discuss and prepare notes based on the indicators.



Self pollination of the first generation

Tt X Tt

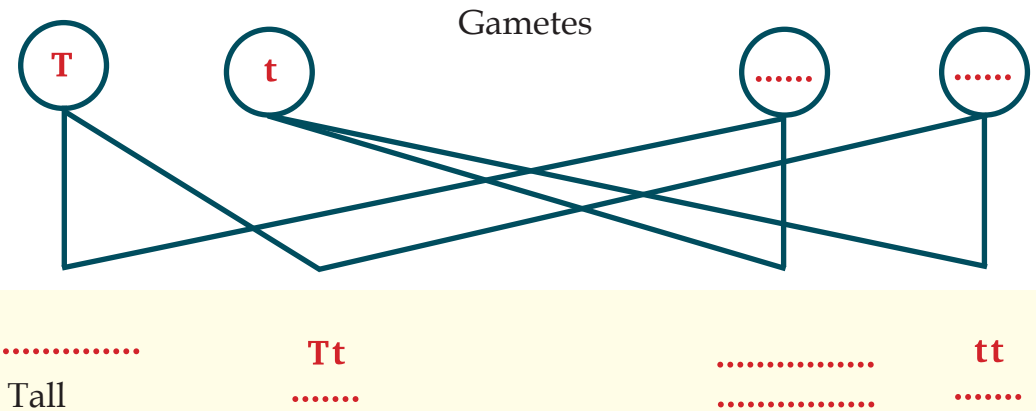


Illustration 1.10 Monohybrid cross

Indicators

- Phenotype and genotype of the parental plants
- Phenotype and genotype of first generation plants
- Genotype of the tall parental plant and the first generation plant
- Ratio of the traits in the second generation

The following are the inferences drawn by Gregor Mendel from monohybrid cross. Analyse them and answer the questions given below.

Mendel's Postulates

- A trait is controlled by two factors.
- When a pair of contrasting traits is subjected to hybridisation, only one of the contrasting traits is expressed in the offspring of the first generation and the other remains hidden. The trait that appears in the first generation is called dominant trait and the hidden trait is called recessive trait. The trait hidden in the first generation reappears in the second generation.
- When gametes are formed, the factors that determine trait gets separated without mixing.
- The ratio of dominant to recessive traits in the offspring of the second generation is 3:1.

? Why was a plant with intermediate height not formed by the combination of tall and dwarf?

? Hasn't the character that is not expressed in the first generation appeared in the second generation? How would that be?

In the next stage, he observed the inheritance of two pairs of contrasting traits of the same plant. This is known as dihybrid cross. Analyse the illustration 1.11 of hybridisation experiment conducted by considering height of the plant and shape of the seed based on the given indicators, and note down your inferences.

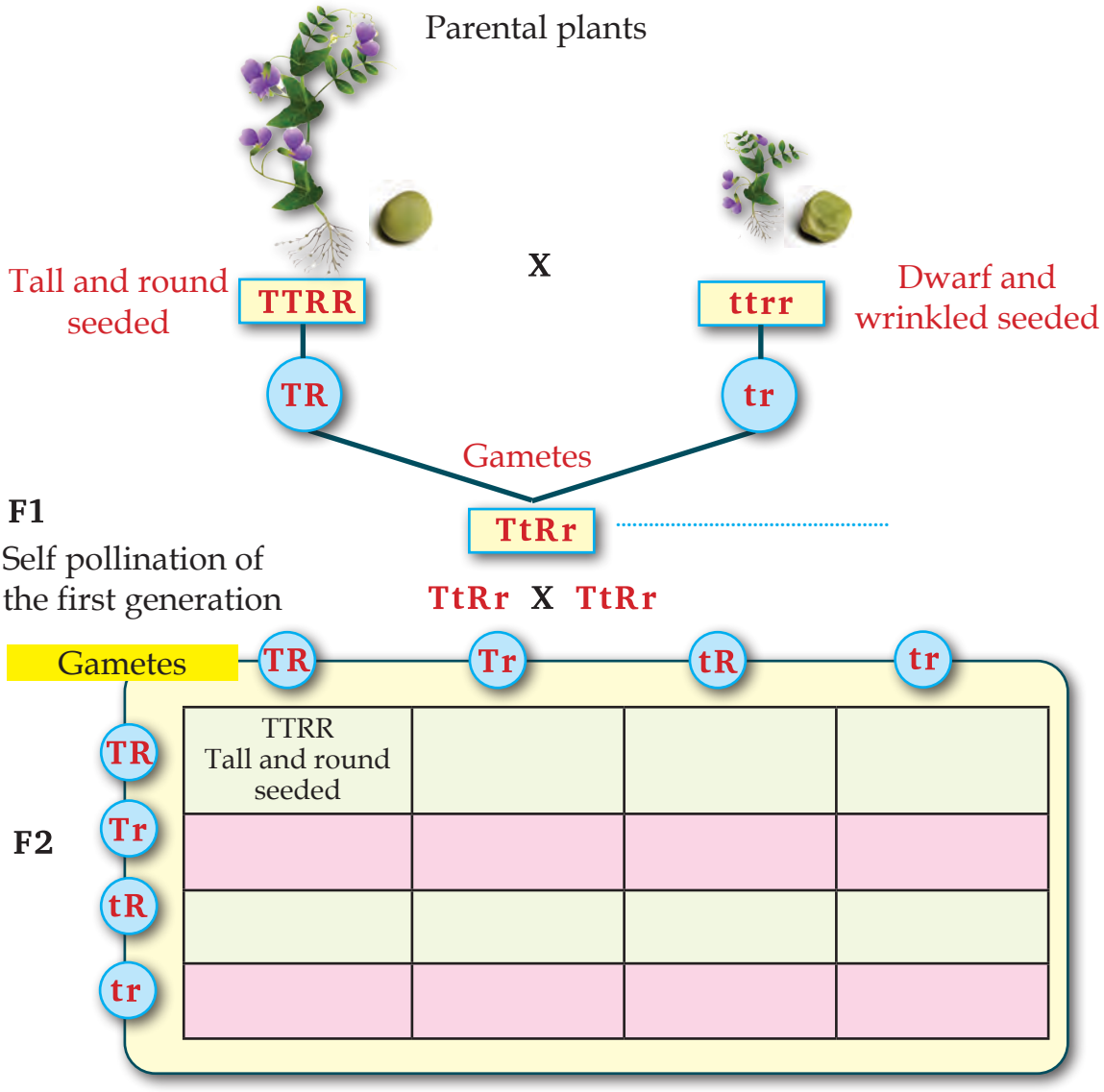


Illustration 1.11 Dihybrid cross

Indicators

- Characters considered and their contrasting traits
- Phenotype and genotype of the parental plants
- Dominant and recessive traits of the first generation
- Alleles of the gametes produced by the first generation
- Phenotype of the plants in the second generation
- Phenotypes observed in the second generation that differed in contrast to the parental plants and their genotypes
- Phenotypic ratio of the second generation

The inference that Mendel drew from this experiment is given below. Analyse it and find out the answer to the given question.

Mendel's Postulates:

When two or more different traits are combined, each trait is inherited independently to the next generation without mixing each other. (A pair of alleles in an organism does not influence the separation of another pair of alleles.)

? Characters that are not found in the parent plants are found in the second generation. Why?

Don't you notice the child's doubt when she observed the flowers? What is your opinion?

Mendel's laws were the foundation of genetics. However, it could not fully explain the diversity of traits observed in organisms. Later studies about the complex interaction among genes, environment and other factors revealed some of the limitations of Mendel's laws. This gave rise to the concept of Non-Mendelian Inheritance.

Analyse various situations given below and find out how they differ from Mendel's hypothesis and then answer the child's doubt.

Non Mendelian Inheritance

If a red flowered four o'clock plant is hybridised with a white flowered plant, the resulting offspring will have pink flowers.

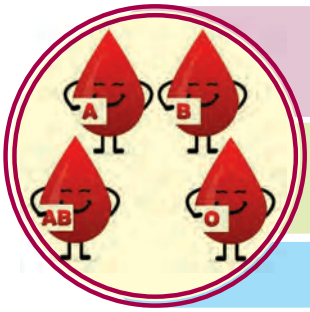
A dominant allele cannot fully hide the allele of the recessive trait.

Incomplete Dominance

Roan coat pattern, found on some cattle and horses

Both alleles exhibit their traits at the same time.

Co-dominance



ABO blood group in humans

The gene that determines blood group in human beings has more than two alleles. Three alleles IA, IB and i determine the blood group.

Multiple allelism

Difference in skin colour

More than one gene controls the colour of the skin. The action of these genes cause variation in the production of melanin that causes difference in skin colour.

Polygenic inheritance

Peculiarity *Reason* *Name of the inheritance*

Table 1.3 Non Mendelian Inheritance

Explore more situations and examples of Non Mendelian Inheritances and present in the class.

Behind the colour difference

Melanin is the primary pigment that gives colour to skin. The amount and type of melanin determine the colour of the skin. The geographical region from where an individual's ancestors emerged is a major factor that influences skin colour. As the intensity of sunlight varies in different geographical regions, genetic variations suitable for the skin colour of each region have occurred. Environmental factors such as sunlight, diet, and vitamin D also influence skin colour. The human race is genetically diverse, and skin colour is only one aspect of this diversity.

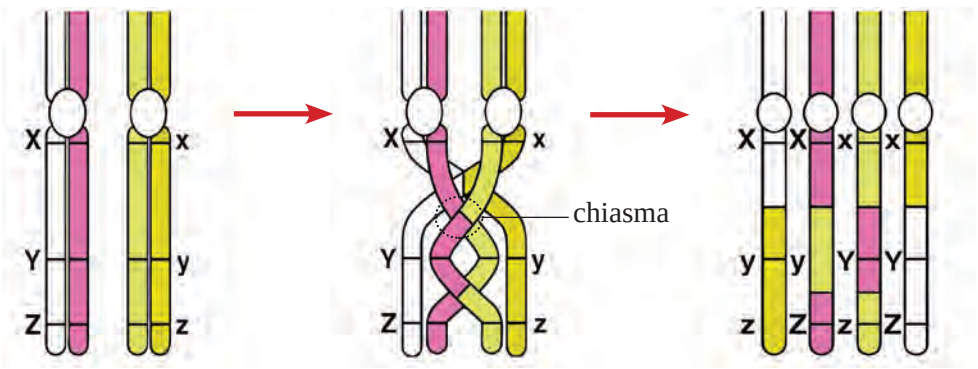
Haven't you noticed the child's doubt?

The characteristics the offspring receives from parents may not always be the same. The chief genetic processes which are responsible for this diversity among individuals are given below. Analyse them and find out the answer to the child's doubt.

Genetic processes responsible for variations

Crossing over

Meiosis is the type of cell division that is responsible for the formation of gametes. Analyse the illustration 1.12 to gain an understanding about the process of crossing over, which occurs during the first phase of meiosis.



Pairing of homologous chromosomes (Identical chromosomes inherited from the parents of an organism)

The point of contact of the paired chromosomes is called **chiasma**. The chromatids break at this region and the broken segments are exchanged with each other.

This exchange causes a recombination of alleles. This leads to the appearance of new traits in the offspring.

Illustration 1.12 Crossing over

Indicators

- Phase in which crossing over occurs
- Process of crossing over
- Role of crossing over in the formation of variations

Mutation

Mutation is the sudden heritable change in the genetic constitution of an organism.

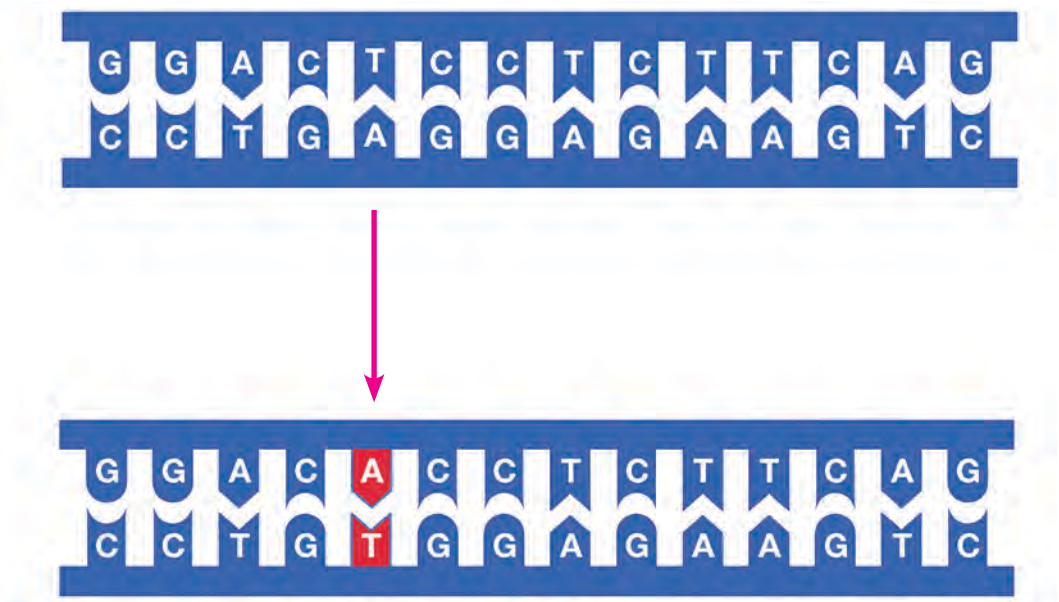


Illustration 1.13 Mutation

Mutations can be caused by errors during DNA replication, exposure to certain chemicals, radiations, etc. Mutation causes changes in genes. These genes are transferred through generations which leads to variations in characters. Mutations play a crucial role in the process of evolution.

Indicators

- Mutation
- Reasons for mutation
- Importance of mutation

Haven't you understood that recombination of alleles during fertilisation, crossing over, mutation, etc. causes variations in organisms?

Collect more information on the processes that cause variations and prepare a slide presentation.

Genetics- Career Opportunities

Genetics is a broad field with various branches, that includes molecular genetics, population genetics, medical genetics, cytogenetics, behavioural genetics, and genomics.

Graduate programmes in genetics and related fields such as biotechnology, microbiology, bioinformatics etc. open doors to a wide range of career opportunities. At the postgraduate level specialised studies in genetic counselling, genomics, medical genetics, and forensic science provide opportunities in healthcare, research, and education. Advanced degrees such as a Ph.D in Genetics equip students for careers in cutting-edge research, pharmaceuticals, agriculture, and other industries. The world of genetics is so vast that it offers endless opportunities for new discoveries and research. For those who are curious about the mysteries of life, genetics is a scientific field that offers more possibilities to explore more domains.

Genetics is the branch of science that unravels the mysteries of life. Genetics provides an understanding about how genes function and how they get transmitted from one generation to the next. Advances in this field have led to significant developments in genetic engineering. We have covered certain steps that lead to the answer to the child's doubt regarding gene editing. We will be able to get a complete answer as we go through the upcoming chapters.

Discoveries in genetics help us to understand and explain how evolution takes place. The combination of various genetic processes determines the characteristics of an organism. These processes are fundamental to the diversity and evolution of life. We will understand how it is, in the next chapter.

Let us Assess

1. Are basic building blocks of DNA and RNA the same? Explain.
2. Analyse the statements and choose the appropriate one.
   i. F_1 has similarity with both the parents.
   ii F_1 has no similarity with any of the parents' character intermediate to them.
   iii F_1 has similarity with one of the parents
      a) i - Dominance, ii - Incomplete dominance, iii - Co-dominance
      b) i - Incomplete dominance, ii - Dominance, iii - Co-dominance
      c) i - Co-dominance, ii - Incomplete dominance, iii - Dominance
      d) i - Dominance, ii - Co-dominance, iii - Incomplete dominance
3. Which of the following is contributed by organisms that reproduce sexually, to their offspring?
   a) All genes
   b) Half of their genes
   c) One fourth of their genes
   d) Double the number of genes
4. A tall pea plant with purple flowers (dominant character) is crossed with a dwarf plant with white flowers.
   a) Illustrate the dihybrid cross of these and write the F_2 ratio.
   b) Did characters that differ from the parents appear in the F_2 generation? Why?
   c) If both the genes are not assorting independently, how does it affect the F_2 ratio?
5. How does dominance, co-dominance and incomplete dominance differ from one another?
6. Different phenotypic ratios are obtained in monohybrid and dihybrid cross. Why? What does it indicate about the inheritance of characters?
7. Even though a gene responsible for certain characters has more than two alleles, why does that particular gene have only two alleles in an individual ?

8. Although the DNA possesses all genetic information for protein synthesis, RNA is also required for protein synthesis. Why?
9. How do co-dominance and multiple allelism function in the determination of blood group in the ABO blood grouping in human beings? Explain.
10. All ova formed in females contain one type of sex determining chromosome. Why?

Extended activities

1. Present the process of transcription and translation in the class, using coloured beads or paper strips to indicate nucleotides.
2. Prepare and present a time-line animation in class that depicts the steps in the development of genetics.
3. Conduct Mendel's hybridisation experiment on pea plants using dices or beads to represent alleles.
4. Collect data and draw conclusion on how sex determination in various species takes place and the influence of environmental factors on it.
5. Discuss the scientific, social and cultural dimensions of skin colour variation.

2

Paths of Evolution

Case study

A young man who was admitted to hospital with severe cough and phlegm was diagnosed tuberculosis by the doctor after testing his chest X-ray and lung fluid. He was given several antibiotics for six weeks and further, a specific antibiotic for 33 weeks. Ten months after the beginning of treatment, a culture of the lung fluid and a chest X-ray were performed to confirm that the tuberculosis was cured, and the treatment was completed.

Two months later, the young man was again admitted to hospital with the same symptoms. Despite having treated with various antibiotics as done previously, he died due to breathing difficulty after 10 days. Further examination revealed that the disease got relapsed as the tuberculosis bacteria were activated again. To find out where these antibiotic-resistant bacteria came from, DNA of these bacteria was compared with the DNA of tuberculosis bacteria that had been collected and stored from the same patient. It was found that a mutation in a specific gene made the bacteria resistant to antibiotics. The mutated bacteria multiplied even in the presence of antibiotics and caused the disease.

You have just read the story happened in 1966 in connection with the discovery of bacteria that can resist antibiotics. Discuss and find out the answers to the given questions and prepare notes.

What was the treatment given initially to cure the disease? What was its result?

.....

Why didn't the disease get cured even after giving treatment for the second time?

.....

How did the tuberculosis bacteria acquire resistance to antibiotics?

.....

What will happen if this bacteria transmit this ability to their next generations?

Does the formation of such bacteria raise challenges in the field of medicine? Analyse the news given below and draft your opinion.

Antimicrobial resistance:
a growing global health issue

Doctors, public health professionals and scientists warn that some of the most trusted antibiotics currently used are ineffective against bacteria called 'superbugs'.

.....

Superbugs

Bacteria that are resistant to antibiotics multiply and cause, diseases. This resistance caused due to mutations can be transmitted to their next generation. Over time, the proportion of resistant bacteria increases and through many other mutations, they acquire ability to resist more than one antibiotic. This leads to the formation of multi-drug-resistant strains (superbugs). The formation of such bacteria has become a major concern in healthcare as common antibiotics turns ineffective against them.

Organisms adapt to or survive the changes in their environment. Behind the formation of today's biodiversity from the primitive cell, a number of such processes may have been involved. The inquiries related to such processes had laid the foundation for the science of evolution. Many scientists were able to explain those theoretically.

Lamarck
1744 - 1829

Lamarckism (Theory of Inheritance of Acquired Characters)

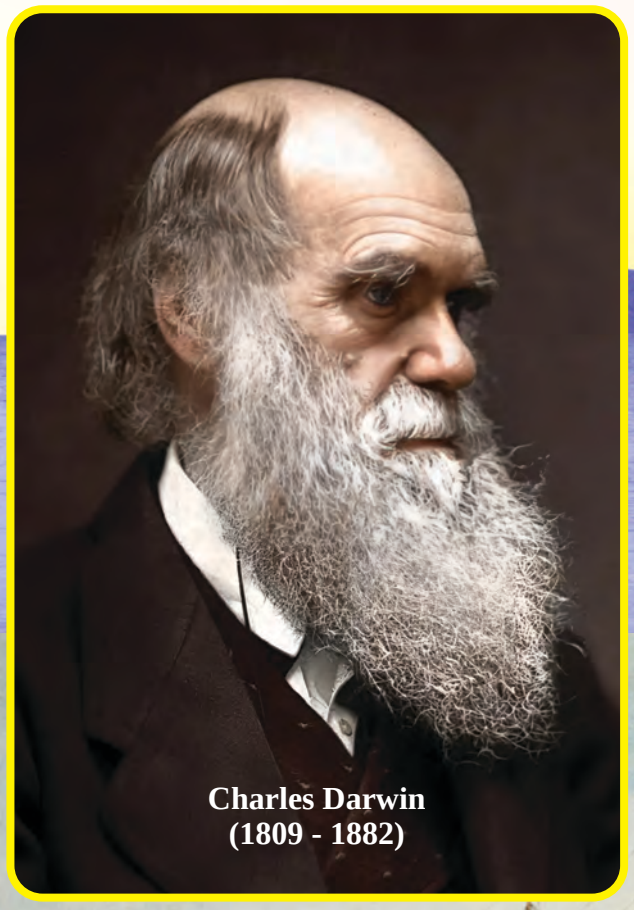
Jean Baptiste Lamarck was the French biologist who initiated early discussions related to biological evolution. His ideas are known as **Lamarckism.** Based on indicators, discuss and prepare notes on illustration 2.1 which substantiates the ideas put forward by him.

Illustration 2.1 Lamarckism

Indicators

- Change in environment
- Formation of acquired character
- Inheritance of acquired character
- Survival of giraffes with longer and shorter necks in a changed environment.

Later scientists proved that acquired characters do not impart change in the genetic structure of organisms and therefore, are not inherited.

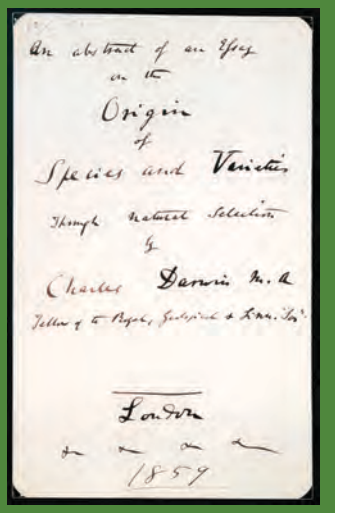


Charles Darwin
(1809 - 1882)

Darwinism
(The Theory of Natural Selection)

The English naturalist Charles Darwin's 'Theory of Natural Selection' or Darwinism marked the foundation for the perspectives of modern evolution.

H.M.S Beagle



Charles Robert Darwin

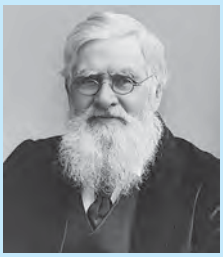
Know the scientist

Charles Darwin was born on 12 February, 1809, at Shrewsbury, England, into a family of well-educated background. Darwin had completed school education as an average student. However, he had shown intense interest in the study of nature. In 1831, at the age of 22, he embarked on a five-year voyage on the ship H M S Beagle for cartographical purpose. During this voyage, Darwin explored areas including South America, Australia, and the Galapagos islands. He had meticulously observed and documented the diversity of flora and fauna there. Returning to England in 1836, Darwin analysed the specimens and observations he had made and deeply studied them by correspondence with other scientists through letters.

Thomas Malthus, an English economist and demographer, argued that when the human population grows rapidly food production will not increase in accordance with that and it may lead to problems such as poverty, disease, and war. This perspective of Malthus had greatly influenced Darwin too.

While Darwin continued with his studies in 1858, he noticed the evolutionary studies of the British naturalist Alfred Russel Wallace. The papers of Darwin and Wallace were presented at a science conference. In 1859, he elaborated and presented his ideas in the book 'On the Origin of Species'. Although his observations were initially opposed by the society, as more and more evidences emerged, Darwin's theory of evolution gained widespread acceptance.

Thomas Malthus
1766 - 1834



Alfred Russel
Wallace
1823- 1913

Darwin's theory of evolution is one among the most influential scientific ideas in the world. It can be applied in fields such as medicine, agriculture, and environmental science, apart from biology.

Charles Darwin was influenced to formulate the theory of evolution by observing the diversity in the beaks of finches at Galapagos Islands. Analyse illustration 2.2 and prepare notes based on the indicators.

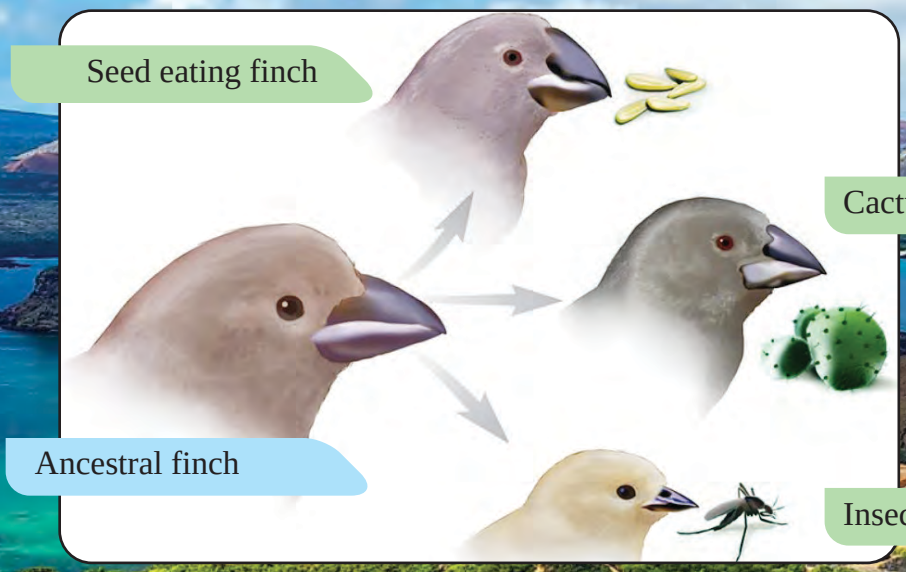


Illustration 2.2 Galapagos finches

There are about fourteen different species of finches in the Galapagos archipelago. Ground, cactus and tree finches are some among them. Of these, ground finches are seed eaters and ground dwellers whereas cactus finches inhabit on cactus and eat seeds. Tree finches which shelter in trees are insectivorous. The major difference these species exhibit is the shape and size of the beak. The beaks of medium-sized seed-eating finches are different from those of large seed-eating and insect-eating ones. The beaks are their main means to obtain food. Birds with beaks of suitable shape or size, depending on the availability of food resources in the environment, will survive and produce more offspring.

Indicators

- Diversity of finch's beak
- Cause of diversity
- The way in which diversity influences survival.

Haven't you understood that organisms with certain characteristics favourable to the environment tend to survive, reproduce and produce more offspring? Draw your conclusions by analysing Darwin's explanation on how these finches later got evolved into new species.

Over production

Organisms produce more offsprings than environment can support.

Variations

Organisms show differences from each other in most features such as the size, immunity and seed production. These variations can be favourable or harmful to the organisms.

Struggle for existence

Limitation of resources including food, shelter and mates will lead to competition among organisms.

Survival of the fittest

Organisms with favourable variations survive in the struggle for existence. They reproduce more effectively and create new generations.

Natural selection

Favourable variations are passed on to the next generations. More variations accumulate over time leading to the creation of organisms that are unable to reproduce within the species. They evolve as new species.

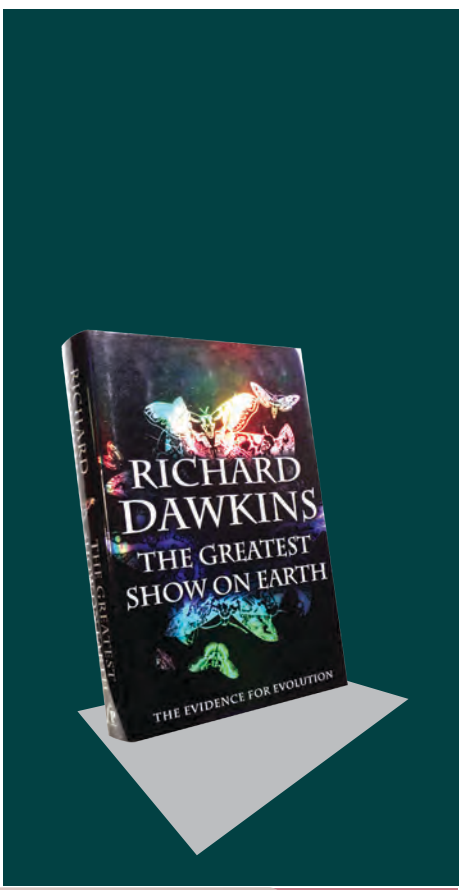
Let's find

A plant produces hundreds of seeds. However only a few among them attain complete maturity.

What would be the circumstances that might lead a new plant species to evolve from this plant after millions of years? Prepare notes based on the theory of natural selection.

The Greatest Show on Earth

Scientists Rosemary and Peter Grant conducted more studies from 1973 to 2012 based upon Darwin's finches at Galapagos Islands. They observed structural changes in the of finch's beak pertaining to its size, depth, and shape as a result of ecological stresses such as drought and changes in food availability. With the help of DNA sequencing technology, they identified BMP4 gene, that influences the depth of the beak and its strength as well as ALX7 gene that influences the shape of the beak. Over time, these genetic variations have led to the development of birds with distinctive beaks at Galapagos Islands, which has diverse ecological niches. This research direct through the studies of genetics, anatomy and molecular biology provided direct evidence for evolution.



Evolution is called the 'Greatest Show on Earth'. Organise a classroom exhibition by selecting books on evolution from school library and other sources.

How could the evolution of giraffes with long necks have happend? Observe the illustration 2.3, compare Lamarckism with Darwinism and prepare notes.

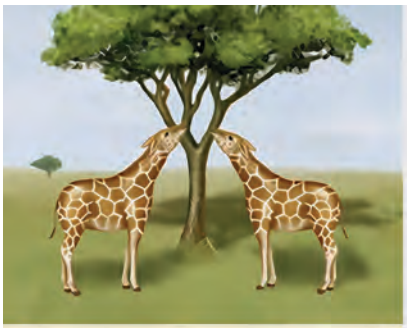
Lamarckism	Darwinism
	
Giraffes of earlier periods possessed short necks.	Giraffes with necks of varying length
	
Giraffes began to stretch their neck to obtain food.	Only the giraffes with longer necks survived in the competition for food
	
By continuous use giraffes with longer necks emerged	Only the giraffes with longer necks survived and become new species.
Environment causes variations in organisms	Environment selects the favourable variations in organisms

Illustration 2.3 Lamarckism – Darwinism comparison

Prepare and present classroom presentation on ' the comparative study between Lamarckism and Darwinism by collecting additional information and including more facts.

Was there any limitation to Darwin's theory related to the origin of species? Did these limitations pose any challenge to Darwinism? Analyse the following description and draw inferences.

Neo Darwinism

Darwin's theory of evolution has been subjected to criticism because Charles Darwin had no idea about the genetic basis of variations and inheritance. However, with the discoveries of Gregor Mendel and the concepts about chromosomes and genes, it was recognised that the causes of variations that lead to evolution were genetic changes, genetic recombination during sexual reproduction, and gene flow. Later Darwinism became uncritically rationalised as more evidences and further studies from the fields of population genetics, palaeontology, environmental science, etc. were added to Darwinism to form Neo Darwinism.

Many modern researches are being conducted, related to evolution. Evolutionary clinical medicine makes use of the ideas of evolution in healthcare. For example, it studies how bacteria or viruses evolve over time to become resistant to drugs. This can lead to the creation of new methods for treatment or the improvement of the existing ones. Personalised medicine is designed by looking at an individual's genes and family genetic history. DNA studies and artificial intelligence help doctors to understand about diseases and to find new ways to resist them.

Haven't you understood the concept of evolutionary tree? Based on illustration 2.4 and the description given below, analyse and draw inferences about how each species is formed.

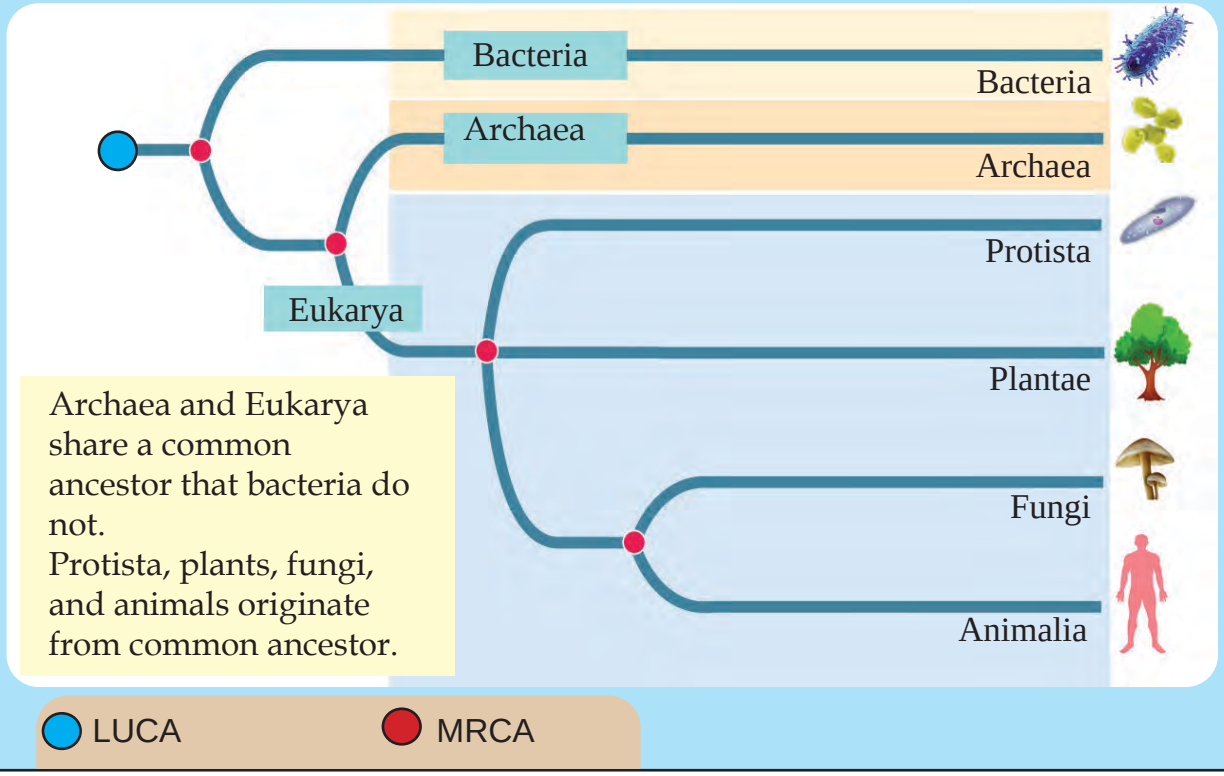


Illustration 2.4 Evolution of different categories of organisms

Biodiversity on earth originated through a process called speciation, in which new species arise from a common ancestor. It is thought that all species have descended from a Last Universal Common Ancestor (LUCA), and different species might have a Most Recent Common Ancestor (MRCA).

Speciation

Although members of a population can produce offspring with differences through reproduction, they remain as a single species.

↓

If the members of a population get isolated from each other by ecological or other factors (mutation, natural selection, genetic recombination etc.) several variations might accumulate over time.

↓

When the members of a species become unable to reproduce new offspring mutually, they will evolve into different species.

Indicators

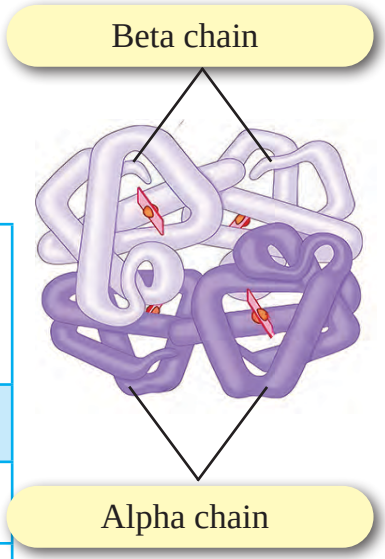
- Compare LUCA and MRCA?
- Which is the category of organism that is nearest to fungi? Why?
- What are the circumstances that lead to the formation of variations in organisms?
- How do these circumstances lead to the formation of species?

Evidences of Evolution

The evidences that support the theory of evolution are overwhelming. Studies ranging from the comparative study of biomolecules to the distribution of organisms on earth help us to understand the interrelationship among organisms.

Molecular Biology

The evolutionary relationship of organisms can be found out by comparing the sequence of nucleotides in the DNA and the sequence of amino acids in proteins in an organism with those of other organisms. You know that globin is the protein molecule of the respiratory pigment haemoglobin. The The arrangement of amino acids in the beta chain of haemoglobin molecule in humans as compared to other organisms is given in table 2.1. Analyse it and draw inferences based on the indicators.



Organism	Difference in the amino acids of the beta chain as compared to humans
Chimpanzee	0
Gorilla	1
Rat	31

Table 2.1 Evidence given by molecular biology

Indicators

- Which organism has the most evolutionary relationship with humans? Why?
- Which organism has a distant evolutionary relationship with humans? Why?
- How does molecular biology help to find out the evolutionary relationship among organisms?

The similarities and differences at the molecular level along with the knowledge obtained from comparative anatomy and palaeontology are correlated to depict the evolutionary tree. This is the most modern tool to understand evolutionary history.

Let's Find

Analyse the given illustration 2.5 and draft your inferences from the comparative study of DNA.

The percentage of matching of the chimpanzee's DNA sequences with the DNA sequences of other organisms.

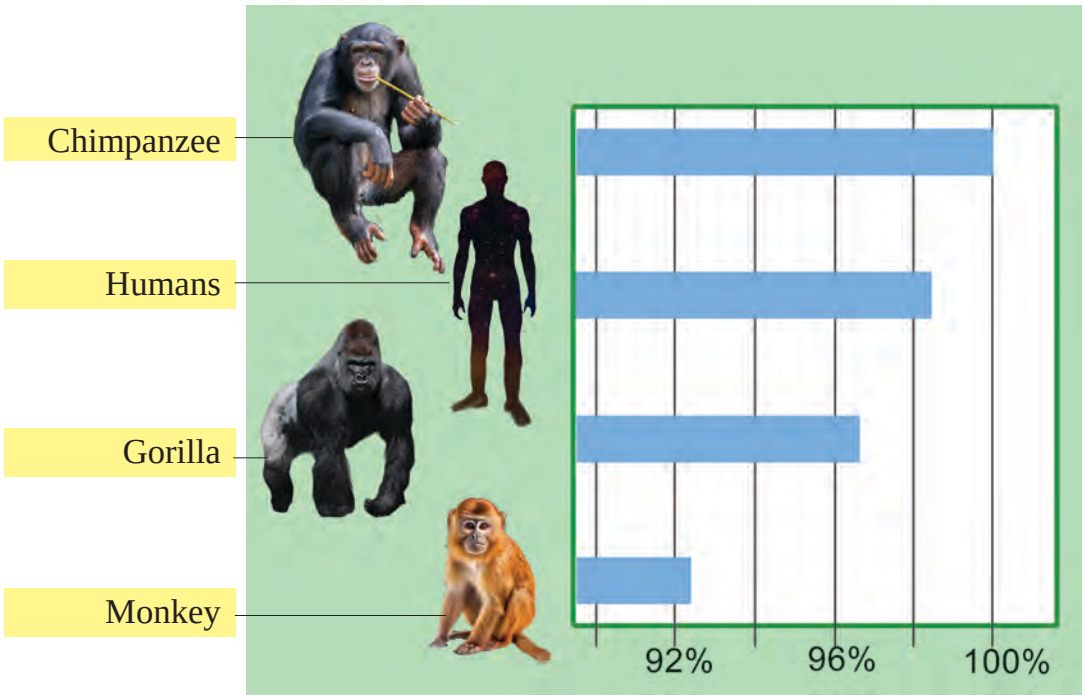


Illustration 2.5 Comparison of DNA sequences

Comparative Anatomy

The comparative study of anatomy of organisms provide strong evidences to evolution.

Analyse the illustration 2.6 and description, given below, prepare notes on how the similarities in the internal structure of different organisms validate the process of evolution.

The bones in the forelimbs of humans and cats, the flippers of whales and the wings of bats are similar. But, these organs differ in their external structure and function.

Illustration 2.6 Anatomy and evolutionary relationship

Fossil Evidences

Fossils are the remains or traces of ancient organisms. Analyse the following illustration 2.7 and prepare a note on how fossils help to understand evolution of life.

Organic evolution is a gradual process.
Eg: The ancestors of horses had shorter legs than the ones in out times.

Fossils which are connecting links reveal the evolutionary relationship between organisms.
e.g.: Archaeopteryx that possesses the characteristic features of both reptiles and birds

It is proven that many species have become extinct that were living on Earth in the past.
e.g.: Dinosaurs, Mammoths

Illustration 2.7 Evidences given by fossils

Evolution – A continuous process

In most of the viruses, RNA is the genetic material. RNA viruses evolve rapidly because RNA has more possibility to undergo mutations than DNA. Mutations play a crucial role in the evolution of the viruses. Certain mutations allow the virus to overcome their host immune system or resist antiviral drugs. They enable the viruses to utilise host cell more effectively and proliferate. Such mutations result in new variants of the virus, promoting their spread through natural selection. The Delta COVID virus spread rapidly because of the mutations that gave it the ability to infect cells. Mutations in Omicron's spike protein have effected them to overcome vaccines and immunity.

Find more evidences that validate evolution, prepare and present a classroom presentation.

Listen to the conversation of children.

Human evolution is a prolonged process that continues for a very long time. What could have been the changes that have happened to humans during this period?

The common ancestors of mammals such as monkeys, apes, and humans belonged to the group of primates. What are the common characteristics of primates?

- A thumb that can be opposed to other fingers
- Binocular vision
-
-
-

Which are the organisms included in the human evolutionary tree?

Observe the illustration 2.8 and based on the indicators, conduct a discussion and draw inferences.

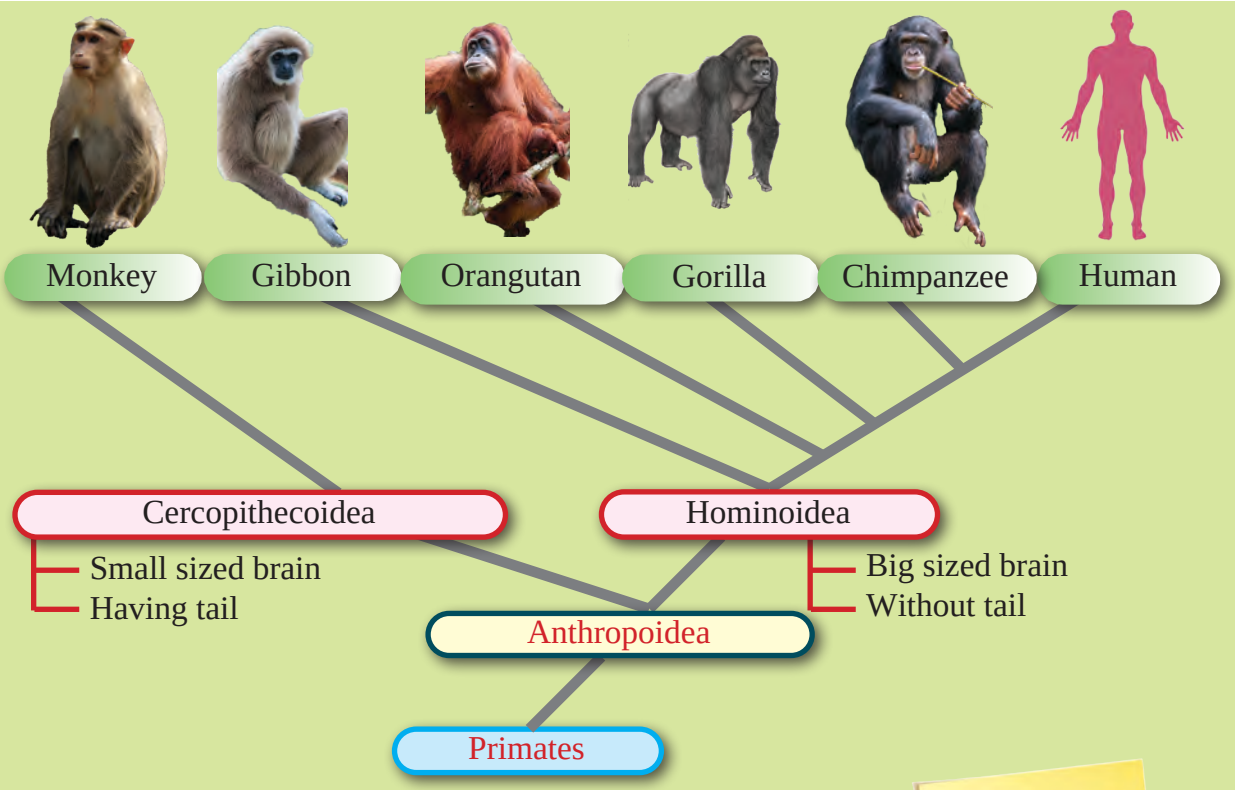


Illustration 2.8 Human Evolutionary tree

Indicators

- Two categories of Anthropoidea
- Common category including apes and humans

Did humans evolve from monkeys? Find out.

Find out the closest organism to humans in the evolutionary point of view. Identify and write down the reason.

Make a self evaluation of the validity of your findings based on the evidences provided by the comparative study of biomolecules of the organisms given in Table 2.1

You have understood that fossils play a vital role in disclosing the history evolution. The scientific world has succeeded in explaining the history of human evolution based on the available fossils.

There may be other organisms also in the human evolutionary path from the MRCA which connects chimpanzees and human beings.

Analyse the given description and complete the table 2.2.

		Cranial capacity
	**Sahelanthropus tchadensis** The first link in the human evolutionary series. Fossils have been excavated from Tchad in Africa.	350 cm^3
	**Astralopethecus** Almost complete fossils of organisms belonging to this group have been obtained from Africa. The skeletal structure confirms bipedalism.	450 cm^3
	**Homo habilis** Fossils are obtained from Africa. Large skull. Made tools with stones using hands. Lived in small groups. Began hunting.	600 cm^3
	**Homo erectus** Fossils are obtained from Africa, Asia and Europe. They were able to walk upright on two legs. Large forehead, omnivores, used excellent stone weapons for hunting.	900 cm^3

Homo neanderthalensis

1450 cm^3

Contemporaries of modern man. Fossils have been found from Germany. They had small, sloping forehead and thick eye brows. They buried dead bodies.

Homo sapiens

1350 cm^3

Modern man. They acquired technology and agricultural methods. They domesticated animals and built cities. They are culturally the most evolved category.

Humans	Cranial capacity	Characteristics
Sahelanthropus tchadensis		
Astralopethecus		
Homo habilis		
Homo erectus		
Homo neanderthalensis		
Homo sapiens		

Table 2.2 Members in the human evolutionary path

What is the evolutionary trend in the development of human cranial capacity?

.....

.....

What influence does brain development have in human evolution? Discuss and draw conclusions based on the information given below.

Neanderthals and modern man

Both Neanderthals and modern man possess a common ancestor. They had been inhabiting together for thousands of years and have exchanged genes with each other. Genetic evidences suggest that non-African modern man contains nearly 1-2% of Neanderthal DNA. Cranial capacity of Neanderthal man was slightly larger than that of modern man. Their brain structure was more suitable for vision and body control. But, the brain of modern man is helpful for social interaction and complex thinking. Neanderthals got extinct 40,000 years ago.

In the last 3 to 4 million years, increase in the brain capacity is a major trend in human evolution. The size of the brain nearly trippled over the course of two million years.This gave complex social behaviour, to make tools, to use language, and to perform higher-level cognitive functions. The increase in cranial capacity has also helped man to adapt to changing environments, develop culture and to use advanced technologies. Brain development laid the foundation for the transition from 'small-brained' ancestors to Homo sapiens.

Understanding the nervous system, which includes the brain and related parts, can help us gain more evolutionary insights.

Human Nervous system

You know that the nervous system plays a major role in controlling and coordinating the vital functions of the body. The nervous system consists of the brain, spinal cord, nerves and receptors.

Neurons

Nerve cells or Neurons are the basic building blocks of the nervous system. They are specialised cells which are capable of receiving stimuli from the surroundings and to form suitable messages. Based on the description given, analyse the illustration 2.9, make notes on the structure of the neuron and illustrate a flow chart, showing the path of messages through it.

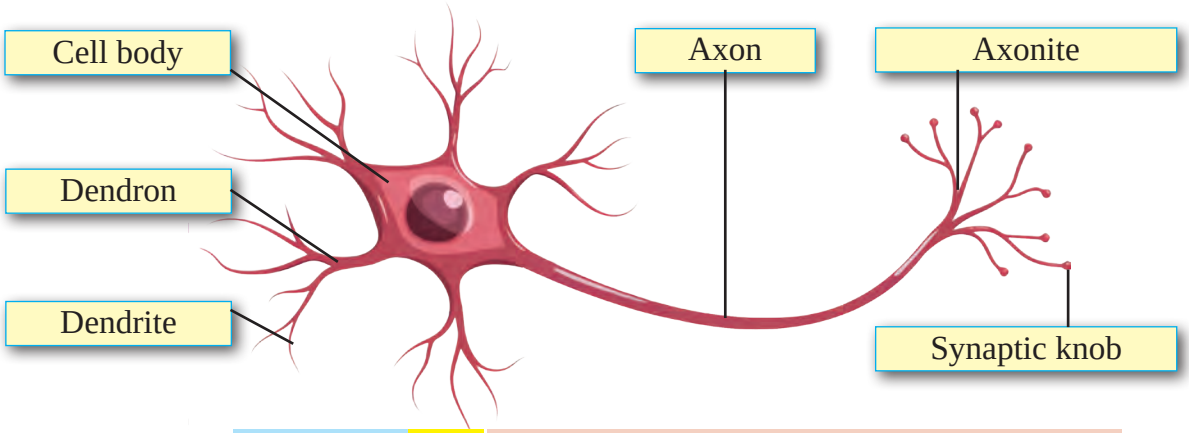


Illustration 2.9 Structure of neuron

Cell body or cyton is the centre of the neuron. Cell membrane, cytoplasm, nucleus and cell organelles are seen here. The fine fibres arising from the cell body are called dendrons. Their branches are called Dendrites. The messages received by the dendrites from the adjacent neurons are transmitted to cyton through the dendrons.

The longest fibre from the cell body is called Axon. Its branches are called Axonites. The impulses from the cell body reach the axonites through axons. The knob like structure seen at the tip of the axonite is called Synaptic knob. It contains the neurotransmitter (e.g.: Acetylcholine) to transfer chemical messages to its adjacent neuron.

Find more examples for neuro transmitters.

Are there only nerve cells in the nervous system?

Observe figure 2.1 and description given below and prepare notes.

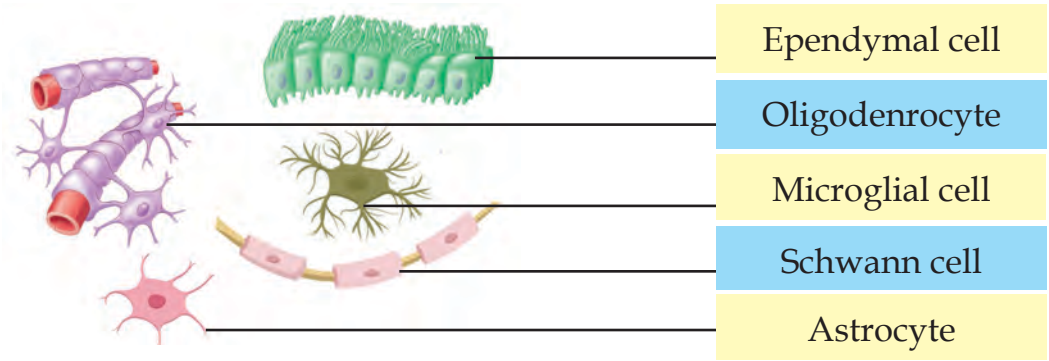


Figure 2.1 Cells in the nervous system

Neuroglial cells

More than half of the brain and spinal cord are the cells which are shown in figure 2.1. They are neuroglial cells. These cells which have the ability to divide cannot receive stimuli or transmit messages. The different functions of neuroglial cells are given below. Add more functions of neuroglial cells, including the information you will get as you learn the upcoming topics.

- Bring nutrition necessary for neurons
- Eliminate wastes
- Act as defence cells
-

Find out the difference between the neuron given in illustration 2.9 and the neuron illustrated in fig 2.2 below. Analyse the given description and gain an understanding of the usefulness of this structural peculiarity to the neuron.

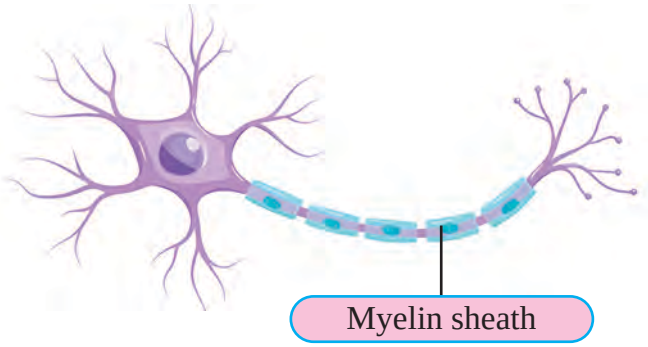
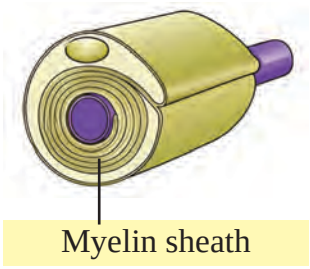


Figure 2.2 Myelin Sheath



You have understood that, in some neurons, the axon is covered by a layer called myelin sheath. It is made up of a shiny white fat called Myelin. The major functions of the myelin sheath are to increase the speed of transmission of messages by acting as an insulator, to provide nourishment to the neuron and to protect the axon from external injuries. Myelin sheath in the brain and spinal cord is produced by oligodendrocytes and in the nerves by Schwann cells.

In the brain and the spinal cord, the part where myelinated neurons with are more abundant is called the white matter and the part where the cell bodies and parts of the neurons without a myelin sheath are seen is called the grey matter."

The cyton parts of a group of neurons are covered by a membrane. These parts, seen in the spherical shape are called ganglia.

In humans, who are at a higher level of evolution, there exists a nervous system mechanism that functions to generate and coordinate physical responses in accordance with external and internal changes.

Observe the given illustration 2.10 and gain an understanding of the main parts of the human nervous system.

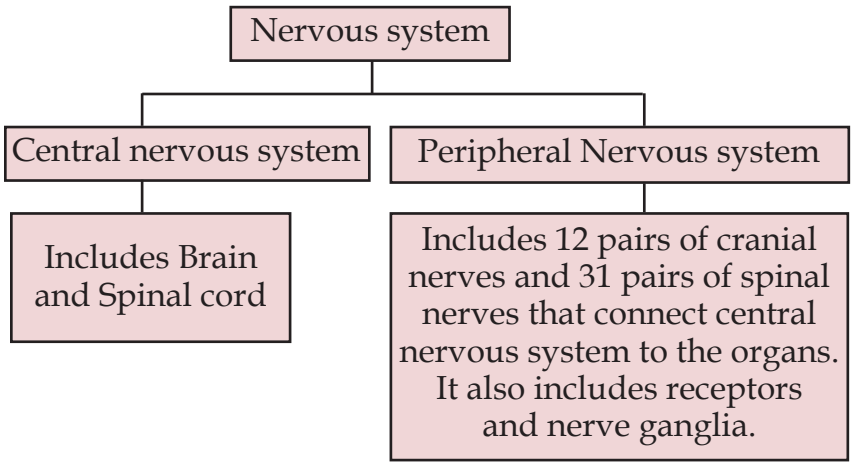


Illustration 2.10 Parts of the nervous system

Brain and Spinal Cord

Analyse the illustration 2.11 and its description, and prepare a note on how the parts of the central nervous system, such as the brain and spinal cord are protected.

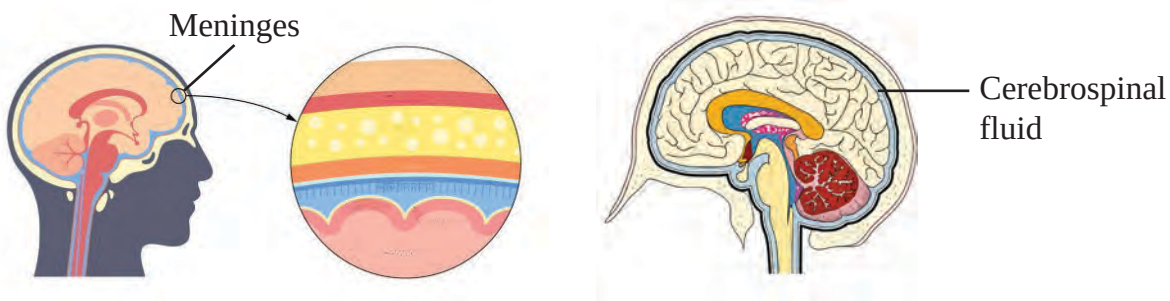


Illustration 2.11 Protection of the nervous system.

Brain and spinal cord are covered by the three-layered Meninges. The cerebrospinal fluid is the fluid that is filled in between the inner membranes of the meninges, in the cavities of the brain and in the central canal of the spinal cord. Ependymal cells play a role in the formation of this fluid. Cerebrospinal fluid performs the following functions in the central nervous system.

- Provides oxygen and nutrients to the tissues
- Eliminates wastes
- Regulates the pressure
- Protects from external injuries

Analyse illustration 2.12 and understand the features and functions of the parts of brain and complete table 2.3.

Cerebrum

The largest part of the brain. The outer part where the grey matter is seen is called the cortex and the inner part where white matter is seen is called medulla. Plays an important role in problem solving, planning and voluntary movements. Centre of memory, intelligence, thinking and imagination. Provides various sensory experiences.

Cerebellum

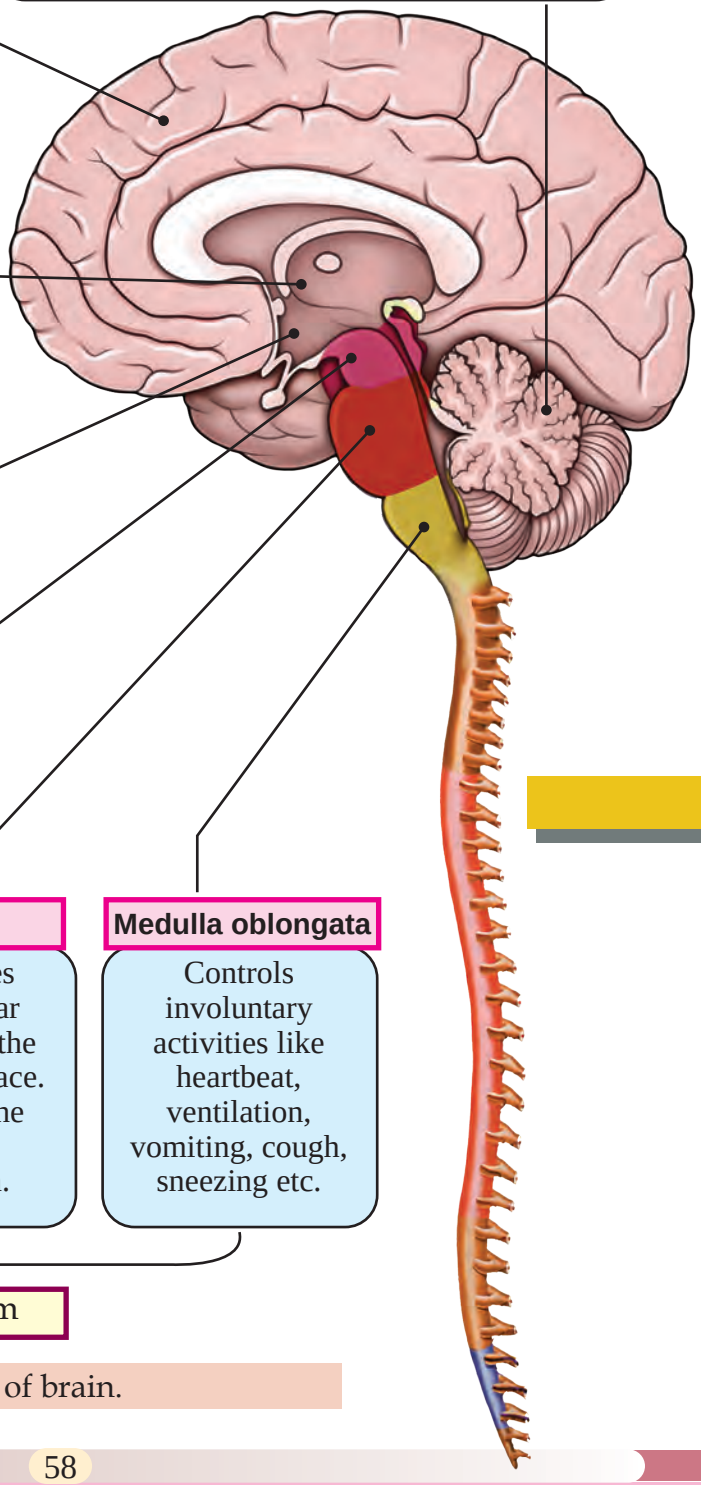
The second largest part of the brain. Seen behind and below the Cerebrum. Helps to maintain equilibrium of the body by coordinating muscular activities.

Thalamus

Seen in the inner part of the brain. Acts as the relay station of messages to and from the cerebrum. Pain killers act on this part of the brain.

Hypothalamus

Helps in maintaining homeostasis by regulating body temperature, hunger, thirst and emotions.



Mid brain

Initial assessment of messages regarding vision and hearing. This part has a role in the movement of eyes and eye brows.

Pons

Coordinates the muscular activities of the eye and the face. Regulates the rate of ventilation.

Medulla oblongata

Controls involuntary activities like heartbeat, ventilation, vomiting, cough, sneezing etc.

Brain stem

Illustration 2.12 Parts and functions of brain.

Part	Functions
Cerebrum	
Cerebellum	
Thalamus	
Hypothalamus	
Mid brain	
Pons	
Medulla oblongata	

Table 2.3 Parts and functions of brain

How do smoking, consumption of alcohol and drug abuse affect the health of brain? Find out.

Spinal Cord

Spinal cord is the part of the central nervous system seen as the continuation of medulla oblongata. Analyse illustration 2.13, its description and prepare a note.

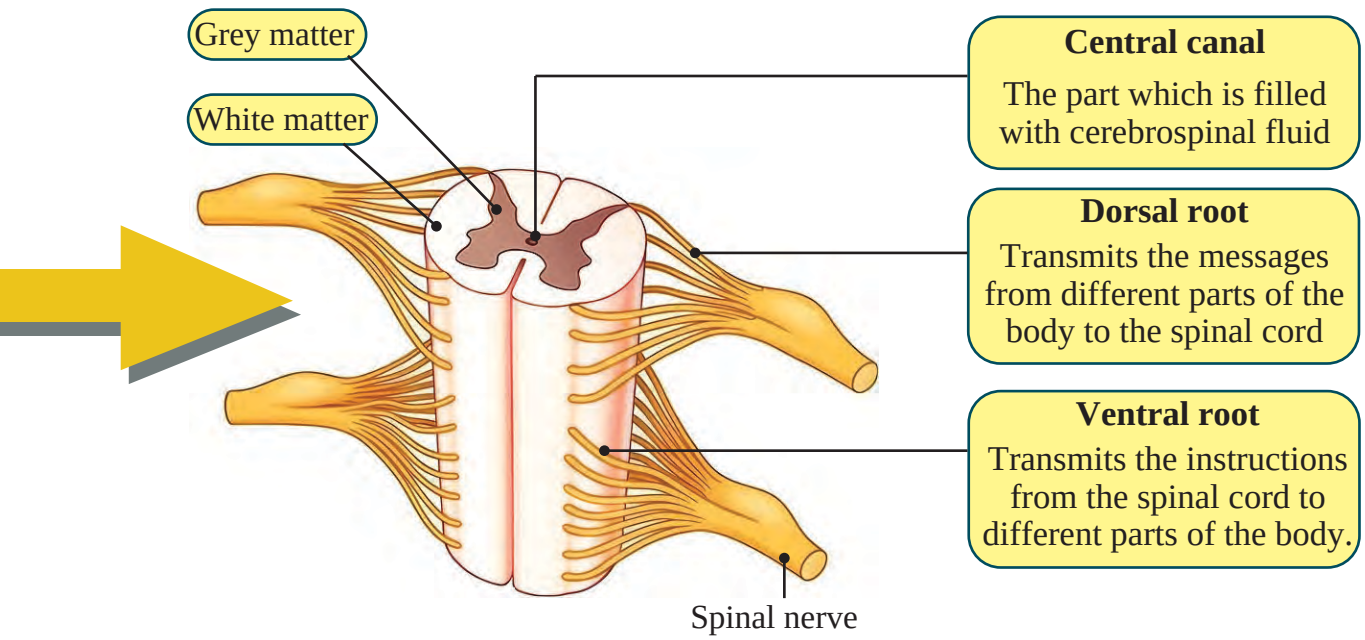


Illustration 2.13 Spinal cord - structure

Spinal cord transmits messages from different parts of the body to the brain and transmits instructions from brain to the different parts of the body.

Aren't messages transmitted through the neuron? How does it happen?

Didn't you notice the child's doubt ?

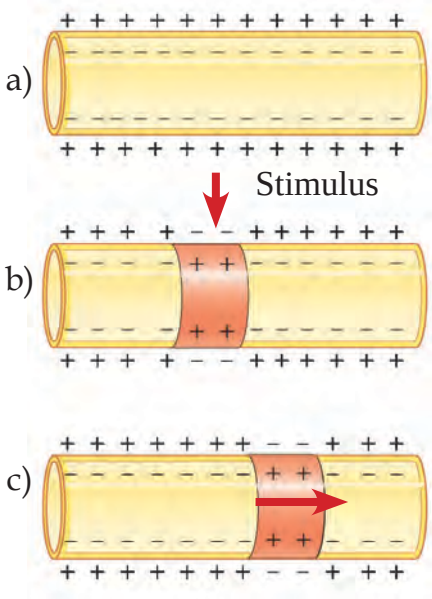
The messages transmitted through the neuron are called nerve impulses.

How do they get transmitted?

Illustration 2.14 given below, analyse and discuss the following processes.

All cells, including neurons, have an electric charge. The inner side of the cell membrane has a negative charge, compared to their outer side. When stimulated, positive ions from outside the cell membrane enter the cell, causing a temporary charge variation in that region.

Identify, record and explain the child's doubts.



The outer surface of the cell membrane is positively charged and the inner surface is negatively charged when not stimulated.

.....
.....

.....
.....
.....

Illustration 2.14 Transmission of impulses

Will impulses be transmitted through a neuron to different parts of the body?

To transmit a nerve impulse from one part of the body to another, it has to travel through different neurons. The part where an impulse is transferred from one neuron to another is called a synapse. Discuss the given illustration 2.15 based on the indicators and prepare a note on the synapse, which is formed by the connection of neurons.

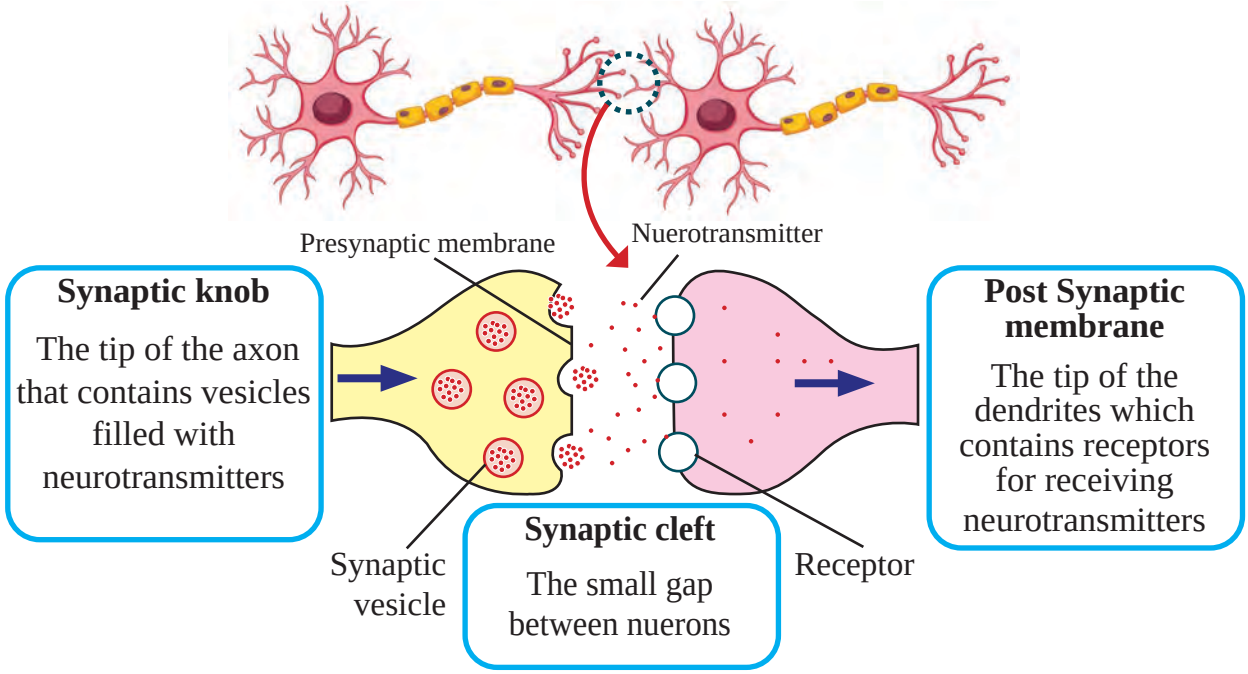


Illustration 2.15 The structutre of synapse

The synaptic knob secretes neurotransmitters to the synaptic cleft when the impulses reach there. These neurotransmitters bind with the receptors of post synaptic membrane and stimulates that neuron. Synapses transmit the impulses to only one direction and increase the speed of the impulses.

Are synapses found anywhere else other than the junctions neurons meet? Find out.

indicators

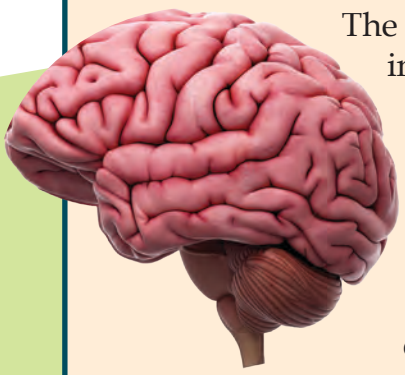
- Parts of the synapse
- Transmission of impulses through the synapse
- Role of the synapse in controlling the direction and speed of the impulses

Are there any organisms with brain size larger than those of humans? Find out.

Prepare a model of synapse using available materials and exhibit it in the class.

An excerpt from an article about the synapse of the brain published in a science magazine is given below. Analyse and discuss the peculiarities of the human brain that distinguish it from those of other mammals and gain understanding of it.

Neocortex



The cerebral cortex of the brain of mammals is modified into a complex structure of a six-layered neocortex. It is more developed in humans as compared to other mammals. It is estimated that the human neocortex contains approximately 16 billion neurons. In each of them, an average of about 7000 synapses are created with each other. Advanced mental processes such as thinking, decision-making, learning, recalling, etc. are made possible with the help of the synapses of neocortex. When we learn new things or gain new experiences, the number of these synapses increases, making our brain more efficient and effective.

Different types of neurons

Observe the illustration 2.16 about different types of neurons and complete the given table 2.4.

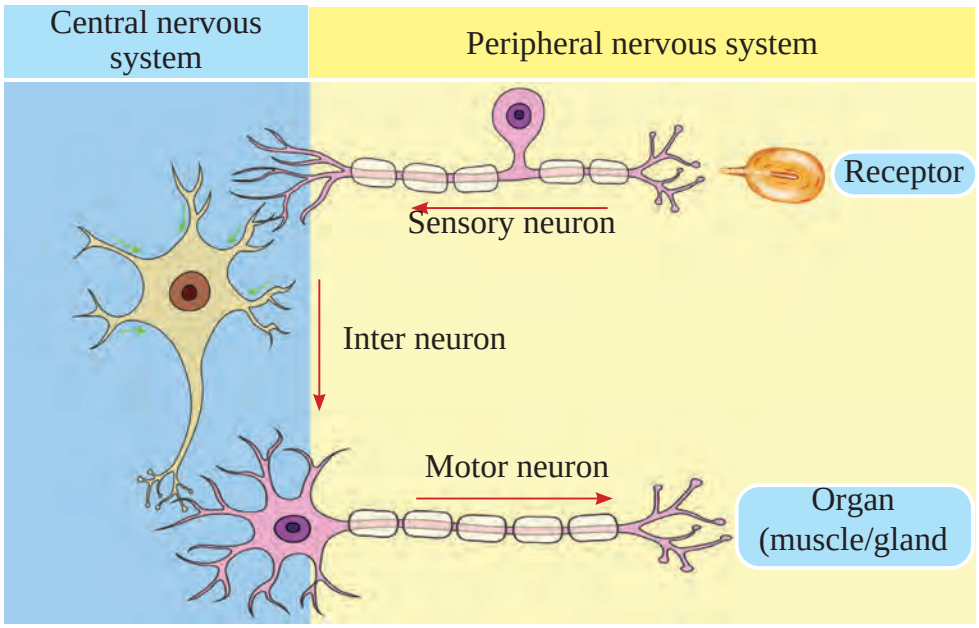


Illustration 2.16 Different types neurons

Neuron	Function
Sensory neuron	
Motor neuron	
Inter neuron	

Table 2.4 Different types of neurons and functions

Nerve

Nerves

Nerves are made up of the axons of a group of neurons covered with a layer of fat and connective tissue. Different types of nerves are tabulated on the basis of the peculiarities of the building blocks. Complete table 2.5 suitably.

Nerve	Building block	Function
Sensory nerve	Sensory neuron	
Motor nerve		Transmits instructions from the central nervous system to the organs
Mixed nerve	Both sensory neuron and motor neuron	

Table 2.5 Different types of nerves and their functions

Don't many activities, such as heartbeat and breathing, take place in our body without any conscious control over them? Haven't you understood the importance of the central nervous system to regulate such activities? Is its regulation is always possible by the central nervous system alone? Draw inferences by analysing the given instructions and complete table 2.6 appropriately by observing in the illustration given in 2.17.

Autonomous Nervous System

Autonomous nervous system is a part of the peripheral nervous system that regulates body activities by itself. It includes the sympathetic nervous system and the parasympathetic nervous system. Sympathetic system equips the body to respond during emergency situations. Parasympathetic system prepares the body to relax, and perform routine functions such as digestion.

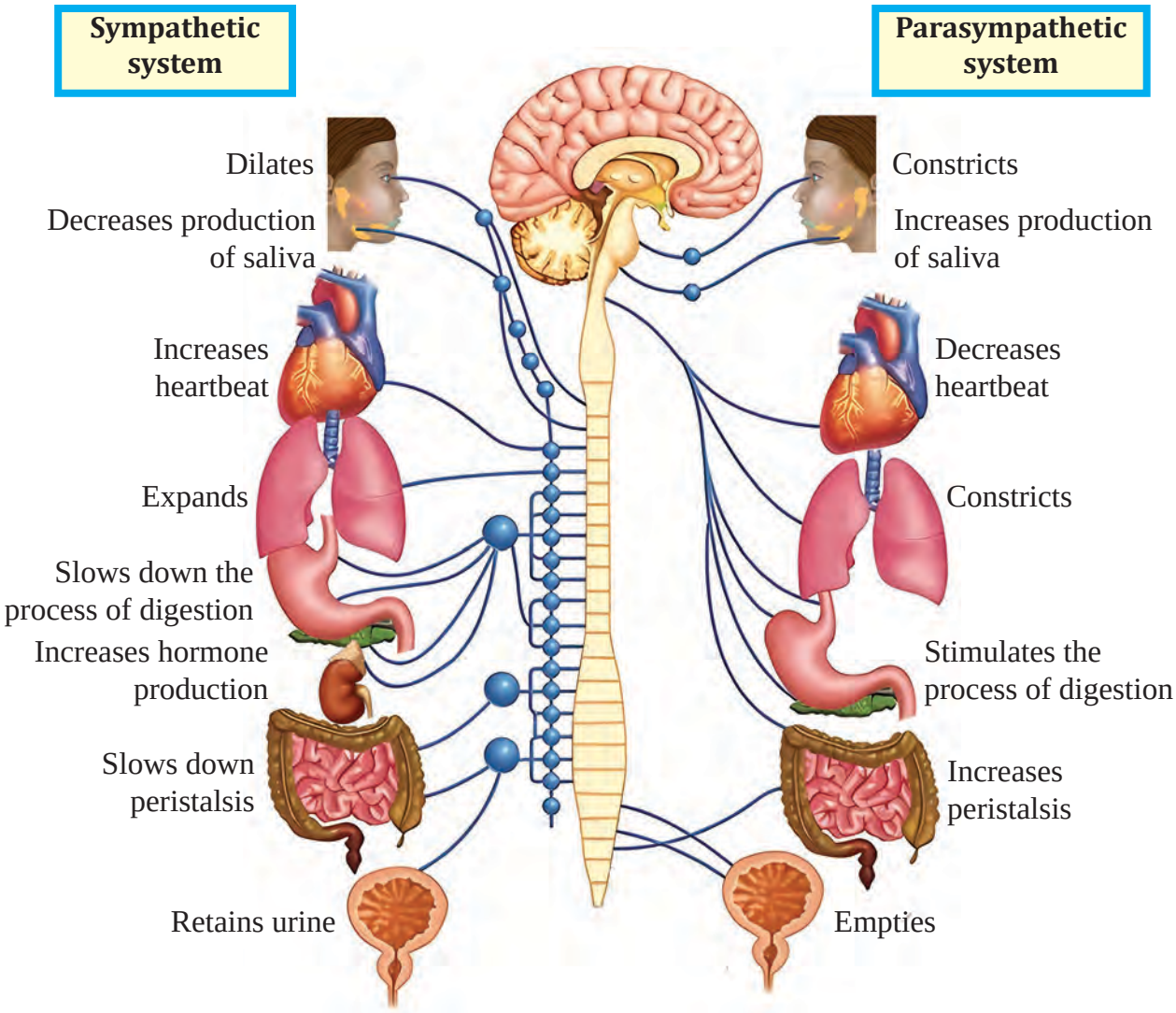


Illustration 2.17 Autonomous nervous system

Organ/part	Sympathetic system	Parasympathetic system
Pupil of the eye		
Salivary gland		
Bronchiole		
Heart		
Adrenal gland		No direct influence
Stomach		
Small intestine		
Urinary bladder		

Table 2.6 Sympathetic and Parasympathetic System - A comparison

Haven't you understood the role of the autonomous nervous system, which is a part of the peripheral nervous system to regulate various physiological activities that take place beyond our consciousness?

The central nervous system also plays a significant role to produce spontaneous responses according to stimuli.

Don't we withdraw hands when we touch a hot object unknowingly? List out more similar situations.

- Blinking of eyes when light falls on it
-
-

Do we respond consciously in such situations?

Spontaneous Responses

Reflex actions are reactions that occur spontaneously and involuntarily in response to stimuli. These actions can originate from both the spinal cord and the brain. The pathway through which impulses are transmitted in a reflex action is called a reflex arc. Analyse illustration 2.18 based on the indicators and prepare a note.

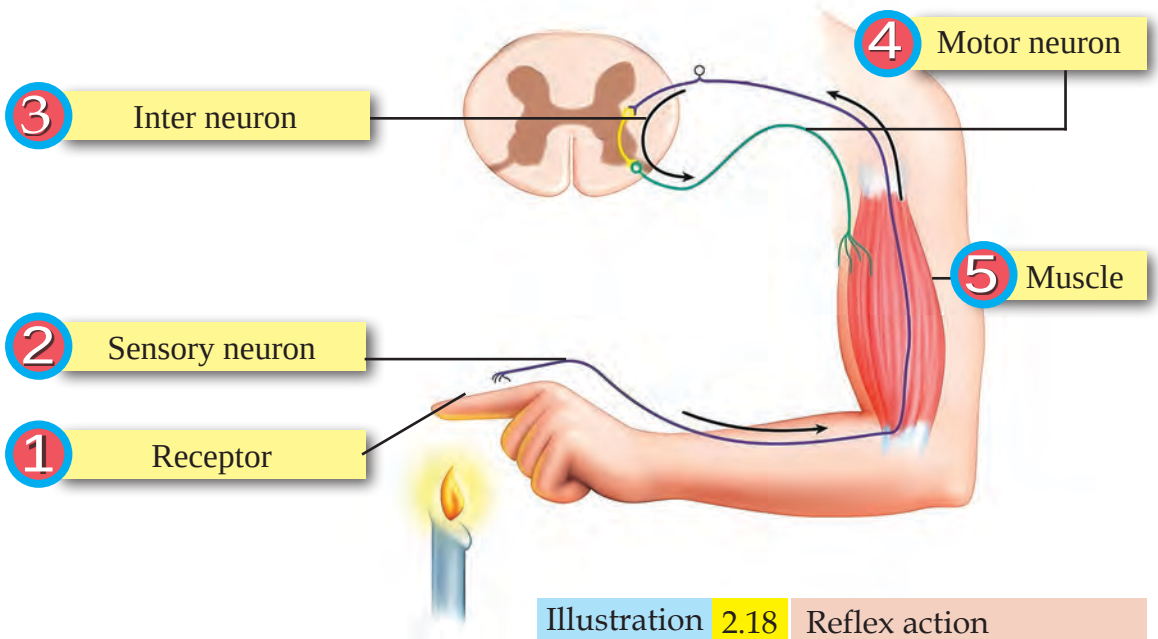


Illustration 2.18 Reflex action

Indicators

- Parts included in the reflex arc
- Functions performed by each part
- Significance of reflex actions

Tabulate the situations listed above, as controlled by the brain and controlled by the spinal cord.

Shouldn't the health of the nervous system, that plays a key role in enabling the control and co-ordination of physiological activities, to be protected? The major ideas in a notice published by the Department of Health related to the healthcare of the nervous system are given below. By analysing this and collecting additional information, prepare a note on the precautions and habits to be followed for the protection of the nervous system.

- Use a helmet, seat belt, etc. while riding a motor bike/driving.
- Take necessary precautions while playing.
- Taking bath in stagnant water may cause infections. Therefore, avoid such situations.
- Those who engaged in jobs with the risk of brain injuries must use safety equipments such as helmets and safety belts.
- Avoid habits suchas smoking, alcohol consumption and drug abuse. Do exercises.
- Lack of adequate sleep can affect brain function, which leads to memory loss, anxiety, difficulty in learning and hinders emotional development. Therefore, it is essential to sleep for at least 8–10 hours a day.

Shouldn't the nervous system differ according to the complexity of organisms?

Analyse the given illustration 2.19 based on the indicators and write inferences.

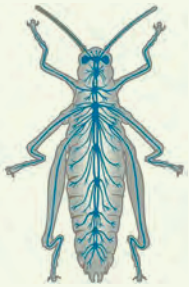
Hydra	Planaria	Insects
		
A neural network with no control center is seen.	A pair of nerve ganglia in the head region coordinates the instructions.	The neurons in the head region unite to evolve into a clear and somewhat developed brain. The ganglia of paired nerve fibers emerging from this are seen in each segment.

Illustration 2.19 The nervous system of different organisms

Indicators

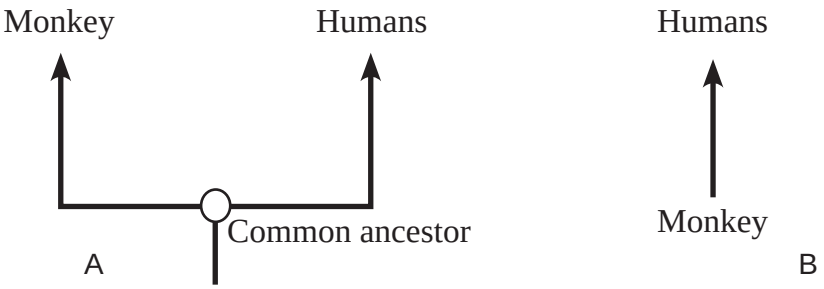
- Compare the nervous system of hydra and that of planaria
- Peculiarity of the nervous system of insects

Evolution is the prolonged process of the origin of complex multicellular organisms from simple, unicellular ones. Evolution also gives a remarkable transition from simple nervous structures to highly complicated nervous systems. Such an evolution of the nervous system is the reason for the acclimatisation and survival of organisms in diverse environments. The development of a complex brain played a crucial role in human dominance over nature, enabling unique cognitive and technological progress. The presence of neocortex developed during the long course of evolution and the resultant language, intelligence and creativity like higher mental processes makes humans different from other organisms.

Have you understood that the activity of the nervous system plays a remarkable role in enabling the organisms to make aware of their surroundings and respond accordingly. If the activities of the nervous system needs to take place completely and smoothly, the information from the external and internal environment should reach the central nervous system. The information from the external environment is perceived through sense organs. Do the sense organs in humans have the same proficiency compared to other organisms, though the human brain is more developed? This can be evaluated only when the relation between sense organs and the brain is analysed. Sensations provided together by the sense organs and brain are also to be understood. You will learn this in the succeeding chapters.

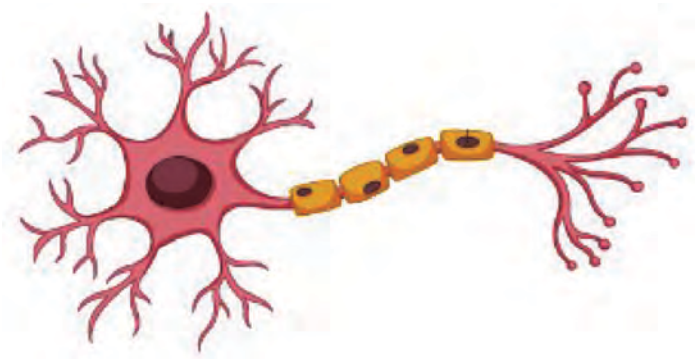
Let us Assess

1. Two illustrations related to human evolution are given below. Based on the theory of natural selection, find out the correct one and explain the reason.



2. Although dolphins have a larger brain than that of humans, the level of thinking, language skills and social relationships are higher in humans. Evaluate this statement based on the following indicators.
   - Difference in the structure of the brain
   - Influence of natural selection

3. Redraw the figure of the neuron and label the following parts by writing their names.



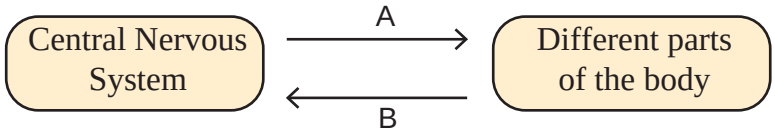
   (a) The part of the neuron that receives impulses from the adjacent neuron

   (b) Part that contains neurotransmitter

   (c) Part that acts as insulator

4. Darwin failed to explain the reasons of variation even though he argued that variations occur continuously in organisms. Evaluate this statement based on the findings of Neo Darwinism.

5. Observe the illustration and answer the questions.



(a) Identify the nerves A and B.

(b) Are messages being exchanged between A and B? Explain.

6. A table that includes the parts of spinal cord and their functions is given below. Arrange column B appropriately in accordance with column A of the table.

A. Part	B. Functions/ Peculiarities
Central canal	Neurons with myelin sheath are numerous
White matter	Transmits impulses to the spinal cord
Dorsal root	Fluid present here nourishes the spinal cord
Grey matter	Transmits impulses to different parts of the body
	Cell body of neurons are numerous.

7. Based on the information obtained from fossils, some human ancestors and their characteristics are given below. Find out the one which is arranged correctly from the given answers.

(A) Homo habilis

(B) Homo neanderthalensis

(C) Astralopithecus

(D) Homo erectus

(i) buried dead bodies

(ii) able to stand upright on two legs

(iii) made tools with stones using their hands

(iv) The skeletal structure confirms bipedalism

(a) A : i, B : ii, C : iii, D : iv

(b) A : iii, B : i, C : iv, D : ii

(c) A : iii, B : iv, C : ii, D : i

(d) A : iv, B : i, C : iii, D : ii

8. Examine the information mentioned in the boxes labelled as P, Q, R, S. Identify the part of the brain associated with them and choose the correct answer.

Maintaining Homeostasis	Provide Sensory experiences	Relay station of impulses	Controls the rate of ventilation
P	Q	R	S

(a) P – Medulla oblongata Q – Pons R – Hypothalamus S – Thalamus

(b) P – Pons Q – Hypothalamus R – Medulla oblongata S – Cerebrum

(c) P – Hypothalamus Q – Cerebrum R – Thalamus S – Pons

(d) P – Thalamus Q – Cerebrum R – Hypothalamus S – Medulla oblongata

9. Complete the table by including the following in appropriate columns.

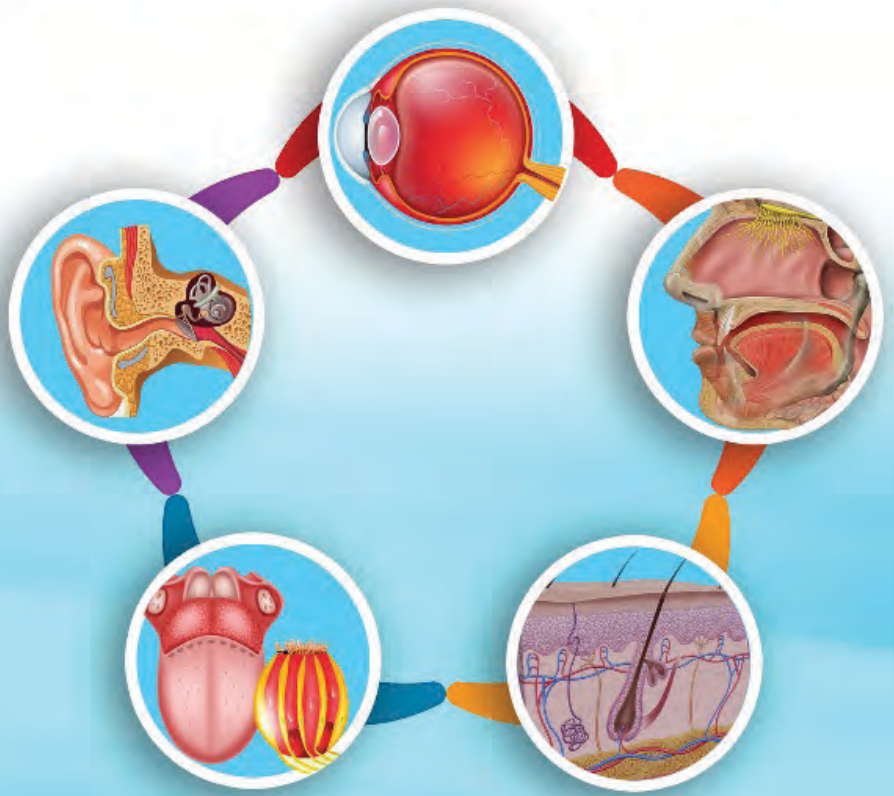
- Only long necked giraffes survive
- Use and Disuse
- Natural selection
- Variations acquired in the life span
- Through continuous use, giraffe's neck elongates
- Inheritance of variations

Lamarckism	Darwinism
• • •	• • •

Extended activities

1. Prepare the human evolutionary tree by including maximum organisms and exhibit it in the class.
2. Not only the origin of life, but mass extinctions also had occurred on earth. Collect more information about these and organise a seminar.
3. Prepare a script for a short play to clarify the protection of the nervous system and present the play in schools and public places.
4. Make a model of a nerve cell by using various materials such as beads of different colours, thin wires, woollen yarn etc. and present in the class.
5. **Is artificial intelligence a challenge to the human brain?**
   Organise a debate on this.

3



Behind Sensations

Didn't you notice? A group discussion is going on.

The topic for discussion is that the body responds in various ways, recognising the changes inside and outside it.

Children talk about various responses and the reasons behind them.

You can also present some examples. Include them in the given table 3.1.

Reasons	Responses
Seeing a friend	
	Covering the ear
	Drinking water

Table 3.1 Responses and reasons

Haven't you understood that these responses are caused by changes happening in the surroundings.

Responses are formed due to various biological and chemical processes that takes place in the body of organisms.

There are numerous processes happening behind various responses made when seeing friends.

- Light rays from the friends' enter the eyes and the image is formed.
- The impulse from the image reaches the brain through the eyes.
- The brain analyses this impulse and recognises the friends.
- Then, instruction for responses are given to the muscles.
- Various responses are formed as a result of muscular activities.

Haven't you understood that we can respond when we see friends because of the combined action of the eyes, the brain and the muscles?

Stimuli and Responses

Stimuli are the circumstances that lead to responses in living beings. They can be divided into external stimuli and internal stimuli. Analyse the given hints and draw inferences regarding the diversity of stimuli.

- Takes food, when hungry
- A rabbit, upon seeing a lion, gets scared and runs away.
- Blanketing to keep out cold
- Holding an umbrella to keep out the rain
- Body temperature increases during certain diseases

How does the body recognise stimuli? Analyse the given illustration 3.1 and description, and make notes.

Receptors and Impulses

Stimuli are recognised by the body through specialised cells or nerve endings. They are known as Sensory Receptors.

Electrical impulses are produced in receptors in response to external and internal stimuli. These impulses are known as **receptor potential**. When such impulses are in higher concentration, **action potential** is formed in the neurons associated with receptors. Action potential travels through neuron as nerve impulses.

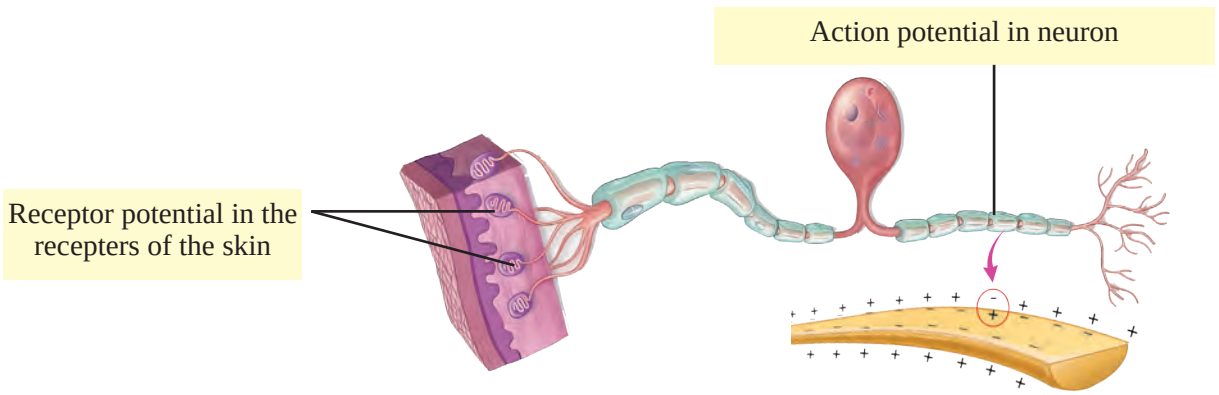


Illustration 3.1 Action potential in neuron

Nerve impulses reach the related parts of the brain and form appropriate response instructions. Muscles and glands respond to these instructions accordingly.

Haven't you understood the neural activities behind the ability to respond when you see your friends?

Sensory receptors and Senses

Senses that can be recognised through receptors are divided into two types: general senses and special senses. The receptors in skin, muscles, joints, internal organs and blood vessels help to detect general senses such as touch, pain, heat, pressure etc. But the receptors concentrated only in certain organs help to recognise specific senses such as vision, hearing, taste and smell, etc.

Discuss the receptors found in the sense organs that help to identify special senses and the stimuli they detect and complete the table 3.2.

Sense organs	Receptors	Stimulus
Eye	Photoreceptors	
		Sound
	Chemoreceptors	
	Touch receptors	
		Smell

Table 3.2 Sense organs, receptors and stimuli

Haven't you understood the receptors for identifying the special senses and their characteristics?

The tongue can detect taste, but the ears can't. What could be the reason?

Discuss and find the answer to the question based on the understanding gained from the distribution of receptors.

Let us understand how special senses are recognised.

Eye

The eye is an important sense organ that provides perception about the external world.

Analyse the illustration 3.2, and its description based on the indicators and prepare notes about the position and parts related to the eye.

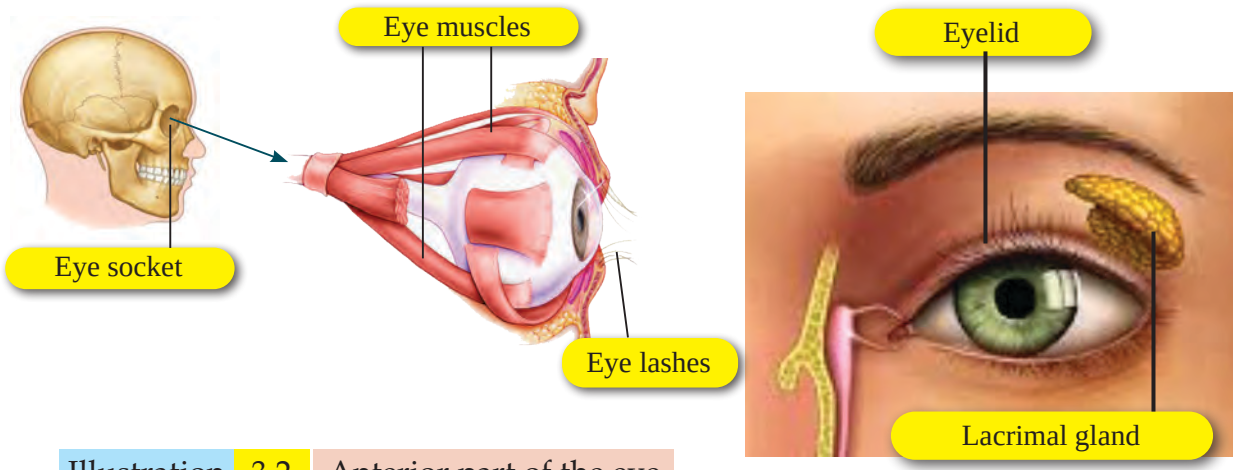


Illustration 3.2 Anterior part of the eye

Conjunctiva

Conjunctiva is the membrane that covers the anterior part of the eye, including the eyelids except the cornea. Its functions are to protect the eye, keep it moist and lubricated, and prevent dust, germs and other particles from entering the eye.

Lacrimal glands

Tears are produced by the lacrimal glands. These glands are present in the eyelids towards the upper part. Tears are essential for keeping the surface of the eye moist, providing nutrients and eliminating waste materials. The enzymes called lysozyme present in tears help to protect from infections.

Indicators

- Position of the eye
- Function of eye muscles
- Importance of the eyelid, eyelashes, etc.
- Importance of conjunctiva, tears

Layers of the Eye and Associated Parts

What are the major parts of the eye? Analyse the figure 3.1, table 3.3 and identify the peculiarities of each layer, associated parts and prepare notes.

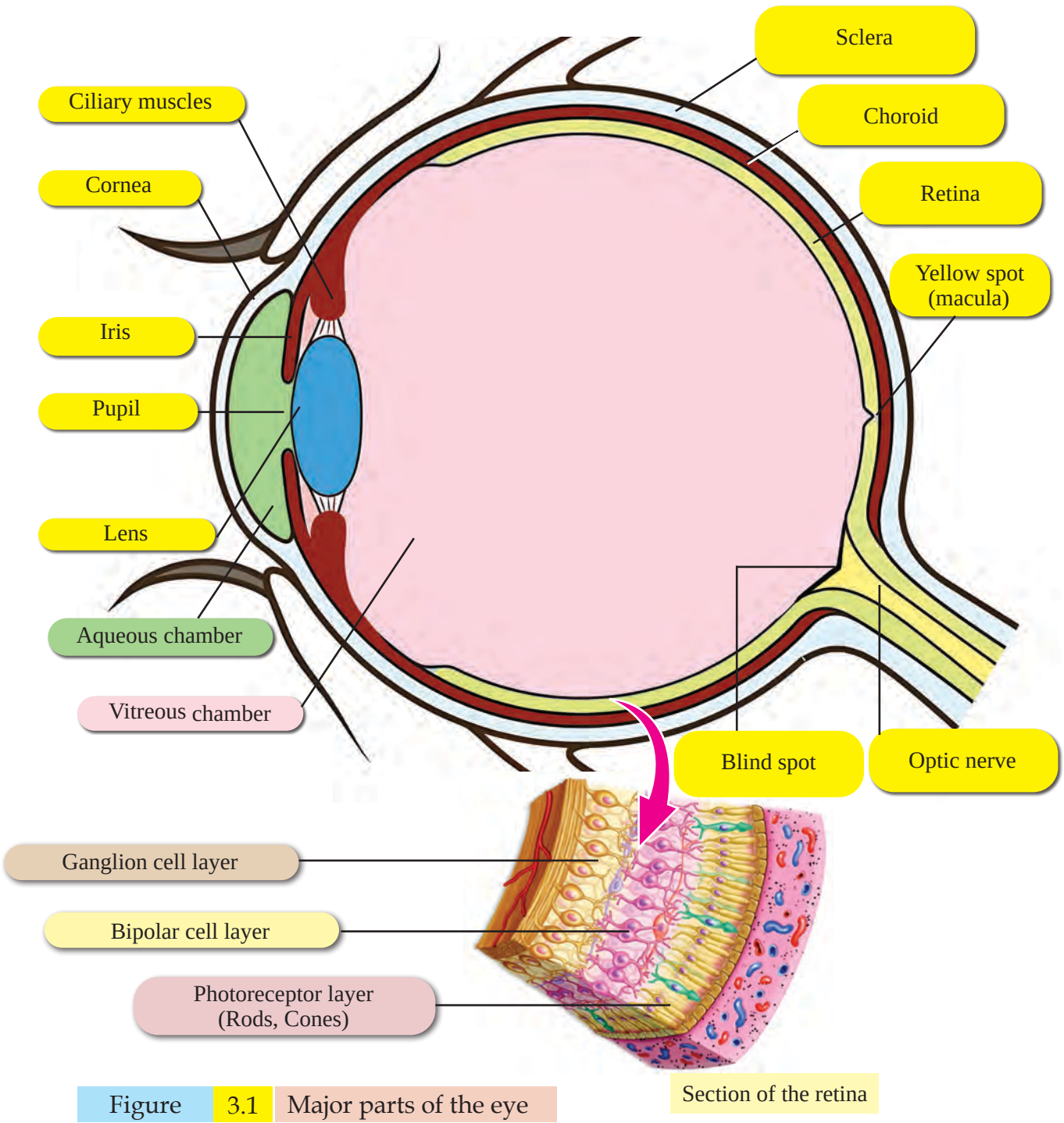


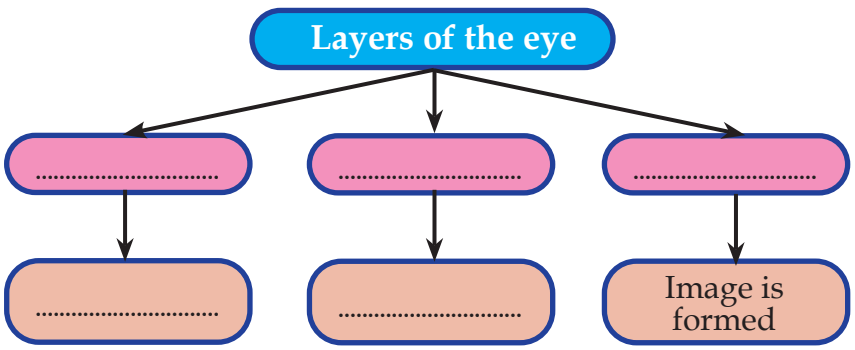
Figure 3.1 Major parts of the eye

Layers of the eye	Associated parts	Characteristics and function
Sclera (outer layer) provides firmness and protection to the eye	Cornea	The transparent anterior part of the eye Allows light to enter the eye.
Choroid (middle layer) Provides oxygen and nutrients to the inner layer of retina and regulates temperature	Ciliary muscles	Adjusts the curvature of the lens
	Iris	Two types of muscles in the iris regulate the size of the pupil depending on the intensity of light. Iris contains the pigment called melanin. Melanin gives the iris its characteristic colour as well as absorbs ultraviolet rays. Regulates the amount of light.
	Convex lens	Forms a small, real and inverted image of the object on the retina.
Retina (inner layer) Contains photoreceptor cells. The image is formed.	Layer of photoreceptors	The photoreceptor cells called rod cells recognise objects in both dim light and in shades of black and white. The cone cells provide vision in intense light and also help in recognising colours.
	Bipolar cell layer	Transmits impulses from the photoreceptors to ganglion cells.
	Ganglion cell layer	Transmits impulses from bipolar cells to the optic nerve.

Table 3.3 The layers of the eye - Characteristics and Functions

The bipolar cell layer consists of two types of cells, namely on bipolar cells and off bipolar cells.

Complete the given flowchart 3.1 by including the layers of the eye and their functions.



Flowchart 3.1 Layers of the eye and its function

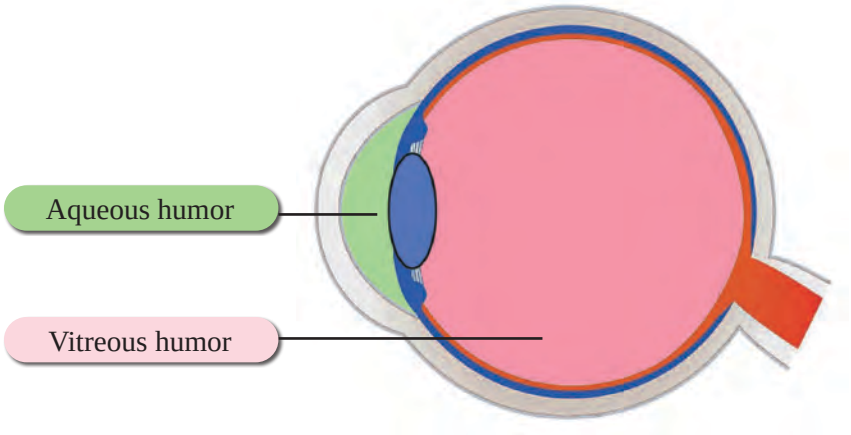


Figure 3.2 Fluids in the eye

There are no photoreceptor cells in the retina where the optic nerve originates. This part having no vision is known as the **blind spot.** The **yellow spot** (macula) is seen in the middle of the retina where cone cells are abundant.

Haven't you noticed the fluids indicated in the figure 3.2?

What is their significance? Analyse the given description and identify the function of the fluids present in the eye.

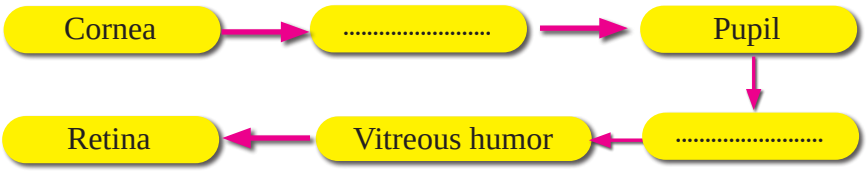
Eye chambers and Humors

The eye has two chambers. The aqueous chamber is seen between the cornea and lens. The watery **aqueous humor** is present here. It oozes out from the blood like tissue fluid and is reabsorbed into the blood . This is how the pressure in aqueous chamber is regulated. Lens and cornea get oxygen and nutrients from this fluid.

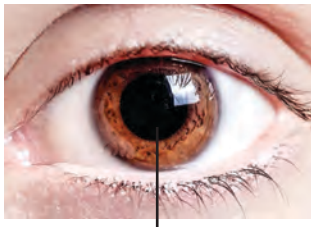
The vitreous chamber lies in between the lens and the retina. The transparent jelly like **vitreous humor** present there maintains the shape of the eyeball.

Make a table by comparing the aqueous humor with the vitreous humor.

Complete the flowchart 3.2 including the parts involved in the path of the light rays that pass through the eye.



Flowchart 3.2 The path of light through the eye



Pupil

Iris is the part seen behind the cornea. The **pupil** is the aperture seen at the centre of the iris. The normal size of the pupil is from 2 to 3 mm. When the size of the pupil increases, it becomes possible to direct 16 times more light on to the retina than normal.

In which situations are the size of the pupil changed? How does it become possible?

Analyse the illustration 3.3 and description that denotes the muscular activities of the pupil based on the indicators, and prepare notes.

The size of the pupil is regulated by the radial muscles and circular muscles seen in the iris. The size of the pupil has to be regulated in order to see the objects clearly in dim light and to prevent damage to the retina in intense light.

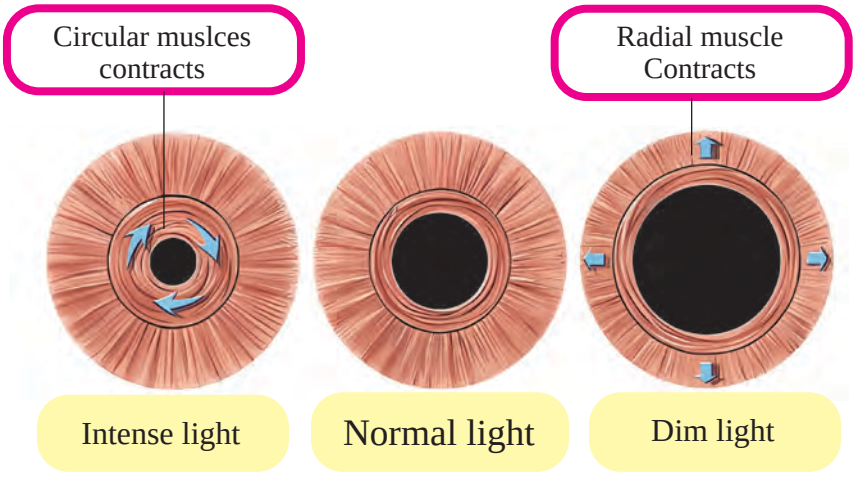


Illustration 3.3 Muscular activity in the pupil

Indicators

- Muscles associated with the pupil
- Muscular activity and difference in the size of the pupil

The lens has three main parts. They are an elastic membrane called the capsule, within which are the lens fibres and the epithelium, which is located solely in the anterior part, between the lens fibres and the capsule. It is the epithelium that continuously produces lens fibres throughout an individual's lifetime. The main structural component of the lens is a protein called **crystallin**. The lens derives nutrients from the aqueous humour. Age-related changes affect the flexibility and transparency of the lens as well as vision..

Redraw the figure of lens and label the parts capsule and lens fibres.

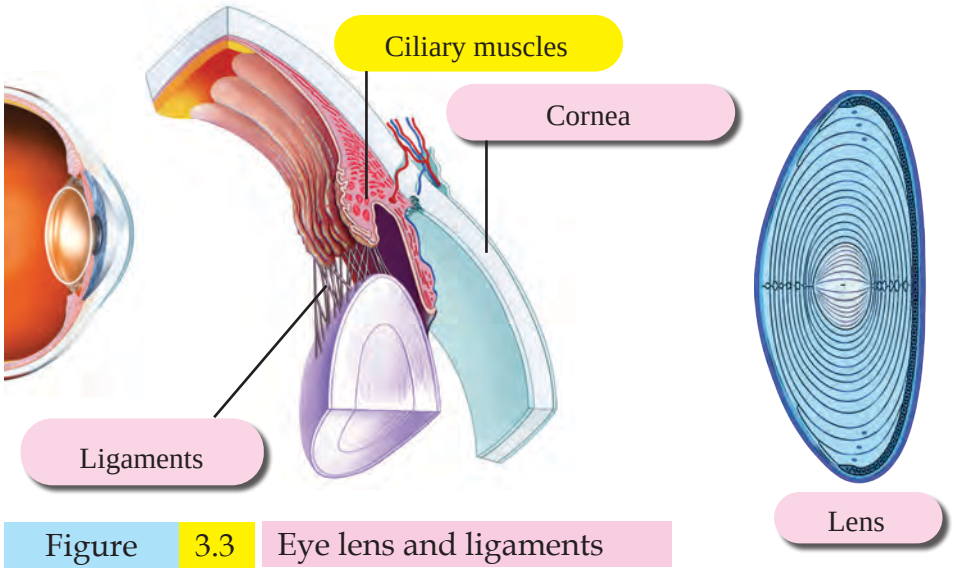


Figure 3.3 Eye lens and ligaments

From Figure 3.3, it can be understood that lens got attached to the ciliary muscles through ligaments.

What is the importance of this arrangement? Discuss and record your inferences.

.....

Analyse the given description, illustration 3.4 and record your inferences.

The ability of the eye to foucs images of both near and distant objects accurately on the retina is called the **power of accommodation**. This is achieved by changing curvature of the lens, by the actions of the ciliary muscles.

Notice the arrangement of the lens, ciliary muscles and ligaments while viewing distant objects as given in illustration 3.4

Discuss the change in the activities of these parts of the eye while viewing near objects and complete the illustration 3.4.

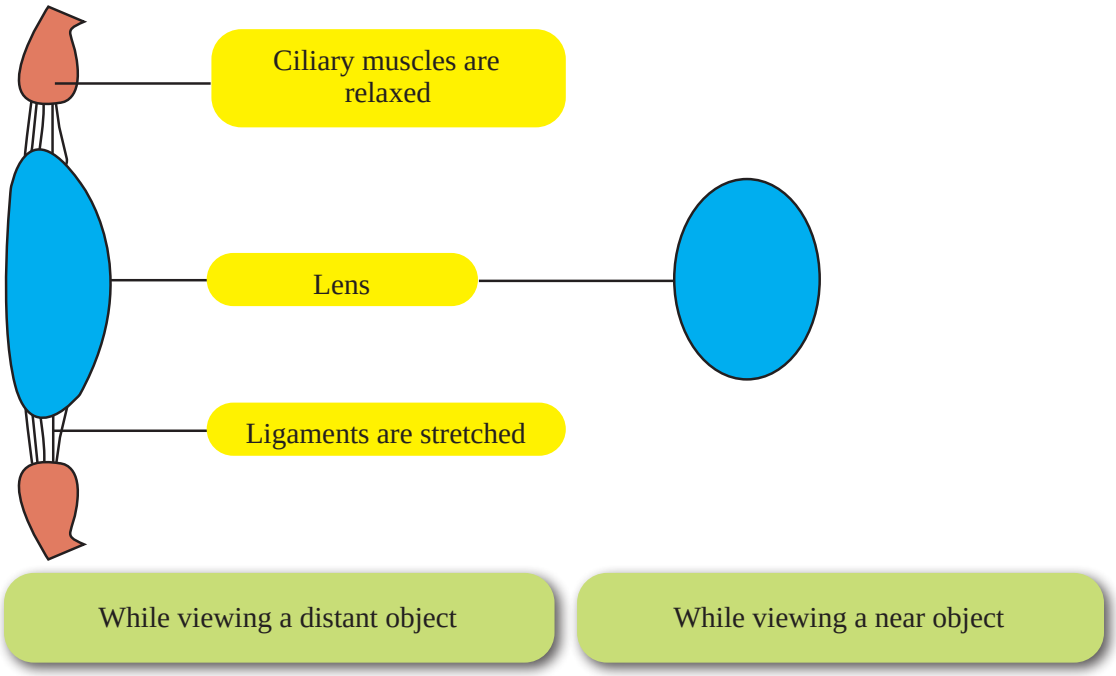


Illustration 3.4 Change in the curvature of the lens

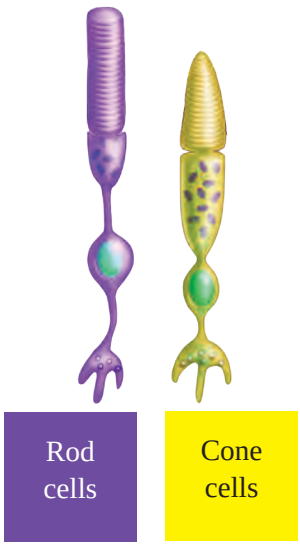


Figure 3.4
Photoreceptors

Can we see the object as soon as the image is formed on the retina? Analyse the given description based on indicators and record your inference.

Retina

You have understood that the rod cells and the cone cells are the photoreceptors. Rod cells are cylindrical and cone cells are cone shaped (Fig.3.4). Rod cells are about more than 9 crores in number and cone cells are about 45 lakhs. Rod cells contain the pigment called **rhodopsin** and in cone cells is **photopsin.** The components of both pigments include a protein namely opsin and retinal, formed from Vitamin A. However, the chemical structure of retinal is different in rhodopsin and photopsin.

Indicators

Photoreceptors – Shape, number

Photoreceptors – Pigments and its components

What are the changes to the photoreceptors in the presence and absence of light? How does this make vision possible?

Analyse the given flowchart 3.3, gain an understanding and prepare a note.

What is the importance of pigments in photoreceptors? Find out.

Photoreceptors to the brain

Glutamate acts as the primary neurotransmitter in photoreceptors. Variations in glutamate production are responsible for the perception of darkness and light.

In the dark, photoreceptors continuously produce glutamate.	In the presence of light, photorecptors do not produce glutamate.
↓	↓
On bipolar cells (those that sense light) are inactivated and off bipolar cells (those that sense darkness) are activated.	On bipolar cells become active and off bipolar cells become inactive.
↓	↓
Off bipolar cells that indicate the absence of light form impulses that reach the brain through the optic nerve, creating a sense of darkness.	On bipolar cells that indicate the presence of light form impulses that reach the brain through the optic nerve, creating a sense of vision.

Flowchart 3.3 Photoreceptors and Vision

Indicators

- Stimulation of photoreceptor cells
- Synthesis of glutamate and bipolar cells
- Ganglion cells and impulses

Haven't you understood the functions of rod cells and cone cells? How do cone cells help in recognising colours? Analyse the description given below and gain an understanding as to what the basis of colour vision is.

Colour vision

In the retina, there are three types of cone cells recognise primary colours. S - cones show better sensitivity at short wavelengths (blue light), M - cones at medium wavelengths (green light) and L - cones at longer wavelengths (red light). Colour vision is made possible when the three types of cones get stimulated in varying proportions when exposed to coloured light depending upon the intensity and wavelength of light. When red and green cones are stimulated together, the perception of yellow colour is formed. The stimulation of all the three types of cones creates the sensation of white light.

Is retina necessary to see black colour? Find out.

The gene responsible for the production of pigments in cone cells which are sensitive to green and red are found in the X chromosome. The gene which is responsible for the production of blue cone pigment is found in chromosome 7.

Can you find out the reason for colour blindness?

Based on the indicators, collect more information and prepare a note.

Indicators

- Why are men more affected by colour blindness?
- The possibility of colour blindness in women
- The mode of inheritance of colour blindness

Impulses related to the image formed in both eyes reach the visual centre of the brain through the optic nerve.

Why don't we see objects as two, even though images are formed in both eyes?

Analyse the given illustration 3.5 and description and record your inferences.

Since each eye receives light from different angles, there will be two slightly different images on the retina. These two images are sent to the **visual cortex** in the brain. The brain compares these images and combines them(fusion). This process is known as **binocular fusion**. This will help to determine the difference between the two images. Thus, we get 3D vision. It enables to understand how distant or near objects are, and also to perceive depth.

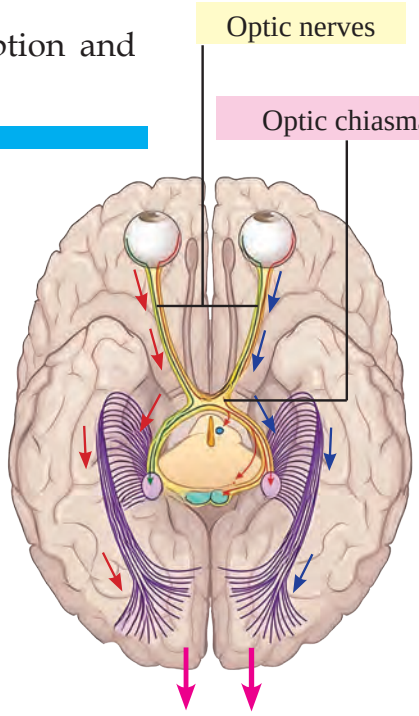


Illustration 3.5 Binocular fusion

If eye disorders or diseases are not prevented or treated in time, vision can become impaired. Which are the eye diseases/disorders?

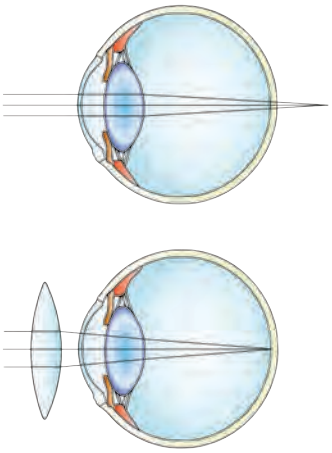
List out, what you know:

- Short-sightedness
-

Analyse the causes and treatments of eye diseases and disorders given in the table. Complete the table 3.4 through discussion and conduct an awareness class on the ways to prevent diseases. Organise an eye testing camp under the auspices of the Health Club.

Eye diseases / disorders	Reason	Treatment
Short-sightedness	Enlarged eyeball	Spectacles with concave lens or contact lens surgery
Long-sightedness		
Astigmatism		Cylindrical lens
Cataract	Eye lens becomes opaque	
Glaucoma	Failure in the reabsorption of aqueous humor, pressure increases and the optic nerve gets damaged	
Conjunctivitis	Infection in the conjunctiva	
Diabetic retinopathy	Uncontrolled diabetes	
Night blindness	Deficiency of vitamin A	
Xerophthalmia	Due to prolonged deficiency of Vitamin A, cornea becomes opaque	

Table 3.4 Eye diseases / disorders



Longsightedness and rectification

Vision problems can affect daily activities and the quality of life. Proper eye tests help in early detection of eye related problems. Analyse the given description and gain an understanding on the importance of eye care.

World Sight Day is observed on the second Thursday of October. The World Health Organisation (WHO) and the International Agency for the Prevention of Blindness (IAPB) call for the observance of this day to raise awareness on the eye healthcare. This also includes reducing screen time and encouraging regular eye tests to care for children's vision. WHO eyes, a free application available in 14 languages enables free eye test for ages 8 and above. Some vision problems can be corrected with less expensive methods such as spectacles and cataract surgery.

The message for World Sight Day 2024 is 'Children, love your eyes'. Plan activities that can be organised at the school level and in the society on the World Sight Day this year.

Protection of the eye

Expand the list given below by discussing ways that can be implemented to protect the eye from various disorders and diseases.

- Wash the eyes frequently, with clean water.
- Eat food rich in Vitamin A.
-
-
-

Haven't you heard that **donating the eye is a noble act?** Donating eyes can give vision to two blind people. Cornea gets surgically transplanted. It is beneficial for those who have lost their vision due to the damage of the cornea.

Each one of us has a responsibility to adopt a careful life style to care for the eyes and to develop a positive attitude towards eye donation.

Children below the age of five should spend only an hour or less on digital devices. Those who are below one year should not use such devices.

-World Health Organisation (WHO)

Didn't you notice the news report?

Do only children need instructions? Shouldn't there be a discussion about the teenager's screen time?

Complete the project work by gathering additional information and findings based upon the indicators given on this topic.

Indicators

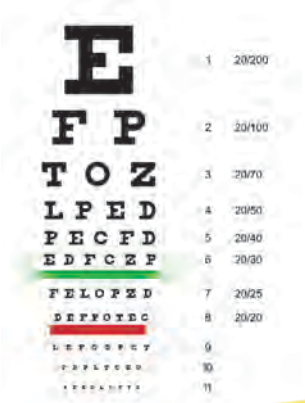
- Recommended screen time
- Physical and mental health, and consequences
- Sleep
- Personal relationships
- Social relationships
-
-

Organise an interview with specialists in the field of ophthalmology to clarify doubts related to this topic.

There are several charts used to test visual acuity. Among them, the commonly used one is Snellen Chart. It consists of rows of letters or symbols that decrease in size from top to bottom. In the test, the person stands twenty feet away and reads the smallest line that can be clearly seen with one eye. The results are recorded as a fraction. This simple but effective test is an important part of routine eye test.

There are many such charts in use that include letters and symbols. In addition to this, many modern devices are used for eye test. Examples include Retinoscopes, Tonometers and Ishihara plates.

Find out how these devices are used in eye tests and then prepare a science article related to this, for presentation.



What do the numerator and denominator of the fraction in an eye test result using Snellen chart indicate? Find out.

Ophthalmology and career opportunities

Ophthalmology is a specialised branch of medicine that deals with the diagnosis, treatment and prevention of eye diseases and disorders. An opthalmologist is a medical doctor trained to provide comprehensive eye care including surgery. This career path begins with an MBBS degree. Further, a graduate or post graduate degree (MD/MS) or diploma in ophthalmology should be obtained. Ophthalmic assistants are those who perform eye examinations along with opthalmologists. They correct lenses, detect early signs of eye diseases and assist in patient care. There are also many opportunities in the field of optical dispensary providing eye glasses and contact lenses. The growing demand for eye care has opened up new avenues for retina specialists, paediatric ophthalmologists and occular oncologists. There are many job opportunities in fields like vision therapy, occular imaging and AI diagnostics. There are many self employment opportunities also. To enter and excel in these fields, one must select suitable courses and acquire necessary clinical and technical skills.

Hearing

You may know that just like vision, hearing is also a sensation. Hearing is the combined experience of the ears and the brain. The sense of hearing also leads to responses.

The human ear also plays a major role in maintaining the balance of the body.

Observe illustration 3.6, identify the main parts of the ear and their associated parts, and complete the given table 3.5.

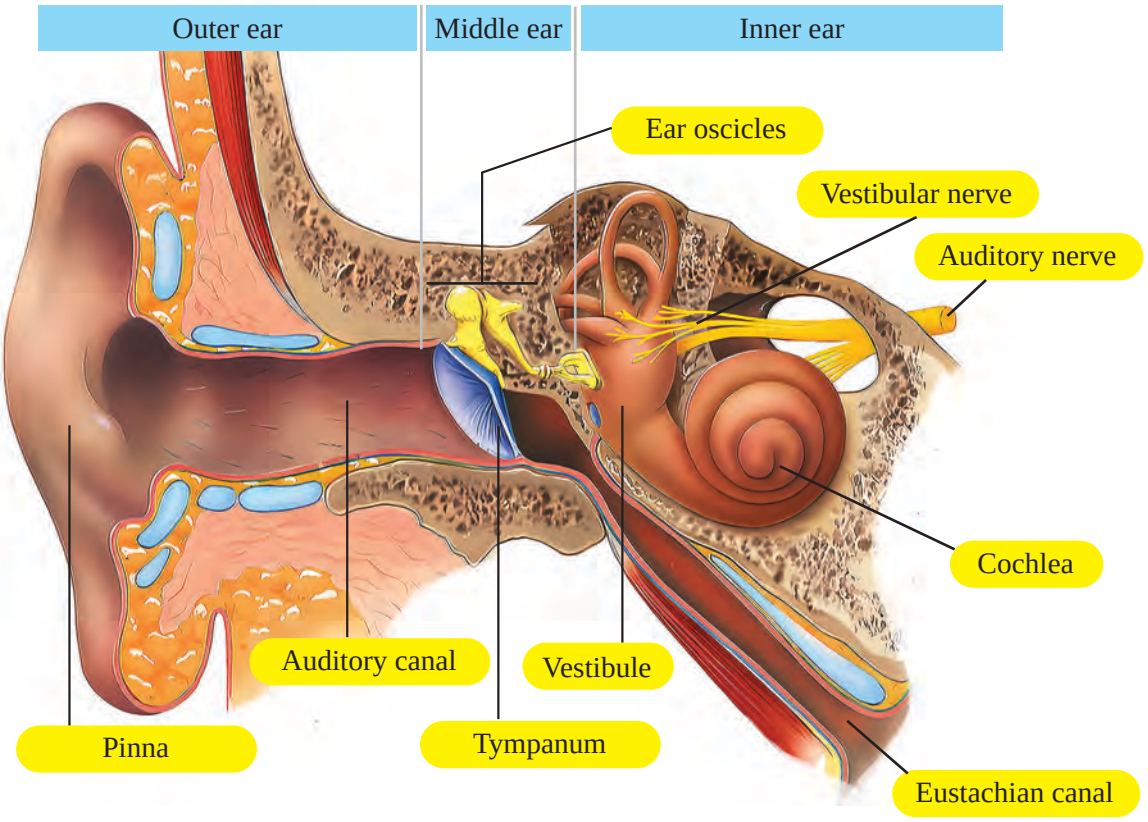


Illustration 3.6 Structure of the ear

Main parts of the ear	Associated parts
Outer ear	

Table 3.5 Structure of the ear

Notice the functions of the pinna listed below.

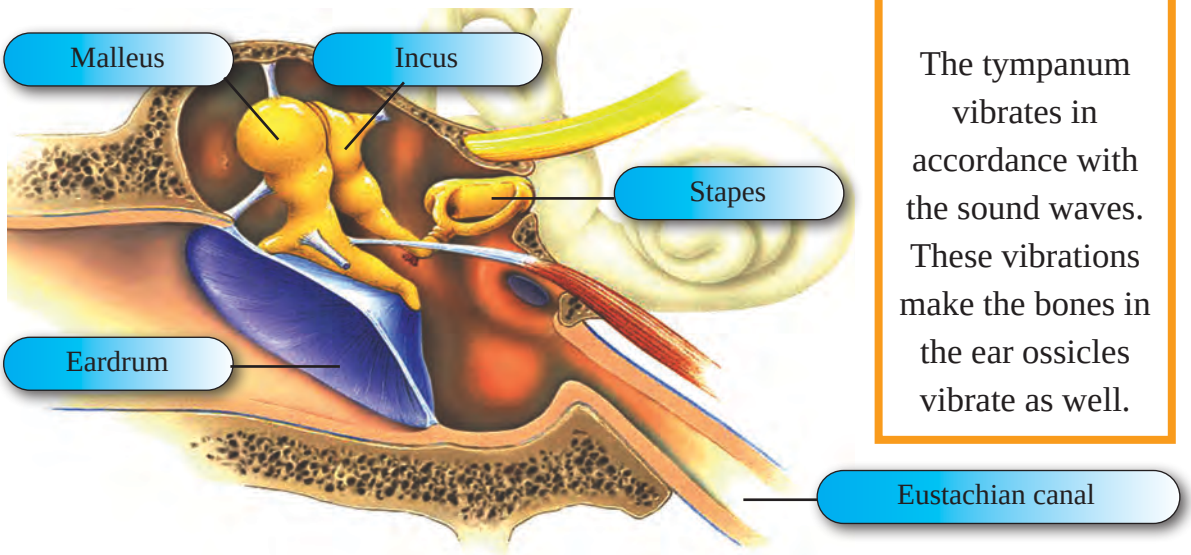
- Directs the sound waves into the auditory canal
- Helps to identify the direction from which sound is produced.
- Protects the auditory canal to some extent from foreign particles.

What are the peculiarities of the auditory canal?

It directs sound waves to the tympanum and protects the tympanum from foreign particles. The hair inside the auditory canal, earwax and sebum secreted by glands in its wall help to prevent dust and germs from entering the ear. Like tears, ear wax also has disinfectant properties.

Tympanum or eardrum is 9-10 mm in diameter and has only 0.1 mm thickness.

In the middle ear, the ear ossicles are arranged in connection with tympanum. Analyse the illustration 3.7, description, gain an understanding and prepare notes.



The tympanum vibrates in accordance with the sound waves. These vibrations make the bones in the ear ossicles vibrate as well.

Illustration 3.7 Parts of the middle ear

Eustachian canal

The eustachian canal is a long tube that is 4 cm long that connects the middle ear to the pharynx. Normally it is closed, but it opens during chewing, blowing the nose etc. It helps to balance the pressure on both sides (middle ear and the atmospheric air in the outer ear) of the tympanum. It also facilitates the flow of mucus and fluids from middle ear to the pharynx.

Where are the vibrations that reach the stapes directed?

What are the mechanisms of the inner ear that help hearing?

Analyse the given illustration 3.8 and the description Now, complete the flowchart 3.4 that indicates the direction of sound waves and the sense of hearing.

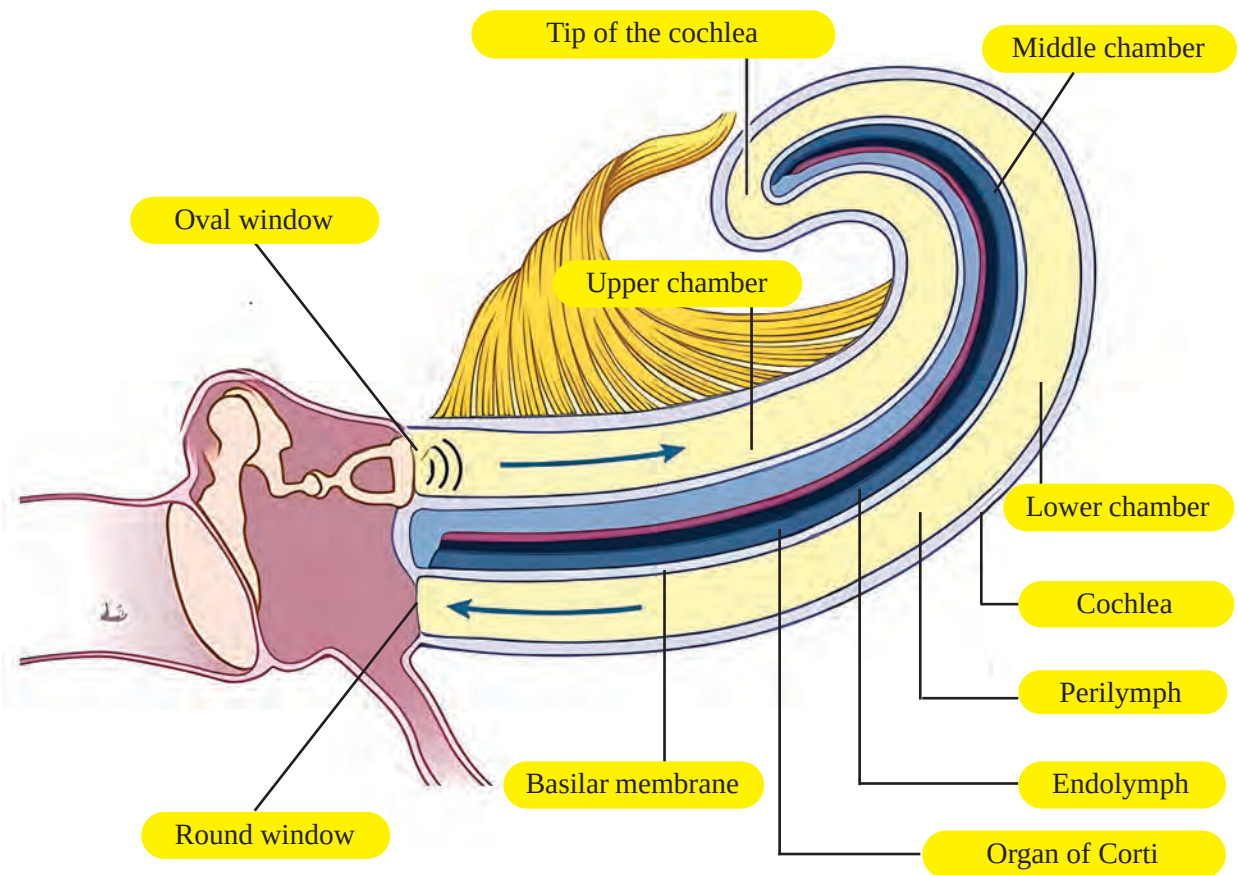


Illustration 3.8 The Inner ear (Cochlea - hearing)

The sense of hearing

Sound waves vibrate the tympanum. From there the vibration passes through the ear ossicles and then vibrates the oval window. The structure of the oval window is also similar to that of the tympanum. The cochlea, having the shape of a snail shell, has three chambers. oval window is the membrane that covers the opening towards the upper chamber. The upper and lower chambers are filled with a fluid called perilymph. The middle chamber is filled with endolymph. The **Organ of Corti** where the auditory receptors are present is situated in the basilar membrane between middle and lower chambers. The vibrations that reach the hair cells present here generate impulses. These impulses reach the brain through auditory nerve resulting in the sense of hearing.

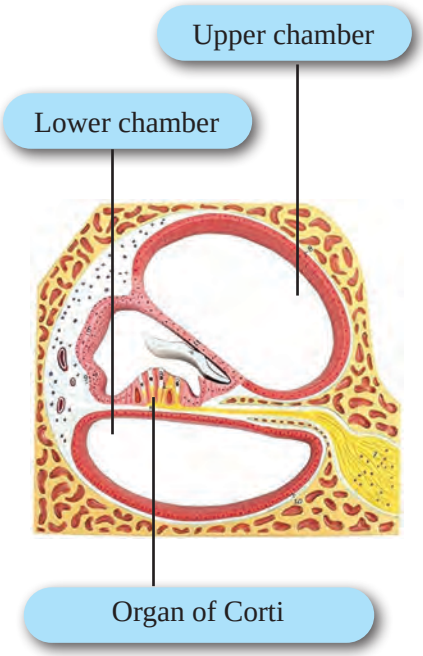
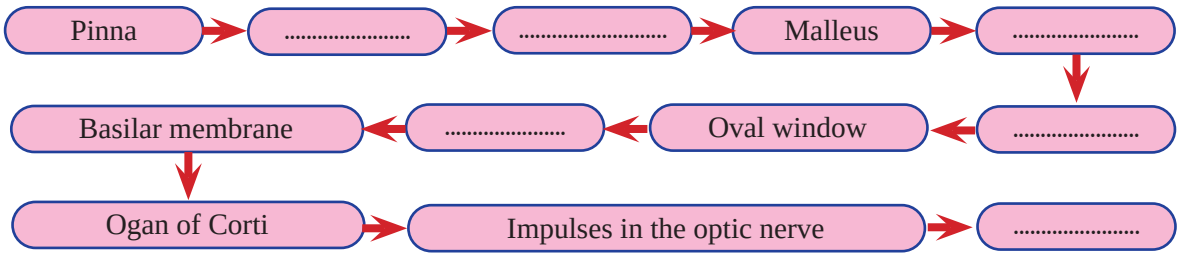


Figure 3.5 Organ of corti



Flowchart 3.4 Behind the sense of hearing

You have understood the main parts and functions involved in the process of hearing.

Expand and complete the table 3.6 by adding the parts that help in hearing.Include their functions also.

Part	Function
Pinna	
Tympanum	

Table 3.6 Parts that help in hearing and functions

A big tree happens to get uprooted in the forest. Was there a sound if no one was there to hear it? Find out.

Another function of the ear is to maintain body balance, isn't it?

Which part of the brain is responsible for maintaining balance?

How are the impulses for maintaining balance transmitted to that part?

Analyse the given illustration 3.9, and its description based on the indicators and find out the role of the ear in maintaining balance. Prepare a flow chart on it.

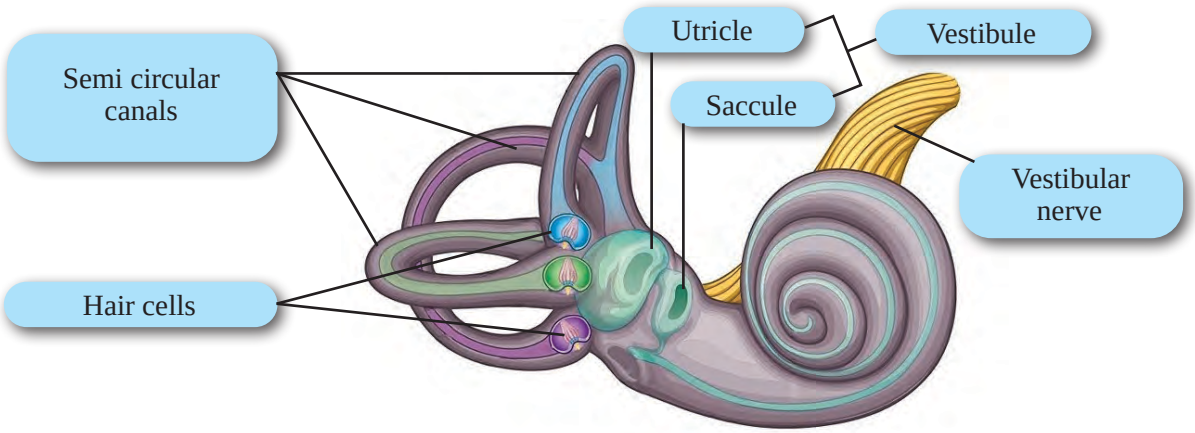


Illustration 3.9 The Inner ear - Maintaining Body Balance

The part of the inner ear that maintains body balance is the vestibular system, which includes three semicircular canals. vestibule and hair cells. The endolymph present in the canals, which are arranged perpendicular to each other, moves with the rotational movement of the head. As a result of this movement, the hair cells present here get stimulated and impulses are formed. The utricle and saccule of the chamber called the vestibule also contain hair cells. The linear movement of the head generates impulses in these hair cells. When the impulses reach the brain through the vestibular nerve, the brain maintains body balance by receiving impulses from the eyes and muscles as well..

Indicators

- The parts of inner ear associated with balance
- Position of the hair cells
- Fluid in the chambers
- The situation in which hair cells are stimulated
- The part of the brain associated with balance

Hearing impairments occur due to many reasons. Depending upon the causes, there are also remedies including surgery. Hearing aids are also available.

An excerpt from a science article related to hearing is given below. Analyse it, discuss the ways to prevent hearing impairments and organise awareness programmes.

Hearing is a divine gift that nature has bestowed on humans. Sound that travels in the form of waves can be transmitted only through a medium. A sound that can be heard in a condition of complete silence is represented as zero decibel. For every 10 decibels, the intensity of the sound increases tenfold. In a normal conversation, intensity of the sound will be between 40 and 50 decibels. It can be up to 60 decibels, while speaking loudly. The normal sound of the honking of a car horn is 70 decibels, while that of an air horn is 100-110 decibels. Intensity of noise above 80 decibels is extremely annoying. Noise pollution is a danger that is most harmful and unfortunately, the most neglected of all the environment pollutions that we face today. Hearing of loud noise (above 85 decibel) for a short time and less noise with a lesser intensity (below 55 decibel) for a very very long time can cause permanent hearing impairment.

Olfaction

You have understood how the eyes and ears help to perceive senses. The tongue and nose are two interconnected sense organs. What are the structural features of these organs to detect taste and smell respectively?

Analyse the given illustration 3.10 and its description. Complete the flowchart 3.5 related to the process of sensing smell.

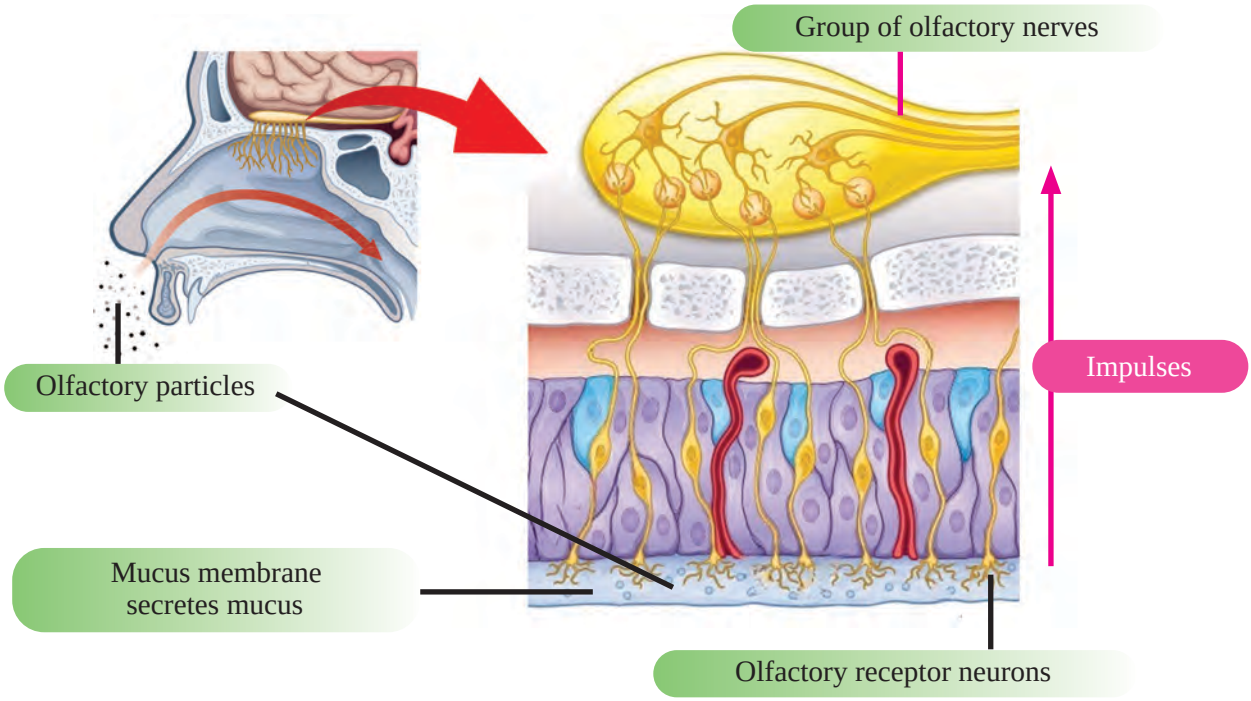
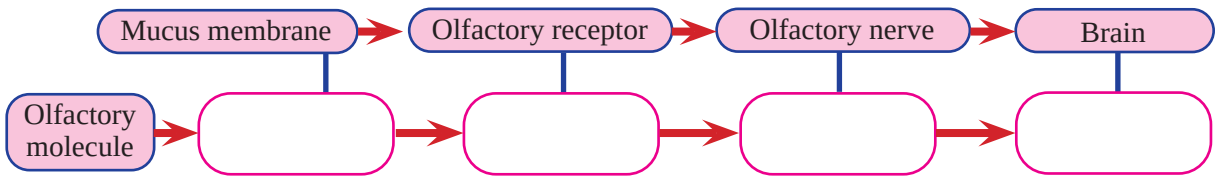


Illustration 3.10 Olfactory receptors

While breathing, the particles responsible for smell enter the nasal cavity. Then it gets dissolved in the mucus produced by mucus membrane. Millions of olfactory neurons in the mucus membrane get stimulated by special olfactory particles. Receptors generate impulses, and they travel through the olfactory nerve to reach the part of the brain recognising smell, and the sense of smell is effected.



Flowchart 3.5 Sense of smell

Taste

One can identify the smell of the food even before tasting it. Taste buds play a crucial role in enjoying the food by helping us to perceive the natural flavours of food. Food made with natural ingredients is safe and healthy rather than the taste of artificial additives or harmful substances.

Analyse the illustration 3.11 indicating the activities of the sense of taste and its description based on the indicators. Record inferences.

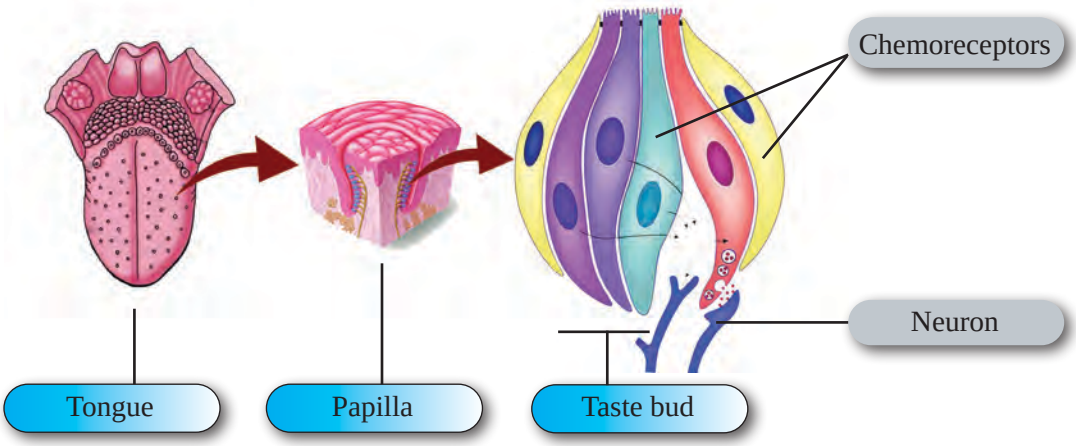


Illustration 3.11 Taste buds and chemoreceptors

A taste bud will have about 100 chemoreceptors. Microvilli from each chemoreceptor, reach the minute pores present in the papilla. Saliva enters through this pore. Substances that give rise to taste are dissolved in saliva and stimulate chemoreceptors. The impulses produced by these molecules in the chemoreceptors reach the brain through the nerve and make the sense of taste. The main tastes we recognise are sweet, sour, salty, pungent, bitter and umami.

Indicators

- Papilla in the tongue
- Position of taste buds
- Chemoreceptors and taste
- Saliva and the sense of taste

Haven't you understood the processes behind smell and taste? Complete the given table 3.7 suitably.

Process	Smell	Taste
The fluid in which substances dissolve		
Stimulated receptor		
The nerve that carries impulses to the brain		

Table 3.7 Receptors and experiences

Skin

Which are the senses that can be perceived through the skin? Are all the receptors which help this the same? Analyse the illustration 3.12 and gain an understanding of the position and function of the receptors.

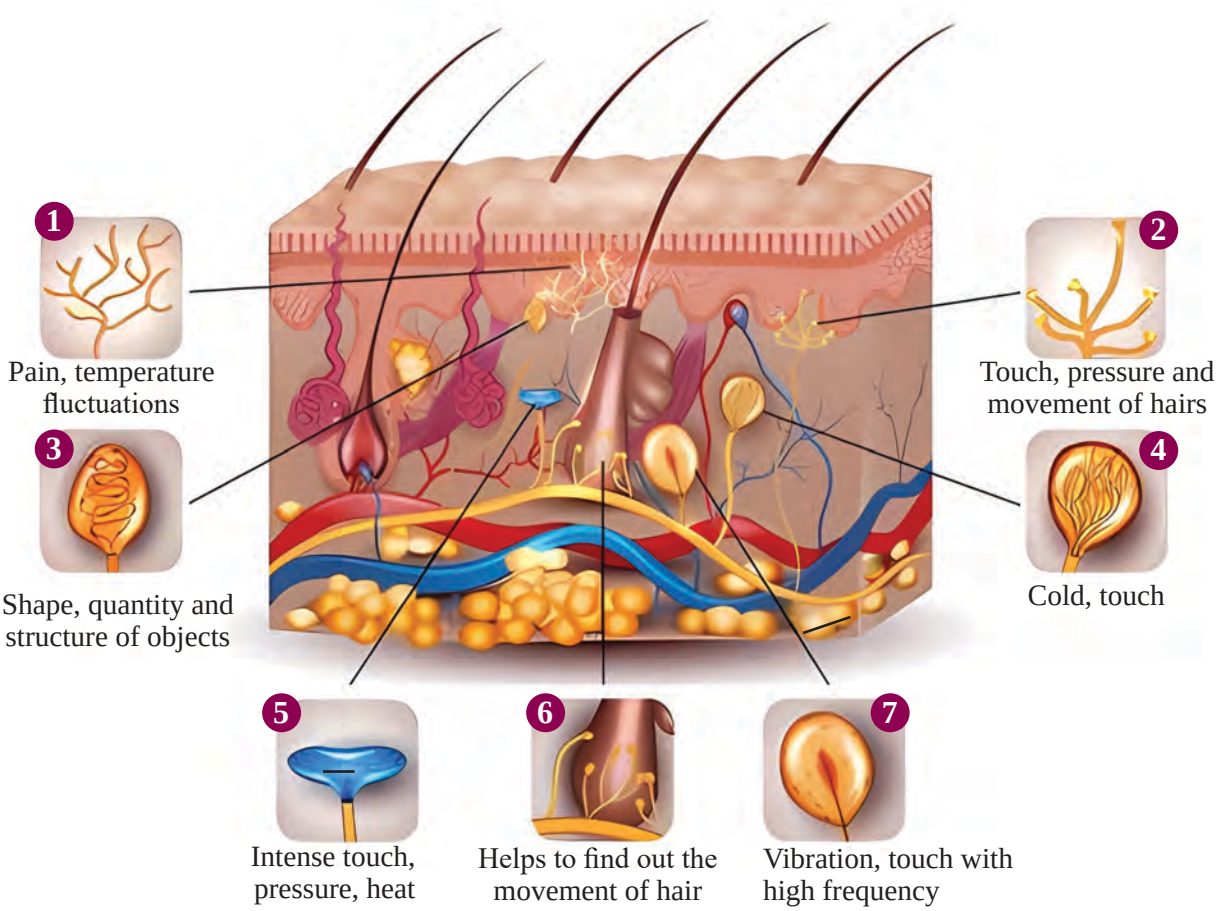


Illustration 3.12 Receptors in the skin

Receptors in the skin

Receptor	Function
1. Independent nerve endings	Pain, temperature fluctuations
2. Merkel disc	Touch, pressure and movement of hair
3. Meissner corpuscles	Shape, quantity and structure of objects
4. Krause end bulbs	Cold, touch
5. Rufini end organ	Intense touch, pressure, heat
6. Root hair plexus	Helps to find out the movement of hair
7. Pacinian corpuscles	Vibration, touch with a high frequency

Pain

Pain is the response that alerts the body to dangers such as injury, wound, infection and that of such kind. The process of identifying pain is known as nociception. Specialised receptors called nocireceptors are nerve endings found throughout skin, muscles and internal organs.

The pain experienced while touching a hot vessel is called nociceptive pain. Here, a sensory neuron or nociceptor, transmits impulses to the spinal nerve and then to the brain. Then pain is experienced.

Due to an infection or tissue damage, the body produces molecules such as cytokines and chemokines. These also lead to pain. Pain can also be experienced in conditions such as neuropathy, where peripheral nerve damage occurs.

Analyse the illustration 3.13 and gain an understanding of the diverse sensory mechanisms found in different organisms. It will help to understand the world around. Modify the illustration by gathering more information. Prepare a wall magazine and display it in your class.

Amoeba/Bacteria

Detects the presence of chemicals in the surroundings and move against them

Euglena

The eyespot (stigma) helps to detect light and move towards it.

Insects

The compound eye made up of Ommatidia. The Antenna helps to detect smell and touch.

Bat

Ears and special type of echo location organ helps in hunting and travelling.

Hawk

Eyes with high vision, systems for long distance vision and detecting ultra violet radiation.

Snake

Jacobson's organ helps to detect smell.

Dog

Highly sensitive olfactory receptors (300 million) are found.

Sensory diversity in organisms

Illustration 3.13 Sensory diversity in organisms

Among mammals, elephants have the largest number of olfactory genes, about 2000 genes. It is only 400 in human beings. Elephants mainly depend on smell for food, not vision. They can detect the presence of water even from a distance of 19 km using the trunk. They can sense the vibration from the ground

Human senses are the powerful tools that connect us to the world around us. They help us to understand, interact and respond with acute awareness. We collect information that form our thoughts, emotions and actions through vision, hearing, smell, taste and touch. Our nervous system equips the body for survival and adaptation through quick and suitable response to these sensations.

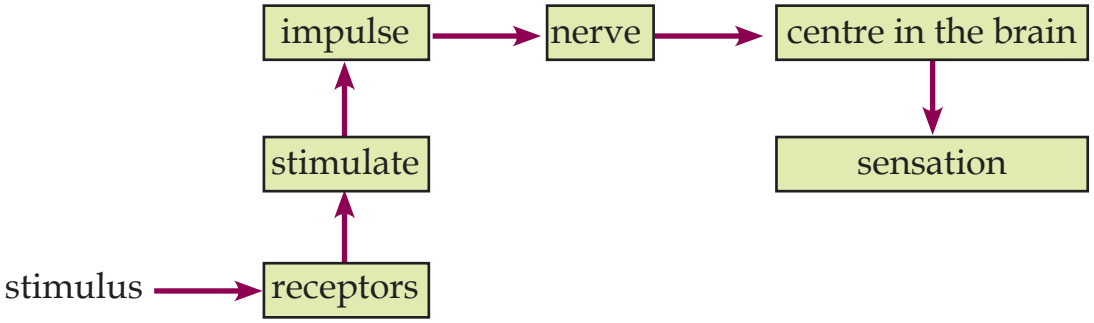
As humans, our ability to interpret and respond to sensory information reflects the complexity of life. Beyond survival, our senses contribute to the richness and beauty of human experience ranging from relishing art and music to forming relationships. Understanding and caring of our senses ensure a healthy and satisfactory life. This enables us to continue our exploration of what remains still uncovered.

Similarly, sensation and perception also happen in the internal environment. Thirst is experienced when the level of water decreases in the internal environment. The receptors, nerves and brain are involved in this. The receptors in the internal environment need not be transformed the nerve cells. We shall study these in detail, in the next chapter.

Let us Assess

1. Which of the following statements is correct?
   a. Each taste bud has different chemoreceptors.
   b. Opsin in rhodopsin contains retinal which is formed from vitamin A.
   c. Photoreceptors are formed from optic nerve.
   d. Both rhodopsin and photopsin contain retinal.

2. Recreate the illustration as given below by including any sense organ.



3. Listen to the conversation between two children. Evaluate it and record your opinion.

   Child 1 - We should be proud of being born as humans. Humans have the most developed and efficient brain and sense organs.

   Child 2 - It is enough to talk about the brain, as the sense organs are its continuation.

4. Analyse the information given in the columns A,B,C. If inter connected information is present in three columns. Rearrange them suitably.

A	B	C
Cochlea	Pharynx	Oval window
Tympanum	Perilymph	Cerebellum
Vestibule receptors	Organ of Corti	Endolymph
Eustachian Tube	Nerve fibres	Auditory receptors
Outer ear	Ear ossicles	Hypothalamus

5. Correct the mistake, if any.

   Impulses are formed in the retina due to the dissociation of rod cells.

6. Analyse the given word pairs below, and find the relationship between them.

   Retinal- Night blindness

   Umami- Taste buds

   Cone cells- Colour Blindness

7. Classify the given activities based on the indicators.

   - The image of your friend formed in the retina
   - Looking at the friend and smiling
   - The impulses of the image formed on the retina is sent to the brain.
   - Photoreceptors are stimulated

Indicators

   - Activity/activities related to sensory nerve fibres
   - Activity/activities related to motor nerve fibres
   - The activities not related to the above ones

8. Which part of the eye helps in focusing the light towards the retina

   a) Cornea b) Pupil

   c) Lens d) Iris

9. What is the main function of a neuron?

   a) Protects organs b) Exchange electric signals

   c) Filters blood d) Produce retinalin

10. How does the arrangement of rod cells and cone cells in the retina affect our ability to see in different conditions of light? Why does this adaptation become beneficial evolutionary?

11. How does the structure of the ear enable it to convert the sound waves into signals that the brain can interpret? How do damages in different parts of the ear affect hearing and balance?

Extended activities

1. In a dark room, gradually increase the amount of light using a flash light or dimmer. Observe how different light levels affect the ability to see colours and details, and record record your findings.
2. Rotate slowly in a circle and try to walk in a straight line to observe how this activity affects your balance and hearing. Record your inferences.
3. Make a simple 3D model of the eye using craft materials (clay, paper, markers) to represent parts such as cornea, lens, retina, optic nerve etc.
4. Set up a few soundzones around the classroom with different sound sources (tapping, clapping, ringing). Each students is blind folded and made to move between the stations. Identify the direction and type of sound. Observe how the structure of the ear helps detect sounds.