LEARNING SCIENCE

Part 4

Biology and Life

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About the Authors

Mrs. Indumati Rao has received degrees from the Universities of Mysore, Kanpur and Purdue (U.S.A.) and certificate in Education from Oxford University (U.K.). She has worked for over four decades in the field of education. She has contributed to developing new methods of teaching and teaching aids. Mrs. Rao has worked as a geography expert in many institutions. She has participated in several teacher orientation programs conducted by the Karnataka State. She has authored books in Geography. At present, she is working as the Honorary coordinator of the multimedia group at Jawaharlal Nehru Centre for Advanced Scientific Research.

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He has received several medals and prizes which include the Marlow Medal of the Faraday Society, Centenary Fellowship of the American Chemical Society, Einstein Gold Medal of UNESCO, the Centenary Medal of the Royal Society of Chemistry, London and the Hughes medal of the Royal Society. He has published more than 1300 papers in the areas of Chemical Spectroscopy, Molecular Spectra and Chemistry of Advanced materials. He has authored 38 books and has been active in science education. He was awarded the Karnataka Ratna in 2001 by the Karnataka Government. He is the first recipient of the India Science Prize, the highest scientific award recently instituted by the Government of India, and the Dan David International Prize for Science (2005). He was recently awarded the "Chevalier de la Legion d'Honneur", the highest civilian award of France (2005). He was also named the `Chemical Pioneer of 2005' by the American Institute of Chemists, USA.

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Preface

Science has become a part of our lives. Applications of science have provided us many benefits, and a better quality of life. The world today uses a language which has a lot of science in it. Without knowing, we use many words and phrases derived from science. We are also becoming conscious of our environment as well as our economy. Science has much to do with both these aspects. It is, therefore, important to learn the language of science. Children and adults alike have to know the rudiments of science and must be able to use the language of science where necessary. They must be able to apply the lessons learnt from science in daily life.

It is for this purpose that we have produced a book entitled **"Learning Science"** in four parts. The book has the following four parts:

Part1: Universe, Solar System, Earth

Part2: The world of physics and energy - Learning physical principles

Part3: The world of chemistry: Of molecules and materials,
Air around us, All about Water.

Part4: Biology and life

It describes various aspects of science in simple language. It is hoped that this will be useful to school children as supplementary reading material and to all others who want to learn science and partake in the excitement of this experience.

Bangalore
2005

Indumati Rao
C. N. R. Rao

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Biology and life

Objectives

- ★ Our living world is full of wonderful plant and animal species.
- ★ It is essential that we all know something about the structures and organs of plants and animals.
- ★ We shall learn about these aspects in this lesson, along with the evolution of living species.
- ★ We shall also have a brief look at microbes, bacteria and fungi.
- ★ Bacteria were the first amongst the living species in evolution.

  Furthermore,
- ★ Living species are characterised by the cells constituting them.
- ★ We shall try to learn about cells in plants and animals, which play such a crucial role in life processes.
- ★ At a more fundamental level, molecules provide the basis for the processes. Biology is studied both at cellular and molecular levels.
- ★ Besides describing various functions and processes in living systems, we shall also see how microbes can be good and bad.

The amazing journey of the green turtles of Brazil

The warm sandy beaches of Brazil is the home of the green turtles. When the time comes to lay their eggs, the female turtles accompanied by their faithful males, swim nearly 2,250 kilometres to the tiny Ascension islands in the middle of the Atlantic Ocean. When they reach this tiny island, the male turtles remain in water. The female turtles go ashore, lay their eggs and bury them in sand. This done, the female turtles then hurry back into water and start their return journey to their homes in Brazil. The eggs hatch in due course and the infant turtles swim to the unknown beaches of Brazil!

Questions Questions Questions

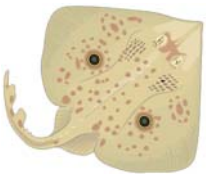
This journey of the green turtle raises many questions. There are miles of warm beaches in Brazil. Yet, the green turtles go to the cold isolated small beaches of Ascension Islands. **Why?**

How do they find this tiny island? How can they navigate to the exact place while swimming in the dark?

How do the newborn turtles find their way to the Brazilian shore that they have never seen? This mystery is part of the amazing diversity of life on earth. **Such mysteries have a biological basis.**

1.0 What is biology?




Biology is concerned with the mysteries of plants, animals and living organisms. It provides knowledge about the living world of which we are a small part.

It is vital that we learn how to live in harmony with other residents of this planet. It is our ignorance that has led to the near extinction of the cheetah and many other species.

Why is biology important?

Biologists

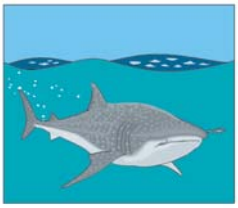
live with chimpanzees.

collect fossils.

grow fungi.

study the dance of the bees.

study humming birds flapping their wings.



study the migration of whales.

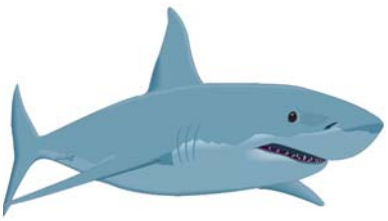
read and decode messages in DNA.

Why do biologists do these things?

Biologists do all these things to understand the diverse living organisms. Even the life of a housefly reveals interesting information! It is like understanding a beautiful painting brushstroke by brushstroke!

Danger to many species

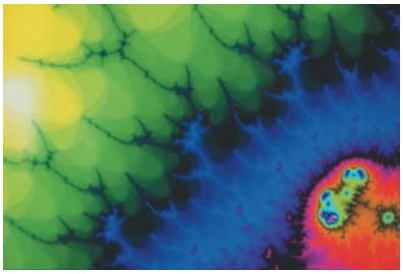
We are destroying their habitats, hunting animals to destruction killing them for gain.



How can we save the threatened species?

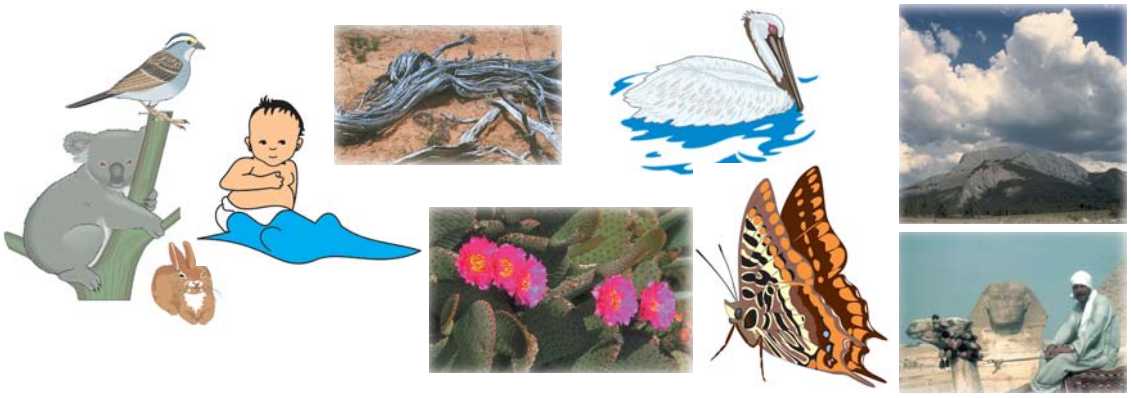
Biology helps us to devise strategies to overcome this man-made crisis.

1.1 The living world around us



Unity in diversity

There are millions of things around us.



Some are living while others are non-living. What is the difference between them?

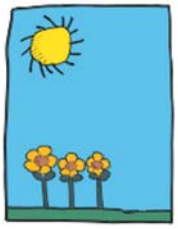
The living and the non-living - what is life?

Two friends find themselves on a unfamiliar hill. There is no one else around. They find something that is big and spherical like a mound. Is it alive? How will they find out?

Various options of finding out

First, one might find out if the object moves. But movement by itself is not a sign of life. Most animals move. Plants do not move but clouds do.

Next, one can poke at the object to find out if it reacts (sensitivity to stimuli). **Almost all living things respond to stimuli.** A dog will not go near fire. A plant grows towards light.



But a tree will not respond to your kick. So this is also not sufficient evidence.

Still groping in the dark

Does the object show signs of development?

We can see growth in the rocks of the Himalayas. Scientists tell us that the Himalayas are growing taller by a few centimetres every year. But the rocks were never alive. So this is not sufficient evidence.

If the mound does not move, you may think that it is dead. **But the evidence is inadequate because unless something has life, it cannot die!**

1.2 Criteria of living things

Living things

have cellular organization.

use energy for growth.

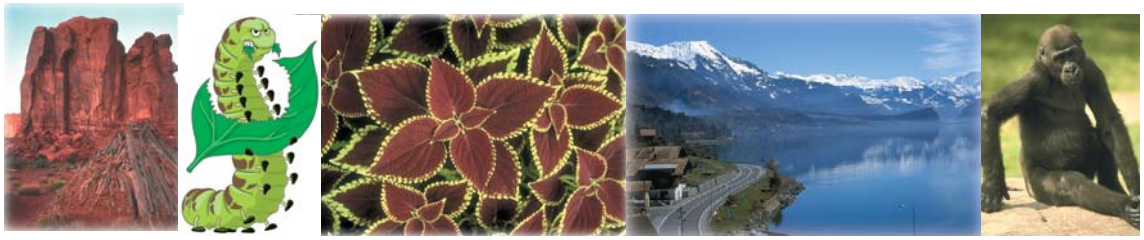
reproduce.

have heredity.

maintain an internal balance.

These characteristics differentiate the living from the non-living.

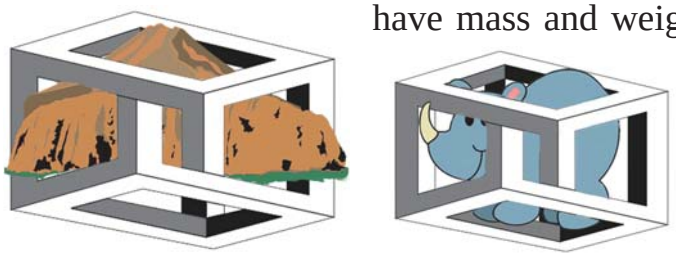
Shared characteristics



Some of these are living and some are non-living. **The living and the non-living share some characteristics.** Are you surprised by this statement?

What do the living and the non-living have in common?

The living and non-living are made up of matter, have mass and weight,



occupy space.

Life processes in the living organisms make the vital difference.

Same yet different

All these organisms have different shapes, sizes, habits, diets and names. But they all have one thing in common - they are all living organisms.

Life stages of living things

All living things start their life at an “infant stage”. They may be


born as babies.

hatched from eggs.


produced from seeds, spores or parts of a plant.

Animals and humans do not grow after a particular age. Plants grow throughout their lives. Generally, all living things grow into adults and eventually die.

Life span of living organisms

All living organisms do not have the same life span.

1 to 4 months

120-150 years

~ 30 years

70 - 90 years

2-3 years

20 years

1 year

20 years

60-100 years

1.3 Making food

Only **green plants** make their own food. Plants are called **autotrophs**. All the other living organisms depend upon plants or other animals for their food. They are called **heterotrophs**.

Autotrophs or self-sustaining organisms

Autotrophs are organisms that can use the radiant energy from the sun to convert carbon dioxide and water into simple, energy-rich carbohydrates.

The autotrophs use the stored energy in simple carbohydrates to produce more complex proteins, fats and starches.

All green plants are the most efficient autotrophs. Autotrophs are the producers in the food chain. They form the base of the food pyramid.

Heterotrophs - the consumers

Heterotrophs cannot make their own food. Organic matter or food produced by the natural vegetation directly or indirectly sustain the heterotrophs. The heterotrophs use, rearrange and ultimately decompose the complex organic materials built by the autotrophs. All animals, fungi as well as most bacteria and many microorganisms are heterotrophs.

Heterotrophs like fungi and bacteria are decomposers. Decomposers break down the dead and decaying organisms and organic waste and the nutrients in them are returned to their sources. These heterotrophs are the final link between the living and the non-living components in an ecosystem.

We are what we eat - food habits of animals

All animals depend directly or indirectly on plants for their food. Depending on their food habits, animals are classified as

What are you?

herbivores

carnivores

omnivores

All animals do not live in the same type of shelters or animals have different habitats

Some live

in forests,

in lakes and rivers,

in seas and oceans,

on the trees,

in villages and cities.

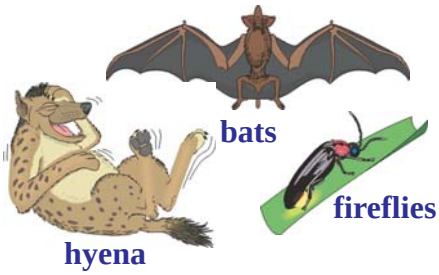
underground,

Some animals do not like light while some are attracted to light.

Night is day and day is night

As a rule, we sleep at night and work during the day.
But there are some animals and birds and insects which are wide awake at night and sleep during the day. Some of these are owls, bats, fireflies, and hyena.

owls



bats

fireflies

hyena

They are called nocturnal animals and birds. Do you know any other nocturnal animal?

1.4 What are species?

Each of these living organisms has many individuals. The individuals of a particular organism

- ★ share certain similar characteristics.
- ★ and at the same time have differences.

The word species means **kind** in Latin. **Species comprise a class of organisms that share certain common characteristics.** One of the most important characteristic of a species is the tendency to mate with only fellow members. This helps the species to retain the special traits or characteristics.

John Ray (1627-1705), an English scientist-clergyman was the first to propose a general definition of species. He was also the first to point out that all individuals belonging to a species could breed with one another and produce individuals.

Even if two different looking individuals are born out of a single mating, they are still considered to belong to the same species. All dogs belong to one species, all pigeons to another. Horses and donkeys do not belong to the same species; neither do carp and gold fish.

How to identify species

The similarities are

in the body parts,

the body functioning,

the food consumed

and their habitats.

They reproduce similar individuals.
A group of individuals showing these similarities is called a **species**.

How are the species named?

"What is in a name?" We all know that names are important. They help to identify an individual. They may be called by different names in different languages. It is more difficult to name the animals, birds and plants. Therefore, they have scientific names which are accepted by all.

How are the names of species written?

Most of us have

- ★ a family name.
- ★ and an individual name.

An animal /a plant /a bird also has

- ★ a last name or a group name.
- ★ and a species name.

How is the scientific name of a species written?

When the scientific name is written,

Mangifera (group name)

indica (individual name)

Mango or Mangifera indica

- ★ the group name is written first.
- ★ the first letter of the group name is a capital letter.
- ★ the individual name follows the group name.
- ★ the first letter of the individual name is written as a small letter.

Example; Mango: Mangifera indica, Human being: Homo sapiens.

How many species of animals and plants are there?

This diversity is called **biodiversity**. India has rich biodiversity both in plants and animals.

~ 400,000 species

~ 1,600,000 species

Flora of India

India is the home to diverse flora. The diversity of flora of India is the result of India's varied relief, land forms and climate. We have identified and described 49,000 different species of plants. Of these 5000 species are exclusive to India. Both flowering and non-flowering plants such as ferns, algae and fungi show a wide variety. Our flora ranges from the typical flora of the tropics to the flora of the Arctic zone.

The original vegetation cover of India consisted of forests, grasslands and shrubs. The major vegetation types of India are: the tropical evergreen forests, tropical deciduous forests, thorn forests, tidal forests and montane vegetation.

Varied fauna of India

The wide variety of flora found in India has resulted in an equally rich and varied fauna. India has over 81,000 known species of animals, around 25,000 species of fish (both fresh water and marine water habitats and 1,200 varieties of birds. Among mammals, India has elephants (in the jungles of Assam, Kerala and Karnataka), camels (in Rajasthan) and wild asses (in Rann of Kutch), Rhinoceros live in the swampy regions of Assam and West Bengal. Antelope and black bucks, gazelle and deer grace our forests. Swamp deer, spotted deer, musk deer and mouse deer also make their home in our forests. India is famous for its lions, the Bengal tiger, leopards, clouded leopards and snow leopards.

1.5 Ecosystem

Life around a pond

Birds eating insects.

Pebbles and pieces of rocks.

Birds and bees drinking honey from flowers.

Frogs jumping into and out of water.

Fishes eating tadpoles.

Apart from these, what you cannot see are bacteria and fungi,

Both the living and the non-living are in a particular physical setting - the pond.

The living organisms and the physical environment together form a fundamental **biological unit**.

This biological unit is called the ecosystem.

Ecosystem

Ecosystem includes all living organisms, all their physical environment and their mutual relationships in that particular physical setting. An ecosystem consists of minerals, climate, soil, water, sunlight (in short all the non-living elements) and members of all the living organisms in that setting. An ecosystem can be large or small, natural or man-made. Each element of the ecosystem interacts directly or indirectly with all the other elements and contributes to the functioning of the entire ecosystem.

The two major forces - the flow of energy through the ecosystem and the cycling of nutrients within the ecosystem - link the living and the non-living components of the ecosystem.

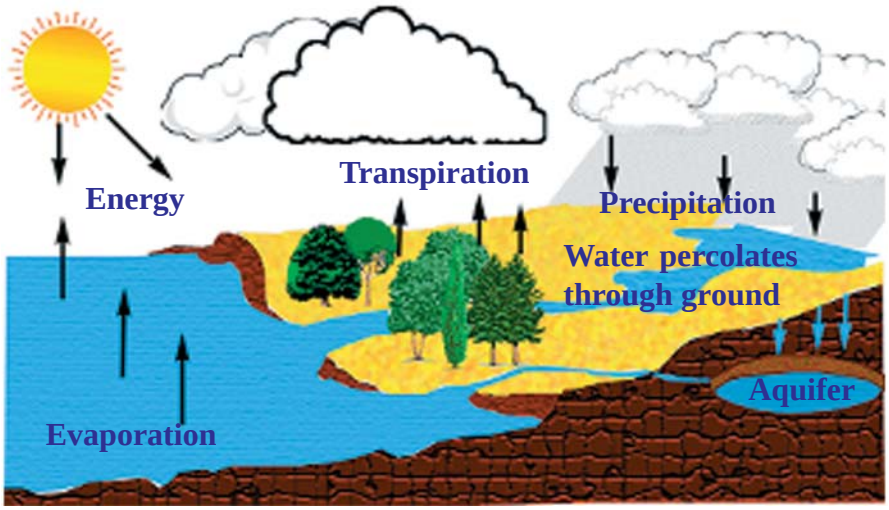
Importance of the physical environment in an ecosystem

Water, oxygen, carbon, nitrogen and a number of chemicals (salts) pass from the atmosphere, seas (and oceans) and rocks into the living organisms and then are returned to their sources.

Cycling of nutrients in nature

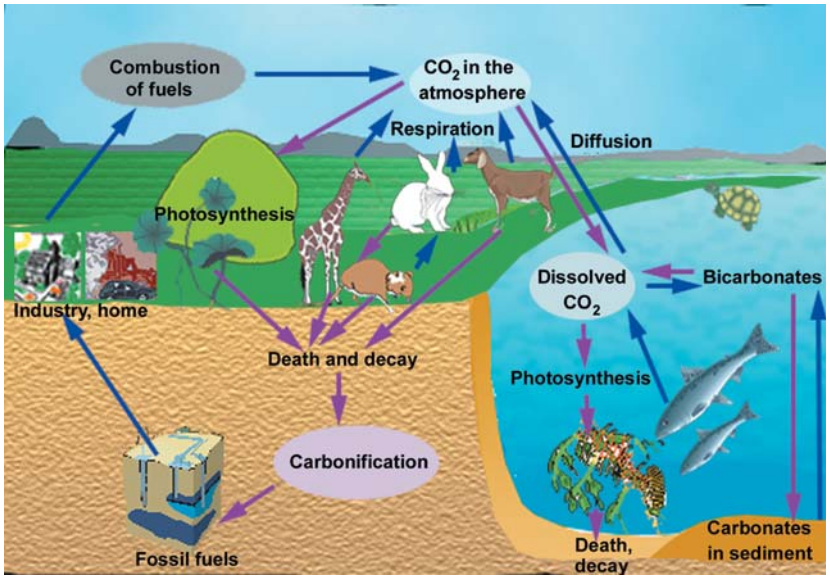
There is a continuous cycling of nutrients in the ecosystems. We will look at a few of the important cycles in nature.

The water cycle



The water cycle is unique to our planet. This cycle ensures a continuous supply of water to all the living organisms on earth.

The carbon cycle



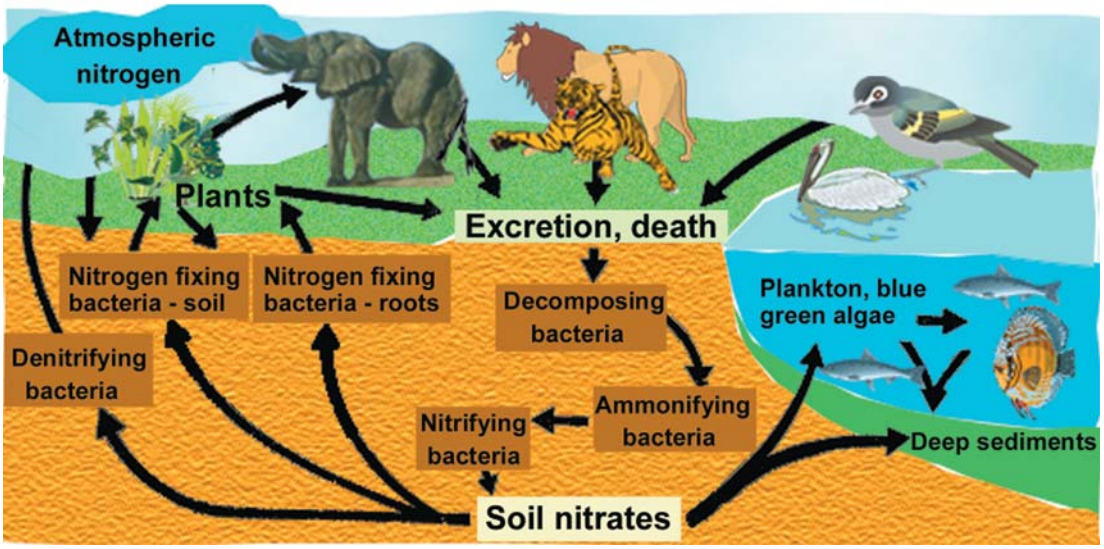
Plants, algae and some bacteria play a crucial role in recycling carbon.

Importance of nitrogen to living organisms

Nitrogen is vital for living organisms. It is necessary to synthesize proteins, nucleic acids and other nitrogen containing compounds.

The nitrogen cycle

Even though the atmosphere has 78% nitrogen, the total amount of nitrogen fixed in the soil, oceans and organisms is only 0.03%.



Leguminous plants, certain bacteria and fungi play an important role in **nitrogen fixation**.

Nitrogen fixation

Nitrogen is essential for all living organisms. Plants cannot utilize the abundant nitrogen in the atmosphere. **Bacteria** play a crucial role in the production of usable nitrogen. In well aerated and not highly acidic soil, certain specific bacteria convert ammonium salts present in the soil to nitrite. Nitrite in turn is converted by other bacteria to nitrate. Highly soluble nitrate is taken by the roots of plants.

Rhizobium bacterium present in the roots of leguminous plants (such as peas, beans) **fix the atmospheric nitrogen**. Some other bacteria reduce the nitrates in the soil to nitrogen and nitrous oxide. These gases are then released into the atmosphere.

Different ecosystems

There are many kinds of ecosystems. They can be **on land** or **in the seas**. Our earth provides the living organisms more than land to roam about and the sea to swim around. It provides a well balanced and integrated ecosystem for the living organisms.

Importance of balance in ecosystems

There is a delicate balance between living organisms and the natural environment. It is being constantly disturbed by human activities. The consequence of this can be far reaching. **We must halt our harmful activities before it is too late.**

2.0 Evolution of life on Earth

Our world was not always teeming with a variety of life forms.
For nearly a billion years after the birth of our planet, there was



no grass on land, no fish in the sea and no birds in the sky.
The earth was a barren planet.

The earth then and now


Primitive earth was a molten rocky mass with violent volcanic activity. Now our planet is in a diametrically opposite situation. Life is in profusion.

We do not find life in a blast furnace or a nuclear reactor.

How did this dramatic change come about?


We do not have a time machine to take us back billions of years. Neither are there any witnesses to this change. We can only gather evidence from the fossils and draw certain conclusions.

Evidence from fossil bacteria

Fossil bacteria provide the key to unlock the mystery. To understand the diversity of life today, we have to understand

what our planet was like four billion years ago. The earliest bacteria-containing fossil is ~ 3.5 billion years.

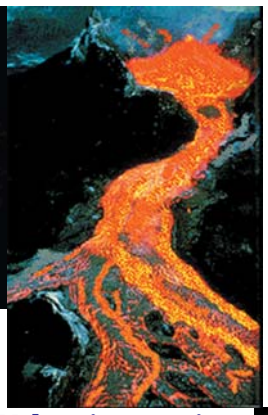
Fossil bacteria - evidence of life on primitive earth

For a long time scientists believed that fossils could not be found in the specimens of rocks dating back to 3.8 billion years. The fossil bacteria were too small to be seen by using ordinary microscopes. Electron microscope images have revealed that the earliest fossils (of about 3.5 billion years) are of bacteria. Huge marine deposits produced by cyanobacteria were abundant in fresh water and marine communities. These fossils of bacteria date back to 2.8 billion years.

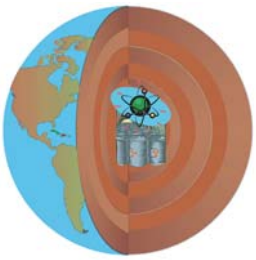
In the early history of life on earth, the only living organisms were bacteria. Fossils containing unicellular bacteria are around 1.5 billion years old. Fossils of multicellular organisms in rocks dating back to 630 million years were found in southern Australia.

2.1 Evolution of life from inanimate inorganic substances

The sun



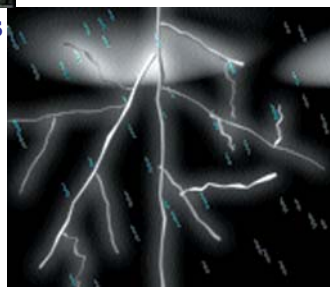
Volcanic eruptions



Decay of radioactive materials inside the earth

Energy from the sun, volcanic eruptions, decay of radioactive materials inside the earth and lightning set in motion, dramatic chemical reactions.

Scientists believe that lightning from the sky transformed inorganic molecules to the simplest single cell life forms in the oceans.



Lightning

The earliest bacteria

The earliest bacteria were small, were tough, probably did not have external growth and did not have an internal structure. They were called **Prokaryotes** (**Pro** meaning **before** and **karyotes** meaning **kernel or nucleus**).

Bacteria - the earliest life forms on earth

The simplest organisms are the bacteria. Bacteria are single celled organisms and do not contain chlorophyll. Instead of surviving by photosynthesis and producing their own food, they use a variety of biochemical means to obtain energy.

They are heterotrophic i.e. they feed on living and decaying organisms. They occur in every possible environment and they exist in large quantities. One drop of a liquid can contain 50 million bacteria and one ounce of soil on average can contain more than 30 billion bacteria.

Bacteria can cause many dangerous diseases but fortunately, they are outnumbered by bacteria that are beneficial to us.

For nearly two billion years, bacteria were the only living organisms on earth.
Compare this to the present day world!

2.2 Diversity in the evolution of bacteria

Bacteria learnt the adaptations required to survive in the ancient world. They learnt to survive in places with little oxygen like the depths of the seas, in the

boiling waters of hot springs. Some of them survive even today in these environments. They are called **fossil bacteria**. Bacteria can thrive in varied habitats. They can thrive

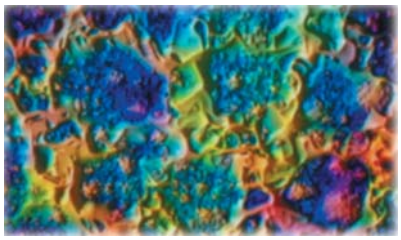
In hot springs where the temperature is around 78^{0}C.

In the deep sea vents where both the pressure and the temperature are extremely high.

In the extreme cold of the Arctic and the Antarctic snow.

In the bodies of animals and humans.

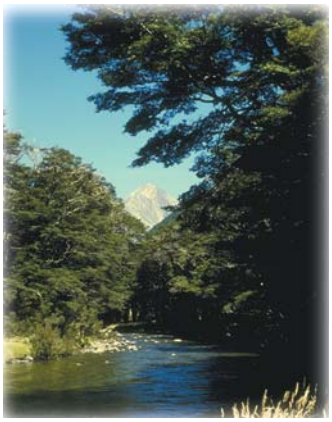
Photosynthetic bacteria



Photosynthetic bacteria show a great diversity. The most important photosynthetic bacteria is the **blue green algae or cyanobacteria.** They have, in addition to chlorophyll, blue or red pigments. They appeared on earth at least three billion years ago.

Modern bacteria - how did they originate?

Evolution of life forms on earth was a case of experiments with survival strategies. Many early forms of bacteria became extinct. But a few of them became the ancestors of life on earth. Their descendents include the fungi,



plants, animals and human beings.

Beneficial action of bacteria

Bacteria are responsible for

- ★ the decomposition of dead plants and animals.
- ★ restoring essential mineral to the ecosystem.
- ★ preventing waste accumulation and pollution.
- ★ assisting digestion, aiding nitrogen fixation.

Some bacteria are used to manufacture vinegar, making yogurt, cheese, fermentation of sugars to lactic acid. Bacteria were responsible for the conversion of organic matter to fossil fuels millions of years ago.

Bacteria, our constant companions

Bacteria

- ★ play an important role in the web of life on earth.

- ★ have a crucial part in the recycling of minerals in the ecosystem.
- ★ are present in everything we eat, and in everything we touch.

Shapes of bacteria

Bacteria can have a variety of shapes. Their shapes can be rod-like (bacilli),

spherical (cocci) or spiral. Bacterial cells have a simple structure.



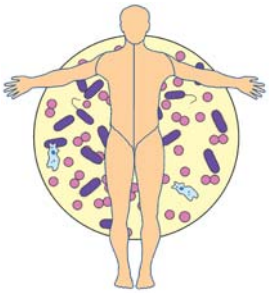
Reproduction and growth in bacteria

Bacteria reproduce both

- ★ by dividing themselves and
- ★ by sexual reproduction.

Bacteria can grow **without oxygen (an anaerobic growth)** or **with oxygen (aerobic growth).**

2.3 Impact of bacteria



Bacteria have a great impact on life on earth. Bacteria had a leading role in the formation of soil when they were the only organism on earth. They are also the invaders, causing untold misery to the internal systems of all animals including ourselves.

Useful role of bacteria

Bacteria

- ★ help to change milk to curds.

- ★ decompose dead plants and animals. (This process returns carbon and nitrogen to the environment)
- ★ renew the life-supporting properties of soil.

- ★ and help in the formation of humus.

Deadly bacteria : Bacteria and diseases

Bacteria are responsible for a number of diseases that cripple and kill humans and animals. Some of the diseases caused by bacteria are: typhoid, cholera, plague, tetanus, whooping cough, tuberculosis, leprosy and caries.
Vaccines have been developed to prevent these diseases. Bacteria also cause plant diseases.

Dental caries - the bacterial disease

Dental caries affects almost everyone. This disease starts in the film on our teeth (or dental plaque). This film consists mainly of a polysaccharide layer surrounding bacterial cells. Tooth decay is caused by the bacteria present in the plaque. (They remain in places that are difficult to reach even with a toothbrush).

Eating sugar-rich food causes the local loss of calcium from the teeth. Once the hard tissue starts to break down, it is followed by the breakdown in the tooth enamel. People do not generally realise that tooth decay is an infectious disease caused by bacteria. Fluoride retards (slows down) dental decay. Regular gargling after each meal is essential to prevent dental bacterial infections.

What is a Vaccine

Vaccine is a substance that prevents a healthy individual from developing that particular disease when the vaccine is injected into the healthy individual. Vaccines are disease specific. Generally, vaccine are effective for a specific period. Vaccines have saved us from many life-threatening diseases. Vaccines prevent infectious diseases from spreading.

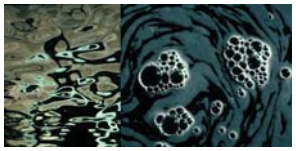
Bacteria and plant diseases

Almost all plants can develop bacterial diseases. While the bacterial diseases of plants vary, they are usually manifested as spots of various sizes on their stems, flowers, leaves or fruits, local rotting and wilting.

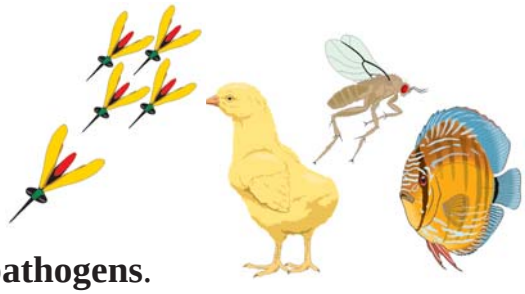
Rust in wheat and citrus canker are examples of bacterial diseases in plants. These diseases cause tremendous loss to the farmers. Herbicides are used to control bacterial diseases in plants.

How do bacteria attack?

Disease-causing bacteria can be



water-borne, air-borne or carried by a host animal



Disease-causing bacteria are called pathogens.
In developing countries, water-borne bacterial diseases are common.

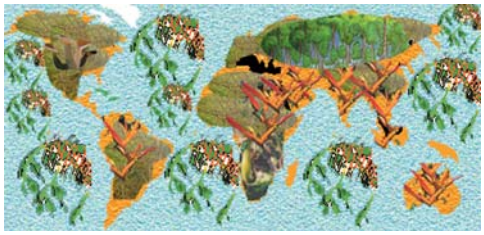
Staphylococcus - the air borne bacteria

Staphylococcus is an important air-borne bacteria. This is the cause of a number of hospital infections. Toxic shock characterised by fever, lowered blood pressure, vomiting, diarrhea and rashes which result in skin peeling are caused by this air-borne bacteria.

3.0 The amazing plant kingdom

Almost the whole of the earth's surface has plants.
The plants

- ★ cover the land.
- ★ float in the seas.
- ★ are the sole source of food for all living organisms.



What are plants?

Plants are characterized by the following features.

- ★ Their photosynthetic method of preparing food.
- ★ Their unlimited growth throughout their life-span. (Their embryonic tissues or meristems remain active throughout).
- ★ Their cells contain cellulose in their walls. (This makes plant cells more or less rigid).
- ★ They lack organs of locomotion and sensory and nervous systems.

3.1 Evolution of plants

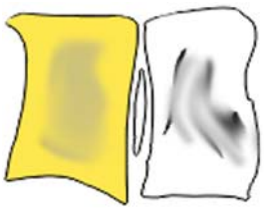
Plants have taken a relatively short time in the history of our planet to evolve into a diverse group. The great plant communities have in turn helped the **evolution of insects, fungi and vertebrates.** There are around 266,000 plant species.

Fungi: the many coloured micro-organisms

Fungi, unlike bacteria, require a moist environment. Fungi can be found

on fruits.

on stale pickles or jam.



on damp clothes.

on old shoes.

on stale bread.

on moist tree trunks.

Fungi - the organisms that are found almost everywhere

Fungi, like all heterotrophs, cannot synthesize their own food. They obtain their nourishment by taking in soluble materials produced by organisms that feed on decaying matter or by parasites that feed on other living organisms. All fungi reproduce by spores - some sexually and some asexually. The cell walls of fungi usually contain cellulose.

There is a wide variety of fungi. Scientists believe that there are more than 100,000 species of fungi. They are widely distributed and occur in diverse places. They include aquatic molds, bread molds, yeasts and mushrooms, mildews.

Fungi have an important place in an ecosystem as they help in the recycling of nutrients. They decompose the dead and decaying complex organisms to simpler structures.

Types of fungi

Fungi are mainly of two types:

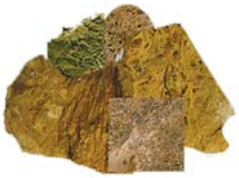
Molds (these are usually multicellular). Molds require oxygen to thrive. They are aerobic (like us).

Yeasts (which are usually unicellular). Yeast can flourish both in an aerobic environment (with oxygen) or in an anaerobic environment (without oxygen). Yeast is present in air as well.

When did the plant invasion begin?

How old are the plants?

The earliest evidence



of plants in fossils is ~ 410 million years old.

of shrubs, ferns and forests is ~ 360 million years old.

of flowering plants is ~127 million years old.

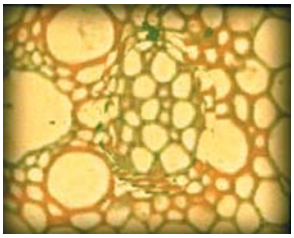
of seed-bearing conifers with feather-like leaves is 248-286 million years old.

What features helped plants to colonize our planet?

Plants had specialized features that helped colonization of the earth. They have these features even today. The features are

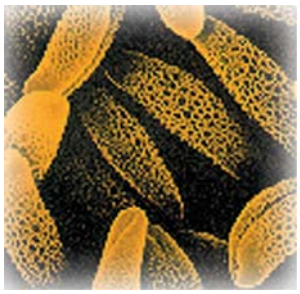
cuticles

bark or water resistant outer coverings.



tissues for transporting water and nutrients.

stomata or special openings in the leaves for gas exchange.



drought resistant pollen and spores.

Cuticle - the protective layer

Cuticle is the outer layer of a living organism that comes in contact with the outside environment. In plants, cuticle is the protective layer that covers the epidermal cells of leaves and other parts of a plant. Cuticle contains a waxy, water-repelling substance called **cutin**. This substance is found in the cell walls of corky tissue. Cuticle limits water loss through transpiration. Cutin is found on the outer skin of many fruits (such as apples, plums, cherries). These fruits get a shine when they are rubbed with a cloth or when buffed.

Bark - the skin of a woody plant

Bark is the tissue outside (or external to) the growth layer of the vascular cylinder in woody plants. The inner bark is soft and consists of secondary phloem and conveys the food prepared in the leaves to other parts of the plant. The outer bark consists of dead tissues and is made up of cork cells. The hard cork cells are lined with a fatty substance. As a result, gases and water cannot pass through the outer bark.

Gas exchange between the inner tissues of the cork covered roots and stems and their surroundings takes place through the spongy areas in the cork tissues.

Ancestors of plants

The ancestors of plants were the green algae capable of carrying out photosynthesis. Most algae are aquatic or have been semi-terrestrial.

We can certainly learn the secret of adapting to water and land, and heat and cold, from plants.

Blue green algae or cyanobacteria

Blue green algae occur everywhere - in all fresh water habitats, in the seas, in the soil as slime and gelatinous growths on rocks and damp man-made surfaces and as the algal partner in lichens. Blue green algae cell is prokaryotic. Photosynthetic pigments are present in its internal membrane.

Different combinations of chlorophyll, teacherxanthophylls, phycocyanin (blue) phycoerythrin (red) are present in organisms that are blue-green and yellow. Some blue-green algae aid in nitrogen fixation. This is of great ecological and economic importance.

For example, the fertility of paddy fields depends upon the nitrogen fixation by the blue green algae rather than on the application of nitrogenous fertilizers.

Algae, the ancestors of life on earth

Algae are primitive plant like organisms. They are capable of photosynthesis but they do not have true leaves, stems, roots or vascular system. The size of algae varies from algae measuring a few microns to leafy kelps measuring approximately 62 metres (203 feet).

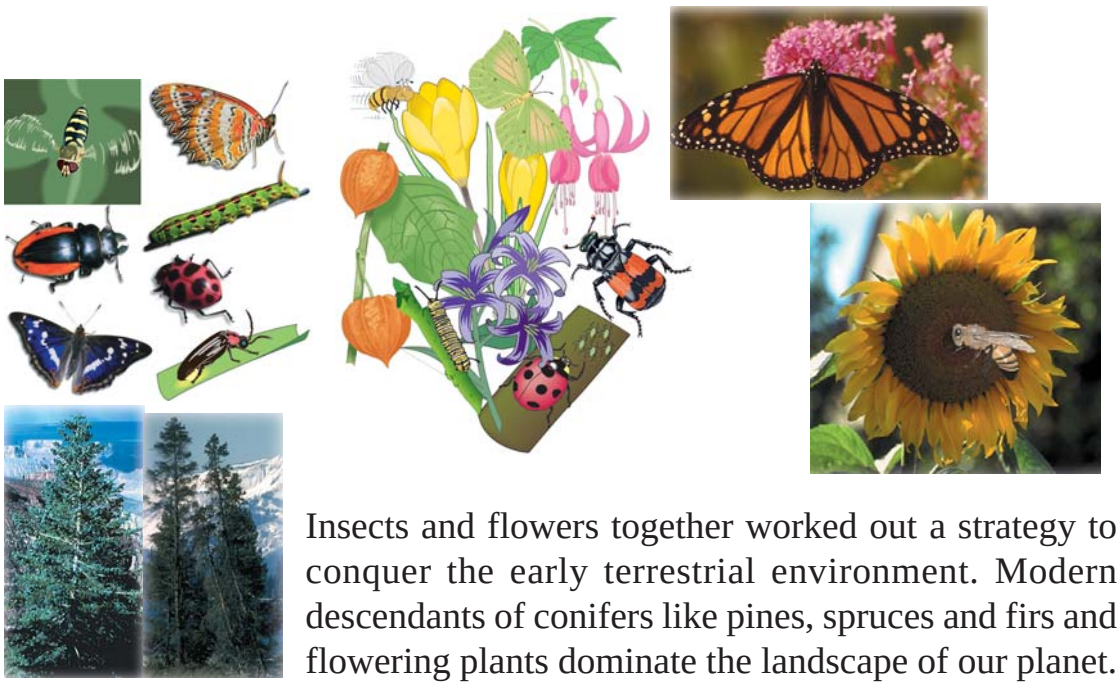
Algae are found almost everywhere on the earth's surface. Some form of algae or the other is found in the temperate regions and in the tundra region. They are found in soil, in snow and even in hot springs.

Plankton algae are the crucial link in the food chain of oceans and all forms of marine life depend upon this algae. Algae have been used as food since prehistoric times.

There are three major groups of algae - green algae, brown algae and red algae. Scientists believe that algae played a major role in creating the oxygen-rich atmosphere early in the history of our planet.

3.2 Evolution of plants on land

Plants and **insects** are two of the major groups that have evolved on land.



Insects and flowers together worked out a strategy to conquer the early terrestrial environment. Modern descendants of conifers like pines, spruces and firs and flowering plants dominate the landscape of our planet.

Insects: the survivors from the primitive times

Insects account for approximately 83% of the animal species. In addition to the nearly 1,000,000 known species, scientists believe that there are anywhere between 1,000,000 to 4,000,000 species yet to be described! Insects are the most successful life forms on earth.

Their tremendous adaptability has enabled them to survive for more than 400 million years through major climatic changes which destroyed many bigger animal species.

Insects show wide variety in form, shape and colour. Their life spans vary from a few hours to many years. They may be solitary or social in their habits. Their feeding habits also show differences - some feed on plants, some on animals and organic waste. Some even eat other insects.

Role of insects

Insects are both beneficial and harmful to other living organisms. Apart from their obvious role in the pollination of flowers, insects fulfill many important ecological functions. Insects promote the decay of organic matter, formation of soil. Insects are a major link in the food chain.

Insects produce valuable commodities like honey, silk, wax and dyes. Some insects are agents in controlling other potentially harmful insects and some are useful in scientific and medical research. Insects are also harmful. They destroy food, are carriers of (crop, livestock or human) diseases, infest and destroy buildings, garments and carpets.

Types of plants

Plants can be non-flowering or flowering. Flowering plants generally have fruits with seeds or pods with seeds.

Flowering plants or angiosperms

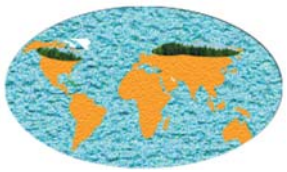
Flowering plants or angiosperms are the culmination of the evolutionary process of plants. They appeared on our planet ~127 million years ago.

The flowering plants or angiosperms dominate all regions of our planet except these regions.

The polar regions.

The high mountain regions.

The dry desert regions.



The northern forests region.

Angiosperms or the flowering plants

Angiosperms are members of the species of flowering plants that have roots, stems, leaves and well developed conducting tissues - xylem and phloem. Angiosperms can be monocotyledonous (having one cotyledon or seed leaf) or dicotyledonous (having two cotyledons or seed leaves).

The variety in size, shape and habitat of angiosperms is truly amazing. There are more than 250,000 species of angiosperms. They are found practically everywhere. Some angiosperms live only for a few weeks while some live upto 1,000 years. They generally reproduce through seeds.

What has helped the flowering plants to dominate the plant kingdom?

The flowering plants are found everywhere because of the cleverness of the flowers. Flowers are responsible for the transfer of pollen.

They use and control the activities of insects, birds and animals.
Flowers, fruits, insects and animals from a unique partnership in carrying pollen to distant parts.

3.3 Classification of plants

All plants are not the same. Plants are classified as

trees

shrubs

ferns

climbers

herbs

Plants can also be classified as xerophytes, epiphytes and parasites.

Xerophytes or drought resistant plants

Xerophytes are plants that can grow in dry habitats where the annual rainfall is less than 70 centimetres. They do this by special adaptations and mechanisms that can store water (as in succulents). Plants that can store water in dry regions have thick fleshy stems or leaves.

Plants in the cold and dry regions have different adaptations. For example, the conifers of the northern forests have needle shaped leaves to prevent loss of both heat and water. Other adaptations of xerophytes include coating of the leaves with a wax-like substance, ability to shed leaves during dry periods, ability to fold the leaves to reduce the absorption of heat and the development of a dense hairy leaf covering.

Epiphytes or air plants

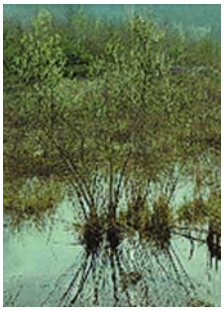
Epiphytes are plants that are attached to another plant (or object) only for physical support. Epiphytes are generally found in the tropical forests. Epiphytes are also known as “air plants” as they are not attached to the ground or other obvious source of nutrients. They get water and minerals from rain and nutrients from the plant litter that collects on the supporting trees or plants. Orchids and some variety of ferns are common tropical epiphytes. Mosses, lichens, liverworts are the typical epiphytes of the temperate regions.

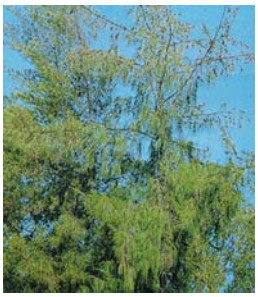
Plant parasites

Most plant parasites do not have chlorophyll. Therefore they do not have the ability to produce their food. They take what they need directly from the host plants. Because of this dependence on their host for their nutritional needs, the parasitic plants often have to sacrifice their independence. The parasites generally twine around the host’s stem (or trunk) and penetrate the stem (or trunk) with small projections.
They suck the nutrients from the hosts through the projection. Often, deprived of the nutrients the host plant dies. It is an example of killing the hen that lays the golden egg!

Shapes of plants

Plants show a wide variety in their shapes and sizes.





The size varies from a tiny plant to a giant redwood tree or to a banyan tree.




All these plants have a similar structure, with modifications to suit their environment. Plants reflect the climatic conditions of their natural habitats. **Plants live in harmony with the environment.**

The redwood trees - nature's giants

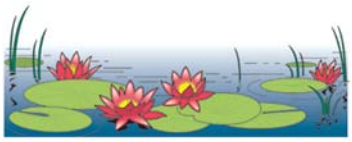
The redwood tree is a coniferous evergreen timber tree. The natural habitat of the redwood tree is the fog belt of central Oregon and central California, U.S.A. **Redwood trees are the tallest living trees.** They are often more than 90 metres or 300 feet tall. As the tree ages, the lower branches fall away. A mature redwood tree, therefore, has a thick trunk resembling a column. The reproduction takes place through seed production. However, only a small percentage of seeds germinate. Its dark brown, fibrous, deeply furrowed bark is resistant to insects, fungi. The bark of an old redwood tree can be 30 centimetres or 12 inches thick. Its timber is highly valued.

Plants and their environment

Plants show remarkable flexibility in adapting to their environment. For example: desert plants have thick leaves that store water and nutrients. They have spikes to minimise water loss and generally do not grow very tall so as to conserve energy.

Plants in the cold tundra regions grow close to the ground to protect themselves from the harsh winds and winter. They spread out both above the ground (shoots) and below the ground (roots). Leathery cuticles cover the leaves of some plants. Coniferous trees have broad base to give stability,

drooping branches to help snow to slide, flexible branches to withstand strong winds and needle-like leaves to limit both heat and water loss.
Plants of fresh water - These plants generally do not have fixed roots. They are free floating or if they have fixed roots, the leaves float on water. The leaves have water-repellent cuticles on the upper surface (water lily). These are only a few examples. The list is endless.



What is common between a pitcher plant and a tiger?

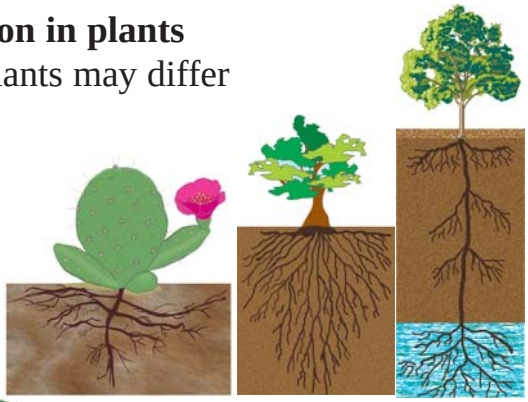
Pitcher plant and tiger are both **carnivores**.
How does a pitcher plant catch its prey?
Pitcher plant has pitcher shaped leaves. The inside of the pitcher plant is bright like flowers. The walls of the pitcher has sugar-rich secretions and the pitcher is filled with water and digestive enzymes.

Once an insect enters the pitcher, it slips down and drowns in the liquid. The enzymes in the liquid digests the insect. The plant then enjoys its meal.

3.4 Structure of plants

The structure of plants or organisation in plants
There is an infinite variety of plants. Plants may differ

- ★ in their root system,
- ★ in their shoot system
- ★ in the arrangement of leaves.

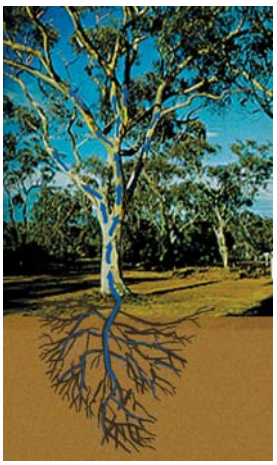


But all plants share certain common features.

These look completely different from one another. But there is a fundamental unity

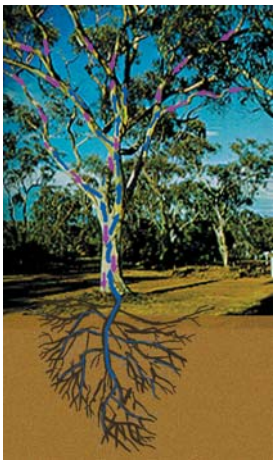


- ★ in the architecture of their bodies.
- ★ in the way they grow.
- ★ in the way they produce and transport food.
- ★ in the way they regulate their growth.

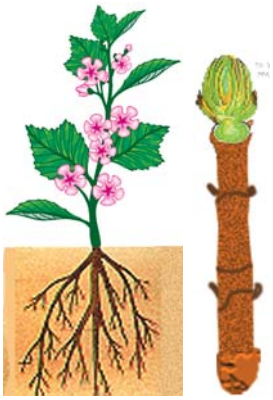


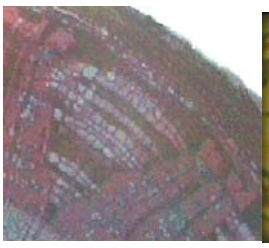
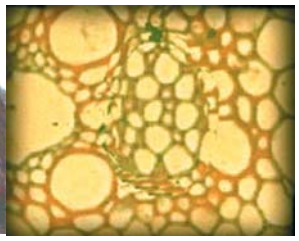
Plants in spite of their diversity, have the same architecture. Plants grow at the tips throughout their life. All parts of plants have an outer covering.


All plants transport **water and nutrients upwards from the roots.** All plants conduct **food produced in the leaves to the other parts.**

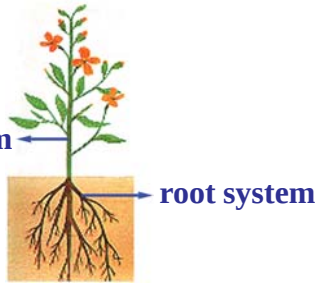


Plants universally add colour and variety to life on earth. A plant certainly has a definite life span but it never becomes an adult in the sense an animal or a human being does. Most plants keep growing by adding new cells and tissues and new organs at the **root tips and shoot tips**.



3.5 Parts of a plant



A plant generally has a root system and a shoot system. There are some plants

which do not have a distinct root system or a shoot system.

The amazing roots

All plants have roots, but all roots are not the same. Pull out a bean plant and some tufts of grass. Compare their roots. The root of the bean plant is long and tapering. It has small branches of roots and root hairs. This is typical of the **tap root system**.

Grass has no main root or tap root. The roots of grass are bunched together and spread out horizontally. This is typical of the **fibrous root system.**

Different types of roots

Tap root system

Fibrous root system

Modified root system

Aerial root system

Roots can be

- ★ long as in a bean plant (Tap root system).
- ★ bunched at the base and growing laterally as in grass (Fibrous root system).
- ★ swollen as in carrot (Modified root system).
- ★ growing from the branch to the ground (Aerial root system).

Functions of roots

Roots

★ fix the plants to the ground.

★ absorb water and nutrients from the soil.

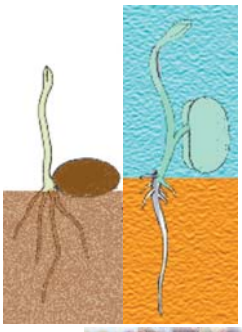
★ fix the soil and provide additional support (in some plants).

★ store food in some plants.

The shoot system of a plant

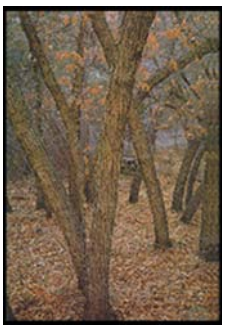
The shoot of a plant can be considered as the portion that is generally **above the ground, lies above the cotyledons.**

The shoot of a plant consists of both the stem and the leaves. The stem provides the framework to position the leaves properly. The leaves must face the sun. Flowers, fruits and seeds are formed on the shoots.



Stem of a plant

The stem is the link between the roots, the leaves and flowers. It generally holds the plant upright. The stem of a tree is called the **trunk**. The trunk is the strongest part of a tree, covered with bark which protects the inner parts of the tree. Some plants have weak stems.



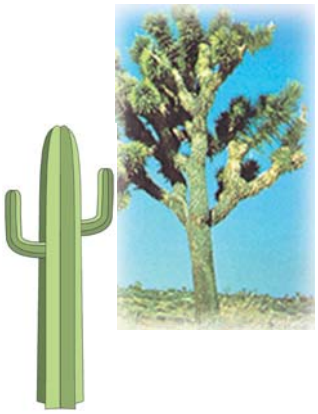
Stems have

- ★ nodes (places where leaves are formed).
- ★ internodes (portion between nodes).
- ★ buds (tiny side shoots).
- ★ axil (the angle between a leaf where it starts and the stem) and
- ★ terminal bud.

Functions of the stem

A stem

- ★ provides support to the plant and a framework to the plant.
- ★ helps the leaves to face the sun.
- ★ houses the twin transporting channels.
- ★ stores food in some plants.



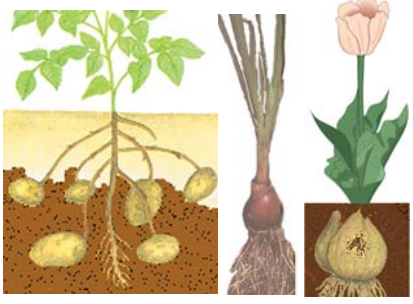
The twin transporting channels in plants

The vascular plants have an efficient system to conduct water and nutrients from the roots and the carbohydrates (food) prepared in the leaves to all parts of the plant through two separate tubes or channels.

The two channels have specialized cells and run parallel to each other. The fluids flowing through the two channels never get mixed. Water and nutrients (in solution) are used by the leaf to prepare food and the sugar molecules manufactured in the leaves are used for growth.

The modified stem - root or stem?

These grow underground. Are they, therefore, roots? They are actually **stems.**



Cactus - is it a stem or a leaf?

Have you seen a cactus plant?
The cactus is green. But it is not a leaf.

It is a modified stem.
The stem

- ★ stores food.
- ★ stores water for long periods.
- ★ synthesises food.
- ★ has spines to reduce transpiration.

The cactus stem shows the modification required for survival in hot and dry places. **Why does the cactus have thorns?**

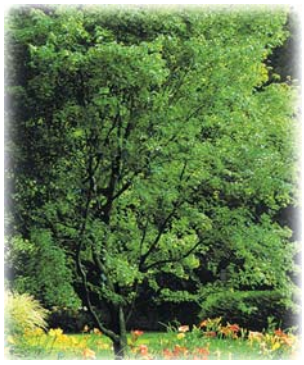
3.6 Leaf - the food factory of life on earth

Each part of the plant is an amazing demonstration of efficient organisation. The leaf has the most efficient organization. **Leaves are the light capturing part of the plant.**

The size of the leaves and the arrangement of leaves are of critical importance to the plant.

The unselfish leaves

A large plant or a big tree has hundreds of leaves. How do leaves at the lower parts of the plant capture sunlight?



The leaves at the top do not cut off all the sunlight. The arrangement of the leaves is such that some amount of sunlight reaches every leaf no matter where it is.

Leaves around us

Look at the leaves of plants in your neighbourhood. You will find that some leaves are

elongated

small

big

round

needle shaped

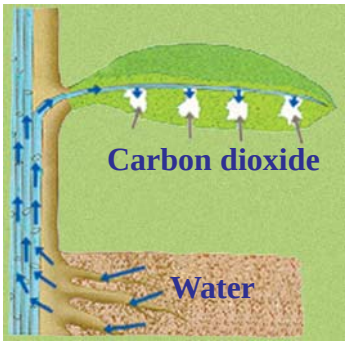
Variety of colours in leaves

We say leaves are green. Have you observed how many shades of green are there in nature?

We can never duplicate the variety in nature. Also, all leaves are not green.

Observe the leaves of a common croton plant. There are subtle differences in shapes, colours and designs.

Leaves - the intricate machine



Photosynthesis or "putting together with light" is carried out in the leaves. The design of a leaf is ideally suited to carry out the synthesis of sugar and starch from water and carbon dioxide using the light energy from the sun. Each part of the leaf has a specific role in the complex chemical process of photosynthesis. Let us first examine the structure of a leaf.

Photosynthesis or preparation of food

This complex chemical process that takes place in the leaves is responsible for feeding all the other living organisms. The raw materials of photosynthesis are - **carbon dioxide** from the air (taken in through the leaves) and **water** (usually from the soil) taken in through the roots.

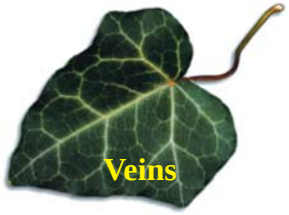
Sunlight is the energy source and chlorophyll or green pigment is the means of using sunlight. Water is first broken down to oxygen (which is released to the atmosphere) and hydrogen by photolysis (breaking down by light). Hydrogen then reduces carbon dioxide to simple sugars containing hydrogen, carbon and oxygen.

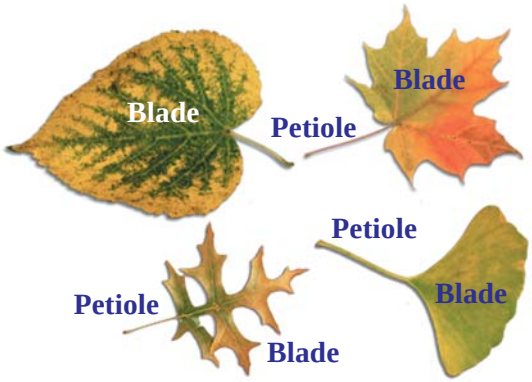
Photosynthesis is a complex process taking place in many stages but the reaction can be summed up by the simple equation:

$$6CO_2 + 6H_2O \xrightarrow{\text{(Light + Chlorophyll)}} \underset{\text{(Glucose)}}{C_6H_{12}O_6} + 6O_2$$

Parts of a leaf

Look at these different leaves. Most leaves have pores or stomata on the underside. Veins transport water and nutrients from the roots and food from the leaves to the other parts of the plant.





Veins of leaves

Veins are on the underside of leaves. The arrangement of veins in all the leaves are not the same. Veins may be

- ★ parallel veins (parallel venation). Monocotyledonous plants have parallel veins.
- ★ or a network of veins (reticulate venation). Dicotyledonous plants have reticulate venation.

Division of responsibilities

Each part of a leaf has definite responsibilities.

1. Capturing light energy the flat surface of the blade.
2. Transportation of water, nutrients from the roots and food from the leaves. tubes in the stem and the veins in the leaves.
3. Exchange of gases - taking in carbon dioxide from air and releasing oxygen to air. the pores or stomata on the underside of the leaves.
4. Controlling the loss of water or maintaining water balance. special cells (guard cells) at the opening of the pores.

Water movement in plants

Water acts like a hydrostatic skeleton that helps the plants to be upright. Most plants wilt if there is not enough water. Water moves continuously through a plant. Water from the soil enters root hairs by crossing the semipermeable membranes surrounding the cells of root hairs (or by osmosis). This dilutes the cell contents.

As a result, water passes through the membranes to the next cell. An osmotic chain is formed through the cell to the water conducting tissues (or xylem) in this manner. A similar chain is set up in the leaves.

Water passes up the plant from the roots because of the osmotic root pressure, capillary effect of the narrow tubes, and osmotic suction pressure of the leaves.

Transpiration or water loss through the leaves

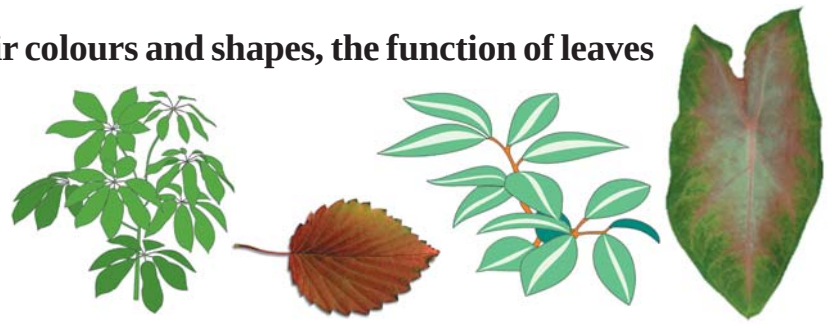
The transpiration stream involves the movement of water into the roots along xylem vessels and finally through the leaf cells to be evaporated. This evaporation or transpiration takes place through the stomata.

Transpiration acts like a suction pump that draws water from the roots against gravity up the xylem tubes to the leaves. This pressure is enough to transport water to the top of the tallest tree.

The amount of water loss per day is not the same for all plants. Depending upon the weather conditions such as humidity and temperature, a corn plant may lose nearly 3.8 litres or a gallon of water per day. This is equal to the corn plants losing approximately 3,040,000 litres or 3,25,000 gallons per hectare in a growing season.

Factors that affect food production in leaves

Irrespective of their colours and shapes, the function of leaves is the same - to prepare food.



Factors affecting photosynthesis

Photosynthesis does not take place at the same rate always. The rate at which photosynthesis takes place is affected by the following factors:

Availability of sunlight: At low light intensity, the rate of photosynthesis is proportional to the light intensity. At high levels, beyond the point of light satisfaction, the rate does not increase.

Carbon dioxide concentration of the air: An increase in carbon dioxide speeds up photosynthesis.

Availability of water. Lack of water causes the stomata of the leaves to close. This prevents carbon dioxide from entering the leaves.

Seasonal shut down of the factory

Nature's food factory shuts down during summer in the hot regions and during winter in the cold regions as the machinery breaks down. Leaves do this deliberately. No mechanic is needed to get the machinery started again.

Once the summer or winter is over, the leaves again appear on the tree and the production of food starts all over again.

Effect of winter on leaves

As the winter approaches in the temperate or cooler regions, both the light energy and the heat energy from the sun diminish gradually. As a result, leaves cannot produce food efficiently. A corky layer develops across the stem of the leaf during this period. This causes the supply of nutrients and water to be cut off and also the break down of chlorophyll and the leaf dying and falling off. This process is gradual.

Splendour of forests in autumn

Seasonal opportunity for other colours to blaze forth. **Chlorophyll** is the most dominating pigment in leaves. Once the breakdown of the chlorophyll occurs during autumn, the glucose present in the leaf disintegrates. This results in the suppressed colours to come out.

- ★ Shades of orange from **carotene**,
- ★ Shades of yellow from **xanthophyll**,
- ★ Reds and purples from **anthocyanin** and shades of brown from **tannin**.

Self-protection mechanism in leaves

Leaves are under constant attack from animals and us. They have developed clever strategies to protect themselves. Leaves of some plants

sting or cause itching when touched.

send out gaseous warnings when attacked.

release tannin which causes stomach upsets if the leaves are eaten.

become carnivores.

Leaves - the miracle workers

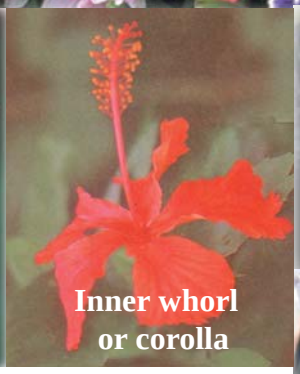
Leaves are essential for all living beings.

Without leaves all animals including ourselves will die because of suffocation and starvation. Next time you pass by a plant, remember this.

3.7 Basic structure of a flower

A flower generally has four whorls.

The outer whorl or **calyx**: This protects the flower and attracts insects.



The inner whorl or **corolla**: Its individual parts are called **petals**.

The third whorl has **stamen**. Stamen produces pollen grain.

The innermost whorl or **carpel**. The ovules are in the carpel.

Whorls of a flower

A whorl is a circle of parts (of a flower) that are present at a single level along the axis of a flower. The main functions of the outer two whorls of the flower are (i) to protect the flower and (ii) to attract the insects and birds. The inner two whorls contain the reproductive organs.

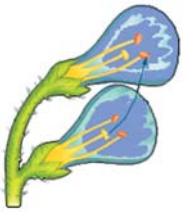
3.8 Seeds

Seeds of a plant are like the yolk of an egg. Seeds protect the embryo plant from

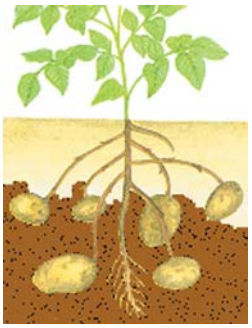
- ★ drying out.
- ★ being eaten.
- ★ starvation.

Reproductive strategies in plants

Plants have survived for millions of years by adapting their reproductive mechanism to their environment.



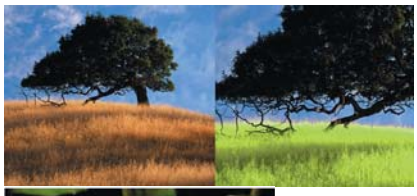
Reproduction in plants can be **vegetative** (this is called **asexual reproduction**) or reproduction can be **sexual**.



Asexual or vegetative reproduction in plants

In asexual reproduction, a small portion of the plant gives rise to a new plant. The portion of the plant may be a small part of the stem, bud or leaf. This new plant or the offspring of the mother plant has the same genetic make up i.e. the offspring or the new plant has identical cells as its parent.

Many of the garden plants, both flowering plants as well as ferns and herbs, are grown by this method.



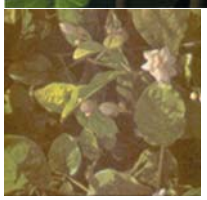
The old dry stems of grass give rise to new grass after rains.

A part of a potato gives rise to a new potato plant.

Bulbs of onions, lily and tuber rose give rise to new plants.

Cut leaves from plants give rise to new plants.

Cut stems reproduce new plants (sugar cane).



Jasmine stems produce daughter plants.

How do these plants do this?

Parts of these plants have **merismatic tissues**.

Sexual reproduction in plants

The reproductive structures are not permanent parts of adult plants. Flowers develop reproductive organs when the conditions are most favourable for pollination.

Fertilization in flowers is carried out by pollination

Pollination can be carried out by

insects

animals

wind

Reproduction of seeds is done by the dispersal of seeds. Self-pollination can also occur in flowering plants or angiosperms of the temperate regions.

Advantages of self-pollination

Self-pollination is advantageous in harsh climatic conditions. The plants do not need the assistance of either insects or animals to produce seeds.

Self-pollination helps plants to grow in adverse regions like the high mountains or the cold tundra where animals and insects are scarce.

Self-pollination produces uniform offsprings. These offsprings are generally well adapted to that habitat. Many weeds are self pollinating.

Pollination by insects and animals

The relationship between the pollinators and the flowering plants has contributed immensely for the evolution of both the species.

Plants use pollination cleverly to disperse the gametes on a regular basis, and in an ordered fashion. The plant itself is rooted to one place!

Gametes

Gametes are the reproductive or sex cells. They are either the female sex cells or the male sex cells that take part in fertilization. After fertilization, the nucleus of a gamete fuses with the nucleus of another of the opposite sex. This results in a new individual (or plant) developing.

What makes pollination by insects effective?

For pollination to be effective, the pollinators (insects) must visit a number of plants of the same species.

How do the plants achieve this?

Flowers do this by using their colour and shape.

Colour, shapes and pollination

Biologists have found that insects (particularly bees) are attracted by yellow colour and birds are attracted by red. Some flowers have attractive floral tubes filled with nectar. This type of flowers are pollinated by humming birds, moths and butterflies.

How do plants attract insects and animals?

The strategy of plants is to offer a favourite meal to the insects and animals.

Grass and other types of tasty leaves and stems for animals.

Bright coloured flowers to attract insects and small birds.

Nectar to attract bees and small insects.

Pollination by bees and beetles

Bees are the most frequent and characteristic visitors to a class of flowers. There are ~20,000 species of bees.

Beetles were the favourite pollinators in the primitive times.

Pollination by wind

In some angiosperms, wind is the pollinator. The pollen, blown by the wind, reaches the stigma passively. For pollination by wind to be effective, individuals of a plant species must grow close together or grow in stands.

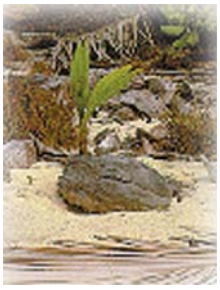
Characteristics of flowers pollinated by wind

The flowers of wind-pollinated angiosperms are

★ small (the petals are small or absent).
★ greenish.
★ odourless.

The flowers do not appear to dress up for the unseeing wind!

Role of flowers and seeds



Flowers and seeds are crucial for the sexual reproduction of plants. In a flower

★ the egg gets fertilized.
★ the fertilized egg develops into a seed.
★ the seed contains a plant embryo surrounded by a protective coat.

Under suitable conditions of water, light and heat, new plants are born.

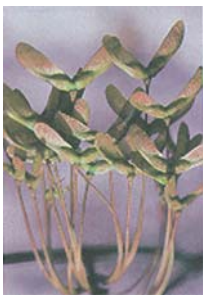
Seeds and plant mobility

Seeds help the immobile plants to move to new places. The evolution of seeds was the most significant development in the evolution of plants.

Seeds have helped the plants to dominate the earth's surface.

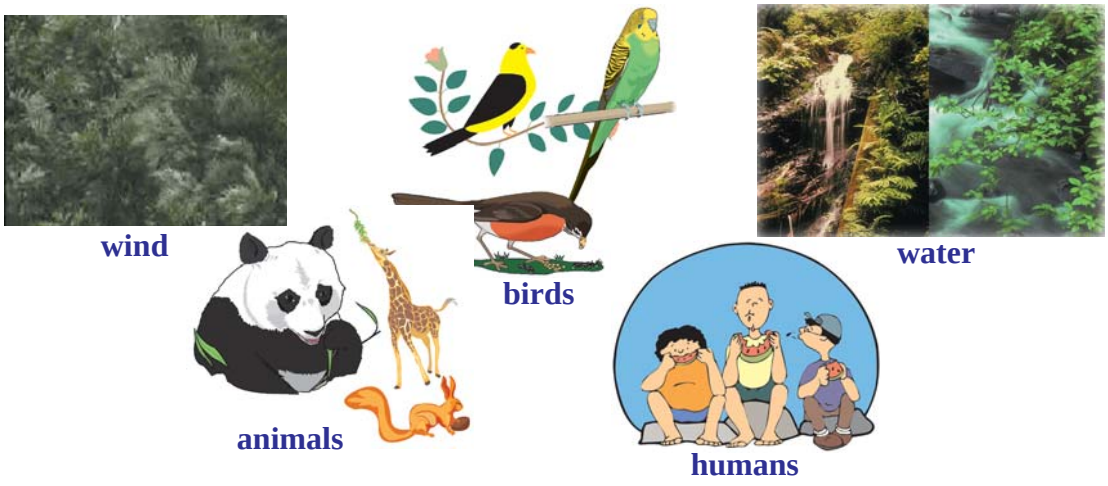
How do seeds get around?

Some seeds get around on their own as they have 'wings' and plumes.



Dispersal of seeds - summing up

Seeds are dispersed in many ways. Dispersal of seeds is carried out by



3.9 Plants - food, energy and medicine

There is nothing like a useless plant or a useless tree. All plants and trees contribute to the well-being of the rest of the living kingdom.

Plants are sources of food, energy and medicine. People who live in close contact with plants understand the vast potential of plants.

Importance of plants

The oldest plant fossils date back to precambrian era (over 300 billion years ago). Plants prepared the condition in which animal life could exist. Primitive atmosphere contained no free oxygen and was rich in carbon containing gases. The green plants manufactured starch and sugar by photosynthesis and in the process released oxygen. This revolutionized the nature of the atmosphere of the planet. Only after this change, the air of the atmosphere could be utilized by animals.

Even today plants are the source of primary needs of other living organisms. Plants are generally autotrophic but there some plants which are parasites, some plants are carnivorous and some are epiphytes.

Medicine in your backyard

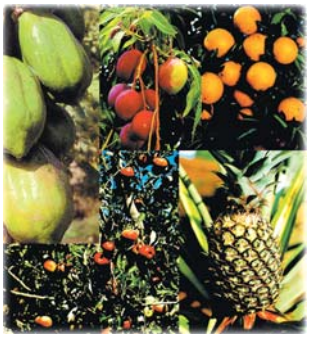
"The herb in your backyard is no medicine" a popular proverb. This proverb draws our attention to the wonderful medicinal properties of some plants.

Plants serve us in many ways

Plants may be

food producing plants

fibre producing plants



fruit yielding plants

spices yielding plants

medicinal plants

timber yielding plants

ornamental plants

Plants and their special properties

All these plants have been used for centuries for their special properties.

Amla or gooseberry

Neem leaves

Papaya

Ginger

Eucalyptus

Haldi or turmeric

Tulsi or basil

Plants used in different countries

Guayale or parthenium argenteum	native shrub of North Mexico and South-western USA	Rich source of rubber
Periwinkle the garden plant	Native of Madagascar island	rich in lysine, an essential amino acid for animals and humans
Grain amaranth	Latin American highlands of Aztecs	rich in lysine
Winged bean	First cultivated in New Guinea and Southeast Asia	nutritious food, edible oil.

From an obnoxious weed to a power resource?

Water hyacinth has beautiful flowers but clogs water bodies in the tropics. Can this weed (water hyacinth) partly help the power crisis? Hyacinth is also a source of large biomass, energy, pulp for paper and cattle feed.

Spirulina - a solution to malnutrition?

Spirulina is a blue-green algae. Spirulina is shaped like a spiral and thrives well in alkaline soil. Spirulina

- ★ fixes the atmospheric nitrogen.
- ★ carries out photosynthesis.
- ★ has a higher protein content than soya beans.
- ★ is ten times more productive per hectare than wheat.
- ★ is used traditionally as food in Africa and Mexico.

Green thumbs or sensitive to love?

You must have heard the expression "**green thumbs**". A person with "green thumbs" does not have green coloured thumbs, but loves plants. A person with "green thumbs" can literally make a dry barren place green.

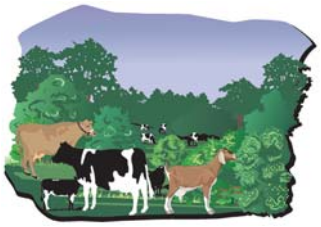
Professor J.C. Bose, a famous Indian scientist from Calcutta proved that **plants respond to stimuli!**

Treat plants with care

It is known that plants, communicate with each other and warn each other of the approaching danger.

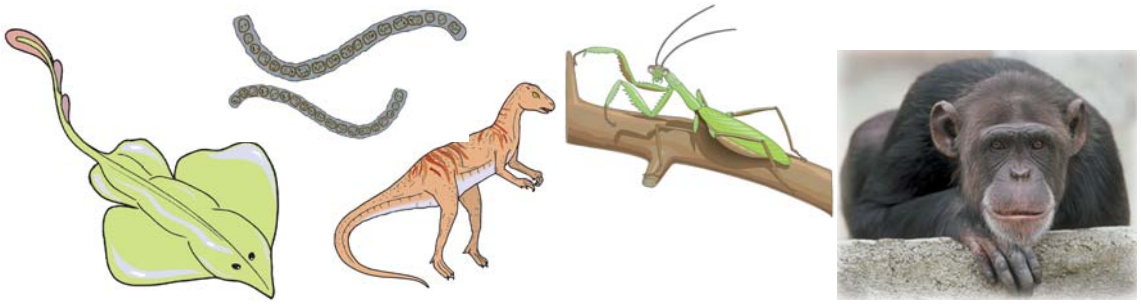
Next time, you pass by a plant, do not

- ★ beat it with the stick or the bat in your hand.
- ★ pluck or shred leaves and flowers.
- ★ or break branches.



Plants selflessly work for us. Take care of them.

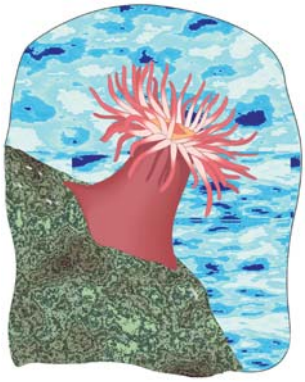
4.0 Origin of the animal kingdom



From the seas to the land

Animals originated in the seas millions of years ago. The earliest animals had no distinct tissues or organs.

From the simplest no-tissue, no-organ animals to the complex animals with well defined organ systems and specialized tissues, has been a long journey.

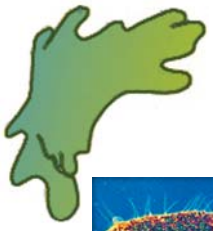


Even now, only certain animals like the insects, birds, monkeys and us are fully land bound.

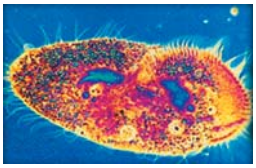
4.1 Protozoa - the first animals

It is hard to imagine that in a planet with such a diversity of shapes and colours, **the first "animals" protozoa are**

invisible to our eyes. Protozoa are found in moist places. They are found in diverse habitats like the seas, lakes, ponds, snow-covered mountains and soil.



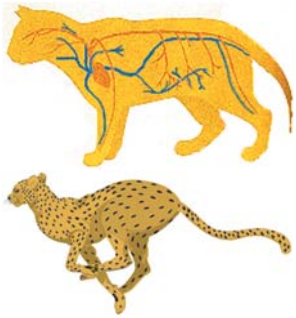
Amoeba and paramecium belong to this group.



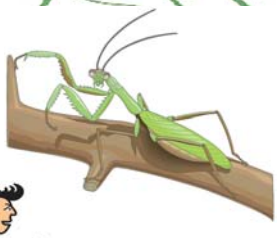
Amoebic dysentery is a common disease. It is caused by drinking contaminated water.

Survival on land - key adaptations

As the animals moved from water to land, their architecture underwent drastic changes. The key changes were the ability



- ★ to use oxygen in air for respiration (development of lungs).
- ★ to circulate oxygen through the body (development of the circulatory system).
- ★ to move from place to place on land (development of limbs).



Starting with reptiles, the process reached its climax in human beings.

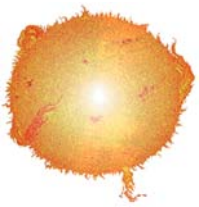
4.2 Difference between plants and animals

The fundamental difference between plants and animals is in the way they obtain food. Plants cannot move around.

Therefore, they have to prepare their food with the easily available materials.

Carbon dioxide from the air

Water from the soil.



The energy from sunlight

Animals can roam around and obtain their food.
There are some plants which can move around (volvox) and some animals are rooted to one place (sponges).

Sponges - Animals without tissue

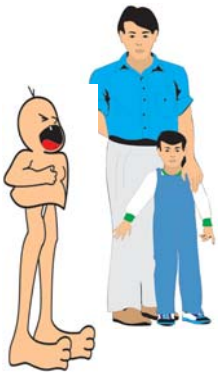
Sponges are unique in the animal kingdom. They are the simplest of animals. They do not have organs and cells are not organised into tissues. The bodies of sponges consist of masses of cells embedded in a gelatinous substance. The body of a young sponge is shaped like a sac or vase. The body is perforated by tiny holes. Sponges acquire food and oxygen and expel waste through the holes. The movement of water through holes or pores and channels of sponges is a primitive form of circulatory systems. There are about 5000 species of marine sponges and various species of fresh sponges. In the sea, sponges are abundant at all depths.

Did you know that a sponge can pass through a fine silk cloth or mesh with the individual cells separating and then regrouping on the other side?

The way animals grow

What is the difference between the way animals including ourselves grow and plants grow?

Animals including ourselves grow uniformly from a child to an adult. If we grow only in one organ say legs, we would look like the figure shown.



But the way a plant grows is because it has special tissues at the tips of the root system and the shoot system.

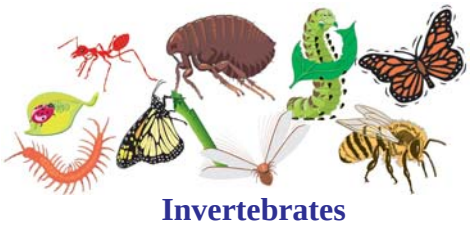
General features of animals

Animals have been familiar to people from the ancient times. There are no photosynthetic animals. Most animals

- ★ have specific tissues.
- ★ have specific organs for specific functions. (The organs are made of tissues).
- ★ reproduce sexually. (Their eggs and sperm do not divide by **mitosis**).

Diversity among animals is astonishing. Yet, they have many common features. Generally, animals can be classified as **vertebrates; animals with backbones** and **invertebrates; animals with no backbones.**

Vertebrates



Invertebrates

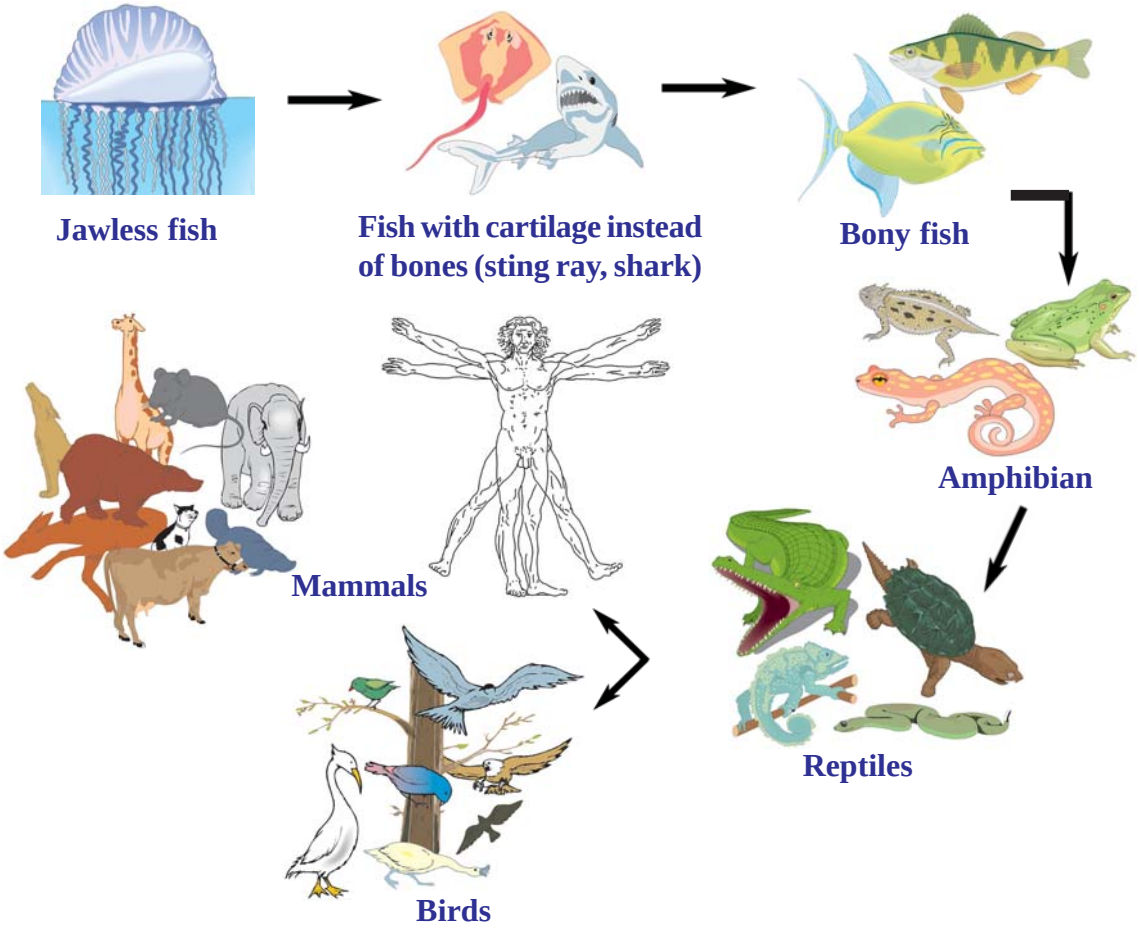
Mitosis

Mitosis is a process of reproduction. During mitosis, one cell gives rise to two (genetically) identical daughter cells. The cytoplasm of the mother cell divides to form two daughter cells, each containing the same number of chromosomes or structures that carry genetic information.

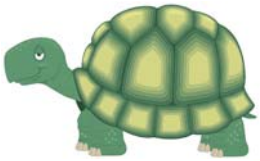
Mitosis is absolutely essential to life as it provides new cells for growth and for replacement of worn out cells. Mitosis may take minutes or hours depending upon the kind of cells and the type of organism. It is also influenced by external factors like time of day and temperature.

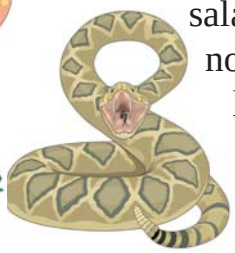
4.3 Evolution of vertebrates

Vertebrates also originated from the seas. **The evolutionary sequence is from the sea dwellers to the initial land dwellers and then to completely land vertebrates.**



The first vertebrates to move on land





The first vertebrates to walk on land were the **amphibians** (frogs, toads and salamanders). They still are not completely adapted to life on land.

Reptiles were the first to adapt to the conditions of life on land.

Amphibians: the first vertebrates to walk on land

Amphibians were the first vertebrates to walk on land. They had limbs efficient enough to crawl on land and an ear structure that could pick up air-borne sounds.

Ichthyostega was a typical primitive amphibian. It lived about 350 million years ago. In spite of the limbs and ear structure adapted to move on land, this prehistoric amphibian still looked like a fish.

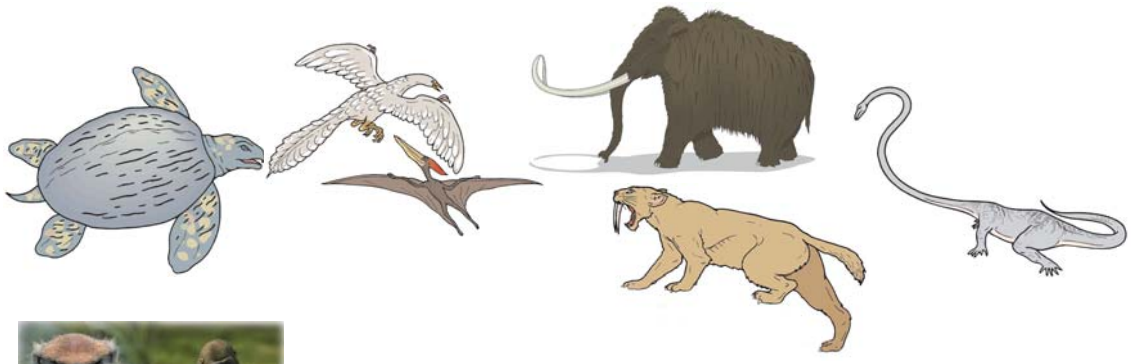
Reptiles

Reptiles are air breathing vertebrates that have internal fertilization and scaly bodies. In the sequence of evolutionary development, they are placed between the amphibians and birds and mammals. There are around 6,000 species of reptiles widely distributed. Most reptiles have four limbs (except for snakes). Some reptiles can climb trees, some can run on land and some can swim.

Reptiles are cold blooded i.e. their body temperature varies with external temperatures. They depend upon the heat of the surrounding air for warmth. Many species of reptiles are in danger of extinction as they are hunted for food, skin and their medicinal value.

Where did the birds and mammals come from?

Reptiles gave rise to birds, mammals.



Apes have existed for at least 36 million years and homo sapiens (i.e. us) for about 500,000 years.

The world of vertebrates

Have you been to a zoo?
If you have not, let us collect a few of the animals you might see in a zoo.

They all look different from one another and also from us.

But they all share the same body plan or architecture under their skin as humans under the skin.

All these are vertebrates. But, they have different body covers. We can differentiate animals on the basis of their body covers.

Vertebrates also reproduce differently. They can reproduce

- ★ by hatching out of an egg (birds, snake, tortoise)
- ★ by giving birth to young ones.

Animals which give birth to young ones are called mammals.

What are mammals?

Mammals are warm blooded animals. They regulate their body temperature to a more or less constant temperature. They have hair on their bodies. Some mammals are more hairy than others.

Mammals do not lay eggs (except for the duck billed platypus). They give birth to young ones. The young ones are cared for by a parent. The caring period is not uniform for all the mammals.

The most evolved mammal - the human being

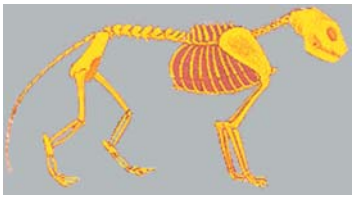
Human being is a good example of a mammal.

The body temperature of a human being is 37^0C or 98^0F.

Human infants are more helpless than infants of other mammals. The development of the human young is very slow.

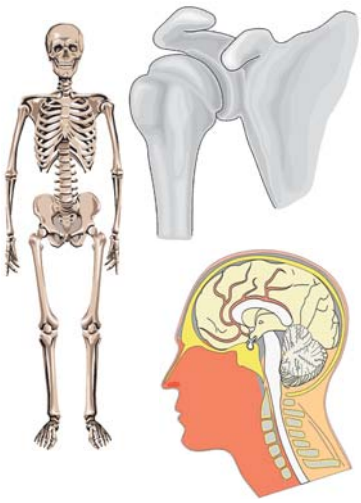
4.4 What are the common features among the vertebrates?

They all have a scaffolding or skeleton made up of bones of various sizes and shapes. The skeleton



- ★ supports the body.
- ★ gives the body a particular shape.

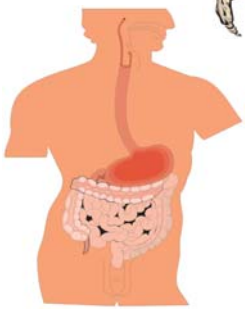
The internal scaffolding of vertebrates



The internal scaffolding of vertebrates supports the body structure. It is made of bones with joints. The bones grow as the body grows. The skull protects the brain.

A bony column or the vertebral column protects the main nerve or the spinal chord. **The spinal chord is the main communication pathway.**

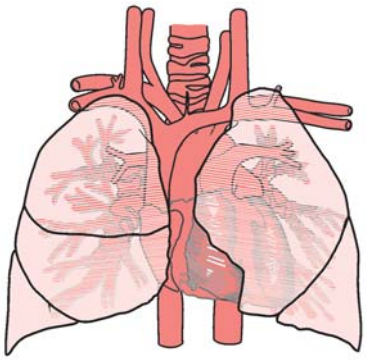
Architecture of the human body



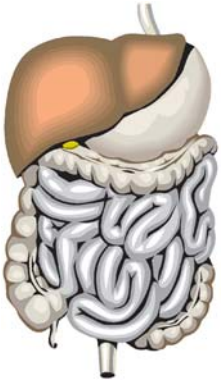
The human body has the same general architecture as the other vertebrates.

It has a long tube open at both the ends that runs from the mouth to the anus.

Internal cavity



Thoracic cavity

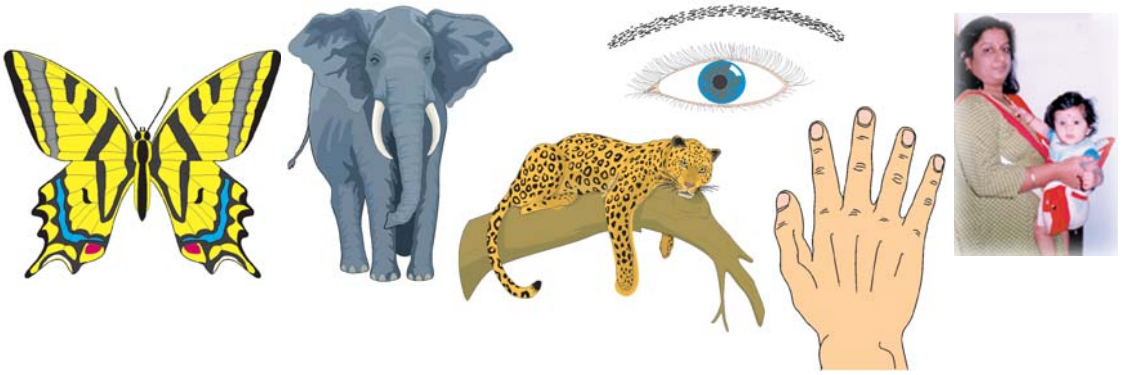


Abdominal cavity

This tube is suspended inside an **internal cavity**.
The internal cavity is divided into the **thoracic cavity** containing the heart and the lungs and the **abdominal cavity** containing the digestive system (the liver, stomach, pancreas and intestines).

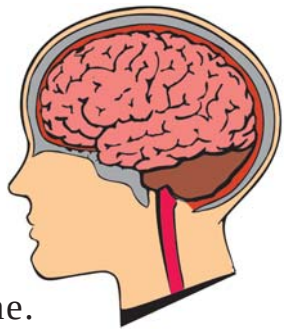
5.0 Biology and life processes

What are living organisms made up of?
These are all made of **cells**.

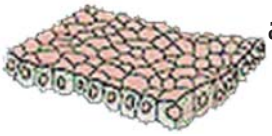


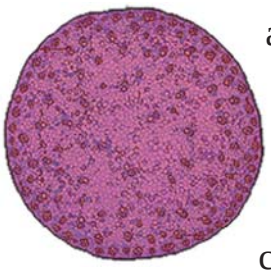
There is no living organism without cells. Very few have single cells. Most have thousands of cells. An adult human being has millions of cells.

5.1 Cell – the smallest unit



Cell means a chamber room in Latin (cella).
The cell is the basic unit of organization of all living organisms. Different cells have different functions. The arrangement of cells depends upon their functions. All cells are not the same. Our brain cells are entirely different from our cheek cells.

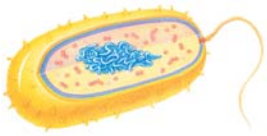


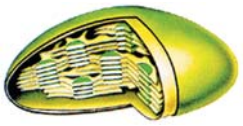
The cells of a banana peel are certainly different from the cells of our skin. Yet, all cells share some similarities.


Structure of a cell

A cell generally has a membrane, a nucleus which directs the activities of the cell and a cytoplasm that contains sugars, amino acids and proteins.

Most cells get their power from the **mitochondria**. Cells of plants, bacteria and fungi have an outer shell.

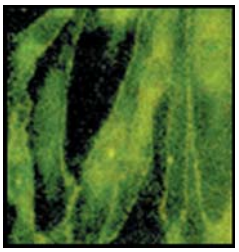
Plant cells contain chloroplasts in addition to mitochondria.

Mitochondria

Mitochondria are the tubular or sausage-shaped organelles. They are bounded by two membranes. Mitochondria resemble aerobic bacteria. They act as the chemical furnaces of the cell and carry out the oxidation process in the cell.

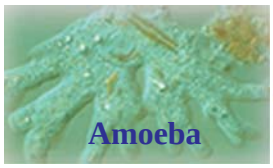
From an infant to an adult or from a plant to a tree – How does this happen?

Many cells grow in size after digesting the food consumed by the organism and divide after reaching a particular size. The cells of our skin grow and divide throughout our lives. Our brain cells and nerve cells do not grow after a certain age.



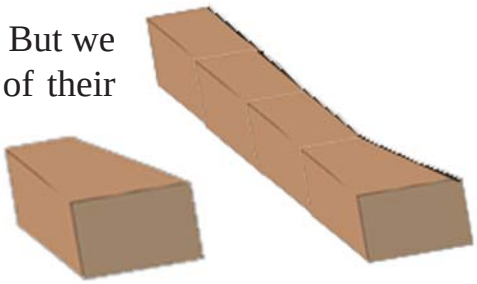
Nerve cells

Cells of single-celled organisms



Amoeba, yeast and paramecium look different but they are all single-celled organisms. Their cells perform all the basic functions. The structure of the cell suits the habitat of the organism. For example, paramecium lives in water. Therefore, it has a whip-like or hair-like **flagella** which helps it to swim.

Cells and cell size



Our body contains about 100 trillion cells. But we cannot see a single one of them because of their lack of size.

Biologists say that if each cell in our body had the size of a shoe box and if they were placed from end to end, it would be 500 million kilometres long. Long enough to take us to Mars and bring us back!

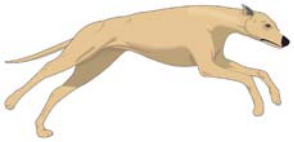
5.2 Cells and tissues in plants and animals

The ageless plants


In a sense, plants never grow old. How do the plants manage to do this? They add new cells and tissues at the tips of their shoot system and root system. Redwood trees grow for hundreds of years.

Some grasslands have been growing for 10,000 years. A potato can be grown over and over again from parts of the same plant.


How do plants function?

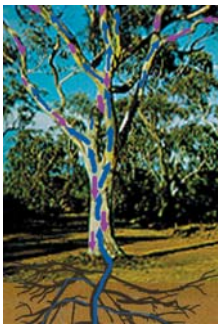


A plant or a tree does not look as vibrant and exciting as the leaping of a hound or a gazelle, the flight

of a bird, the dance of a peacock or the growl of a tiger. But do not be fooled.

The immobile and solid appearance of a tree hides many complex internal systems.

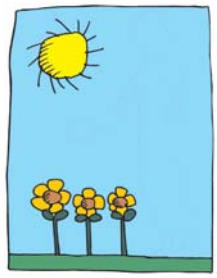
Characteristics of plants



Plants share almost all the characteristics with the animals. They have a well developed plumbing system - a sort of one way system for transporting fluids from the roots to all parts of the plant and the food prepared in the leaves to all parts of the plant. Plants have

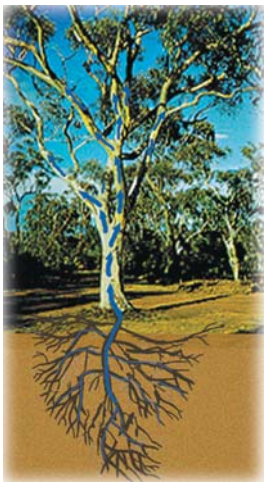
- ★ **a unique food factory.**
- ★ **well organized and diverse reproduction methods**
- ★ **special chemicals to regulate growth.**

Plants respond to stimuli



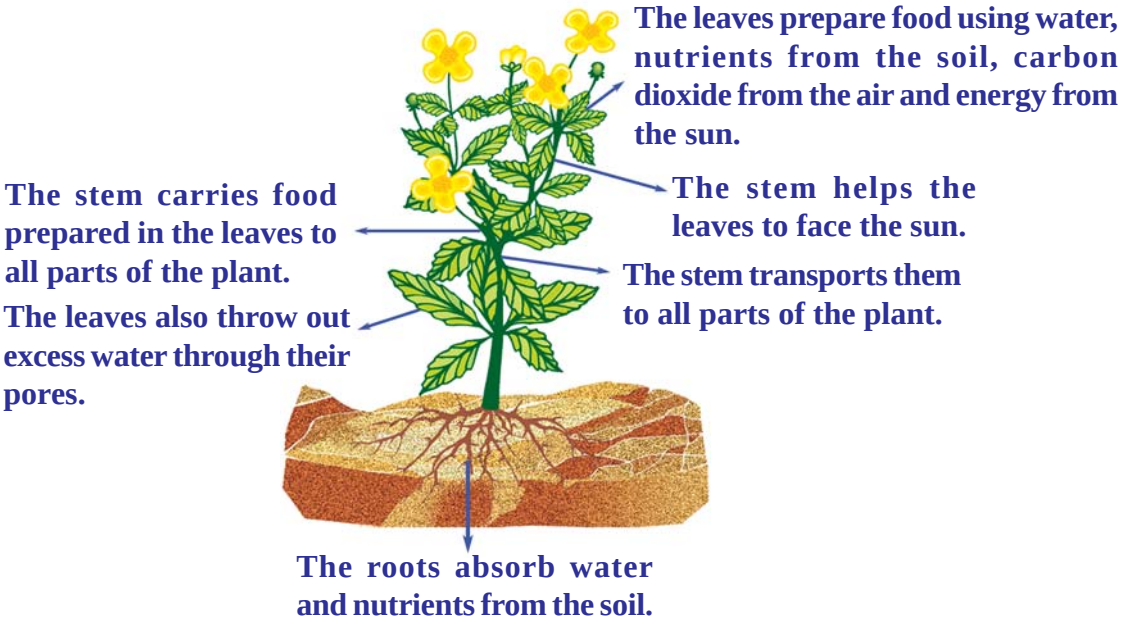
Plants respond to touch, grow towards light, devise mechanisms to transport nutrients and water against gravity from the roots to all parts of the plant.

Plants are also sensitive to the length of the day.



Organs and organ systems in plants

Let us look at the amazing division of labour in plants and trees.



In fact, regulating the level of water loss and exchange of gases (taking in carbon dioxide from the air for preparing food and giving out oxygen liberated during the process) are two of the important functions of the leaves.

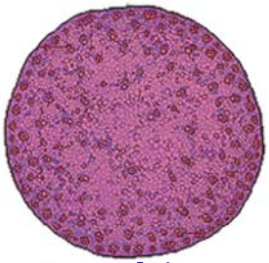
How do different parts of a plant know what to do?

The leaves "throw out" the excess water through their pores. The roots transport water and nutrients upwards against gravity to the stems. The stems transport food downwards but grow upwards. How do they know what to do? **The cells in these different parts send instructions to them!**

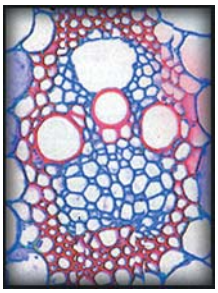
Different functions, different arrangements

Plant cells are tubular when they have to transport nutrients (food). They are packed together when their function is to protect. **Specific cells bundle together to form tissues.**

Plant organs and tissues

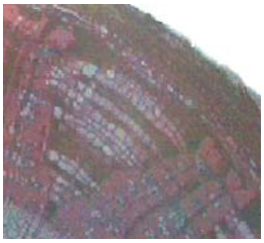


Dermal tissue



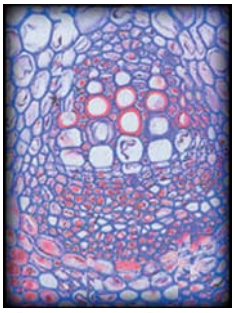
Root, stem and leaves are the organs of a plant. They are all made of tissues. The combination of tissues is different in different organs. It is specific to the function of each part.

There are four main types of tissues in plants. The following are the microscopic images of plant tissues:



the dermal tissue

the merismatic tissue



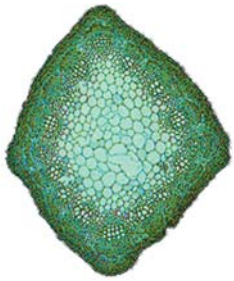
the ground tissue

the vascular tissue

Role of the different types of tissues in the growth of plants

Primary growth in plants takes place as a result of division of cells in its tissues. The cells in a tissue can be either **round or elongated.**

The function of cells in the merismatic tissue or the meristem is to divide rapidly. When one of the cells divides, one cell remains at the tip and the other differentiates into specific cells.

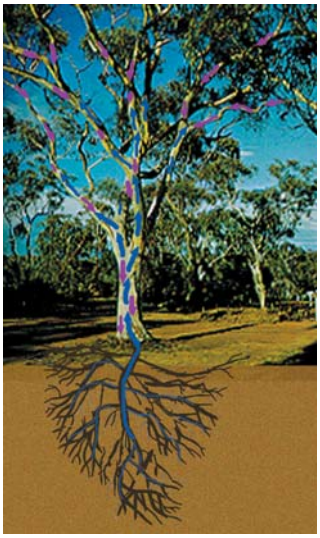


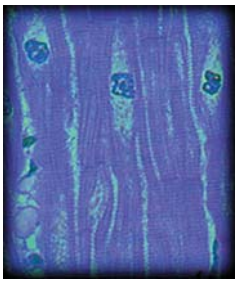
The cells of the ground tissue are least specialized. The ground tissue forms masses in the leaves, the stems and the roots.

Roots

Leaves

Stems





The **vascular tissues** have two specific functions. **Vascular in the Latin language means tubes and vessels that transport liquids.** Vascular tissues carry out exactly this function in plants. These tissues carry the water and nutrients absorbed by the roots to all parts of the plant and the food that is prepared in the leaves to the different parts of the plant.

Water and nutrients from the roots (transported in the upward direction) and the food from the leaves (transported downwards) do not get mixed. One way traffic is strictly followed!

Xylem

How does the vascular tissue perform the upwards and downwards transport of fluids without the fluids ever getting mixed?

The vascular tissue is made up of two kinds of tissues: **the xylem** (meaning wood in the Greek language) and **the phloem** (meaning bark in Greek language).

The xylem transports water and nutrients to the leaves and the phloem transports food from the leaves to the other parts.

Phloem

Xylem – the upward highway

Xylem is the main water conducting tissue of plants. It forms a continuous chain that runs through the plant body. Water as well as dissolved minerals pass from the roots upwards against gravity through the shoot to all parts of the plant in an unbroken stream. When the water reaches the leaves, it is used for the production of food and the excess water passes into air as water vapour through the stomata (pores on their underside).

Phloem – the downward highway

Phloem is the main food-conducting tissue in vascular plants. Phloem cells can be sieve cells in which pores have roughly the same diameter or sieve tubes. In the sieve tubes, the phloem cells occur end-to-end forming a series of sieve tubes. The phloem cells lose their nucleus as they become mature.

The merismatic tissue and the nature of plants

The ways in which merismatic tissues function determine whether a plant is a **woody plant or a herbaceous plant**. Herbaceous plant can be

Annual (they complete their life cycle within a year).

Perennial (they produce shoots year after year).

Annual

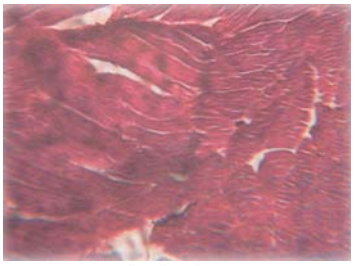
Perennial

Biennial

Biennial (they form a leafy shoot the first year and flower the second year).

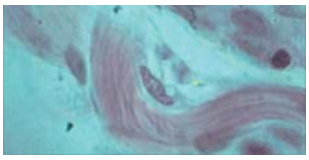
Organization of cells or tissues in animals

Animal tissues, just like the plant tissues, are formed from cells. There are four basic tissues in animals.

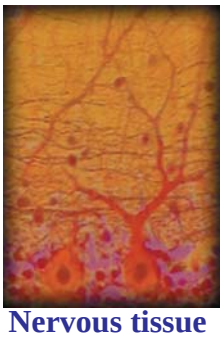


Epithelial tissue

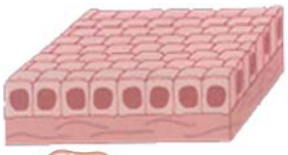
Muscular tissue



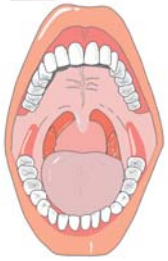
Connective tissue



Nervous tissue

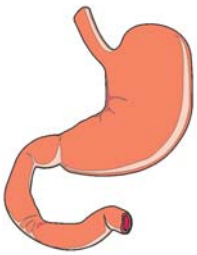


The epithelial tissue is similar to the dermal tissue in plants. It covers the outer surface of the skin and the inner surfaces of these organs.



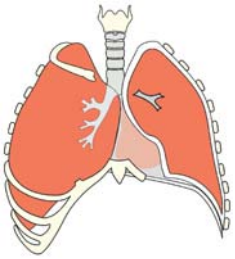
Mouth

Oesophagus



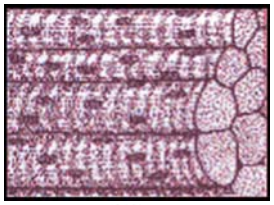
Stomach

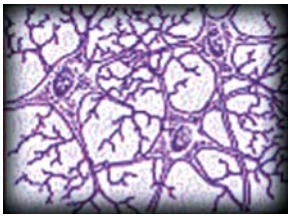
Intestines



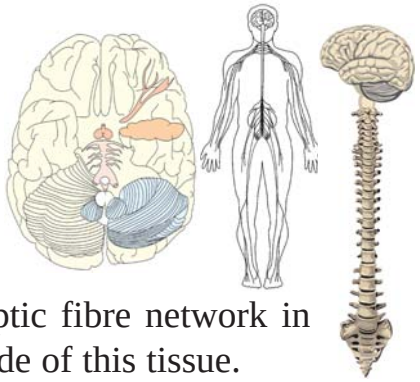
Lungs

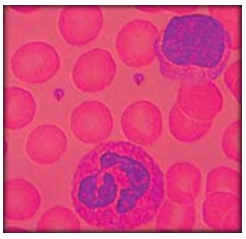
Muscular tissues are long and cylindrical. They can contract and expand. They are found wherever there is movement.

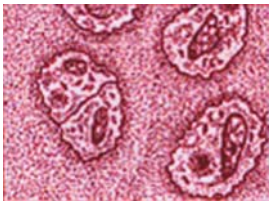




The **nervous tissue** or the nerve tissue is made of a cell body. The cells are joined from end to end. They carry messages to and from the brain. They act as the optic fibre network in animals. The brain and the spinal chord are made of this tissue.

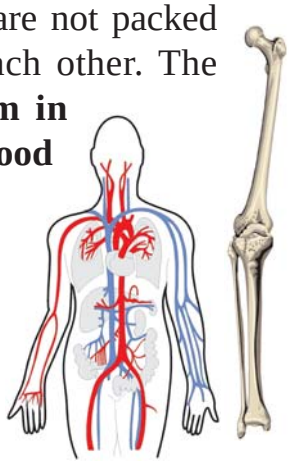






The cells of the **connective tissue** are not packed together but are separated from each other. The empty space is filled with **calcium in bones** and **blood plasma in the blood cells.**

The functions of this tissue are mainly to support the framework as in cartilages and to transport materials to all parts of the body.



The nervous tissue or the nerve tissue

This tissue is made up of two types of cells: **1. Neurons which carry nerve impulses to and from the brain. 2. Supporting cells which supply the neurons with nutrients.**

The cell body of a neuron contains two projections- **dendrites,** the thread-like projections which act as the antennae. They receive the nerve impulses from other cells or the sensory system and **the axons** or the nerve fibres. They are long and tubular extensions of the cell. The axons carry the nerve impulses from the cell to the distant parts of the body.

Size of the nerve fibre or the axon

The axons have a myeline or a fatty membrane sheath to enable the axons to transmit nerve impulses or messages rapidly. Depending on their location, the size of the nerve cells, particularly the size of the axons, vary.

Some nerve cells are very large. For example, a single axon can extend from the tip of your finger across your arm and shoulder to your spinal chord! Or in an adult giraffe, a single nerve axon extends all the way up to its back covering a distance of ~3 metres!

What are nerves?

Your nerves or the nerves of a vertebrate animal look like fine white threads to the naked eye. Actually, nerves are bundles of **axons or nerve fibres** held together by connective tissues. Our nerves are like the telephone cables stretching over long distances and connecting the various places.

Bundles of hundreds of axons or nerve fibres are the telephonic communication channels. Neurons are specialized nerve cells. They transmit nerve impulses or messages.

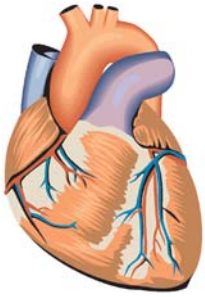
The tissue and the functions of an organ

Each organ of an animal has specific functions to perform. The function of an organ in the animal decides the proportion of different tissues present in

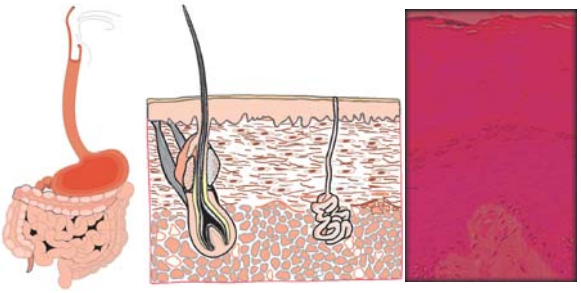
that organ. For example, some insects move about using only muscular tissue and the hydra has very few nerve cells.

Tissues in human beings

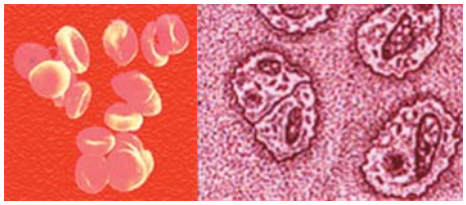
Our organs also have four basic tissues. They are



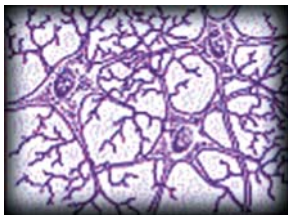
muscular tissue (heart)



epithelial tissue (intestine, skin, mucus membrane)



connective tissue (blood and cartilages)



nervous tissue (brain and the spinal chord)

The functions of the organs decide the proportion of the different tissues present in them.

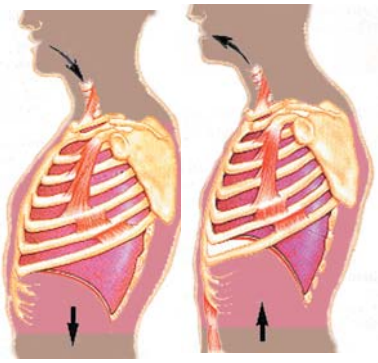
6.0 Same life processes but different methods

Life processes common to all the living organisms are:

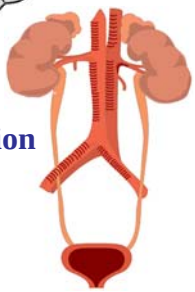
nutrition

heredity

reproduction

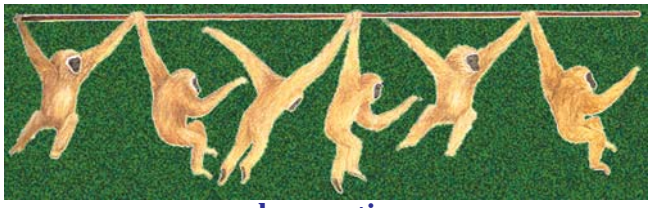


respiration

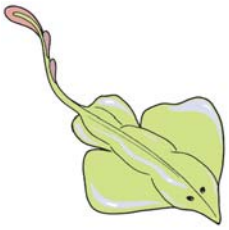


digestion

reaction to stimuli



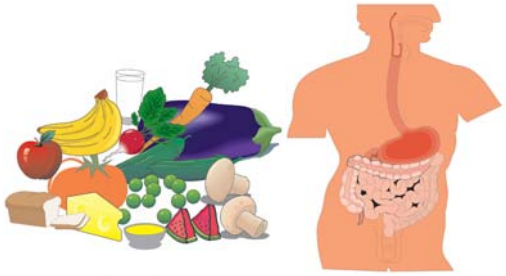
locomotion



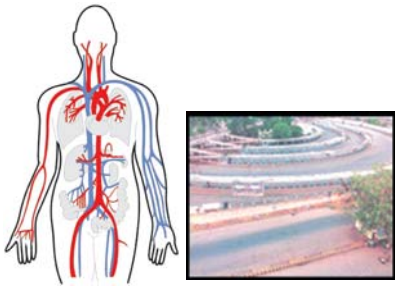
While these life processes are common to all animals, different animals adopt different methods. The methods employed depend on the **structure** of the animal and the **habitat** of the animal or where the animal lives.

The city within a vertebrate animal

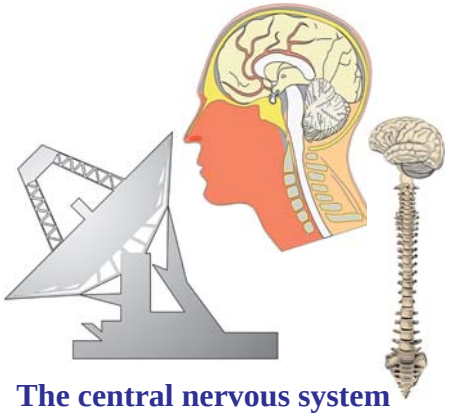
The body of a vertebrate animal has millions of cells. These cells have specific functions to perform and are organized into specific organ systems. Like in a city, it has many individual systems to carry out specialized functions.



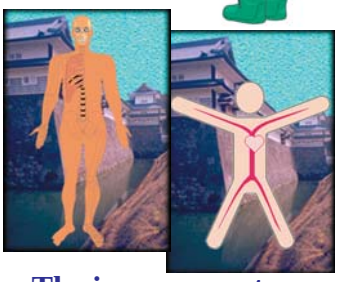
The digestive system



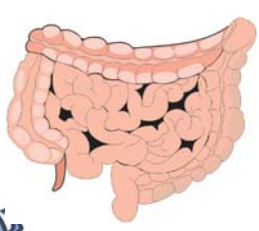
The circulatory system

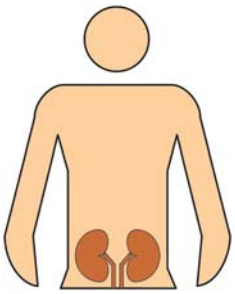


The central nervous system



The immune system





The excretory system

- ★ The digestive system is the food processing unit.
- ★ The circulatory system is the transportation network.
- ★ The immune system is the internal security unit.
- ★ The excretory system is the garbage disposal unit.
- ★ The central nervous system is the central command.

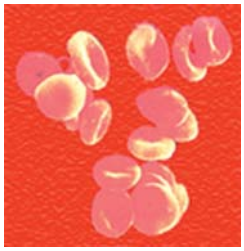
Living organisms use energy, just like a city, to maintain order throughout their bodies and to carry out the various functions. The respiratory system provides the basic raw materials i.e. oxygen for producing energy.

6.1 Nutrition

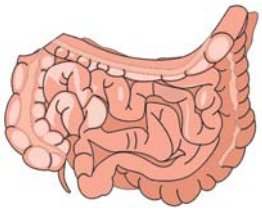
Conversion of food to energy required by the living organism takes place in stages. The different stages are:

ingestion or eating food

digestion



assimilation



egestion or throwing out waste products

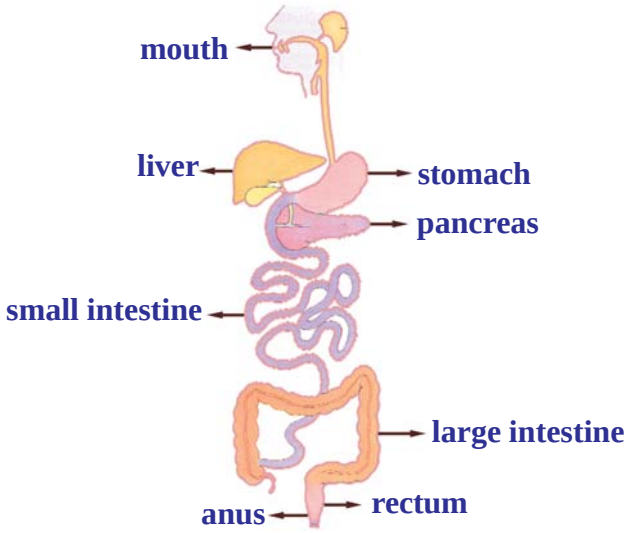
This entire process is called the **process of nutrition**.

Differences in eating habits

There is a variety of food available on earth. Each type of animal chooses its own favourite food. Human beings - what is their favourite food?

The food has to be broken down into simpler molecules before it can be converted into energy. This is done in a specialized organ system - the **digestive system**.

This organ system carries out the **process of nutrition**. It consists of the **mouth, stomach, liver, pancreas, small intestine, large intestine, rectum and anus.**



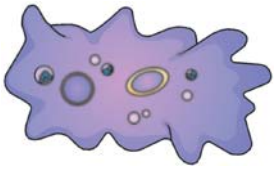
Food begins its journey at the **mouth**. In the mouth, food particles are broken up. The **saliva** in the mouth moistens and lubricates the food. The enzyme **amylase** breaks down the starch present in the food**.**

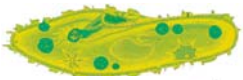
Pharynx swallows the food and **oesophagus** transports the food to the stomach. The stomach stores and churns the food, absorbs the nutrients to a limited extent. Dilute **hydrochloric acid** present in the stomach activates the enzymes to break up the food further and kills germs. The enzyme **pepsin** in the stomach cleaves proteins.

The **liver** breaks down and builds up new biological molecules, stores vitamins and ions, destroys old blood cells and other toxins (poisons). The **gall bladder** stores bile. **Bile** in the liver aids in the digestion of fat. The **Pancreas** play a crucial role in maintaining the glucose level in blood and neutralizing the stomach acids. Various enzymes like trypsin, chymotrypsin and carboxypeptidase present in the pancreas break down proteins and amylase breaks down (starch) glycogen, lipase breaks down lipids and nuclease breaks down nucleic acids.

The **small intestine** completes the process of digestion. Various enzymes present there break down proteins, sugars, starch, lipids and nucleic acids to simpler molecules. The **mucous membrane** protects the walls of the intestine. The **large intestine** reabsorbs water, ions and vitamins. It stores solid waste. The **rectum** expels solid waste through the **anus**. The anus is the opening for solid waste.

Different organisms obtain food differently



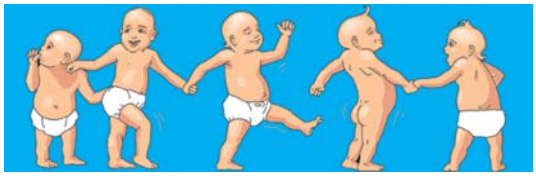


Amoeba uses its false feet. Paramecium uses its brush-like structure (celia) to sweep food particles into its mouth. Frog uses its cleft tongue. A spider weaves a web to catch its prey. Hydra uses its tentacles with sting to catch its food and a butterfly uses its feeding tube to get nectar - its food - from the flowers.

How do vultures catch their prey? Which animals obtain food using hands like we do?

Why should we eat?

Life is a constant flow of energy. We obtain energy from the food we eat.



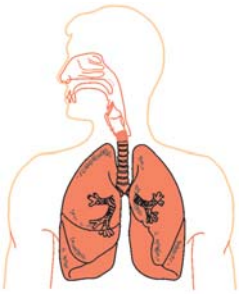
Growth, reproduction and heredity use energy. What will happen if we stop eating?

Our body uses energy stored as fat. Gradually, deprived of an energy source, life stops. We must supply energy to keep life going. So, we need to eat.

How do living organisms obtain energy?

To obtain energy, two things are necessary: Consuming carbon-containing compounds and the burning of these compounds in oxygen-rich air or their combustion. **Carbon dioxide** and **water** are produced. The main challenge is how to take in oxygen and dispose of carbon dioxide.

6.2 Respiration - is it only breathing in and breathing out?



Ask a friend " What is respiration"? Your friend is likely to reply, "It is breathing in and breathing out". This answer is only partially correct. **Respiration is also a process in which metabolic changes take place in the cells.** The cells use oxygen to produce energy and carbon dioxide is generated in the process.

The respiration process

The respiration process consists of the intake of air or oxygen, taking oxygen to the cells, using oxygen for burning carbon compounds obtained from food, releasing energy and eliminating the waste products (carbon dioxide and water).

How is oxygen captured?

There is plenty of oxygen in the air. Animals do not capture oxygen directly from the air, like the plants capture carbon dioxide directly from the air. Animals would require more energy to capture oxygen directly from the air than they would gain from capturing it indirectly. Animals are smart. They capture oxygen indirectly by diffusion of oxygen in the cells.

Exchange of the captured oxygen and the release of carbon dioxide takes place in animals in a variety of ways. The gas exchange takes place through,

amphibian

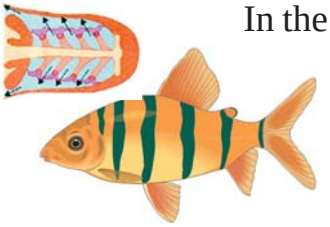
the direct diffusion of gases in amoeba.

amoeba

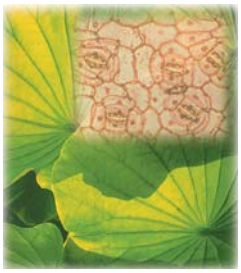
the skin in amphibians.

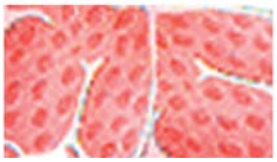
the air passage or trachea in insects. For example, grasshoppers get oxygen through the air tubes in their bodies.

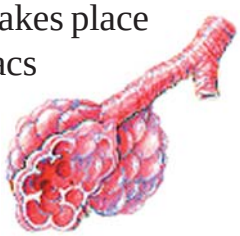
Grasshopper



In the case of fishes, the dissolved oxygen in water is taken in as the water passes over the gills. The earthworms, like the amphibians, absorb oxygen through their moist skin. The gas exchange takes place through the thin air sacs or alveoli in the lungs of mammals. Plants use the pores or stomata in the leaves for the exchange of gases.







Gills and breathing

The gill of a fish is an efficient respiratory organ. Gills are suspended between the mouth cavity and the outside body of the fish. There is a hard cover over the gill. When the fish opens its mouth, the volume of the mouth cavity increases and water enters the mouth cavity. When the fish closes its mouth, the volume of the cavity decreases. This forces the water with the dissolved oxygen in it to flow over the gills and go out of the fish's body through the gills.

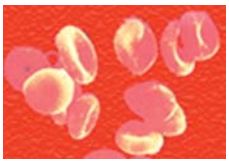
Why does a fish die when it is out of water?

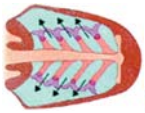
A fish breathes through its gills. The gills are made up of fine membranes. The gill membranes lack structural strength. They are supported by water to avoid collapse. Air is less buoyant than water. The gills, therefore, collapse into a mass of tissue when the fish is out of water. The fish dies due to suffocation.

Respiratory system

The evolution of the respiratory system in animals is linked to the capture of oxygen by diffusion. The most efficient mechanisms are the counterflow mechanism in bony fishes and the lungs of birds, and through

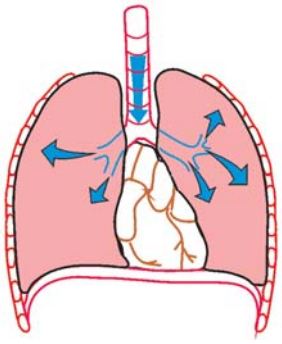
haemoglobin in the vertebrates.



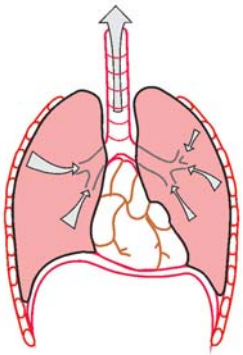


Respiratory organs are different in aquatic animals and in the land-based or terrestrial animals. **Aquatic animals have gills and terrestrial animals have lungs.**

Need for the evolution of the lungs

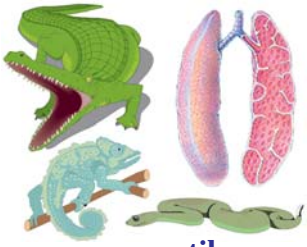


Once the living organisms became land-based or terrestrial organisms, air became the source of oxygen. An entirely new method to take in oxygen was required. This had to be based on the internal passage of air. This resulted in the evolution of the lungs.

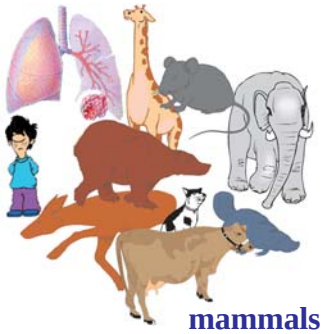


Lungs of

amphibians



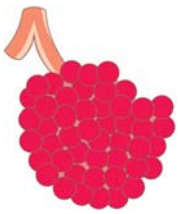
reptiles



mammals

From moist skin to alveoli

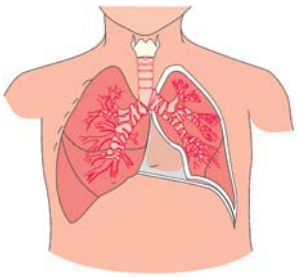
Stages in the evolution of the lungs



The amphibian lung is a sac with internal membranes. The reptile lung has internal air sacs called **alveoli**. This modification was necessary as the reptile has an air-tight body and needs more energy.

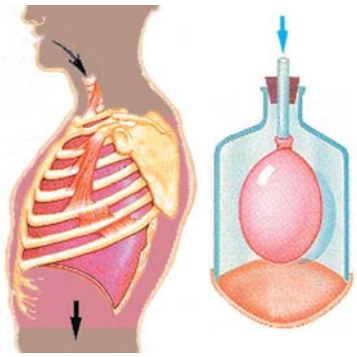
There are **clusters of alveoli** in birds and mammals.

The human lung



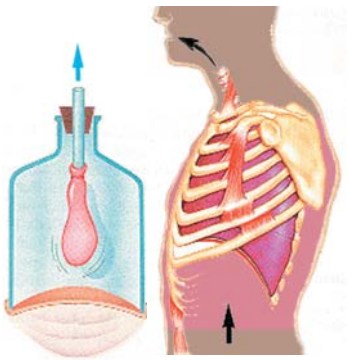
The human lung is the most efficient oxygen capturing machine. There are ~300 million alveoli in the two lungs of an adult human being. This increases the surface area enormously for diffusion of oxygen to occur. The diffusion area is ~80 square metres or roughly 40 times the surface area of the human body.

Working of the human lung has two basic movements - **inhalation or breathing in and exhalation or breathing out.**



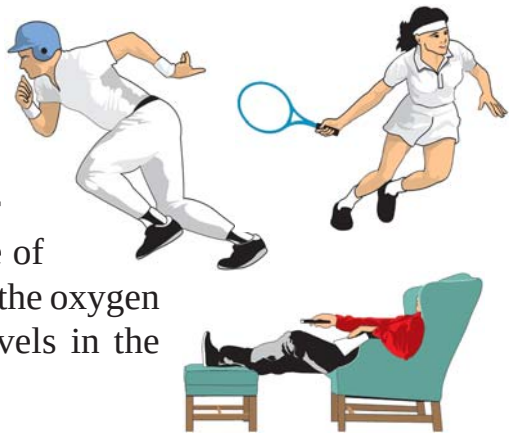
During inhalation, the diaphragm pushes up and the chest cavity expands. As a result, the volume of the chest cavity increases and air is sucked in.

During exhalation, the diaphragm and the chest walls come back to their original position. This reduces the volume of the chest cavity. As a result, air is forced out.



Brain and breathing

Our need for oxygen is not the same all the time. Our need for oxygen is more when we are active and less when we are resting or asleep. Our brain regulates the rate of breathing according to the oxygen and carbon dioxide levels in the blood.

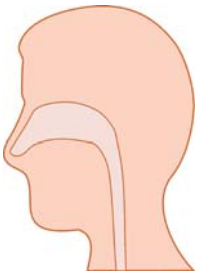


Why do we breathe faster or harder when we exercise?

The change in our rate of breathing is regulated by a respiratory centre in the brain stem. This is a simple feedback mechanism. The receptors present detect changes in the carbon dioxide level in the blood. This information is sent through nerve impulses to the respiratory centre. The respiratory centre, in turn, sends appropriate signals to the muscles of the diaphragm and the rib cage. This is done continuously and automatically.

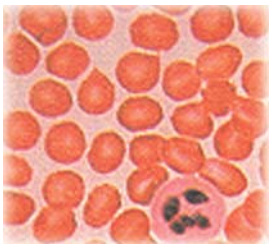
When the carbon dioxide level rises, the respiratory centre sends a message to increase the rate of breathing so that the necessary amount of oxygen is available for the gas exchange. When we exercise, we burn more oxygen to have more energy and therefore, produce more carbon dioxide. As a result, our body needs more oxygen and we breathe faster.

Cellular respiration: energy producing process



The food we eat and the air we breathe are both the essential raw materials to produce energy. Energy is produced when glucose formed by the breaking down of the food "**burns**" in oxygen, in the cells. **This internal burning or combustion is actually oxidation.** Glucose gets converted to carbon dioxide (CO_2) and water (H_2O). This process is called **cellular respiration**.

What happens to the carbon dioxide produced during cellular respiration?

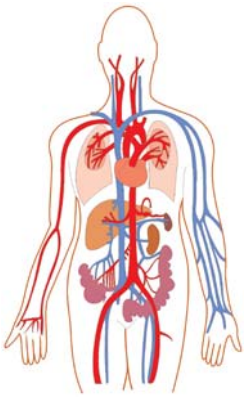


Excess carbon dioxide in our system is harmful to us. Therefore, it has to be thrown out. How does the body achieve this? The carbon dioxide produced during cellular combustion is released from the cells to the blood. Carbon dioxide is carried by the blood to the lungs and is exhaled or breathed out.

6.3 Circulatory system or the transport system

Cellular respiration does not occur in one central site. The nutrients and oxygen have to reach all parts of the body. To do this, an efficient transport system is required.
Single-celled amoeba uses **simple diffusion** to transport nutrients and oxygen. This method is unsuitable in a multicellular organism.

Circulatory system of a vertebrate animal

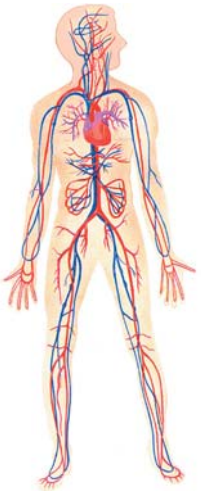


Just like roads and side walks in a city transport a variety of goods, the circulatory system of a vertebrate transports red blood cells travelling between the lungs and the tissues of all parts of the body, nutrients to the tissues and the waste products from the cells and tissues.
The circulatory system can be either **closed** or **open**. The main functions of a closed circulatory system are:

- ★ the transportation of nutrients and oxygen to the cells,
- ★ the transportation of carbon dioxide and other waste products of cellular respiration,
- ★ the circulation of hormones and the maintenance of the body temperature.

In an open circulatory system, there is no distinction between the body fluids and the circulating fluid or blood.

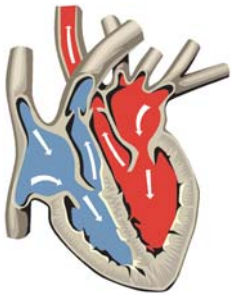
What does the circulatory system consist of?



The circulatory system consists of:
the heart or the pump.
Arteries. They are the network of highways and state roads that carry the oxygen-rich blood from the heart to all parts of the body.
Veins. These are the return highways that bring the waste products of cellular combustion back to the heart. The major vein takes the impure blood to the lungs for purification.

Capillaries. These are the distribution and collection networks. These are the side roads branching off to the different parts of the body. They distribute oxygen-rich blood and collect carbon dioxide-rich blood. **The traffic on the highways is only in one direction. There is no mix up at any time.**

Heart - the efficient pump



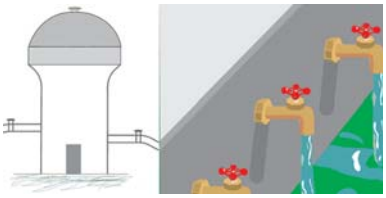
The heart is the efficient muscular pump that helps to circulate blood throughout the body of an animal. In mammals and birds, it has separate chambers to keep the deoxygenated blood returning from all parts of the body and the oxygenated blood coming from the lungs. The heart sends the oxygenated blood to all parts of the body. This pumping process goes on continuously as long as the animal lives. In lower vertebrates, the oxygenated and deoxygenated blood are not separated and in invertebrates, the heart does not have a major role to play in the distribution of oxygen throughout the body.

Did you know that blood is a vital tissue?

Blood has red blood cells which carry oxygen to all parts of the body, white blood cells which fight infections and platelets which help blood to clot or coagulate. Did you know that a person will bleed to death if the platelet count is very low? This is a serious disease. It is called **hemophilia.** All these cells are immersed in plasma. Plasma contains proteins and ions.

The pump and the pipes

Transporting nutrients and oxygen in the birds, reptiles, mammals and you and me, can be compared to transporting water from a tank to the taps.

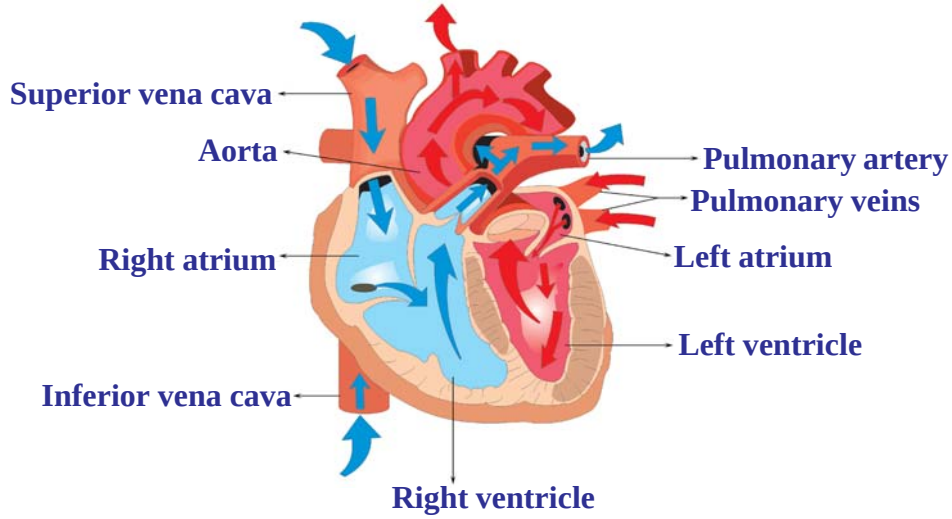


The heart is the pump and the oxygen-rich blood is the water. The blood vessels are the various pipelines and the different parts of the body are the different taps in the house.

Shape of the heart in different vertebrates

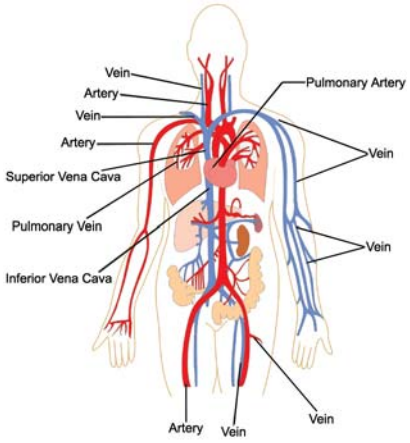
The pump of fishes, amphibians, reptiles and birds.

Route of the blood flow - From the heart back to the heart



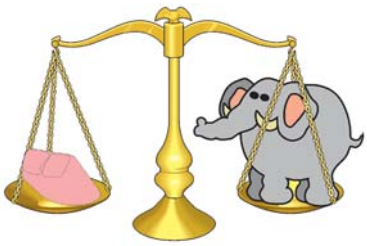
The blue arrows indicate **deoxygenated blood** returning from all parts of the body to the heart on its way to the lungs. The red arrows indicate **oxygenated blood** returning from the lungs to the heart on its way to all parts of the body.

- ★ The heart pumps oxygen-rich blood via the arteries.
- ★ The arteries carry blood to all parts of the body.
- ★ The capillaries deliver oxygen to the tissues.
- ★ Return journey starts with the capillaries collecting the waste products from the cells.
- ★ The capillaries deliver the blood with the waste products to the veins.
- ★ The veins take the impure blood back to the heart from where it is sent to the lungs.

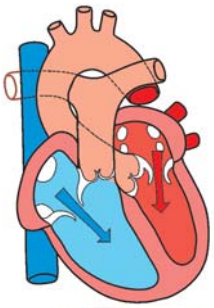


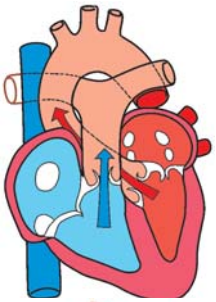
Size of the heart

Did you know that the heart is ~0.6% of the total body mass of a mammal regardless of the size of the mammal? **This is true of a mouse as well as an elephant or a whale.**

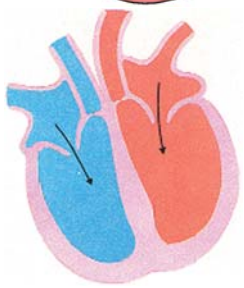


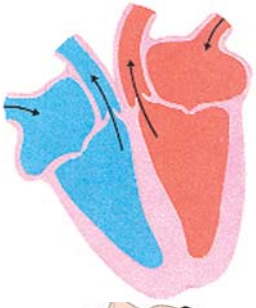
Lub dub: the beat of the (human) heart



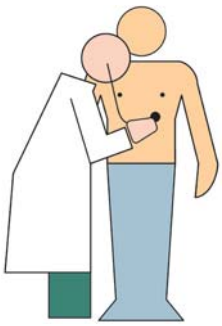


The heart pumps blood by a series of contractions and relaxations. The heartbeats are in the **lub, dub** sequence. When the oxygenated blood enters the upper chamber, it is squeezed into the lower chamber and the valve closes making a sound. This is the **low pitched lub**. Another stronger contraction pushes the blood into the arteries. The valve closes at the end of the contraction with a louder sound, **dub. Lub is called the diastolic pressure**. This has a lower pressure valve. **Dub is called the systolic pressure.** This has a higher pressure valve.





Monitoring the beats



How can we know if the heart is functioning well?

We can do this by monitoring the heartbeats. This can be done by

- ★ listening to the lub-dub,
- ★ monitoring the blood pressure
- ★ recording the electrical impulse by using an electrocardiograph (ECG).

Normal blood pressure values are from 110/70 to 140/80 (Systolic/Diastolic)

What is high blood pressure?

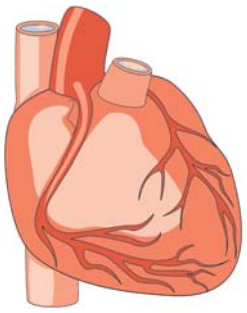
The blood pressure in the arteries is kept at a constant level by the central nervous system and the hormonal balance. Arteries have pressure receptors. A reflex action of these receptors regulates the blood pressure up to a few minutes. Regulation of blood pressure in the arteries involves hormonal and neural mechanisms. All these regulate the volume of blood flowing through the arteries and the veins. Kidneys play a major role in the re-absorption of salt and water. When these long term hormonal and neural regulators break down, there will be a chronic rise in the pressure of the blood flowing in the circulatory system. **This state is called high blood pressure or hypertension.**

High blood pressure – the silent killer

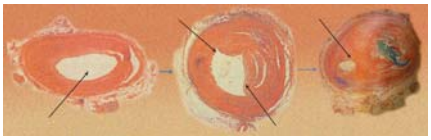
Chronic high blood pressure is extremely dangerous as it can cause rupture of the blood vessels, stroke due to the blood vessels in the brain being ruptured, heart failure due to the extra work load on the heart, accumulation of fat on the inner walls of the arteries that supply blood to the heart muscles and kidney failure.

Heart attack - the killer disease

What is a heart attack?



Heart muscles are supplied nourishment (oxygenated blood) through the major arteries. When the blood supply to the heart muscles is not enough, the tissues and cells die. Heart attacks can be caused by blood clots in the



arteries or by the narrowing of the arteries due to the deposit of fatty materials and calcium on their inner walls.

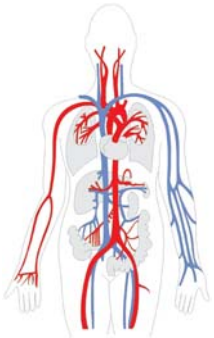
The stages of a heart attack – the beginning of the end

The stages are: minor blockage, severe blockage by fatty materials, coronary artery almost completely blocked.

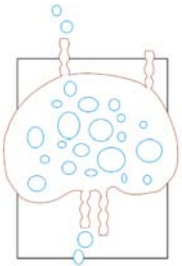
Does the heart give a distress signal?

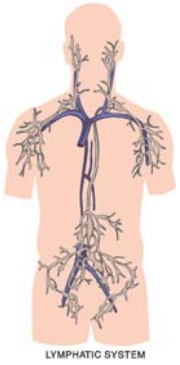
Generally, a heart attack does not occur without warning. Our body sends signals that all is not well. If we recognize the danger signals in time, we can prevent a heart attack from occurring. **Angina pectoris**, or literally "**chest pain**" is an early warning. The pain may be felt in the region of the heart or in the left shoulder and arm. **Consult a doctor before it is too late.**

6.4 Fluid recovery organ systems – the lymphatic system



Blood circulates through a closed system where all blood vessels are connected to one another and there is not a single open tube. In this circulatory system, tiny blood vessels or capillaries and the thin walls result in loss of fluids. An adult human body loses close to 2.8 litres of fluids this way. This fluid must be returned to the closed circulatory system. This is done by the **lymphatic system**

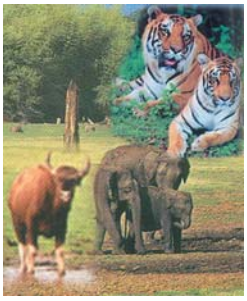




The lymphatic system is an open circulatory system. This open circulatory system consists of a network of vessels. The network collects the water within the blood plasma forced out during the passage of the blood through the capillaries and returns it to the blood stream. The lymphatic system also returns proteins to the circulation, transports fats absorbed from the intestine

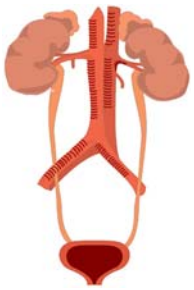
and carries bacteria and dead blood cells to the **lymph nodes** and **the spleen** to be destroyed.

Vertebrates and water balance




Water affects all living organisms. Vertebrates have to balance the water and the salt content in the body. Vertebrates can live on land, in rivers, lakes, seas and oceans. These environments present specific problems and determine the amount of water retained by the vertebrates. **Which organ takes care of this complex task of maintaining the water balance?**

The kidneys in the vertebrates are designed to take care of this complex task. The functions of the kidneys are maintaining the water balance by excreting the excess water as urine, maintaining the salt or electrolyte balance and eliminating waste products.



Can kidneys be replaced?

Kidneys can be damaged by hypertension (high blood pressure), diabetes, viral or bacterial infection. The two basic treatments for restoring the life-saving functions of the kidneys are **dialysis** and **replacement of the kidney**.

In the dialysis method, an external device is used to remove the toxic waste. This method is expensive and does not replace all the functions of the kidneys such as regulating the water and salt balance. It also restricts the normal activities of the person undergoing dialysis.

A damaged kidney can be replaced by kidney transplantation. The main problem of kidney transplantation is the rejection of the donor's kidney by the immune system of the person receiving it. It is important to match the tissue types of the donor and the recipient and use appropriate drugs to suppress rejection.

The amazing kangaroo rat

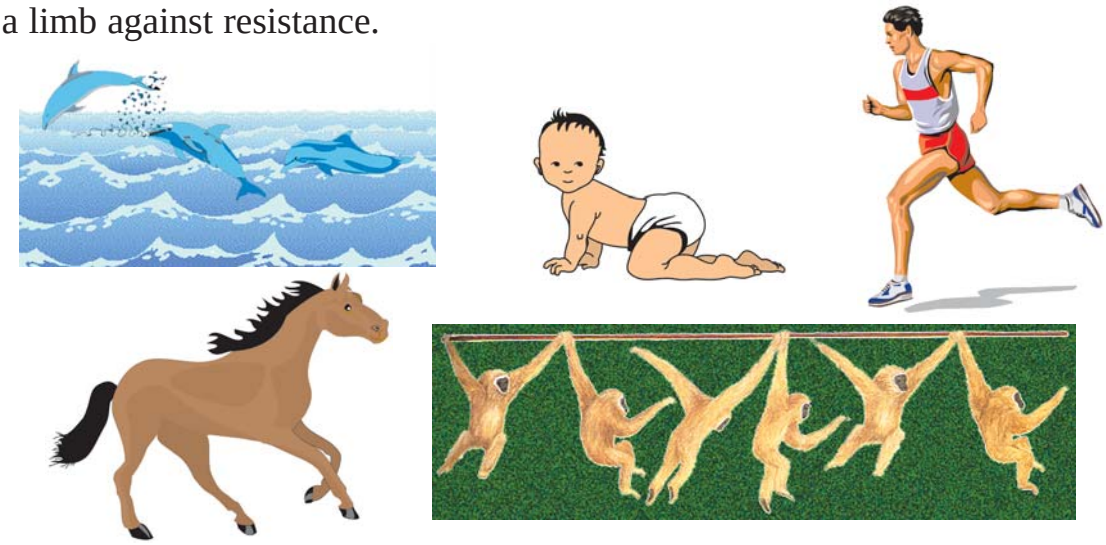
Kangaroo rat is a hopping rodent that lives in the hot and dry deserts of North America. In many ways it resembles a kangaroo in its body structure. It is a nocturnal animal that eats seeds, leaves and other vegetation. Kangaroo rat has

- ★ short fore limbs and long and strong hind limbs like a kangaroo.
- ★ large eyes, ears and head, a short tail with tuft. The tail helps the kangaroo rat to balance.
- ★ external fur-lined cheek pouches. These pouches are used to store food.

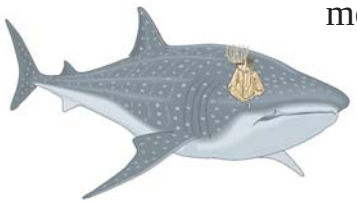
Kangaroo rat has a very efficient kidney that recycles the water in the body of the animal by concentrating the urine to a high degree. This enables the kangaroo rat to minimize water loss so that it hardly needs to drink water.

6.5 On the move: Locomotion

What is the major difference between the plants and animals? Animals move about but plants cannot even if they want to! Movement requires shifting of a limb against resistance.



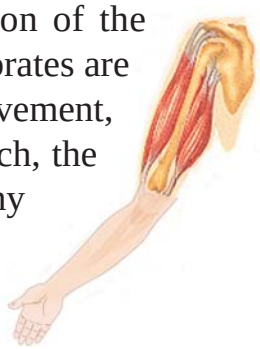
The only animal not able to move around is the barnacle. It makes up for this by riding piggy back on whales. It surely moves around more than you and me!



Moving along requires contraction and relaxation of muscles attached to the limbs and stretching the outer skin. What would happen if the outer skin does not stretch when we move?

Stretching of the skin and movement

Movement is caused by the stretching and contraction of the muscles. The muscles attached to the skeleton of vertebrates are covered by soft and flexible skin. Whenever there is movement, the skin covering the joints stretches. If it did not stretch, the skin would tear every time any muscle stretched or any joint moved. Imagine the consequences! Your skin would be tearing every time you bent your knee or your elbow. What a messy situation!!



Locomotion in different organisms

Muscles produce locomotion or movement. But they can produce movement only if they are attached to something. Soft bodied invertebrates do not have an external or internal skeleton. They move by directing the muscle force against the **"water skeleton"** in their bodies. This type of skeleton is called the **"hydro skeleton".**

Earthworms on land and **jelly fish** in the seas move like this. How does hydra move?

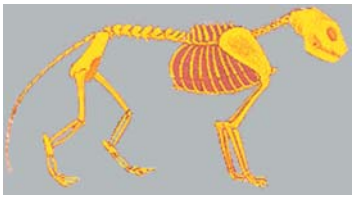
How do insects move?

In many insects, the muscles are attached to the hard parts of their bodies. These hard parts are on the outside. This type of skeleton is called the **"exoskeleton".**

Contraction of their muscles results in the beating of their wings or lifting of their legs.

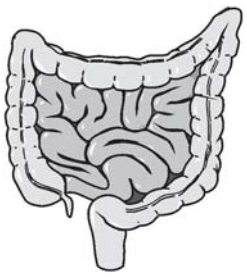
Movement in vertebrates

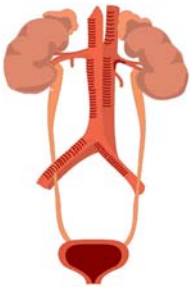
In the vertebrates, the muscles are attached to an internal scaffolding. This scaffolding or skeleton is both rigid and flexible. This skeleton is called the **"endoskeleton".** All vertebrates have a soft and flexible exterior covering – the skin. This can stretch to accommodate movement.



The excretory system

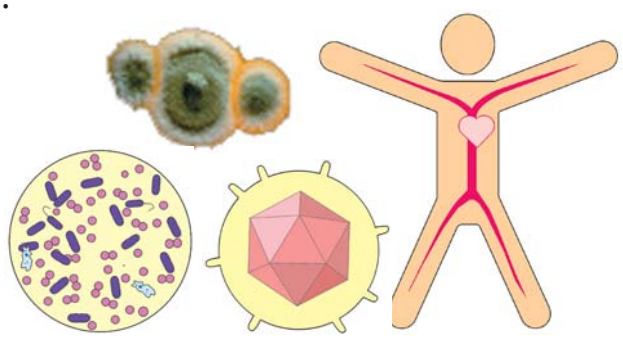
Disposal of waste products is an essential activity of living organisms. All living organisms – big and small - are chemical factories. The chemical reactions or the metabolic activities that take place in a living organism produce both solid and liquid wastes. In human beings, the **large intestines** throw out the solid waste and the **skin and the kidneys** throw out the liquid waste or waste water.





Our body under attack

We are under constant attack from invisible enemies - **the microbes.** Our body is threatened by invasion from land (fungi), water (bacteria) and air (viruses).

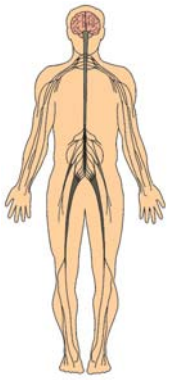


The invasions if successful cause microbial infections that weaken the body and sometimes even cause death.

The defense system

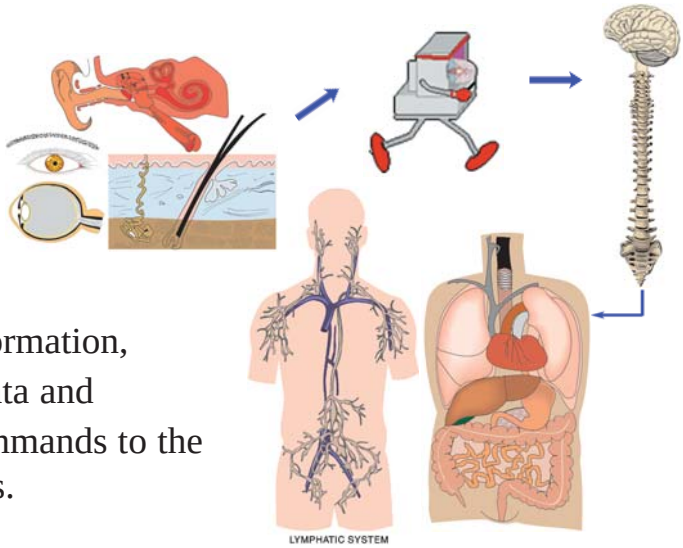
The organization of our defense system can be compared to the defense system in our old cities. **Skin and mucous** membranes are like the **moats and the fort walls**. They are the first line of defense. They make the invasion difficult. The chemicals and some of the cells in our bodies act as the patrolling police. The three basic patrols are: **macrophages**, the foot soldiers, **neutrophils**, the suicide squads and the **natural killer cells**, the internal security patrol.

The command centre or the nervous system



The diverse functions of a living organism need to be coordinated and regulated. All animals except **sponges** use a network of neurons to

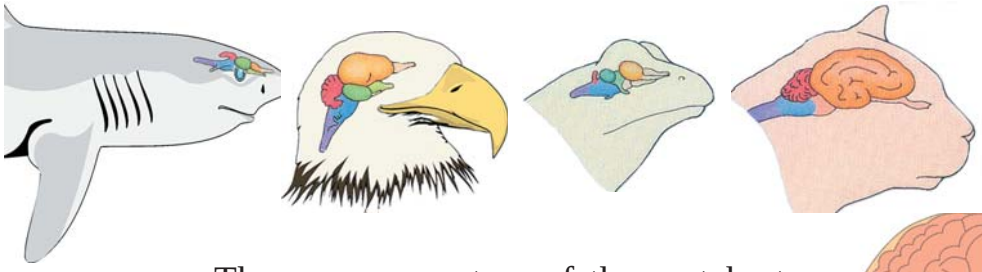
★ gather information about the condition of the various systems and the environment,

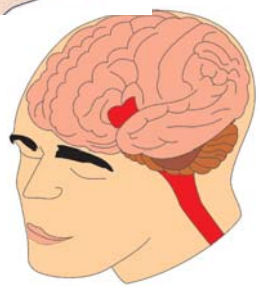


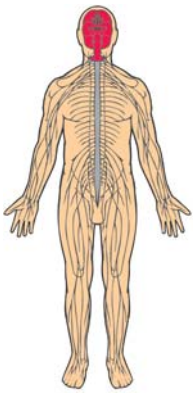
★ process the incoming information,

★ integrate the processed data and

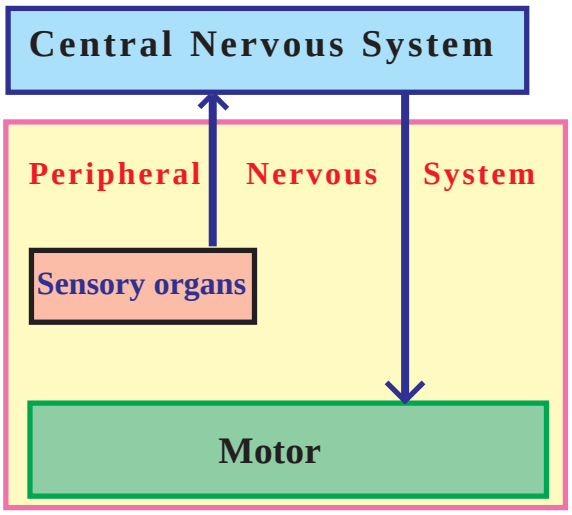
★ issue instructions and commands to the various tissues and glands.







The nervous system of the vertebrates consists of the following basic units: the central nervous system or the **CNS** consisting of **the brain** or the central data processing centre, the **spinal chord**, and the peripheral nervous system consisting of both the **sensory pathways** and the **motor pathways** - nerves that bring information to the brain and nerves that transmit the orders from the brain to different parts of the body respectively. The nerves bring information to the brain and transmit commands from the brain by nerve impulses. In many illnesses, there is a breakdown of the communication system**.**

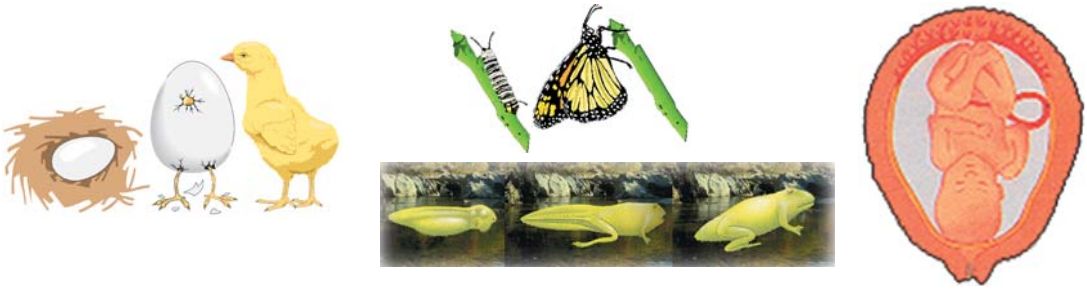


The different functions of the sensory pathway and the motor pathway

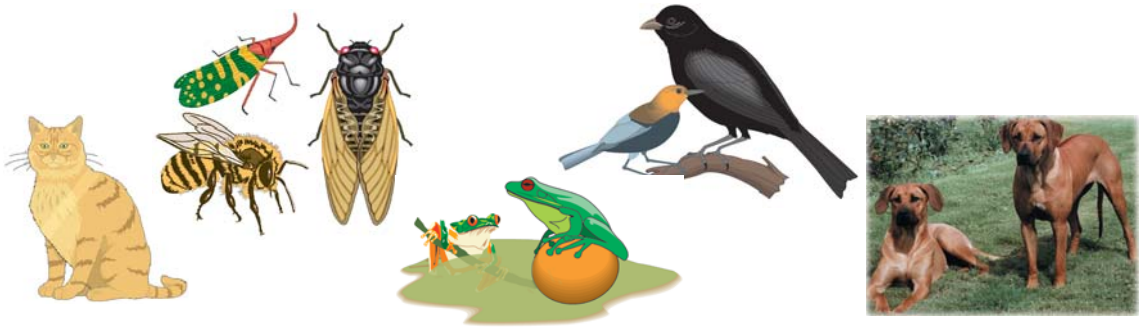
The diverse activities of a vertebrate animal are coordinated and regulated by the CNS. To do this, the CNS depends upon the information gathered and brought by the sensory pathway. Based on the information received, the brain builds a picture of not only the external environment but also the body's internal status. The brain also takes into account both the site of the sensory neurons and the frequency of the messages sent by them. The brain then uses network of motor neurons to issue appropriate commands.

The motor pathways take the commands from the brain to the appropriate part of the body. Motor pathways can be voluntary pathways or involuntary pathways. The brain also regulates the release of hormones. This is of crucial importance as it affects the long term changes in the body functions. Biologists are now trying to unravel the mystery of how the immense number of neurons in the brain function to affect the behaviour of a vertebrate animal.

6.6 Reproduction: the essential act of evolution



You must have heard cries of cats, chirping of insects, croaking of frogs, melodious sounds of birds, howling of dogs.



Often, these are the sounds of reproduction. The compelling desire to reproduce oneself is in-built in all living beings.

Reproduction strategies of the vertebrates

Unlike the plants, almost all the vertebrates reproduce sexually. Fertilization of eggs may be external fertilization as in marine animals and amphibians, or internal fertilization as in terrestrial animals.

Sexual reproduction

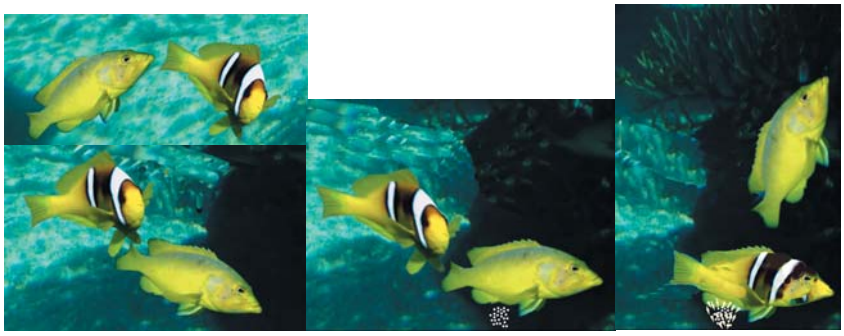
Chromosomes are compact units in which the DNA is tightly packed. Chromosomes in the cell body of an animal or a plant contain two identical sets of chromosomes. A cell, tissue or an individual with a double set of chromosomes is called a diploid, and the reproductive cell with half the number of cells (gametes) is called a haploid.

During fertilization, the male reproductive cell or sperm fuses with the female reproductive cell or egg, to form a diploid chromosome. This diploid chromosome again undergoes division to form either sperms or eggs.

Sexual reproduction, therefore, alternates between fertilization and division (or differentiation). An outstanding feature of sexual reproduction is that every individual offspring inherits genes from the sperm of the father and egg of the mother.

Evolution of sexual reproduction

Sexual reproduction, like life on earth, first evolved in the sea. Female fishes produce eggs in batches. They release the ripe eggs into the water. The male fishes release sperms into the water already containing the ripe eggs. The release of the eggs and the sperms must coincide. Fertilization takes place externally. **How do the fishes get the timing right?**



The moon cycle and the cue to the fishes

Most fishes release the sperms and the eggs over brief and well-defined periods. How do they know when to do it? The moon provides them with the vital cue. The revolution of the moon around the earth causes variations in

the tides. This variation is accompanied by changes in the water pressure. Fishes are sensitive to these changes and release the eggs and sperms at the most appropriate time. The lunar cycle determines the external fertilization occurring in the seas.

The major problems of external fertilization in marine environment are

★ the eggs and the sperms get diluted quickly in sea water.
★ the release of the eggs and the sperms must coincide.

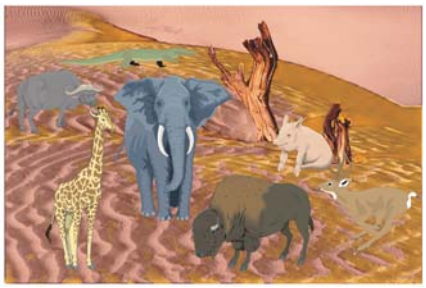
The amphibian way - the half-way stage of adaptation

The amphibians provide the link between the external fertilization of the fishes and the internal fertilization of the land vertebrates. The frog is a typical amphibian. Fertilization of frog eggs also takes place externally. **How is this different from that of the fishes?**

Frog's life cycle is also tied to water. The female frog releases a large mass of eggs inside a jelly like bag into water when a male frog hugs it tightly. The male frog releases the sperm onto the eggs. The eggs develop into larvae inside the bag.

Landward invasion of animals and the need for change of reproduction strategies

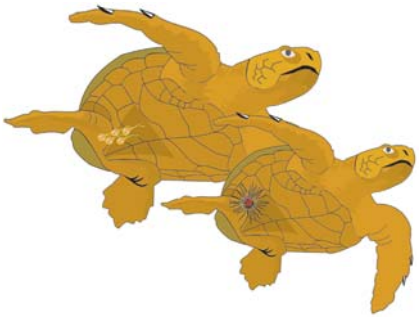
Arriving on land, the vertebrates faced a new danger: extinction due to drying out. Plants and fungi successfully adapted to the change



from the wet marine environment to the dry land environment. **What innovations did the vertebrates come up with?**

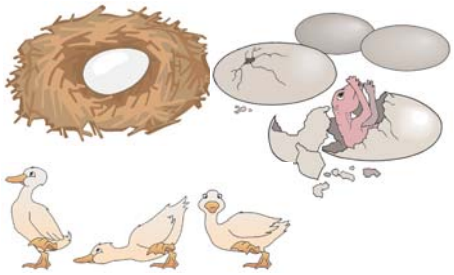
The first to adapt to land environment

Reptiles were the first land vertebrates to abandon external fertilization in the water environment. Reptiles practice internal fertilization. Here, the male introduces the semen into the body of the female. The eggs are fertilized inside the mother's body.



Similar strategy of reptiles and birds

Reptiles and birds share the same strategy. The male introduces the semen (fluid containing sperms) into the female's body. The eggs are fertilized inside the female's body. Fertilization still takes place in a wet environment.

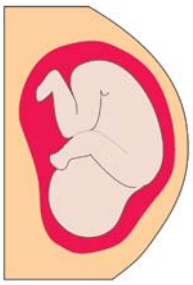


The eggs have a hard shell. Most reptiles, and all birds deposit the eggs outside. They are **oviparous** (i.e. the eggs develop after leaving the mother's body).

The significance of the hard shelled eggs

The hard shell of the eggs of reptiles and birds is a clever and important adaptation to living on land. This adaptation freed the land animals from the water habitat. The egg is encased in a thin membrane inside a hard shell. The yolk stores enough nourishment for the development of the fertilized egg. The fertilized egg grows into a miniature adult and breaks out of the shell to face the world.

Reproduction strategy in mammals



The fertilized eggs in mammals develop inside the mother's body. The zygote develops into a baby. A fully developed baby is born.

The infants are nourished and protected by the mother.

Zygote - the original you

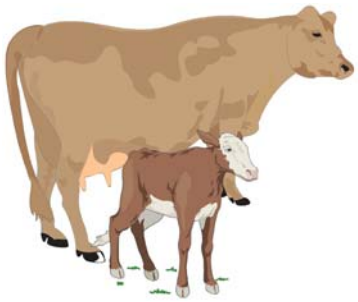
The life cycle of all organisms which reproduce sexually follow the same basic pattern. The process alternates between the diploid chromosomes number (total number of chromosomes of two sets containing identical number of chromosomes) and the haploid chromosome number (half of the diploid number).

Two haploid chromosomes (the sperm of the male and the egg of the female) fuse after fertilization to form the first cell of a diploid individual. This first cell is called **zygote**. A human zygote divides by mitosis. Starting from this individual single zygote, an adult human body eventually has approximately 100 trillion cells! The amazing feature is that each of your ~100 trillion cells (when you are an adult) is identical to the zygote from which you became you!

What is the difference between a kangaroo and a cow?

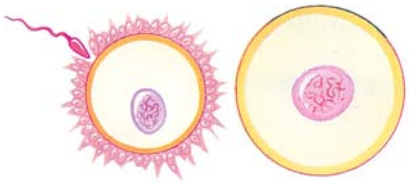
A kangaroo gives birth to a tiny animal (not bigger than your thumb). This crawls into the pouch (in front) on the mother's body. It continues to grow there and comes out only when it is able to function on its own. It is a marsupial.

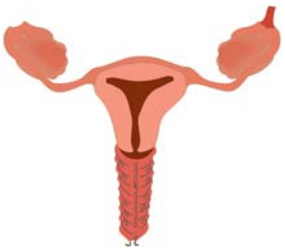
A cow has a massive network of blood vessels called placenta. The embryo gets the required nutrients from the mother's blood. The young calf is born when it is fully developed.

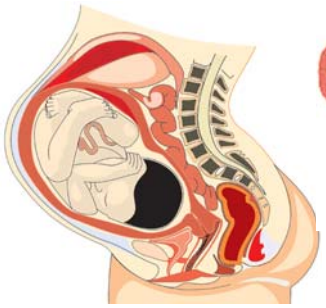


Reproduction in humans

In the human reproductive system, the sperm of the male joins the egg cell of the female. The egg is fertilized within the female's special organ called the **uterus**.





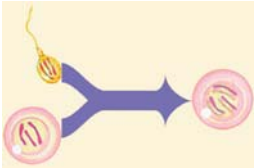


The zygote develops into a fetus in the placenta and matures into a miniature individual. The young baby is born alive. Some babies do not survive the difficult passage to life. They are called "still born" babies.

Reproduction strategies - summing up

Fertilization is the union of an egg of a female with sperm of a male to form a zygote.

Fertilization can be external as in fishes and amphibians or internal as in reptiles, birds and mammals.

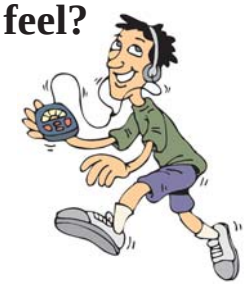


Mammals are **viviparous** (reproduction in which eggs develop within the mother's body). Birds are oviparous. Reptiles can be either oviparous or viviparous.

7.0 Energy sensors

How do we see, hear and feel?





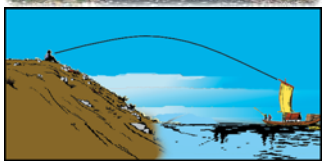


Our brain receives signals from different nerve endings. Light sensitive receptors in our eyes are sensitive to light energy. Similarly, nerve endings in our skin are sensitive to heat energy. The nerve endings in our ears are sensitive to sound energy. Without these energy sensors, we will be living in a dark, cold and silent world.

7.1 Perception of light or vision

Light is the most important stimulus for learning about our environment. Visual information is vital because it can be used to gauge both the direction and the distances of objects.





However, vision is not the only energy sensor used by vertebrates for getting crucial information of their environment.

Vertebrate and energy sensors

Even though visible light is the most important stimulus used by almost all vertebrates to assess their surroundings, many vertebrates use many other energy sensors to gather crucial information about their surroundings,

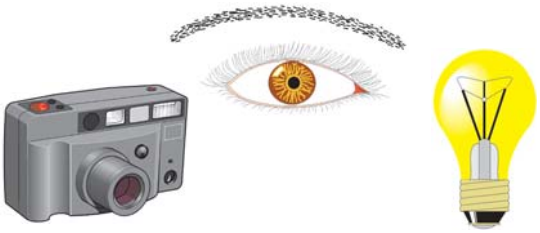
Generally, vertebrates use the sensors best suited to their environment. For example;

- ★ Fishes use sensors that can detect electric field and liquid pressure.
- ★ Snakes use sensors to detect heat as air transmits heat better than water.
- ★ Bats use sensors to detect ultra sound.
- ★ Birds use sensors to detect the earth's magnetic field.

How does the eye receive and interpret light?

The eyes contain sensory receptors
These receptors

- ★ are located at the back of the eye.
- ★ are organized as in a camera.
- ★ can detect light.



The eye

The eye lies in the orbit of the skull. It is held in place by the muscles that move it. Eye is cushioned by fat. The eyelids cover the cornea and the conjunctiva (a thin mucous membrane that covers the exposed surface of the eye). These two together protect the interior of the eye.

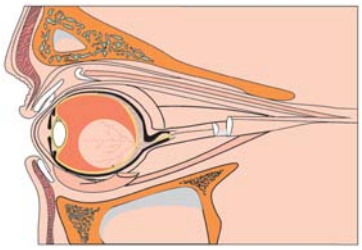
Light enters through the cornea, it is refracted and passed through the iris to the lens. The lens focusses in the fovea. Optical impulses are passed through the optic nerve to the brain.

Structure of the human eye

The human eye, like the other parts of the human body, is perfectly organized to do its job efficiently.

The outermost layer is the **cornea**. This is a transparent layer. The cornea covers the **iris**, the coloured part of the eye. The iris has a small opening called the **pupil**.

The pupil contracts when the light is very bright and dialates or opens wide when the light is dim. The **lens** is behind the pupil. Its focal length is adjustible.



The **retina** is like a screen that catches the image cast by the lens.

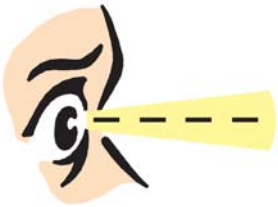
Retina

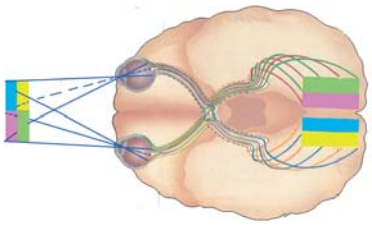
Retina has receptor cells, rods and cones. The retina has approximately three million cones and one billion rods. The visual pigment in vertebrate eyes is located in the tips of special cells called **rods and cones.** Rod cells are responsible for black-and-white vision in faint light and cones are responsible for colour vision. **Fovea**, the central region of the retina, has mostly cones. Sharp images are formed in this region.

Human eyes are lens-focussed eyes

The passage of light in the human eye

Light begin its journey by first passing through the transparent cornea. The lens then focusses the light from the object on the retina. **The image is formed on the retina.** The optical nerves convey the image as electrical impulses. All these happen instantaneously.





Evolution of the eye

Generally, the evolution of various organs and organ system in different animals can be traced. However, the differences in the structure of the eyes of insects, amphibians, reptiles and homosapiens appear so great that it is difficult to trace the evolution of the eye.

Eyes of some animals have a single photoreceptor while eyes of vertebrates generally have focussing lenses and are sensitive to colours. Eyes of some vertebrates are located toward the front of the head. As a result, two fields of vision overlap producing stereoscopic vision, while some vertebrates have eyes located on the sides of the head. Such animals do not have overlapping or stereoscopic vision. Can you name a few animals that do not have stereoscopic vision?

Common eye defects

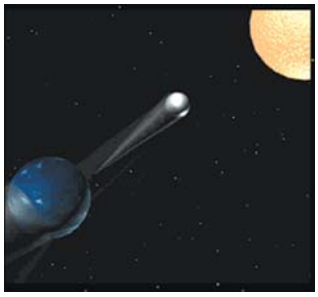
The image must fall on the retina whether the object is far off or near by. The common eye defects are caused by

★ the image forming in front of the retina. This is called **myopia**. People with this defect cannot see **distant objects** clearly.

★ the image forming behind the retina. This defect is called **hypermetropia**. People with this defect cannot see **nearby objects** clearly.

Myopia can be corrected by using a concave lens. Hypermetropia can be corrected by using a convex lens.

Eye care




Do's and dont's of eye care

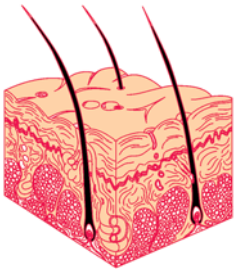
★ Do not look directly at the sun during a solar eclipse.
★ Clean your eyes with cold water.
★ If dust particles get into your eyes, do not rub your eyes.
★ Wear protective glasses when welding or when working in a chemical laboratory.

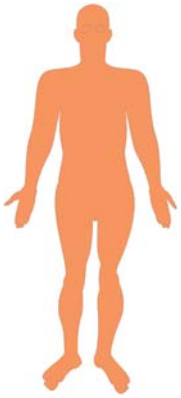
★ Wear cooling glasses in bright glare.

Eyes are precious. Take care of them.

7.2 Skin - the largest organ of a vertebrate

Our skin is the first defence against microbial invasion.
The skin





- ★ is a water tight organ. This prevents excessive loss of water by evaporation.
- ★ has nerve ends.
- ★ has sweat glands and oil glands.
- ★ has heat sensing and cold sensing nerve endings.
- ★ is a pressure sensing organ.

The skin of a vertebrate has three layers

They are

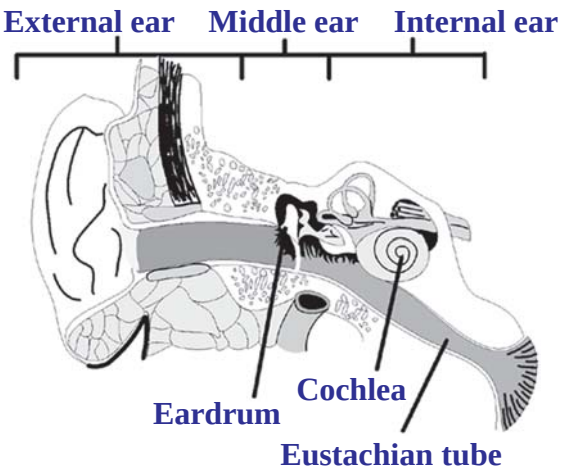
- ★ the epidermis (It is a thin layer).
- ★ subentraneous layer. It is the shock absorber and the insulator.
- ★ the lower dermis, which provides support for the epidermis.

7.3 The human ear

The human ear is designed to collect sound vibrations, pass them to that part of the ear that vibrates the sound. The human ear has three distinct sections. **The outer ear** (collects the sounds).

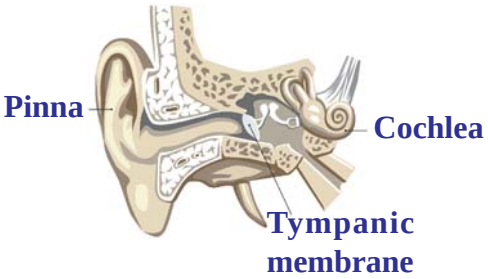
The middle ear (The ear drum is in this section).

The inner ear (The auditory nerves are connected to this section).



The outer ear: In mammals sound waves beat against a large membrane of the outer ear called the **tympanic membrane or ear drum**. This causes corresponding vibration in the three small bones - the hammer, anvil and stirrup. These bones act as a lever system. The amplified sound reaches the inner ear. Terrestrial vertebrates detect vibration in air by means of mechanical receptors located in the ear.

The middle ear: It is the hollow space between the eardrum and the inner ear. In human beings it contains three small bones that transmit sound waves from the eardrum to the ear.



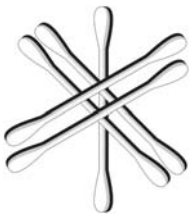
Inner ear: It is the innermost part of the ear. It is behind the middle ear. It contains the essential organs of hearing and balance.

How do we hear sounds?

When the sound reaches the eardrum, it vibrates to and fro. The auditory nerves convey the vibrations as signals to the brain. **The eardrum in the middle ear is crucial for us to hear the sounds.**

Taking care of the ear

The ear is a very delicate organ. It is important, therefore, to take care of our ears.

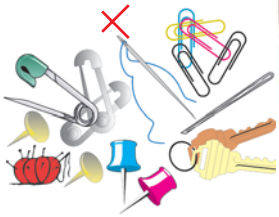


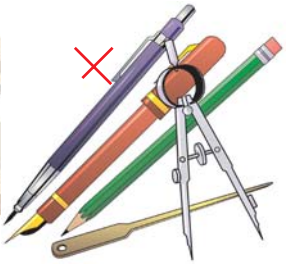
Do's and dont's of ear care.

Get your ears cleaned regularly.

Do not hear loud music. This can cause deafness.

The eardrum can get perforated easily. Do not use pins, hair pins, small keys. Do not use sharp instruments to clean your ears.





Energy sensors - Conclusions

Almost all vertebrates live in a world filled with light and sound. They also come constantly into contact with other living organisms and non-living objects.

However, no vertebrate, including the most evolved vertebrate (i.e. us), has all the sensory perceptors that help it to assess the information and fine tune its response.

We could have utilized the energy sensors to detect thermal radiation (as the snakes do), or the sensors to detect ultrasound (as bats do) and the sensors to detect the earth's magnetic field (as birds do) to have a better understanding of our environment.

We must remember that the vertebrates have evolved the sensory systems best suited to the challenges that they are likely to face.

8.0 The invisible world of microbes

Microbes are found everywhere in the soil, in air and in water. Microbes are so tiny that they are called micro-organisms. Micro-organisms have no specific habitat. They are found


in ice cold water.


in saline water.


in water with organic matter.


in hot springs.


in wet soil.


in dry desert soil.


in decaying flesh.

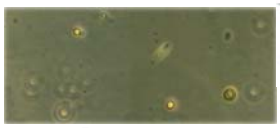
Characteristics of microbes

Microbes are hardy. Some microbes reproduce freely and some need a host (viruses). Microbes can survive hot and dry conditions by forming a hard coat called a **cyst**.

Like an embryo plant in a plant seed, the microbes remain inactive in the cyst. Under favourable conditions they emerge from the shell, multiply and go through their life cycle.

Inhabitants of the microbial world

There are five major microorganisms. They are


bacteria


fungi

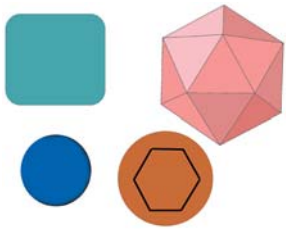

protozoa


algae


viruses

8.1 Viruses - the dangerous microbes

What are viruses? Are they living organisms or non-living substances? For many years, viruses were considered to be primitive forms of life, perhaps ancestors of bacteria.



Wendell Stanley established in 1933, that viruses

- ★ were not "**living**" organisms.
- ★ did not have a cell body and other structures of living organisms.

Nature of viruses

Viruses

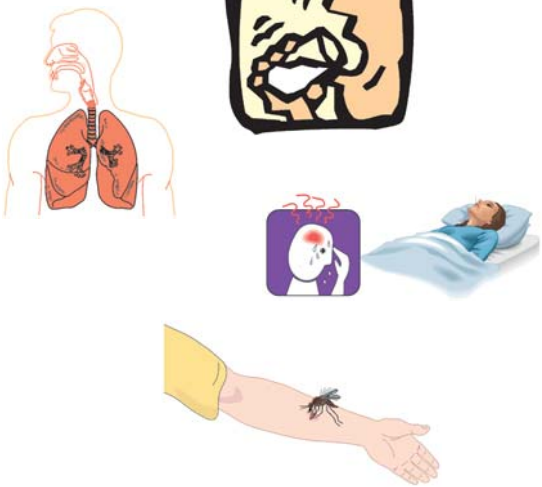
- ★ are non-living
- ★ cannot grow or replicate on their own.
- ★ can occur in every kind of living organism.
- ★ can multiply only in another host organism.
- ★ are host specific.
- ★ vary in size and appearance.

Viruses can be seen by using a high resolution electron microscope.

How do micro-organisms invade us?

Micro-organisms can enter our bodies

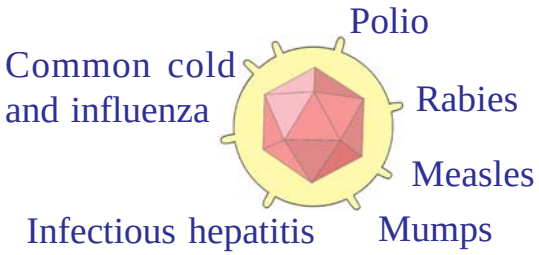
- ★ through the air we breathe.
- ★ through the water we drink.
- ★ by contact with an infected person.
- ★ or by insect bites.



Microbial diseases that can spread from an infected person to a healthy person are called **communicable or infectious diseases.**

8.2 Viruses and diseases

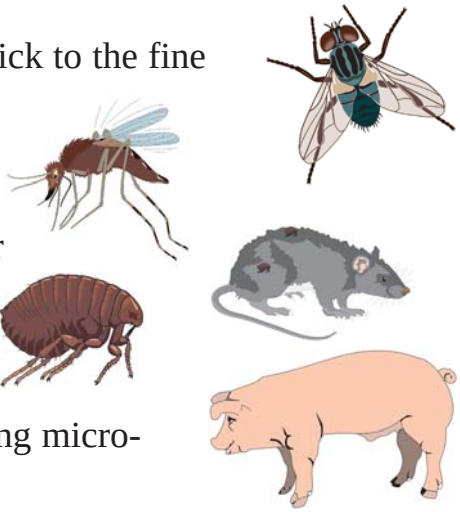
Diseases caused by viruses have been known and feared for thousands of years. Some of the diseases caused by viruses in humans are:



AIDS (Acquired Immuno Deficiency Syndrome) is the most dreaded disease caused by a virus.

Spread of diseases - Role of insects and animals

Some animals and insects act as carriers of disease-causing micro-organisms. They are



- ★ the housefly (harmful microbes easily stick to the fine hair on the legs of the fly).
- ★ anapheles mosquito (host to the malaria causing micro-organism).
- ★ aedes mosquito (host to the yellow fever causing micro-organism)
- ★ fleas on rodents (hosts to the plague causing micro-organism)
- ★ pigs (hosts to a number of disease-causing micro-organisms).

Insects and animals that carry specific micro-organisms are called vectors.

Helping our body defense system to keep out infections

We can minimize dangerous microbial infections

- ★ by keeping our surrounding free of stagnant water.
- ★ by not throwing garbage in the open.
- ★ by keeping water bodies clean.

★ by not allowing stray dogs and other animals to roam freely in the streets.
★ by preventing breeding of pigs and rodents. They are carriers of dangerous bacteria and viruses.
★ by not eating cut fruits and food kept in the open.
★ by not allowing food to be sold near garbage dumps.

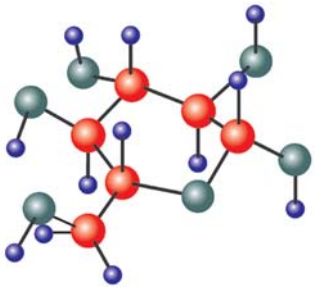
8.3 Biology and molecules

We learnt earlier that cells are the basic constituents of plants and animals. We can understand biology through a study of cells (**Cellular Biology**).

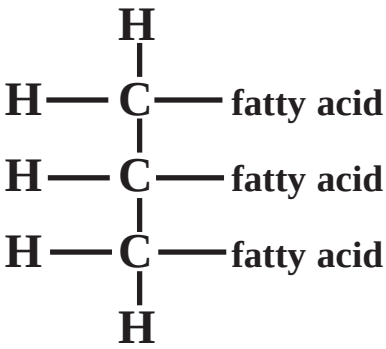
A still more basic approach is to study molecules in plants and animals. It is believed that we can understand life processes through the transformations of molecules (**Molecular Biology**).

Molecules in biology

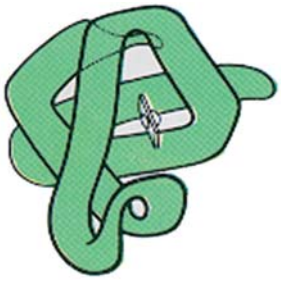
The important molecules in biology are



Carbohydrates
Sugar (glucose)



Lipids - fats and oils
(triglycerides)



Proteins
(enzymes, viruses)

Nucleic acids
DNA, RNA (Genetic Code)