Senior Secondary Course

BIOLOGY (314)

2

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विद्याधनम् सर्वधनं प्रधानम्

NATIONAL INSTITUTE OF OPEN SCHOOLING

(An Autonomous Institution under MHRD, Govt. of India)

A-24-25, Institutional Area, Sector-62, NOIDA-201309 (U.P.)

Website: www.nios.ac.in, Toll Free No. 18001809393

Printed on 60 GSM Paper with NIOS Watermark.

May, 2015 (20,000 Copies)

Published by the Secretary, National Institute of Open Schooling, A-24-25, Institutional Area, NH-24, Sec. 62, Noida-201309, and printed at M/s Aravali Printers & Publishers Pvt. Ltd., W-30, Okhla Industrial Area, Phase-II, New Delhi-110020.

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Supported by
Ministry of Human
Resource Development
Govt. of India, India

Funded by
United Nations Population
Fund (UNFPA)
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Chairman's Message

Dear learner,

As the needs of the society in general, and some groups in particular, keep on changing with time, the methods and techniques required for fulfilling those aspirations also have to be modified accordingly. Education is an instrument of change. The right type of education at right time can bring about positivity in the outlook of society, attitudinal changes to face the new/fresh challenges and the courage to face difficult situations.

This can be very effectively achieved by regular periodic curriculum renewal. A static curriculum does not serve any purpose, as it does not cater to the current needs and aspirations of the individual and society.

For this purpose only, educationists from all over the country come together at regular intervals to deliberate on the issues of changes needed and required. As an outcome of such deliberations, the National Curriculum Framework (NCF 2005) came out, which spells out in detail the type of education desirable/needed at various levels of education - primary, elementary, secondary or senior secondary.

Keeping this framework and other national and societal concerns in mind, we have currently revised the curriculum of Biology course at Senior Secondary level, as per the Common Core Curriculum provided by National Council of Educational Research and Training (NCERT) and the Council of Boards of School Education in India (COBSE) making it current and need based. Textual material production is an integral and essential part of all NIOS programmes offered through open and distance learning system. Therefore, we have taken special care to make the learning material user friendly, interesting and attractive for you.

I would like to thank all the eminent persons involved in making this material interesting and relevant to your needs. I hope you will find it appealing and absorbing.

On behalf of National Institute of Open Schooling, I wish you all a bright and successful future.

(Prof. C. B. Sharma)
Chairman, NIOS

A Note From the Director

Dear Learner,

Welcome!

The Academic Department at the National Institute of Open Schooling tries to bring you new programmes, in accordance with your needs and requirements. After making a comprehensive study, we found that our curriculum is more functional related to life situations and simple. The task now was to make it more effective and useful for you. We invited leading educationists of the country and under their guidance, we have been able to revise and update the curriculum in the subject of Biology.

At the same time, we have also removed old, outdated information and added new, relevant things and tried to make the learning material attractive and appealing for you.

I hope you will find the new material interesting and exciting with lots of activities to do. Any suggestions for further improvement are welcome.

Let me wish you all a happy and successful future.

(Dr. Kuldeep Agarwal)
Director (Academic)
National Institute of Open Schooling

A Letter to Learner

Dear Learner,

Welcome to the revised Biology course of National Institute of Open Schooling (NIOS) based on the common Core Curriculum prescribed by COBSE/ NCERT. Biology is the science of life and the revised course includes both Classical and Modern Biology. The course content begins from Biodiversity classification; Structure and function of the living; their reproduction and development and also Genetics, Molecular Biology, Biotechnology and Immunology which are the modern fields of Biology. An exhaustive treatment of the environment in all its aspects is also contained in the curriculum and so are topics like some common human diseases and health and nutrition which are closely related to human welfare.

The Biology course has three parts. Parts 1 and 2 have theoretical part and Part 3 has laboratory work. The book has 5 Modules broken up into 31 lessons. The modules are:

***Module-I** Diversity and Evolution of Life**, Module-II** Forms and Functions of Plants **and Animals Module-III** Reproduction and Heredity **Module-IV** Environment and Health and Module-**V** Emerging Areas in Biology*

*Please note that now the load on final public examination has been reduced. Out of 31 lessons, 09 lessons have been kept apart for you to study and be assessed through Tutor Marked assignments (TMA) only. These are **Origin and Evolution of Life and Introduction to Classification**, **Cell Structure and Function**, **Root system**, **Respiration in Plants**, **Nutrition and Digestion, Homeostasis: The Steady State**, **Genetics and Society**, **Pollution** and **Some Common Human Diseases** that you work upon throughout the year. The Public examination (PE) or final exam shall have the lessons other than those earmarked for TMA. For self evaluation there are intext questions and terminal exercises. Also a summary, at the end of each lesson and glossary at the end of the book have been provided for ready reference. Kindly submit your work in time and complete the practical at your PCP centres.*

Hope you will enjoy your journey with this "Teacher in print". A course in science is known to lead students into becoming critical thinkers and decision makers and cultivate "scientific attitude and scientific temper".

For any queries feel free to contact us and share your views and comments regarding the book. All help is assured. Our website is www.nios.ac.in

We hope you will enjoy the course and find it interesting.

Wish you all the success,

(Dr. Sanghmitra Suryapani)
Course Coordinator, Biology
E-mail: aobio@nios.ac.in

How to use the Study Material

Your learning material has been developed by a team of Biology experts in open and distance learning. A consistent format has been developed for self-study. The following points will give you an idea on how to make best use of the print material.

Title is an advance organisor and conveys an idea about the contents of the lesson. Reflect on it.

Introduction highlights the contents of the lesson and correlates it with your prior knowledge as well as the natural phenomena in operation in our immediate environment. Read it thoroughly.

Objectives relate the contents to your desired achievements after you have learnt the lesson. Remember these.

Content of the lesson has been divided into sections and sub-sections depending on thematic unity of concepts. Read the text carefully and make notes on the side margin of the page. After completing each section, answer intext questions and solve numerical problems yourself. This will give you an opportunity to check your understanding. You should continue reading a section till such time that you gain mastery over it.

At some places you will find some text in **italics and bold**. This indicates that it is important. You must learn them.

Solved Examples will help you to understand the concepts and fix your ideas. In fact, problem solving is an integral part of training in Biology. Do them yourself and note the main concept being taught through a particular example.

Activities are simple experiments which you can perform at your home or work place using readily available (low cost) materials. These will help you to understand Biology by doing. Do them yourself and correlate your findings with your observations.

Intext questions are based on the concepts discussed in every section. Answer these questions yourself in the space given below the question and then check your answers with the model answers given at the end of the lesson. This will help you to judge your progress. If you are not satisfied with the quality and authenticity of your answers, turn the pages back and study the section again.

What have you learnt is essentially summary of the learning points for quick recapitulation. You may like to add more points in this list.

Terminal exercises in the form of short, long and numerical question will help you to develop a perspective of the subject, if you answer these meticulously. Discuss your responses with your peers or counsellors.

Answers to intext questions : These will help you to know how correctly you have answered the intext questions.

Audio: For understanding difficult or abstract concepts, audio programmes are available on certain content areas. You may listen to these on FM Gyanvani or may buy the CDs from Priced Publication Unit, NIOS

Video: Video programmes on certain elements related to your subject have been made to clarify certain concepts. You may watch these at your study center or may purchase these CDs from Priced Publication Unit, NIOS.

www These are few selected websites that you can access for extended learning.

Studying at a distance requires self-motivation, self-discipline and self-regulation. Therefore you must develop regular study habit. Drawing a daily schedule will help you in this endeavour. You should earmark a well-ventilated and well-lighted space in your home for your study.

SENIOR SECONDARY BIOLOGY COURSE
Overview of the Learning Material

Module	Lesson No.	Name of the Lesson	Mode of Assessment TMA/PE	
Module-I Diversity and Evolution of Life	01	Origin and Evolution of Life and Introduction to Classification	TMA	
	02	The Kingdom Monera, Protoctista and Fungi		PE
	03	Kingdom Plantae and Animalia		PE
	04	Cell Structure and Function	TMA	
	05	Tissues and other Level of Organization		PE
Module-II Forms and Functions of Plants and Animals	06	Root system	TMA	
	07	Shoot system		PE
	08	Absorption, Transport and Water Loss in Plants		PE
	09	Nutrition in plants - Mineral Nutrition		PE
	10	Nitrogen Metabolism		PE
	11	Photosynthesis		PE
	12	Respiration in Plants	TMA	
	13	Nutrition and Digestion	TMA	
	14	Respiration and Elimination of Nitrogenous Wastes		PE
	15	Circulation of Body Fluids		PE
	16	Locomotion and Movement		PE
	17	Coordination and Control - The Nervous and Endocrine Systems		PE
	18	Homeostasis: The Steady State	TMA	
Module-III Reproduction and Heredity	19	Reproduction in Plants		PE
	20	Growth and Development in Plants		PE
	21	Reproduction and Population Control		PE
	22	Principles of Genetics		PE
	23	Molecular Inheritance and Gene Expression		PE
	24	Genetics and Society	TMA	
Module- IV Environment and Health	25	Principles of Ecology		PE
	26	Conservation and Use of Natural Resources		PE
	27	Pollution	TMA	
	28	Nutrition and Health		PE
	29	Some Common Human Diseases	TMA	
Module- V Emerging Areas in Biology	30	Biotechnology		PE
	31	Immunobiology: An Introduction		PE

Total Lessons = 31
Lessons for Public Examination (PE) = 22
Lessons for Tutor Marked Assignment (TMA) = 09

Contents

MODULE - III
REPRODUCTION AND HEREDITY

19

REPRODUCTION IN PLANTS

Reproduction is one of the most important characteristics of all living beings. It is the production of ones own kind. It is necessary for the continuation of the species on earth and also to replace the dead members of the species. The process by which living organisms produce their offsprings for the continuity of the species is called reproduction.

The modes of reproduction vary according to individual species and available conditions. It may be simply by division of the parent cell as in unicellular organisms, by fragmentation of the parent body, by formation of buds and spores, or it may be very elaborate involving development of male and female reproductive organs (stamens and pistils). Irrespective of the mode of reproduction, all organisms pass on their hereditary material to their offsprings during the process of reproduction. In this lesson, you will study about the process of reproduction in plants.

OBJECTIVES

After completing this lesson, you will be able to :

- *define reproduction;*
- *differentiate between vegetative, asexual and sexual reproduction;*
- *describe the methods of asexual and sexual reproduction in unicellular lower plant (Chlamydomonas) and filamentous green alga (Spirogyra);*
- *describe the mode of reproduction in flowering plants;*
- *explain the parts of a dicot flower and their functions;*
- *describe stages of microsporogenesis;*
- *depict with the help of diagram the structure of ovule and mention the steps of megasporogenesis;*

- *describe the stages of development of male and female gametophytes in flowering plants;*
- *state the types of pollination, their significance and various modes of pollination;*
- *explain the steps involved in fertilization, (syngamy and triple fusion), embryo development, endosperm development, formation of seed;*
- *differentiate between structure of dicot and monocot seeds;*
- *explain the formation of fruit and parthenocarpy;*
- *describe seed germination;*
- *define vegetative reproduction;*
- *differentiate between natural and artificial propagation;*
- *explain the advantages and disadvantages of vegetative propagation;*
- *describe the role of tissue culture technique in micropropagation;*
- *state the advantages of micropropagation;*

19.1 MODES OF REPRODUCTION

The various modes by which plants reproduce are of three types –

(a) Vegetative (b) Asexual (c) Sexual

In **Asexual** and **vegetative** mode of reproduction, offsprings are produced from a vegetative unit formed by a parent without any fusion of gametes or sex cells.

– A single parent is involved

– Offsprings are genetically identical to the parent.

(a) Vegetative reproduction may be of the following types—

(i) **Vegetative reproduction :** It involves formation of new plantlets from vegetative (somatic) cell, buds or organs of the plant. Here, a vegetative part of the plant (Root, stem, leaf or bud) gets detached from the parent body and grows into an independent plant. It is similar to asexual reproduciton in that it also requires only mitotic division, no gametic fusion is involved, and newly-formed plants are genetic clones of the parent plant.

We will discuss the different types of vegetative reproduction in angiosperms later in this lesson.

(ii) **Fragmentation :** In filamentous algae, an accidental breaking of the filament into many fragments, each fragment having atleast one cell, may give rise to a new filament of the algae by cell division e.g. *Spirogyra*.

(iii) **Fission :** It Occurs in unicellular organisms like bacteria and yeasts where the content of the parent cell divides into 2, 4 or 8 daughter cells and accordingly the fission is known as **binary** or **multiple** fission. Each newly formed daughter cell grows into a new organism.

(iv) **Budding :** It also occurs in unicellular plants. A bud-like outgrowth is formed on one side of the parent cell and soon it separates and grows into a new individual e.g. in yeast.

(b) **Asexual Reproduction :** Takes place by asexual spores which may be flagellate or nonflagellate.

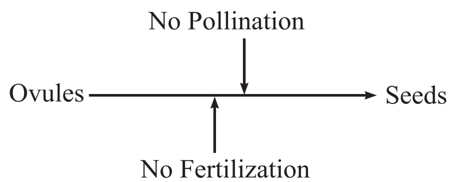
Spore formation : In lower plants including bryophytes and pteridophytes, special reproductive units develop asexually on the parent body. These are called spores. They are microscopic and covered by a protective wall. When they reach the suitable environment they develop into a new plant body e.g. in bread moulds, moss, fern. In higher plants like pea, maize and gymnosperms, asexual reproduction is always heterosporous. Here, spores are produced after meiosis. The small male spores called microspores give rise to male gametophyte. The large female spores are called megaspores, and they give rise to female gametophytes.

(c) **Sexual reproduction** involves fusion of male and female reproductive cells (gametes) which are haploid and are produced by male and female reproductive organs. This fusion is known as **fertilization** and results in the production of a **zygote (diploid)**. Further development of zygote gives rise to a new individual which is diploid.

Here, at some stage of the life history meiosis is involved and the offsprings are not genetic clones of their parents, but are genetically different and generally exhibit mixed characters of their parents.

19.1.1 Apomixis

Apomixis is a unique mechanism of asexual reproduction in certain plants (e.g. dandelions) which produce seeds without pollination and fertilization. (In Greek, apomixis means 'away from act of mixing'). Since there is no fusion of male and female gamete, any somatic cell of ovule which is diploid, gives rise to the embryo and then ovule matures into a seed. The seeds are then dispersed. The interesting fact is that apomixis is an asexual process but disperses its seeds like those of plants that undergo sexual reproduction.



INTEXT QUESTIONS 19.1

1. Define reproduction.

   ....

2. How is asexual reproduction different from sexual reproduction?

   ....

3. What is a gamete?

....

4. Name two types of vegetative reproduction.

....

5. Choose the correct option

   Apomixis is:

   (a) Development of plants in darkness

   (b) Development of plants without fusion of gametes

   (c) Inability to perceive stimulus for flowering

   (d) Effect of low temperature on plant growth

19.2 REPRODUCTION IN LOWER PLANTS

We will study the different types of reproduciton in two lower plants, one unicellular alga (*Chlamydomonas*) and the other multicellular filamentous alga (*Spirogyra*).

19.2.1 *Chlamydomonas* (A Unicellular Alga)

(i) It is a haploid unicellular alga found in fresh water ponds:

(ii) The plant body is pear-shaped with two flagella attached at the narrow end.

(iii) On one side of the cell, a light sensitive eye spot is present.

(iv) A large cup-shaped chloroplast is present.

(v) Towards the centre, a definite nucleus is present.

(vi) Chloroplast contains a single pyrenoid. (Fig. 19.1a).

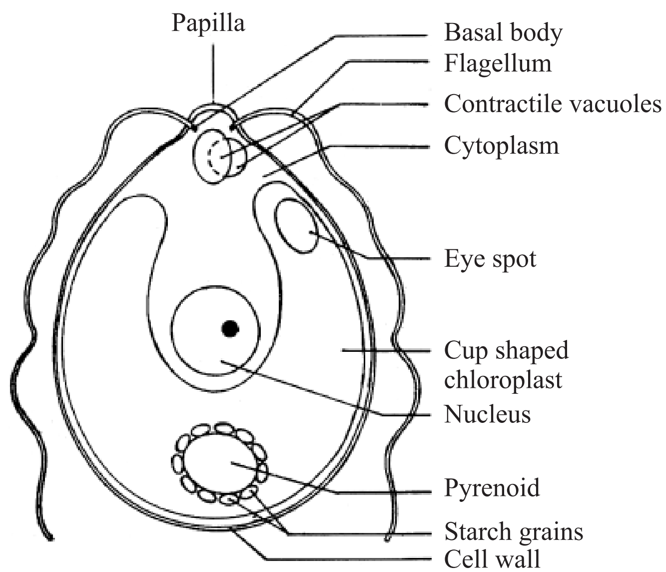


Fig. 19.1a *A Chlamydomonas* cell

Reproduction

A. Asexual reproduction takes place with the help of zoospores, aplanospores or hypnospores depending upon the availability of water for swimming.

Asexual Reproduction by Zoospores :

- If plenty of water is available for free swimming, *Chlamydomonas* reproduces by flagellate thin-walled spores, called zoospores.
- *Chlamydomonas* cell loses flagella and becomes non-motile.
- Its protoplasm (cytoplasm and nucleus) divides mitotically and forms 2-16 daughter protoplasts, each of which develops flagella, and is called a zoospore.
- The parent cell wall is ruptured and zoospores are released.
- Each zoospore develops a cell wall and grows into an adult cell. (Fig. 19.2-b, c)
- After release of zoospores the parent cell does not exist, any more.

A. Asexual Reproduction by Aplanospores and Hypnospores :

- If a thin-film of water is available where swimming is not possible, **Chlamydomonas** produces thin-walled, non-flagellate daughter protoplasts, called aplanospores.
- The parent cell loses flagella and becomes highly extended. Its protoplast divides repeatedly to produce 100 or more daughter protoplasts, each of which is called an **aplanospore**.
- The whole structure containing groups of non-motile aplanospores resembles a non-motile Colonial alga, called **Palmella**, and so this is called **palmella stage** of **Chlamydomonas**.
- If plamella-stage is flooded with water, each aplanospore develops flagella, comes out of the parent cell wall and grows into a normal independent plant.
- If water suddenly dries up, some of the aplanospores develop thick-wall, each of which becomes dark brown or black, and is called a **hypnospore.** When favourable conditions are present and water is available for swimming, each hypnospore ruptures to release protoplast that develops flagella, becomes a zoospore and grows into normal ***Chlamydomonas***-plant.

B. Sexual Reproduction

Chlamydomonas reproduces sexually by isogamy, anisogamy or Oogamy depending upon the species :

Sexual Reproduction by Isogamy

- Isogamy is exhibited by **Chlamydomonas eugametos** and **C. eherenburgii.**
- The male and female cells become non-motile by losing their flagella.

- The protoplasm of each cell divides mitotically into 32-64 daughter cells.
- Each daughter cell develops flagella and is released in water by the rupture of mother cell wall. Each of these cells acts as a gamete.
- The gametes are morphologically identical in structure but differ physiologically or chemically.
- Gametes released in water from two different mother cells fuse in pairs forming quadriflagellate zygotes.
- When the contents of the two gametes fuse, they form a zygote (diploid). This is the only diploid stage in the life cycle of *Chlamydomonas*.
- The zygote develops a thick wall around itself and develops brown to black coloured pigmentation to tide over unfavourable conditions (zygospores).
- On the return of favourable conditions (temperature, food and water) the diploid nucleus of the zygote divides by meiosis and forms four haploid zoospores. (Fig. 19.2 d-i)
- Each zoospore grows into a new adult *Chlamydomonas* plant.

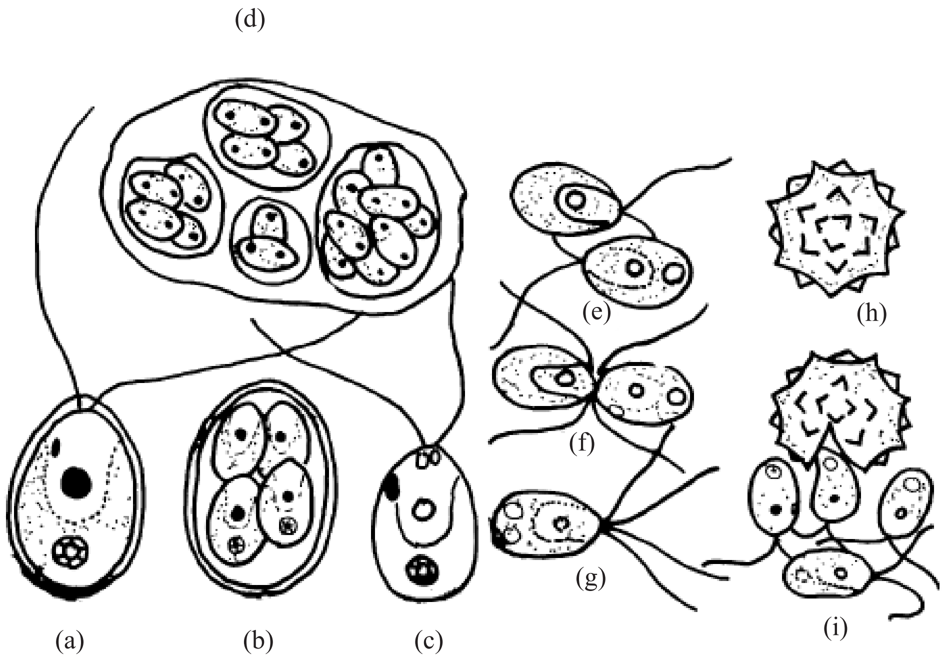
Sexual Reproduction by Anisogamy

- Anisogany is exhibited by ***Chalamydomonas braunii***.
- Male and female cells lose flagella and become non-motile.
- In male cell, protoplast divides repeatedly to produce 32-64 biflagellate gametes but in female cell, protoplast divides to produce 8 to 16 biflagellate gametes.
- Both male and female gametes are released in water.
- When larger female gametes lose flagella and become non-motile, each one is fertilized by a smaller motile male gamete.
- After fertilization, the fusion product loses flagella, becomes spherical and develops thick wall to become a resting zygote.
- On return of favourable conditions of water, temperature and light, the zygote undergoes meiosis and produces four haploid zoospores each of which grows into an independent *Chlamydomonas* plant.

Sexual Reproduction by Oogamy

- Oogamy is exhibited in ***Chlamydomonas coccifera*** and ***C.ooganum***.
- Here, female and male cells lose flagella and become non-motite.
- All the contents of female cell act as female gamete or egg, but the protoplasm of male cell divides to produce 32-64 biflagellate gametes.
- The biflagellate gametes are liberated in water and swim around in search of female gamete.
- Two or more flagellate gametes enter each female cell having nonmotile egg but only one fertilizes the egg and others degenerate, contributing nutrition to the young zygote.

- The fusion product of egg and a motile gamete is called zygote that develops a thick, pigmented wall to enter into resting phase.
- On return of favourable conditions of water, temperature and light, the zygote undergoes meiosis to produce four haploid biflagellate zoospores, each of which on liberation from zygote, grows into an independent plant of *Chlamydomonas*.



(a) Mature cell (b) 4 daughter cells (Zoospores formed by Asexual reproduction) (c) Zoospore after it escapes from the parent cell (d) Palmella-stage of *Chlamydomonas* (e, f, g) Free swimming gametes and fusion of gametes (h) a resting zygote (i) 4 cells formed after meiosis of the zygote cell (zygospores)

Fig. 19.2 Asexual and Sexual reproduction in *Chlamydomonas*

INTEXT QUESTIONS 19.2

1. Define the term isogamy. Which species of *Chlamydomonas* exhibits isogamy.

   ....

2. Where does meiosis occur in *Chlamydomonas* ?

   ....

3. Give the method of asexual reproduction in *Chlamydomonas*. What is the function of zoospores in *Chlamydomonas*.

   ....

4. Name the speicies of *Chlamydomonas* that reproduces by Anisogamy and the species that reproduces by Oogamy.

   ....

5. Define the term zoospore and aplanospore.

   ....

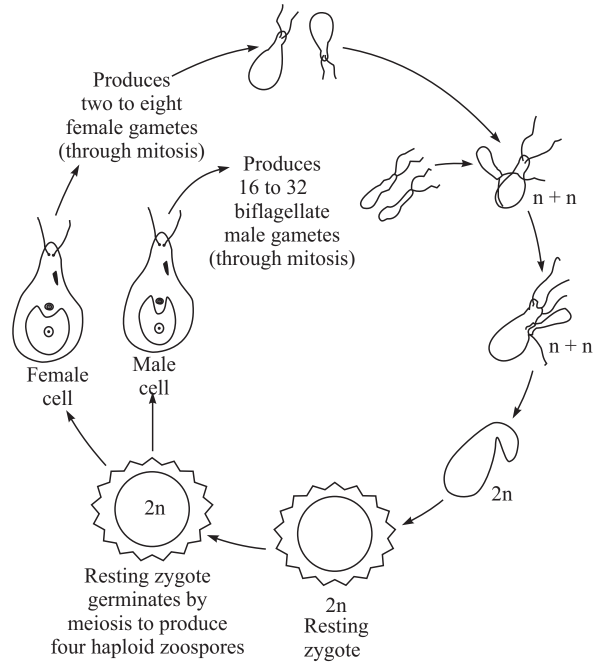


Fig. 19.3 Sexual Reproduction by Anisogamy in *C.braunii*

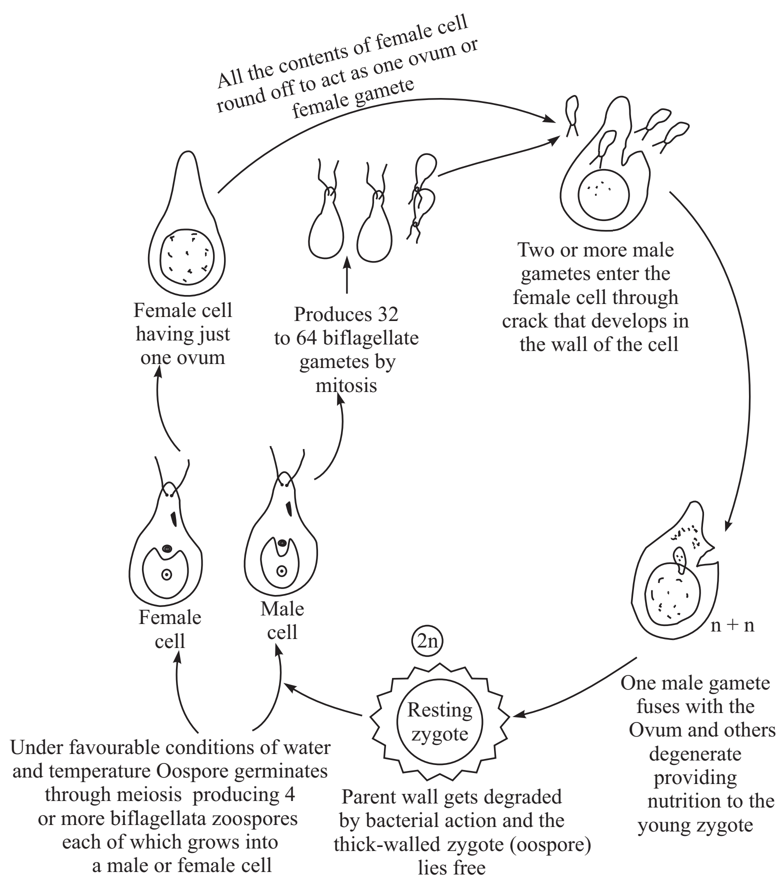


Fig. 19.4 Sexual Reproduction by Oogamy as in ***C.oogamum*** and ***C. coccifera***

19.2.2 *Spirogyra* (A Multicellular Alga)

Structure

(i) It is a free floating alga found in fresh water ponds.

(ii) The body has a row of cylindrical cells joined end to end (filamentous alga).

(iii) Each cell depending upon the species, may have 1 to 14, spiral ribbon shaped chloroplasts with many uni-seriately arranged pyrenoids.

(iv) Central region of the cells has a large vacuole.

(v) The single nucleus is present in the centre of the cells supported by cytoplasmic strands. (Fig. 19.5)

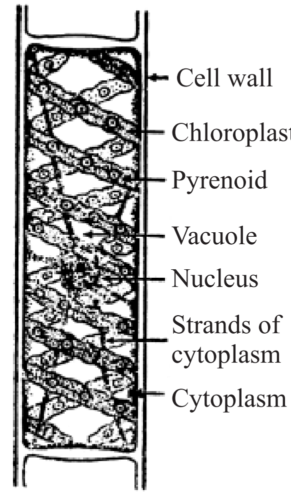


Fig. 19.5 *Spirogyra* : Single cell from the filament.

Reproduction

A. Vegetative Reproduction by fragmentation:

(i) The filament breaks into small fragments, at the point of transverse septum following a physico-chemical change.

(ii) Each fragment having at least one complete cell grows into a new filament by repeated mitotic cell division.

B. Sexual Reproduction : It takes place by scalariform and lateral conjugation.

Scalariform Conjugation (conjugating filaments give a ladder-like appearance). (Fig. 19.6)

- Two filaments come to lie very close to each other so that the cells of the two filaments pair septum to septum and face to face.
- The pairing cells of the two filaments form a contact with the help of a tube called the conjugation tube.
- Cytoplasmic contents of each cell round off to act as a gamete.
- Gamete from one cell (male) passes to the other cell (female) through the conjugation tube, by amoeboid movement.
- The cells of each filament acts either as male or female.
- The contents of two gametes fuse in the female cell and form a diploid zygote. Consequently, after the sexual fusion of gametes, all the cells of male fitament are empty whereas each cell of the female filament has one thick-walled diploid **zygospore**.

- The zygospore develops a thick wall around itself and develops dark brown to black pigment to tide over the unfavourable period.
- On the return of favourable conditions the diploid nucleus divides by meiosis into four haploid nuclei. Three of these nuclei degenerate.
- On germination, wall of the zygospore ruptures and a small tube like structure, containing one haploid nucleus comes out.
- The small tube develops into a long filament by repeated mitotic cell divisions.

Lateral Conjugation

- Here, cells of only one filament are involved in conjugation wherein, male and female cells are arranged in alternate pairs i.e., two male cells alternate with two female cells all along the length of a filament.
- Conjugation tube is formed lateral to the septum separating a male and a female cell. Protoplasm of male cells migrate into female cells.
- After fertilization, a filament would show two empty cells alternating with two cells each having thick-walled diploid zygospore.
- The zygospore under favourabe conditions, germinates as in scalariform conjugation to produce only one independent plant, because 3 haploid nuclei after meiosis, degenerate.

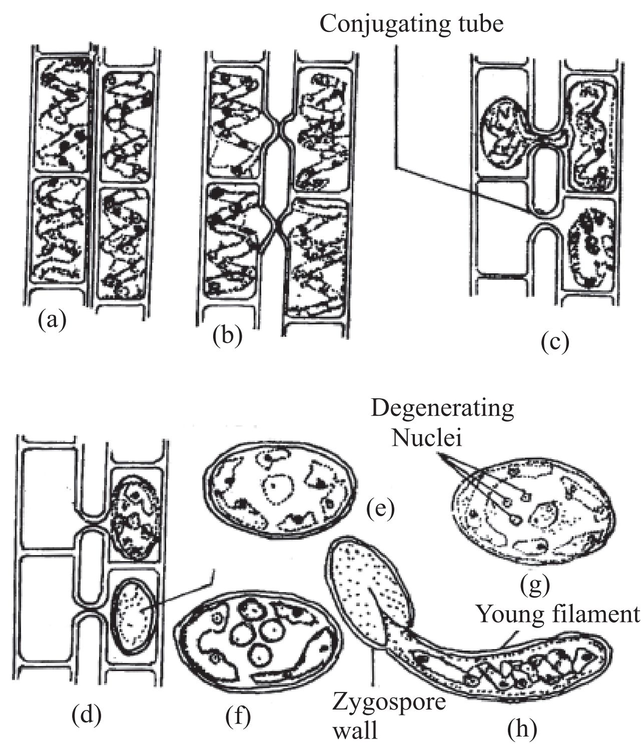


Fig. 19.6 Life cycle of *Spirogyra*: Sexual reproduction-Scalariform conjugation. (a) Two Filaments lie close, (b) Formation of conjugation tube, (c) Transfer of gamete from the donor to the recipient cell, (d) Zygospore within the recipient cell, (e) Zygospore released from female filaments, (f) Meiotic division in zygospore produces haploid nuclei, (g) 3- haploid nuclei degenerate, (h) formation of young filament

> The cell in the main plant body form the gametes without meiosis, therefore *Chlamydomonas* and *Spirogyra* are gametophytes (haploid).

INTEXT QUESTIONS 19.3

1. Vegetative reproduction in *Spirogyra* takes place by means of

   ....

2. Name the kind of sexual reproduction that occurs in *Spirogyra*.

   ....

3. When does meiosis occur in *Spirogyra* ?

   ....

4. How many filaments are involved in lateral conjugation ?

   ....

19.3 REPRODUCTION IN ANGIOSPERMS (FLOWERING PLANTS)

Angiosperms reproduce both by vegetative as well as by sexual methods. In this section we will study the sexual reproduciton in angiosperms. As you know sexual reproduction occurs by fusion of male and female gametes produced in the flower. Thus, flower represents the reproductive unit of a flowering plant.

How frequently do plants flower? There is great variation shown by the angiospermic plants in this respect.

Angiosperms can be classified as annuals, biennials and perennials depending upon the time they take to complete the life cycle includings flowering, fruiting, and death.

(a) **Annuals :** The plants which complete their life cycle including flowering to seed formation within **one season** are called annuals eg. pea

(b) **Biennials :** Plants which complete their life cycle in **two seasons** are called biennials. In the first season these plants remain in the vegetative state, and in the second season, they produce flowers, fruits, and seeds and then die e.g. radish.

(c) **Perennials :** Plants which live for **several years** are termed perennials. Their vegetative stage may last from one to a few years after which they produce flowers, fruits, and seeds every year e.g. mango, peepal, and neem.

(d) **Monocarpic :** All the annuals, all the biennials and, some perennial plants that reproduce only once in their life-time and then die, are called Monocarpic e.g. bamboo, agave, all the annuals and all the biennials.

(e) **Polycarpic :** Plants which flower and fruit many times in their life cycle and live for several years, are called polycarpic e.g. many perennial fruit bearing trees e.g. mango, guava, apple and pear.

Initiation of flowering

As the seed germinates a new plantlet emerges from it. The young plant grows vigorously and continues to grow till it attains a definite shape and size with its vegetative parts (roots, stem, leaves) well developed. This phase of the life cycle represents the **young** or the **juvenile** phase.

Then, at a certain point of time on completion of vegetative growth the plant switches over to its **reproductive phase** or **adult phase** and vegetative shoot apex transforms into a reproductive or **floral apex** and starts bearing flowers. This transition from vegetative to the flowering stage may take several years in trees but only a few weeks or days in annuals.

Table 19.1 Differences between a Juvenile and an Adult Shoot

Juvenile Shoot	Adult Shoot
1. Small, soft stem bearing a few young leaves.	1. Well developed branched stem bearing young as well as mature leaves.
2. Shape and size of leaves remain same.	2. Shape and size of leaves change.
3. Shoot does not respond to stimuli to produce flowers.	3. Shoot responds to stimuli to produce flowers.

> In cereals a minimum of seven leaves must be developed before the plant can produce flowers.

Factors Affecting Flowering

Flowering in a plant is affected by *temperature* (vernalisation) and *light (photoperiodism).*

Vernalisation : Low temperature treatment which stimulates early flower formation in some plants is called **vernalisation**.

Photoperiodism : It is the biological response, in growth and flowering, to the duration of light and dark period received by a plant in a specific sequence. (For details refer to lesson 19).

Sex in flowers : You have studied in Lesson 5 on Shoot System (flower, inflorescence, fruit and families), that flowers may be bisexual (having both stamens and carpels) or unisexual (staminate or pistillate (carpellate)).

In some dioecious species there may be a (i) chromosomal basis of sex-determination, for example **xx** and **xy** chromosomes. (ii) The male and female plants may also exhibit differences in the levels of their growth substances. For example – plants of *Cucumis* which bear male flowers have a high gibberellin content as compared to those which bear only female flowers. The application of gibberellin from outside can induce the formation of male flowers even in genetically female plants and treating male plants with auxin or ethylene may develop functional female flowers. The above response has also been seen in *Cannabis*.

Parts of a flower

As you have already studied a typical flower bears four whorls born on a thalamus or stalk. These whorls from outside are

(a) Calyx - consisting of sepals.

(b) Corolla - consisting of petals

(c) Androecium - consisting of stamens

(d) Gynoecium or pistil - consisting of carpels.

Try to recollect their role in reproduction. The two outermost whorls are known as **non essential** or **accessory whorls** as they aid in reproduction but do not directly take part in the process. The other two whorls i.e. **Androecium** (male reproductive organ) and **Gynoecium** (female reproductive organ) are known as the **essential whorls** as their absence from flowers will lead to failure of sexual reproduction.

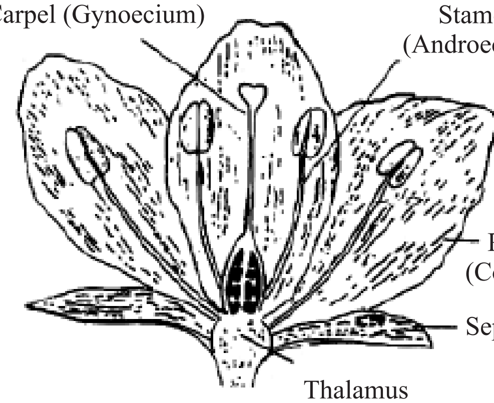


Fig. 19.5 L.S. of a typical flower

INTEXT QUESTIONS 19.4

1. Define the terms (i) Annual (ii) Biennial (iii) Perennial

   ....

2. List the factors which induce flowering

   ....

3. Give one example where external application of hormone can reverse the sex of a flower

   ....

4. Name the essential whorls in a flower.

   ....

19.4 STAMEN, MICROSPORANGIA AND POLLEN GRAIN

Stamen consists of an **anther** containing four pollen sacs or **microsporangia**, supported by a slender filament. Each sporangium contains mass of large cells showing prominent nucleus and abundant cytoplasm. These are the sporogenous cells or the microspore mother cells (Fig. 19.6). Each microsporangium when mature, has a wall made up of distinct layers of cells.

(i) Outer most layer (epidermis)

(ii) Middle layer of thin-walled cells.

(iii) Innermost layer, the *tapetum* consisting of large cells, which nourish the developing pollen grains.

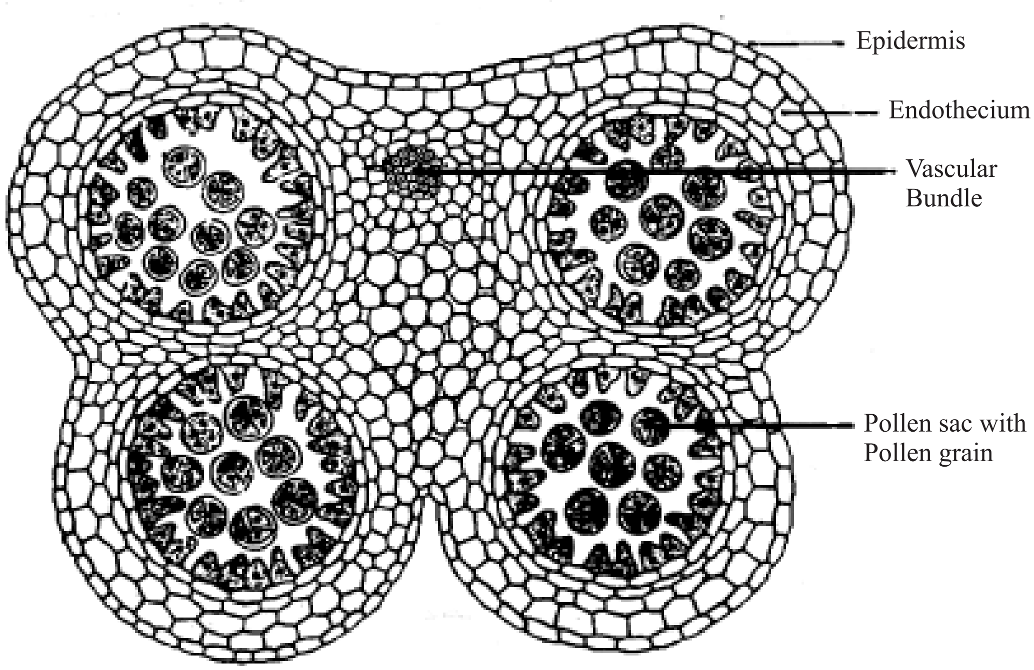


Fig. 19.6 T.S. of anther to show the various tissues.

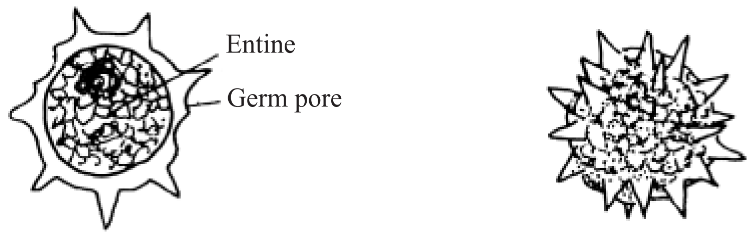
Microspore mother cells undergo meiosis and each of them forms four *haploid* microspores (each of which represents first cell of male gametophyte or the pollen-grain) arranged in a tetrad (Fig. 19.7a)

Development of male gametophyte (pollen grains) from a microspore

(i) The wall of the microspore consists of two principal layers. (Fig. 19.7b)

1. Outer exine, (design may help in identifying species) with some thin spaces (germ pores). Exine is made up of extremely durable substance called sporopollenin. The pollen tube grows out of the pollen grain through the germ pores.
2. Inner, thin cellulosic wall, the intine.

(ii) The microspore nucleus moves towards periphery and the cell divides into a large vegetative cell and a small generative cell.



(a) A pollen grain showing internal view (b) Pollen grain showing external view

Fig. 19.7 Structure of pollen grain

At this stage pollen grains are released by the rupture of the stomium along the line of dehiscence of the anther.

> The Pollen grain itself is not, the male gamete. It is a structure which produces male gametes, therefore pollen grain is regarded as the male gametophyte in the flowering plants.

The pistil, megasporangium and embryo sac

The main part of the ovule is enclosed by two integument (covering) leaving an aperture (micropyle). The ovule is attached to ovary wall by a stalk (funiculus). The region of the ovule opposite the micropyle is called Chalaza (Fig. 19.8a)

Female gametophyte :

The gynoecium or pistil represents the female reproductive part in the flower. Each pistil consists of a stigma, style and ovary. The ovary contains one or more ovules (integumented megasporangia) which after fertilization, give rise to the future seeds. An ovule develops as a projection on the placenta in the ovary. It consists of a parenchymatous tissue called the nucellus which is covered by one or two coverings called integuments. The integuments surround the nucellus all around but leave a narrow passage, the micropyle, through which a pollen tube may enter at a later stage. As the ovule grows it is raised on a stalk like structure called funiculus which is attached to the placenta borne on the inner wall of ovary (Fig. 19.8b).

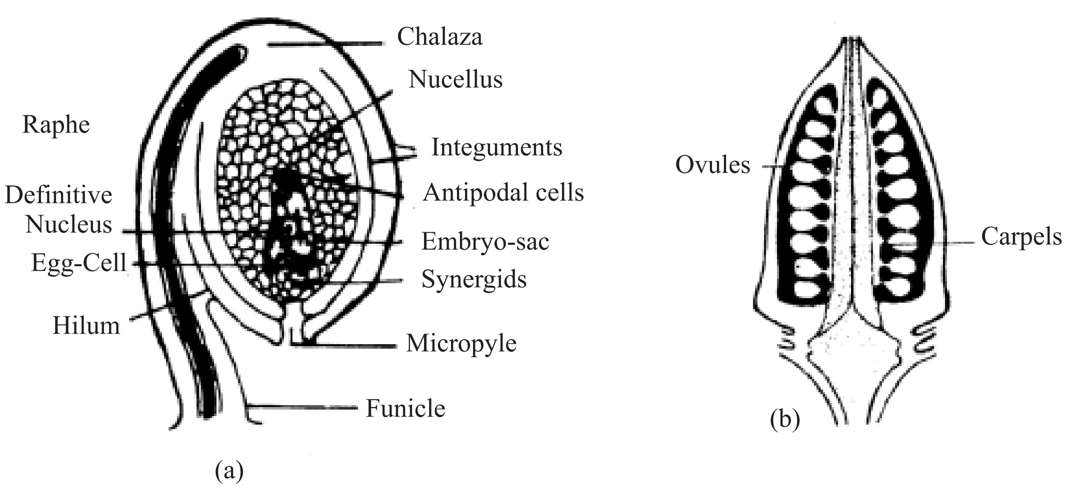


Fig. 19.8 (a) Various parts of ovule (b) Pistil

Development of female gametophyte

Within the nucellus, a single hypodermal cell (below the epidermis) enlarges and becomes the megaspore mother cell, which undergoes meiotic division and gives rise to four haploid megaspore cells, usually three of them degenerate and the remaining one becomes the functional megaspore. The functional megaspore enlarges and its haploid nucleus undergoes three successive mitotic divisions. As a result 8 haploid nuclei are formed. This enlarged oval shaped structure with eight haploid nuclei is referred as the young **embryo sac**. These nuclei then migrate and get arranged into three groups. Three nuclei reach the micropylar end of the embryo sac and other three move in the opposite direction (i.e. the chalazal end) and the remaining two remain in the centre. The cell membranes and cell walls develop around all the nuclei excepting the two at the centre of the embryo sac which now is called the central cell.

Thus, in a mature ovule the embryo sac contains eight haploid nuclei but only seven cells. Three cells at the micropylar end, form the egg apparatus and the three cells at the chalazal end, are the antipodal cells. The remaining two nuclei called the polar nuclei may fuse to form the diploid secondary nucleus. In the egg apparatus one is the egg cell (female gamete) and remaining two cells are the synergids. A fully developed embryo sac with the nucellus, integuments and funiculus, together constitute the mature ovule. In this condition the ovule awaits fertilization which must be preceded by pollination.

Function of cells and nuclei of embryo sac

Secondary Nucleus : During fertilization, the secondary nucleus fuses with one sperm to form a triple fusion nucleus ($2n+n = 3n$). This is called primary endosperm nucleus. It gives rise to the food storing **endosperm** of the seed in many plants.

Egg Cell : Fuses with the second male gamete (sperm) to give rise to the **zygote,** which develops into the embryo. This is called double fertilization.

Synergid Cells : Considered to help in fertilization by directing the pollen tube to the egg cell.

Antipodal Cells : Degenerate just before fertilization and contribute nutrition for the young embryo.

INTEXT QUESTIONS 19.5

1. What is the innermost wall layer of microsporangium called?

   ....

2. Name the organ where pollen grains are formed.

....

3. Name the two layers of pollen grain .... and ....
4. Name two parts of a mature ovule.

....

19.4.1 Pollination

When mature pollen grains, released from anther, are carried to stigma of a flower of the same or different species, it is called pollination.

Pollination : Transfer of pollen grains from the anther to the stigma of a flower.

Pollination is of two types:

Pollination

Self-pollination	Cross-pollination
Transfer of Pollen grains to stigma of the same or from another flower borne on the same plant as in the pea family e.g. pea and gram.	Transfer of Pollen grains from a flower to stigma of another flower borne on another plant of the same species e.g. in palm and maize.

Importance of Pollination :

1. It results in fertilization and stimulates the ovule to get converted into seed.
2. New varieties of plants are formed through new combination of genes in case of cross pollination.
3. During pollination pollen tube produces growth hormones which stimulate ovary to develop into fruit.

Cross pollination is brought about by various external agencies such as, wind, insects, water, birds and other animals. Now let us study the various agencies of cross pollination which carry pollen grains from one flower to stigma of another flower.

Characteristics in Flowers which favour Cross Pollination

1. **Pollination by wind (Anemophily) :** (Anemos : wind, Phile: to love)
   (i) Flowers are small, without colour, nectar and scent.
   (ii) Flowers produce a large number of pollen grains to allow for wastage when pollen-grains are carried by wind to another flower.
   (iii) The pollen grains are small, light and sometimes provided with ‘Wings’.
   (iv) The stigmas are comparatively large, protruding and some times hairy, to trap pollen grains from wind for example, grasses and some cacti.

2. Pollination by insects (Entomophily) : (entomo : insect, phile : to love)

(i) Flowers are usually large, coloured and showy to attract insects.

(ii) Some of these flowers secrete nectar to attract insects. *Salvia* flowers show special adaptations for pollination by bees. (Fig. 19.9a, b).

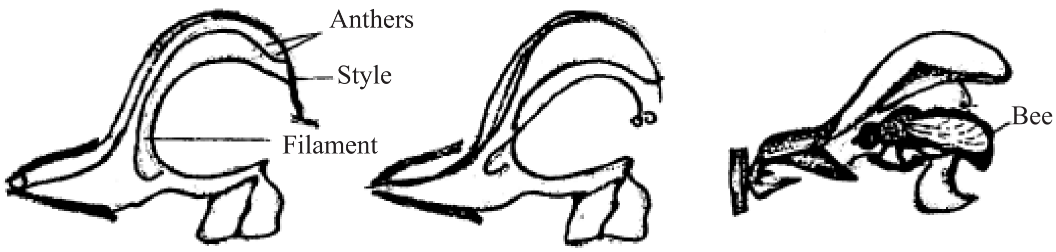


Fig. 19.9 Pollination in *Salvia* by bees

3. Pollination by Water (Hydrophily) (Hydros : water)

This takes place in aquatic plants.

(i) Pollen grains are produced in large numbers.

(ii) Pollen grains float on surface of water till they land on the stigma of female flowers e.g. *Hydrilla*, *Vallisnaria*.

4. Pollination by Animals (Zoophily) (Zoon : animal)

Flowers of such plants attract animals by their bright colour, size, and scent for example sun bird, pollinates flowers of *Canna*, and gladioli, and Squirrels pollinate flowers of silk cotton tree.

> Humans carry out artificial pollination in a number of plants for producing desirable hybrids.

Some Adaptations to Promote Cross Pollination :

1. **Unisexuality :** Flowers may be only male or female, borne on different plants e.g. papaya, palm, or may be borne on the same plant, e.g. maize.
2. **Dichogamy :** Male and female sex organs mature at different times. In sweet pea, and *Salvia*, Anther matures earlier than the stigma and in custard apple (sharifa) carpel matures earlier than the anther.
3. **Self Sterility :** Pollen grains are incapable of affecting fertilization even after being placed on the stigma of the same flower e.g. Petunia, apple.

Devices to ensure self pollination :

(i) **Cleistogamy :** Flowers remain closed until pollination.

(ii) Male and female sex organs mature at the same time (**homogamy**) e.g. groundnut.

INTEXT QUESTIONS 19.6

1. What is pollination?

   ....

2. Mention suitable terms for the following :

   (i) Flowers do not open and get self-pollinated.

   ....

   (ii) Male and female reproductive organs mature at different times.

   ....

3. Give two features of insect pollinated flowers :

   (i) ....

   (ii) ....

19.4.2 Fertilization

- Pollen grains on reaching the right stigma become three-celled (if they are not 3-celled bearing two male garmetes and one tube cell or vegetative cell) and begin to germinate.
- Each pollen grain forms a small tube like structure called pollen tube which emerges through the germ pore. The contents of the pollen grain move into the tube and the tube nucleus occupies the tip of the pollen tube.
- Pollen tube grows through the tissues of the stigma and style and finally enters the ovule through the *micropyle*.
- Vegetative nucleus or the tube nucleus degenerates and the two sperms (or male gametes), now occupy the tip of the pollen tube.
- Tip of pollen tube passes through one of the synergids and bursts to release the two sperms into the embryo sac.
- One sperm fuses with the egg (syngamy) and forms a diploid zygote. The other sperm fuses with the secondary nucleus to form the primary endosperm nucleus which is triploid in nature. Since two types of fusion, syngamy and triple fusion take place in an embryo sac, the process is termed as **double fertilization**.
- After triple fusion, the triploid primary endosperm cell develops into an endosperm.

- Endosperm provides food to the developing embryo.
- The synergids and antipodal cells also degenerate to contribute nutrition to the young embryo.

Significance of Fertilisation

(i) Gives stimulus for the growth of ovary, leading to fruit formation.

(ii) Helps in recombination of characters as genes from two different individuals combine and form the zygote.

Post fertilisation changes

Events that follow double fertilisation are development of endosperm and embryo and maturation of the ovule into seed and ovary into fruit.

(a) **Endosperm :** The endosperm development begins before embryo development. This is needed to provide the nutritive tissue for the growth of the zygote into an embryo. The primary endosperm cell divides repeatedly and forms an endosperm tissue. There are three ways in which the endosperm may develop.

Nuclear type : The primary endosperm nucleus undergoes repeated mitotic divisions to give rise to free nuclei which arrange themselves at the periphery leaving a large central space. Cell wall formation starts subsequently from periphery towards the centre and endosperm becomes cellular at maturity. This is the most common type of endosperm development and is seen in maize, wheat, and rice.

(b) **In Cellular type,** each nuclear division of primary endosperm nucleus is followed by cytokinesis, making the endosperm cellular from the beginning

(c) **In Helobial endosperm,** the first mitosis of primary endosperm nucleus is followed by cytokinesis and it gives rise to two unequal cells. Subsequently, mitotic divisions in both the cells are free nuclear but ultimately, mature endosperm becomes cellular after cytokinesis.

Endosperm may be completely consumed by the developing embryo before seed maturation as in many dicot seeds like pea, and beans or it may persist in the mature seeds or may even be massive considerably as in cereals, and coconut.

Development of embryo

(i) The zygote divides into two cells, the upper cell (embryonal cell) and; lower cell (suspensor cell). (Fig 19.10)

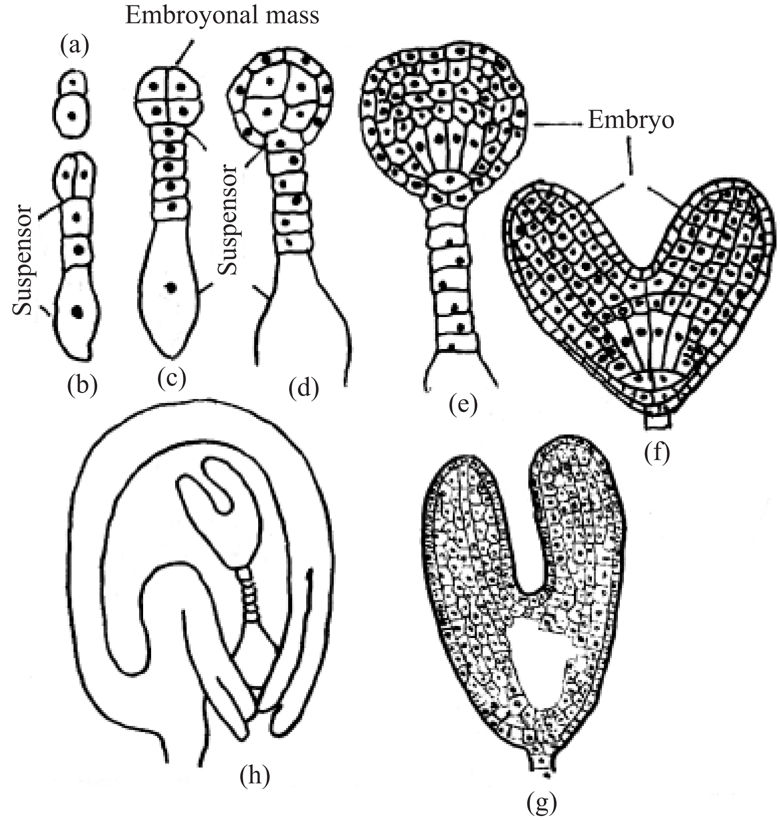


Fig. 19.10 Development of embryo, A-H

(ii) The lower cell divides and forms the suspensor.

(iii) The suspensor pushes the developing embryo into the endosperm to get food.

(iv) The embryonal cell divides several times and finally gets differentiated into radicle, plumule and cotyledon.

(v) The integuments become hardened and thus form the seed coat which protects the seed.

(vi) Thus, a seed may be dicotyledonous with two cotyledons (pea, gram) or monocotyledonous with one cotyledon (wheat, rice).

19.4.3 Polyembryony

Recall embryo development in plants from your text book. Polyembryony is the formation of **more than one embryo** in a single ovule. The development of extra embryos may be due to:

(i) Division of other cells in the embryo sac like synergids or antipodal cells to give rise to additional embryos. This is called **adventive polyembryony**.

(ii) The zygote may divide to give rise to two or more cells each of which develops into a separate embryo. This is called **cleavage polyembryony.**

19.4.4 Seed

The seed is defined as a **ripened ovule.**

- Seed
  - Seed coat
    - Testa
    - Tegmen
  - Embryo
    - Embryonal axis
      - Plumule
      - Radicle
    - Cotyledon (1 or 2)
  - Endosperm (only in albuminous seeds)

Importance of Seed

1. It contains embryo which develops into a new plant.
2. The seed coat protects the embryo against dehydration and mechanical damage.
3. Seeds can be stored and transported from one place to another and thus help in dispersal.

A. Structure of Gram (dicot) Seed :

(i) The seed is enclosed in the pod. (Fig. 19.11a)

(ii) It is somewhat conical in shape. (Fig. 19.11b)

(iii) The seed is attached to a small stalk.

(iv) The point of attachment of seed to the stalk is called hilum.

(v) Testa is the brown seed coat, fused with the inner coat the tegmen

(vi) Below it is a small pore, the micropyle.

(vii) The embryonal axis is enclosed by the two fleshy cotyledons. (Fig. 19.11c)

B. Structure of Maize grain : (Monocot)

(i) The maize grain is broader in shape. (Fig. 19.11d)

(ii) Testa and tegmen are fused together which are further inseparably fused with the pericarp.

(iii) The embryo is towards the narrower side of endosperm.

(iv) The endosperm stores starch and protein. The outermost layer which contains only protein is called aleurone layer.

(v) The embryo consists of one large cotyledon, called scutellum.

(vi) The embryonal axis lies lateral to the scutellum. (Fig. 19.11e)

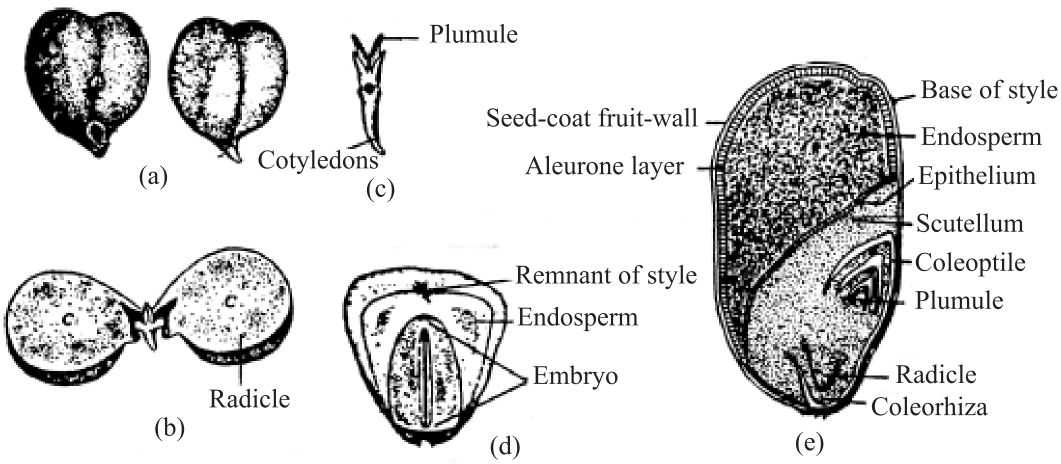


Fig. 19.11 Structure of dicot and monocot seeds : (a) External view of gram seed; (b) Internal structure of gram seed (c) embryo (gram) (d) Maize grain entire; (e) L.S. of maize grain

19.4.5 Fruit

A fruit is defined as a ripened ovary. Different parts are edible in different fruits.

Significance of Fruit :

1. It protects seeds.
2. On decay, fruits which contain chemical substances enrich the soil.
3. It helps in dispersal of seeds.

The unripe fruit has a different taste but no smell. But the same fruit when it ripens has a good taste and smell e.g. mango, banana. The following changes take place during the ripening of fruit :

(i) Starch is converted into sugar.

(ii) The production of various organic substances (esters) gives a different texture, taste and flavour.

(iii) The breakdown of chlorophyll leads to changes in colour of the skin of the fruit.

Parthenocarpy : When fertilisation fails, seeds are not formed. But in certain plants the ovary develops into a fruit e.g. grapes, and banana.

The phenomenon of development of fruit from unfertilised ovary is called **parthenocarpy** and such fruits which are seedless, are called parthenocarpic fruits.

Commercial value of parthenocarpic fruits :

(i) The parthenocarpic fruits are seedless and are hence valued more, for eating purposes and contain abortive seeds which can not develop into a new plant.

(ii) These fruits contain sufficient growth hormones.

INTEXT QUESTIONS 19.7

1. Which part of the ovule forms the seed coat ?

   ....

2. Define a seed.

   ....

3. Give one example of a dicot seed and one of a monocot seed.

   ....

4. Define a fruit.

   ....

5. List the parts of mature seed.

   ....

6. Development of an embryo from a cell of embryo sac other than egg is an example of ....

7. Formation of more than one embryo from a single zygote is called ....

19.4.6 Seed

Seed is the final product of sexual reproduction and on maturity, it becomes relatively dry. The metabolic activity of the embryo slows down and in majority of cases the embryo enters into a phase of inactivity called dormancy or in some cases if favourable conditions are available they germinate. Dormancy helps the plants to survive under unfavourable conditions and ensures its germination only under favourable conditions.

Germination : Embryo lies dormant in the seeds, but when the seed receives the favourable signals and the inputs from the environment (moisture, suitable temperature and oxygen) are available, they germinate. Germination is the process by which the embryo grows and establishes itself as a seedling.

Steps of germination

- Imbibition of water through the micropyle, and by the seed coat.
- Seed swells up as it gets hydrated.
- Enzyme activity converts the reserve seed food into soluble forms (glucose, amino acid, fatty acids)
- The seed coat bursts and radicle emerges (grows into root) and then the plumule grows and develops into shoots.

Germination can be of two types

(a) **Epigeal** where because of more growth of hypocotyl, cotyledons come above the ground and form the first leaves of the new plant e.g. in castor, neem, and bean, and the plumule forms the shoot.

(b) **Hypogeal** where because of poor growth of hypocotyl, cotyledons remain underground and plumule emerges from the soil to develop into the shoot system. e.g. maize, and rice.

19.5 VEGETATIVE REPRODUCTION IN ANGIOSPERMS

Vegetative reproduction in Angiosperm : Reproduciton of new plants from the portion of the vegetative parts of a plant is very common and is called **vegetative reproduction**. Stems, roots, leaves and even buds are variously modified to suit this requirement. This is called **natural** vegetative reproduciton.

The new plants formed by vegetative propagation are genetically similar to the parents.

Natural Method : In natural methods, a portion of the plant gets detached from the body of the mother plant and grows into an independent plant. The parts may be stem, root, leaf or even flower.

You have studied about the various modifications of root, stem and leaf in lesson 4 and 5. You have also learnt that these modified portions perform some special functions and also help to overcome unfavourable conditions.

1. The underground modification of stem, like rhizome, (in ginger), tuber (potato), bulb (onion) and corm (zamikand) are provided with buds which develop into a new plant and are therefore used to carry out vegetative propagation of the plant in the field. Plants with subaerial modification such as *Pistia* (offset) and *Chrysanthemum* (sucker) are also used for vegetative propagation.
2. Similarly, tuberous roots (*Asparagus* and sweet potato) can also be used for propagation as these roots have adventitious buds which grow into a new plant.
3. Sometimes even leaves contribute to propagation of plants for example, leaves of *Bryophyllum* and *Kalanchoe* have buds on the margin and these buds grow into small plantlets. When detached from the mother plant they grow into independent plants.
4. In plants like *Agave* and *Oxalis* multicellular bodies called bulbils develop from flower-buds. These are called bulbils which when fall on the ground, grow into new plant.

Table 19.2 Modes of Vegetative reproduction with examples

Mode of Reproduction	Specialised plant part	Examples
(A) **Natural Methods**		
(a) Roots (Adventitious)		*Asparagus*,
		Sweet potato
(b) Stem	(a) Runner	*Lawn grass*,
	(b) Sucker	*Mint*, *Onion*,
	(c) Bulb	Onion
	(d) Tuber	Potato, *Canna*
	(e) Rhizome	Ginger
(c) Leaves	Adventitious Buds	*Bryophyllum*
(d) Special Parts	Bulbil	*Oxalis*,
		Pineapple, *Onion*
(B) **Artificial Methods**		
(a) Cutting		Rose, Money Plant
(b) Layering		Jasmine,
(c) Grafting		Grapevine
(d) Tissue Culture		*Citrus*, Mango
		Orchids, *Chrysan*
		themum, *Asparagus*.

INTEXT QUESTIONS 19.8

1. Define vegetative reproduction.

   ....

2. Give an example of each of the following :

   (a) rhizome ....

   (b) tuber ....

   (c) bulb ....

   (d) runner ....

   (e) sucker ....

3. Give an example of vegetative reproduction which is carried out by leaves.

   ....

4. Name two ways by which vegetative reproduction occurs in plants.

   ....

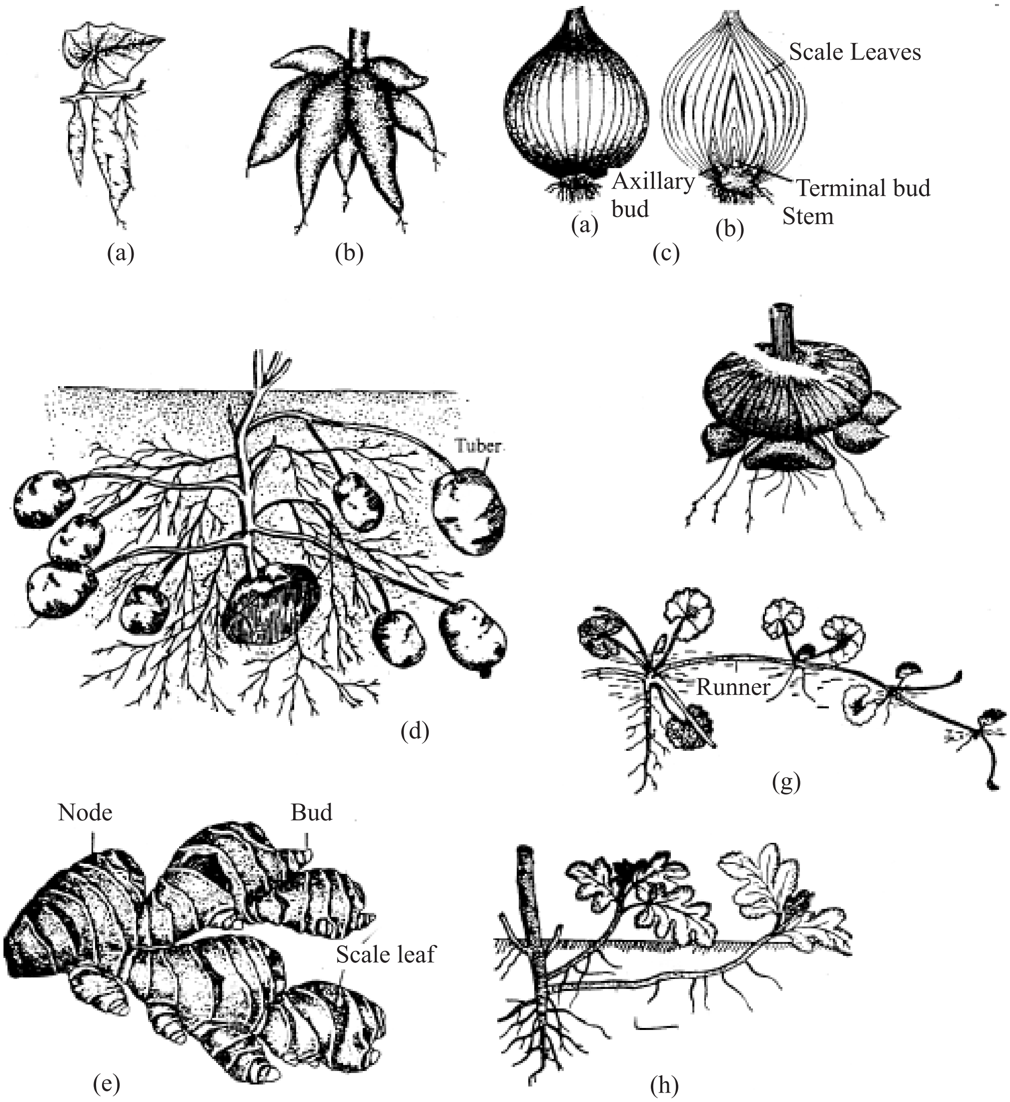


Fig. 19.12a Sweet potato

Fig. 19.12b Dahlia

Fig. 19.12c (a) Bulb of onion (b) L.S. of bulb

Fig. 19.12d Tuber of potato

Fig. 19.12e Rhizome of Ginger

Fig. 19.12f Corm of colocasia

Fig. 19.12g Runner of grass

Fig. 19.12h Sucker of Chrysanthemum

Fig. 19.12 Vegetative propagation of adventitious buds at the margins of leaves in Bryophyllum

19.6 ARTIFICIAL METHODS

Humans have taken advantage of this natural phenomenon and have artificially propagated plants vegetatively by using the specialized parts as described earlier or by cutting, grafting and layering. When, we use the vegetative parts for propagating crops or ornamental plants it is termed as **artificial vegetative propagation**.

(a) **Cuttings :** Many plants like rose, *Bougainvillea*, *Croton*, Coleus, money plant, and sugarcane are grown through their stem cuttings. (Fig. 19.13). Cuttings of these plants can be grown even in water where they strike roots and develop adventitious buds.

Fig. 19.13 Vegetative reproduction by cutting

(b) **Layering :** In this method, a lower branch of a plant is bent down and covered with moist soil leaving the growing tip above the soil. A ring of bark is removed from the stem before it is bent down (Fig. 19.14). In a few weeks time when enough roots have developed on the underground portion above the ringed part, it is cut off from the parent plant and grown separately as an independent plant. Example: Jasmine, strawberry, grapevine, *Bougainvillea*.

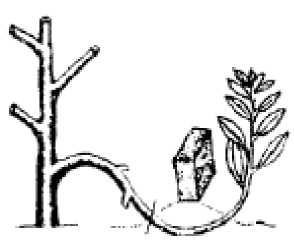


Fig. 19.14 Vegetative reproduction by layering

(c) **Aerial layering or Gootee** is a similar practice where bending of branches is not possible because of the height of plant or due to woody nature of stem. In this method a ring of bark is removed from a selected branch, and it is covered with moist moss and enclosed in a polythene sheet. When roots appear, the stem is cut below the roots and planted to form a new plant Fig. 19.15).

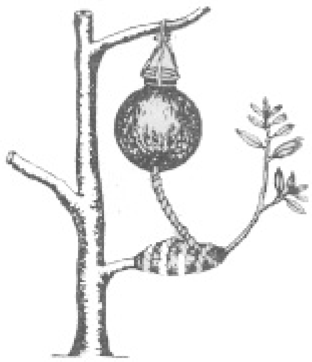


Fig. 19.15 Vegetative reproduction by gootee

(d) **Grafting :** It is especially important for propagation of seedless varieties of plants. It consists of inserting a small branch into a rooted plant. The rooted plant, taken as a stock is resistant to diseases and is physically sturdy. In this stock a branch is inserted which is known as scion or graft. This scion or graft is the stem cutting from the desired plant. Usually the grafted end of stock and scion fit well with each other and are bound firmly with tape or rubber-band until their tissues unite and vascular continuity is established. Grafting is mostly. practised in dicot plants. Grafting has been found extremely useful in propagating improved varieties of various flowers and fruits like rose, *Bougainvillea, Citrus,* mango, apple etc. (Fig. 19.16)

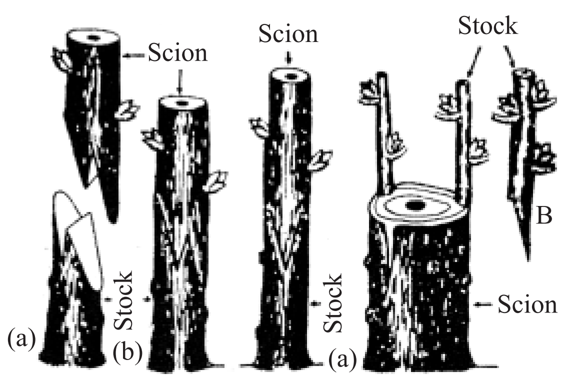


Fig. 19.16 (a) The lower part of the stem of scion is cut in a wedge. (b) The shoot of the plant to be used as a stock is cut off. The stem is slit vertically and the scion is inserted into the stock and is tied with a tape (c) the graft union occurs within a short time

19.7 ADVANTAGES AND DISADVANTAGES OF VEGETATIVE REPRODUCTION

Advantages

(a) Rapid means of reproduction and spread.

(b) Offsprings identical to parent. The desired varieties can thus be preserved genetically for use.

(c) Food storage organs allow perennation or survival in adverse conditions.

(d) Improved varieties of ornamental plants and fruit trees can be multiplied easily.

(e) Vegetative propagation is a quicker, easier and a less expensive method of multiplying plants.

Disadvantages

(a) Overcrowding and competition for space unless separated artificially.

(b) New varieties cannot be produced by this method except by mutation.

(c) Diseases typical of the species are rapidly transmitted and can be detrimental to a crop.

INTEXT QUESTIONS 19.9

1. What are the various methods which man uses for propagating plants artificially?

   ....

2. Name at least four specialised plant parts which help in vegetative ,propagation.

   ....

3. Write one advantage of vegetative reproduction.

   ....

19.8 THE MICROPROPAGATION

The technique of plant tissues culture is utilised for propagation of plants. The process is explained below with the help of diagrams.

A small piece of tissue, organ or even a single cell is taken from a plant and is transferred to a sterilized container with nutrient medium in aseptic conditions. The tissue grows very-very fast into an unorganised mass, called **callus**. The callus can be maintained and multiplied for an indefinite period. When small portions of the tissue are transferred to another specialised medium with hormones, it induces differentiation and plantlets (little plants) are formed.

The plantlets can be transplanted into pots and or soil by a gradual process and are grown to mature plants.

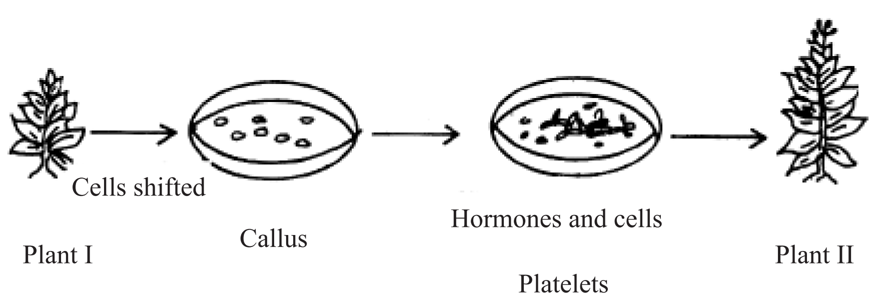


Fig. 19.17 Steps of micropropagation.

19.8.1 Advantages of micropropagation

By this method an indefinite number of identical plants can be obtained vegetatively starting from a small amount of parent tissue.

In orchids, carnations, *Chrysanthemum* and *Asparagus*, micropropagation is being successfully tried in some parts of our country.

INTEXT QUESTIONS 19.10

1. Give two examples each of plants which are propagated by the following methods:
   (a) Cutting
   (i) ....
   (ii) ....
   (b) Layering
   (i) ....
   (ii) ....
   (c) Grafting
   (i) ....
   (ii) ....

2. Name the artificial means of vegetative propagation commonly used in the laboratory.
   ....

3. Give two examples of plants which are propagated by micropropagation technique.
   ....

WHAT YOU HAVE LEARNT

- *Chlamydomonas* reproduces asexually by zoospores and sexually by isogamy, anisogamy and orgamy.
- *Spirogyra* reproduces by vegetative fragmentation, and sexually, by lateral conjugation and scalariform conjugation.
- In angiosperms flowers are the organs of sexual reproduction.
- Temperature and light are two main factors which influence flowering.
- Stamens and carpels are the male and female reproductive organs, respectively.
- Male gametes are produced in pollen grains, formed inside the anther, and pollen grains, are regarded as the male gametophytes in flowering plants.
- Female gamete is produced in the embryo sac in the nucellus of the ovule.

- The mature embryo sac is the female gametophyte of flowering plants, having 3-celled egg apparatus, three antipodal cells and a secondary cell having diploid secondary nucleus.
- Egg cell fuses with one of the male gametes received from pollen grains. Secondary nucleus fuses with the other male gamete. Occurrence of two such fusions is called two flowers borne on the same plant or on two **double fertilisation**.
- Pollination is the transference of the pollen grains from anther to stigma. It may be in the same bisexual flower of a plant (self pollination) or in different plants (cross-pollination).

  Wind, water, insects and animals are agencies of cross pollination.
- Wind pollinated flowers have light pollen grains or winged pollegrains and the stigma is usually large, hairy and projecting out of the flowers.
- Insect pollinated flowers are usually large, brightly coloured, scented and with nectar.
- Most plants have devices to favour cross pollination.
- The zygote develops to produce an embryo.
- The embryo is present in the ovule which later becomes seed and fertilized ovary on maturity becomes fruit.
- Development of fruit without fertilisation is called parthenocarpy.
- Ripening of fruit involves chemical changes in the stored food and pigments of the fruit wall.
- Vegetative reproduction is the production of new plants from plant parts other than flower and seeds.
- Specialised plant parts which bring about vegetative reproduction are as follows
  - (a) Roots - tuberous root of *Dahlia*
  - (b) Stems - runners and suckers near ground surface, rhizomes, tubers, corm and bulb are underground parts.
  - (c) Leaves - adventitious buds in leaf notches as in *Bryophyllum*.
  - (d) Bulbils - Modified buds in the inflorescence of pineapple called bulbils are also used for vegetative propagation.
- All the above kinds of parts have been used by man in agriculture and horticulture as artificial methods of vegetative propagation.
- Micropropagation by tissue culture enables production of little plants on a large scale.
- Vegetative reproduction is rapid, easy and cheap. The plants produced are genetically identical to the parent plant.

TERMINAL EXERCISES

1. Explain the term isogamy taking *Chlamydomonas* as an example.
2. Describe scalariform conjugation in *Spirogyra*.
3. Differentiate between annuals, biennials and perennial plants.
4. Give significance of pollination.
5. Draw a labelled sketch of a mature ovule.
6. Give a labelled diagram of a mature pollen grain.
7. Mention important characteristics in Anemophilous and Hydrophilous plants.
8. Give the significance of fertilisation.
9. Mention the changes that take place when the fruit ripens.
10. Define the following terms :
    (a) Corm (b) Scion
    (c) Callus (d) Micropropagation
    (e) Vegetative reproduction
11. In what ways do plants reproduce vegetatively without human assistance ?
12. In what ways do plants reproduce vegetatively with human assistance?
13. Define and give an example of each of the following:
    (a) Rhizome (b) Stolon (c) Cutting
    (d) Layering (e) Grafting
14. What are the advantages and disadvantages of vegetative reproduction ?
15. In what way is vegetative reproduction simple ?
16. Write short notes on
    (a) Runner (b) Sucker (c) Bulb (d) Tuber
17. In brief describe the various steps of micropropagation.
19. What is the significance of micropropagation ?
19. If a branch of dasehri mango is grafted on a tree producing desi mango. What type of mangoes will be produced on the grafted branch and on other branches of the tree?

ANSWERS TO INTEX]T QUESTIONS

19.1

1. The process by which living organisms produce their offsprings for the continuity of the species.
2. Offsprings reproduce from a vegetative unit produced by a parent without fusion of gamete. In case of sexual reproduction fusion of male and female reproductive cells produced in male and female reproductive organs, is required.

3. Male and female reproductive cells are known as gametes.
4. Fission, budding, fragmentation.
5. b

19.2
1. Male and female gametes are identical in structure.
2. Zygote
3. Asexual reproduction
4. Anisogamy - *C. braunii*; Oogamy - *C.oogamum* and *C. coccifera*
5. A flagellate thin-walled asexual reproductive unit is called zoospore. If a zoospore loses flagella and becomes, non motile, it is called aplanospore.

19.3
1. Fragmentation
2. Scalariform Conjugation.
3. Diploid nucleus in zygote on return of favourable conditions.
4. Only one filament is involved in lateral conjugation

19.4
1. Annual - Plants which produce flowers and seeds and die within one season.

   Biennial - Plants which complete their life cycle in two seasons. In First season they are in vegetative state and in second season, they reproduce and die.

   Perennial - Plants which live for several years. For first few years they are in vegetative state and later, they flower and produce fruits and seeds every year.
2. Temperature, light - day length
3. *Cannabis* or *Cucumis*
4. Stamens and carpels

19.5
(i) Tapetum
(ii) Pollen sac
(iii) Exine and intine
(iv) Nucellus and integuments

19.6
1. Transfer of pollen grains from anther to stigma of a flower.
2. (i) Cleistogamy
   (ii) Dichogamy

3. (i) Flowers are large, coloured and showy.

   (ii) Some flowers secrete nectar.

19.7

1. Integuments.
2. Ripened ovule.
3. Pea or Gram, Maize grain.
4. Ripened ovary.

   Seed coat
5. Embryo

   Endosperm

   Cotyledons
6. Adventive Polyembryony
7. Cleavage Polyembryony

19.8

1. The process of multiplication in which a portion of the plant body becomes detached and develops into new plants.
2. (a) Ginger (b) Potato (c) Onion (d) Lawn grass (e) mint
3. *Bryophyllum*
4. Rhizomes and Bulbs

19.9

1. (a) Cutting (b) Grafting (c) Layering
2. (a) Runner (b) Tuber (c) Bulb (d) Sucker
3. Desirable varieties of ornamental plants and fruit trees can be multiplied easily.

19.10

1. (a) (i) Croton (ii) Money plant

   (b) (i) Jasmine (ii) Grapevine

   (c) (i) Rose (ii) Mango
2. Micropropagation
3. Orchids, *Chrysanthemum*, *Asparagus*.

20

GROWTH AND DEVELOPMENT IN PLANTS

If you sow a seed in your garden or in a pot, after few days you would find a tiny seedling coming out from the seed. As days pass, the tiny seedling grows in size, the number of leaves increases, and later, it grows into a mature plant and produces flowers and fruits. This is the process of growth and development. Besides growth and development plants also show movement, but it is not as clearly visible as in the case of animals. In this lesson you will learn about growth, development and movements in plants.

OBJECTIVES

After studying this lesson, you will be able to:

- *define the terms growth and development;*
- *differentiate between growth and development and explain growth curve;*
- *list the various stages of cellular growth;*
- *explain the various methods of measurement of plant growth;*
- *describe the factors affecting plant growth and importance of growth regulators;*
- *explain the role of growth regulators in dormancy and germination of seeds;*
- *differentiate among short-day plants, long-day plants and day-neutral plants;*
- *define the terms abscission and senescence;*
- *identify the effects of salt stress and water stress on plants;*
- *define the various types of movement like geotropism, phototropism, nastic and turgor movements.*

20.1 GROWTH AND DEVELOPMENT

You must have noticed that all living organisms grow in size. But have you ever thought how a do they grow? Growth takes place due to cell division, which increases the number of cells in the body. This process continues and we observe increase in weight, size and volume of all plants and animals. This is called **growth.**

> Growth in living organisms may be defined as an irreversible increase in the number and size of a cell, organ or whole organism.

Growth in living organisms is not uniform throughout the life span. Growth takes place at a faster rate till the plants or animals attain maturity. Then it slows down and at a particular time it stops. Later in life death occurs. All these changes that occur in an organism starting from its beginning till its death may collectively be termed as development. Development is associated with **morphogenesis** and **differentiation**. **Morphogenesis** is the process of development of shape and structure of an organism; and **differentiation** is the process of change in cells, tissues or organs to carry out different functions.

> **Development is the whole series of qualitative and quantitative changes such as growth, differentiation and maturation, which an organism undergoes throughout its life cycle.**

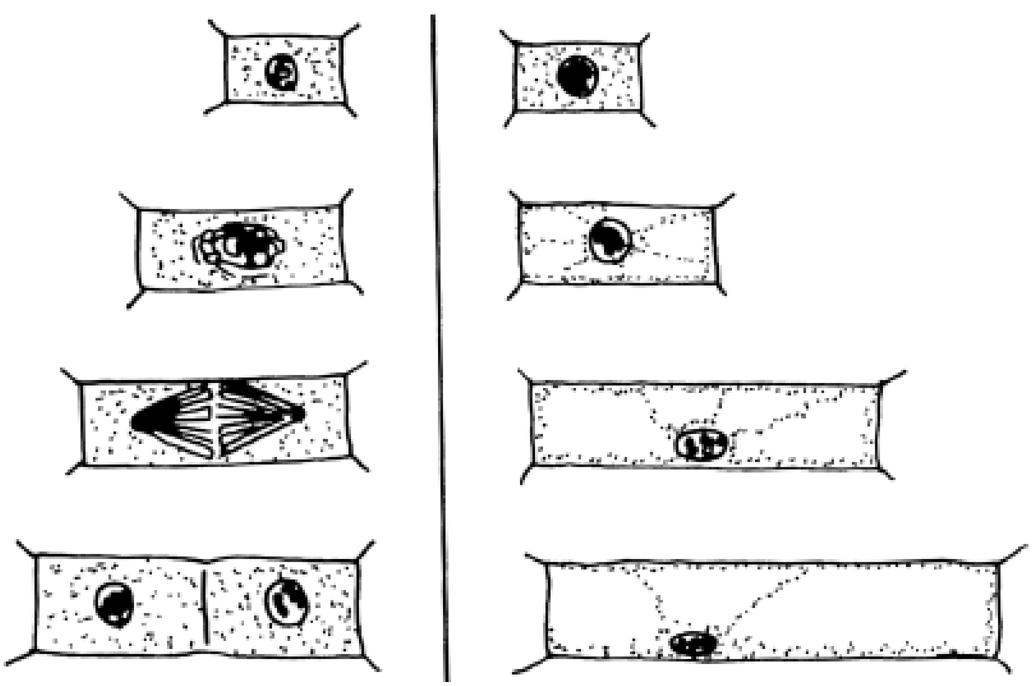
20.2 STAGES OF CELLULAR GROWTH

You have already learnt that growth of an organism is always associated with growth in size and number of cells. The growth of an organ or an organism occurs in three successive stages. They are

(i) **Cell division** : The number of cells increases due to mitosis (Fig. 20.1a).

(ii) **Cell enlargement**: The size of individual cell increases after cell division due to increase in the volume of its protoplasm (Fig. 20.1b).

(iii) **Cell differentiation**: In this stage, structure of the cells changes to perform specific functions. And similar type of cells having same functions form a group, which is known as tissue.



(a) Cell Division (b) Cell Enlargement

Fig. 20.1 Comparison of cell division and cell enlargement

In lower organisms such as bacteria and algae the entire body grows. But in higher organisms like ferns, pine and flowering plants, growth is restricted to the cells present only in the growing regions, like shoot apex and root tip and close to the lateral sides of the stem and root. Growth at the tips leads to elongation of body parts and lateral (side ways) growth leads to increase in the thickness of stem and root.

20.3 GROWTH CURVE

The rate of growth of a plant or plant part is not always the same during its life span. Sometimes it is slow and at other times rapid. If we plot the increase in cell number (growth rate) against time, a typical S-shaped curve is obtained. This is called growth curve or **sigmoid growth curve**. (Fig 20.2)

This curve has three phases of growth.

(i) **Lag Phase** – This is the initial phase of growth when the rate of growth is very slow.

(ii) **Log Phase** – It shows rapid growth and is maximum during the entire life span.

(iii) **Stationary Phase** – Here the rate of growth starts decreasing and finally it stops.

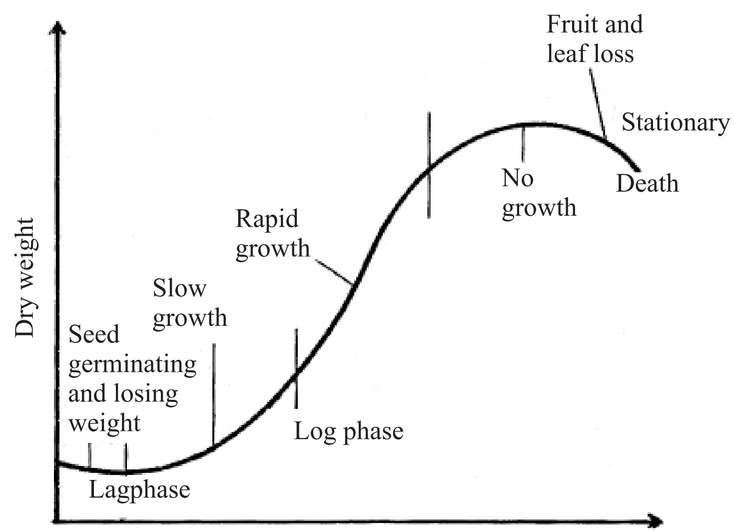


Fig. 20.2 Sigmoid curve

The total time period during which the festest growth of the organ or organism occurs is called **grand period of growth**.

20.4 MEASUREMENT OF GROWTH

After knowing the different phases of growth let us know how to measure growth in plants. Growth in plants being a quantitative phenomenon can be measured in relation to time. It can be measured in terms of

- Increase in length or growth – in case of stem and root;
- Increase in area or volume – in case of leaves and fruits;
- Increase in the number of cells – in algae, yeast and bacteria.

Let us discuss some methods of measuring growth in length.

20.4.1 Direct Method

We know that growth generally takes place at the apical region of plant. So growth in length can be directly measured by means of an ordinary measuring scale at any particular interval of time.

ACTIVITY FOR YOU

Aim

To use an ordinary scale to measure growth in length of the stem of a plant in your garden.

What do you require?

Thread, a piece of stone and a measuring scale.

What to do?

- Tie the stone at one end of the thread;
- Take the length of the stem from above the soil surface with the help of the thread;
- Mark the length of the stem on the thread with the help of a pen;
- Put the thread on the scale and note down the length;
- Record the length citing date of the activity;
- Repeat the procedure and at an interval of one week.

Is there any change in length?

Make a table.

No. of the week	Length in cms.
1	
2	
3	
4	
5	

20.4.2 Auxanometer

For more accurate measurement of length, we can use the specially designed equipment called **auxanometer**. (Fig 20.3). We can use it to measure the rate of growth of shoot length of plants. A thread is tied to the tip of stem of a potted plant and the thread is hung on the pulley of auxanometer. The other end of the thread is tied to a weight. The pulley is fixed with a long needle, which slides over a graduated arc. As the stem grows in length the weight pulls the thread down. The movement of the needle is read on the scale of arc.

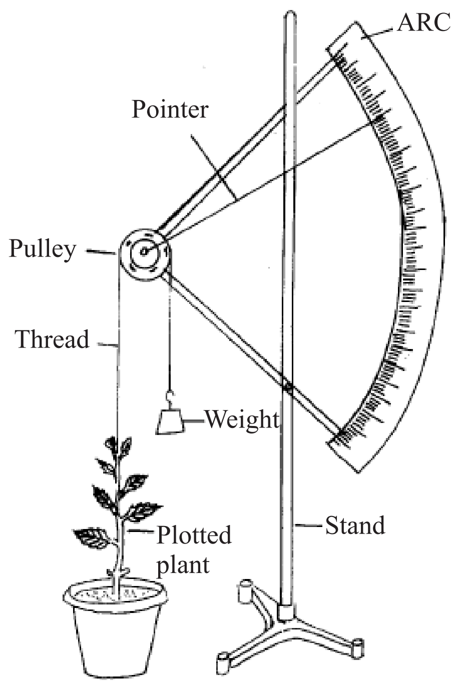


Fig. 20.3 Auxanometer

INTEXT QUESTIONS 20.1

1. Distinguish between growth and development.

    ....

2. What is differentiation?

    ....

3. What role does it play in plant growth and development?

    ....

20.5 FACTORS AFFECTING PLANT GROWTH

Generally plant growth is influenced by a number of factors both external and internal.

20.5.1 External growth factors

External factors are those factors present in the environment that affect the growth of the plants directly or indirectly. These factors are

(i) Light (ii) Temperature (iii) Water (iv) Mineral nutrients

(i) Light

You have already learnt about the necessity of light for the process of photosynthesis. Besides photosynthesis, light is also essential for seed germination, growth of seedling, differentiation of various tissues and organs, and reproduction.

When plants grow in dark, they become tall, yellowish and weak, and the leaves are very small.

(ii) Temperature

Some plants grow in cold climate and some in hot climate. The optimum temperature required for growth of plants ranges between 28-30°C, but it may occur in the temperature range of 4-45°C. All metabolic activities of plants are directly affected by variation of temperature. A very low temperature causes injuries to the plant due to chilling and freezing, and very high temperature stops its growth.

(iii) Water

You have already learnt that a plant absorbs water by its roots, uses it in photosynthesis and other biochemical processes and some of it is lost through transpiration. For proper growth of plants a particular quantity of water is required. Both deficiency and excess of water retards the growth of plants.

(iv) Mineral Nutrients

In the lesson 9 "Plant nutrition" we have already discussed the importance of mineral nutrients for plant growth and development. All metabolic processes require inorganic nutrients. Plant growth is adversely affected by the deficiency of nutrients.

20.5.2 Internal Growth Factors

In addition to the external factors as discussed above, there are some substances produced in the plant body itself, which affects the growth of the plant. These are called **plant hormones** or **phytohormones** or **growth hormones**.

A phytohormone is an organic substance produced in a small quantity in one part of plant body and capable of moving to other parts to influence the growth of that part.

The growth of the plants can also be influenced by certain synthetic chemicals resembling plant hormones both in structure and functions. These are called **growth regulators**. They are not produced by plants naturally.

Growth regulators are chemical substances, other than naturally produced hormones, which promote, inhibit or modify growth and development in plants.

The naturally produced growth hormones are broadly grouped under five major classes. They are

(i) Auxin (ii) Gibberellins (iii) Cytokinins

(iv) Ethylene (v) Abscissic acid

Let us know details about these hormones.

(i) Auxin

Auxin is a growth promoter, generally produced by the growing apex of stem and root of the plants. It helps in the elongation of shoot and root tips behind apical meristem. The naturally produced auxins is Indole-3-Acetic Acid (IAA). They are also produced by chemical synthesis, which show same physiological responses like Auxin. Some of the synthetic auxin are Indole-3-butyric acid (IBA), 2,4-Dichlorophenoxy Acetic Acid (2,4-D), and Naphthalene acetic acid (NAA).

The Greek word **auxein** means “to grow”. It was first isolated from human urine.

An experiment was performed by Fritz Went on oat seedling to see the effect of auxins. When tip of oat coleoptile (early shoot) is removed, growth stops. Then the removed tip is placed on a block of agar (gelatinous material from sea weeds) for about an hour. This agar block is then placed on the cut end of the seedling. It was observed that the growth of the seedling started again. It shows that there is something that has passed from the cut tip into the agar block, which helps to restart the growth. This was named **Auxin**, a plant hormone.

Functions of Auxin

(a) It promotes cell elongation;

(b) It suppresses the growth of lateral bud. If the tip of a plant is removed, the lateral branches begin to grow; In most of the plants apical bud suppresses the development of lateral buds. This is called **apical dominance**.

(c) It delays fall of leaves. (leaf abscission)

(d) NAA (Naphthalene acetic acid) is used for preventing fruit drop in apples before they are ripe.

(e) 2, 4-D (2, 4-dichlorophenoxy acetic acid) acts as a dicot weedicide.

(ii) Gibberellin

Gibberellin or Gibberellic Acid (GA) was initially isolated from a fungus *Gibberella fujikuroi*. In plants, it is produced in embryos, roots, and young leaves and it enhances growth.

Functions of Gibberellins

(a) It helps in elongation of stems in genetically dwarf plants. By using gibberellin the height of the dwarf plants can be increased.

(b) It breaks dormancy of seeds and buds.

(c) It induces parthenocarpy. (Formation of seedless fruits without fertilization) or provides stimulus received by pollination.

(iii) Cytokinins : They were extracted from coconut milk.

Cytokinins are synthesized in root apex, endosperm of seeds, and young fruits where cell division takes place continuously.

Functions of Cytokinins

(a) They stimulate cell division, cell enlargement and cell differentiation.

(b) They prevent aging of plant parts.

(c) They inhibit apical dominance and help in growth of lateral buds into branches.

(iv) Ethylene

Ethylene is a gaseous hormone. It is found in ripening fruits, young flowers and young leaves.

Functions of Ethylene

(a) It induces ripening of fruits.

(b) It promotes senescence and abscission of leaf, and flowers.

(c) In cells it only increases the width not the length.

(v) Abscissic acid

Abscissic acid also known as Dormin is a naturally occurring growth inhibitor found in wide variety of plants. It is synthesised in leaves.

Functions of Abscissic acid:

(a) It induces dormancy of buds and seeds as opposed to Gibberellin, which breaks dormancy.

(b) It promotes the senescence of leaf, i.e., fall of leaves happen due to abscissic acid.

(c) It inhibits seed germination and development.

(d) It causes closing of Stomata.

20.6 PRACTICAL APPLICATION OF GROWTH REGULATORS

We have already discussed that by using the various types of growth regulators we can promote, inhibit or modify growth and development in plants. Now-a-days these are widely used by horticulturists to boost their production. Some of the applications are –

(i) With the help of auxins and gibberellins seedless varieties of fruits can be produced. You might have seen seedless grapes and papayas in the market.

(ii) Early flowering in some plants is possible by applying growth regulators.

(iii) With the use of hormones some fruits can be ripened at an early stage.

(iv) Germination in seeds can be possible by applying auxins.

(v) Germination of potatoes and onions can be stopped in storage by application of growth inhibitors.

20.6.1 Differentiation, Dedifferentiation and Redifferentiation

Differentiation: Differentiation in plants is a permanent, localised qualitative change in size, biochemistry, structure and function of cells, tissues or organs. It refers to the processes by which distinct cell types arise from precursor cells and become different from each other. For example:Vascular tissues, xylem and phloem, are differentiated from meristematic cells, procambium, and vascular cambium and mature to perform specific functions. The hormones auxin and cytokinin are essential for vascular tissue differentiation. During differentiation, cells undergo few to major structural changes both in their cell walls and protoplasm. For example, to form a tracheary element, the cells would lose their protoplasm. They also develop a strong, elastic, secondary cell wall to carry water to long distances even under extreme conditions.

Dedifferentiation: It is the reversal of cell development in plants, so that the differentiation that had occurred previously is lost and the cell becomes more generalized in structure. The living differentiated cells that have lost the capacity to divide can regain the capacity of division under certain conditions. This phenomenon is termed **dedifferentiation**. For example, formation of meristems, interfascicular cambium and cork cambium from fully differentiated parenchyma cells.

Redifferentiation: While undergoing dedifferentiation plant cells once again lose their capacity to divide but mature to perform specific functions. This process is called redifferentiation.

INTEXT QUESTIONS 20.2

1. Name the plant hormones concerned with the following:
   - (i) Elongation of cell ....
   - (ii) Shedding of leaves...
   - (iii) Breaking seed dormancy ....

2. Mention two functions of Auxin
   - (i) ....
   - (ii) ....

3. What is the difference between dedifferentiation and redifferentiation?

   ....

4. Which two hormones are essential for vascular tissue differentiation?

   ....

20.7 DORMANCY AND GERMINATION IN SEEDS

In the previous lesson-7 you have already learnt about formation of seeds in plants. In developed seeds metabolic activities are generally very slow. But at the time of germination, the metabolic activities in seeds increase and they grow into new plants under favourable conditions of growth. This is called **seed germination**.

Seed germination is the return of metabolic activities and growth by the seed tissue to give rise to a new plant by the development of the embryo.

Some seeds do not germinate immediately after dispersal even if suitable conditions of growth are provided. In this period growth of the seeds remains suspended and it is said to be in the rest or dormant stage. This phenomenon is called **dormancy of seeds**. It may occur due to immature embryo**,** hard or impermeable seed coat, and presence of inhibitors like abscissic acid.

20.7.1 Types of Seed Germination

In flowering plants two types of germination are found. They are:

(a) Epigeal germination; and (b) Hypogeal germination.

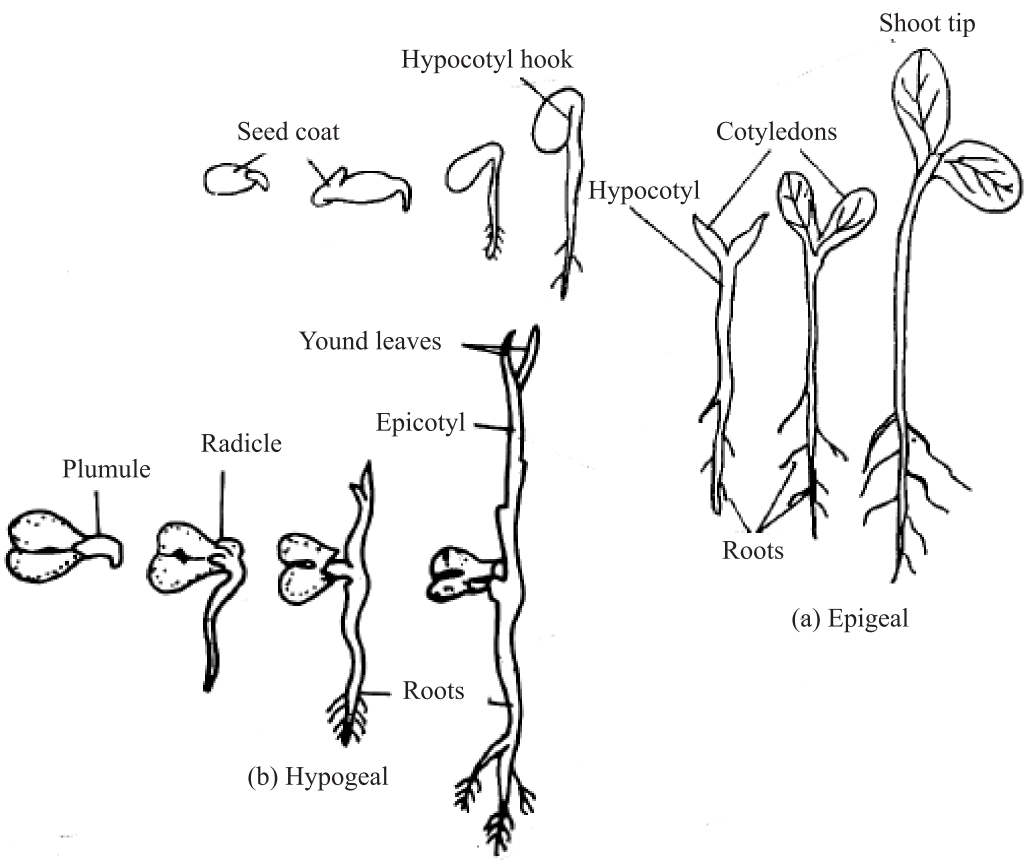


Fig.20.4 Epigeal Germination and Hypogeal Germination
Vivipary (= producing baby plants)

(a) Epigeal Germination

In epigeal (*epi* - above; *geo* - soil)germination hypocotyl elongates and cotyledons come out above the soil surface. Examples : seeds of pumpkin, mustard, tamarind, and french bean.

(b) Hypogeal Germination

In hypogeal (hypo = below, geo = earth) germination the epicotyl elongates and *cotyledons remain below the soil surface*. Examples : Most monocots seed like rice, wheat, maize, and coconut.

> Some plants, which grow in marshy places show a special type of germination called **Vivipary** (Fig. 20.5). Here the seed germinates inside the fruit while it is attached to the parent plant. The weight of the seed increases because of germination and seedling separates from the plant and falls down into the mud. Then roots develop to fix it in the soil. These plants are called viviparous plants. For example, *Rhizophora* and *Sonneratia*.

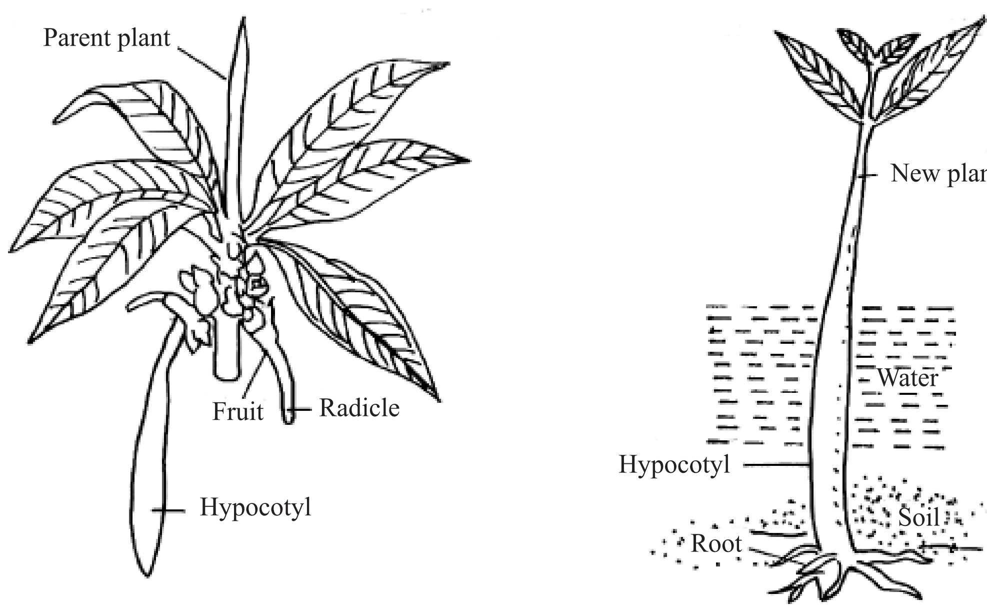


Fig 20.5 Viviparous Germination

20.7.2 Mechanism of Seed Germination

In seed germination, the first step is the imbibition or absorption of water by seed. Then the seed swells and the seed coat ruptures. Through the ruptured seed coat the radicle comes out from one end of embryonic axis. This radicle gives rise to root system. From the other end of embryonic axis the plumule elongates and develops as the shoot of the plant.

20.7.3 Factors Affecting Seed Germination

Seed germination requires five factors : water, temperature, oxygen, light and growth hormones.

(a) Water : The seed must swell up to rupture its seed coat. A ripe seed contains very low quantity of water. So for swelling to cause rupture of seed coats supply of adequate water is essential. Biochemical reactions required for growth and development of the seedling require water.

(b) Temperature : For germination of seeds a particular temperature is required. The degree of temperature required varies from species to species. Warmth accelerates chemical reactions inside.

(c) Oxygen : Oxygen is required in breaking down reserve food of seed and release energy for metabolism of growth of the embryo.

(d) Light : In most of the seeds light is not an essential factor for germination. But in some cases like lettuce and tobacco light is absolutely essential.

(e) Hormone : Besides the above external factors, hormones also control germination of seeds. Some roles played by hormones are as follows.

- Gibberellins can induce germination in some cases even in complete darkness.
- Auxin, Cytokinins and Ethylene can break dormancy in many seeds and initiate germination.
- In some seeds Abscissic acid inhibits germination process.

20.8 PHOTOPERIODISM – RESPONSES DUE TO LIGHT EXPOSURE DURATION

You must have observed plants like spinach, wheat, etc. which produce flowers in summer; and dahlia, cosmos, etc. flower in winter. Why is it so? Because the plants that flower in summer require longer duration of light per day than those flowering in winter. Thus, we can say that duration of light plays an important role in flowering of plants. **This effect of duration of light on the growth of plants is known as photoperiodism**.

Photoperiodism is the response in growth, transpiration, photosynthesis, and reproduction (flowering) of a plant to the specific duration of light, which falls on it per day.

On the basis of day-length required by the plants for flowering, the plants are classified into the following three categories:

(i) **Short-day Plants (SDP) :** Some plants produce flowers when exposed to a light period shorter than a required day-length. These are called Short-day Plants. Chrysanthemum, Cosmos, Dahlia, Soyabean, are short-day plants.

(ii) **Long-day Plants (LDP) :** They produce flowers when exposed to a light period longer than a fixed day-length. Gulmohar, radish, spinach, are long-day plants.

(iii) Day-neutral Plants (DNP) : In these plants flowering is not affected by length of light period i.e. they produce flower in almost all photoperiods.Cucumber, Tomato, and Sunflower, are day-neutral plants.

Though flowering is the best known example of photoperiodism, many other plant processes are also controlled by duration of light. Bud dormancy, bulb formation in onion, and tuber formation in potato are affected by period of light.

20.9 ROLE OF FLORIGEN AND PHYTOCHROME IN FLOWERING

After the discovery of effect of light on flowering, the scientist tried to find out the hormone responsible for flowering in plants. It is hypothesized that a plant hormone called **Florigen** is responsible for initiation of flowering in plants. Florigen is a hypotheticals flowering stimulus synthesized in the leaves under favourable photoperiod, which migrates to shoot apex where flowering occurs.

Have you ever thought how a plant comes to know about the presence or absence of light in its environment? It is due the presence of a particular type of pigment in the plants, called **Phytochrome**. It is also known as light absorbing pigment and it makes the plants sensitive to light and participates in seed germination and flowering. This pigment occurs in two different forms, one Pr and the other, Pfr. While Pr absorbs red light P_{fr} absorbs far-red light (such rays are invisible). Both these forms are inter- convertible. The P_r form absorbs red light and gets converted into P_{fr} form and the P_{fr} form absorbs far-red light and gets converted into P_r form.

$$P_r \underset{\text{Far-red light}}{\overset{\text{Red light}}{\rightleftharpoons}} P_{fr}$$

Fig: 20.6 Inter-conversion of the phytochrome into P_r and P_{fr}

20.10 VERNALISATION—APPLICATION OF LOW TEMPERATURES

You have already learnt that temperature affects growth and development of plants. For flowering in some plants, a particular temperature is required. Studies show that if temperature is reduced to a particular point then flowering occurs at an early stage. For example by applying a temperature ranging between 1-10° C to certain variety of wheat, rice and cotton, growth of seedlings is accelerated and flowering occurs earlier. This method of inducing early flowering in plants at low temperature is called **vernalisation**.

> Vernalisation is the process of accelerating the process of flowering by subjecting or exposing the plant to low temprature.

Practical Utility of Vernalisation

Vernalisation has some practical applications like:

(a) Plants whose life cycle is completed in two seasons (biennials) can produce flower in one season if their seeds are pre-treated to a low temperature.

(b) Crops can be grown and harvested earlier i.e. biennials can be turned into annuals.

20.11 SENESCENCE/AGING OF PLANTS

Like animals, plants also have fixed life span and after completing that perioid, they die. Before death we can observe several degradation processes in their body. You might have noticed yellowing of leaves, and fading of flower colour, in plants. It is due to loss in structure and function of an organ or the whole plant. **The deteriorative processes which ultimately lead to complete loss of organization and functioning of the plant or its parts is known as Senescence**.

Senescence occurs due to the deposition of waste material. In some plants the whole plant dies after flowering and producing seeds. This is called **whole plant senescence.** Example-annual plants like rice, wheat, beans, and tomato. In many other plants, parts above soil die each year and root system stays alive. This is called **organ or shoot-senescence.**

Role of hormones in senescence: Abscissic acid and ethylene promote senescence of leaves but cytokinin delays senescence and helps leaves remain green for long period.

20.12 ABSCISSION – SHEDDING OFF

You might have noticed whenever a leaf becomes old it separates from the plant body and falls down. Again ripe fruits and older flowers also become separated from plants. This detachment of older plant parts or organs from the main plant body is called **abscission**.

In plants, a layer of tissue generally forms an abscission zone at the base of the petiole of a leaf or flower or fruit. The cells of this layer become soft and weak due to destruction of middle lamella and cell wall. So the organ is easily detached by wind or rain fall. Plant hormones like abscissic acid and ethylene promote leaf abscission and auxin prevents it.

20.13 STRESS FACTORS

What happens if you do not supply water to a potted plant for four to five days? You may observe that the leaves bend down and the plant wilts. Here due to lack of water the usual life processes of plant are disturbed. We can say that the plant is facing stress in its life. This may be called as **biological stress**. Not only water, there are a number of factors responsible for causing stress in plants like temperature, salt, shade, light, and pollutants.

Any change in the environmental conditions that may adversely affect the growth or development in plants is called biological stress.

The effect that is produced in plant as a result of stress is called strain. In the above example bending of leaves and wilting of plant are strains.

So the reaction of plant facing the stress is called strain

20.13.1 Types of Stress

There are a variety of stresses to which plants are exposed. Some common stresses are-

(a) Water stress; and (b) Salt stress.

Let us know details about them.

(a) Water Stress

Water stress includes both excess of water (flood) and scarcity of water (drought). Deficiency of water in the plant makes the leaves yellow and they wilt. The various processes in plants like photosynthesis and respiration are reduced, cell enlargement is checked, cell size is deformed and cell rigidity lost due to deficiency of water. Flooding or excess amount of water in soil reduces root and shoot growth, and causes blackening of root tips and yellowing of leaves.

(b) Salt Stress

Salt stress occurs mainly due to the presence of excess amount of calcium and sodium salts in plant body. It causes dehydration of cell, change in shape of cell and disturbance in metabolic processes. Thus cell growth as well as growth and development of plants are retarded.

20.14. PLANT MOVEMENTS

While doing any work our body parts move and also entire body moves from one place to another as per our desire. This is called movement of our body. Plants also show movement. But their movements are completely different from our body movement. Except some unicellular plants, all other higher plants cannot move from place to place as their roots are fixed in the soil. Still they show movement by folding the buds, opening and closing the flowers, and bending towards sun light. These movements in plants are very slow and we have to wait and observe them carefully and patiently to notice these movements. Let us learn about various types of movements shown by plants.

(a) Tropic Movement (directional response or growth movements)

Movement in plants or in any part of the plants towards or away from some environmental factors is known as tropic (trope : turn) movement. You must have observed the movement of plants in the direction of light, the downward movement of roots in the soil, drooping of leaves of some sensitive plants by touch, etc. These are examples of tropic movement.

(i) Phototropism : Induced by light e.g. bending of stems towards light.

(ii) Geotropism : Induced by gravity e.g. growth of roots towards gravity.

(iii) Thigmotropism : Movement caused by contact e.g., twining stem and tendril and the drooping of leaves of sensitive plant by touch.

(iv) Hydrotropism : Induced by water i.e., growth of roots towards source of water.

(b) Nastic Movement

The nastic (nastein : bending) movements are the growth movements resulting due to difference in the rate of growth on **opposite sides of an organ** e.g., opening of petals, coiling of leaves, etc. When upper side of an organ grows faster than the lower side, the movement is called **epinasty**. (e.g., downward curling of leaf, opening of sepals of goldmohur flower. When the lower side grows more rapidly than upper side, it is called as **hyponasty**. (e.g. upward curling of leaf blade)

(c) Turgor Movements

These movements are due to change in the volume of water inside the cell. When more water is present in the cell it is fully expanded and becomes rigid or hard. Such a condition is called turgidity and the cell is said to be **turgid**. When less water is present inside the cell, it is not fully expanded and remains soft. This is called **flaccid** condition. The leaves bend in hot summer due to excessive transpiration on account of loss of turgidity of cells of the leaf.

Some examples of turgor movements are :

(i) Leaves or leaflets of some plants close on the fall of darkness (sleep movement). Example - *Portulaca*, *Acacia*.

(ii) Closing of leaflets and drooping of leaves in response to a strong stimulus of blowing wind or of touch. Example - Sensitive plant (*Mimosa pudica*)

(iii) Closing of leaves of Venus Flytrap to catch a landing insect.

(iv) Seed pods of some plants open on maturity, vigorously expelling their seed. Example - Balsam (Gulmehandi).

INTEXT QUESTIONS 20.3

1. Distinguish between Phototropism and Geotropism

....

2. Give two examples of turgor movement

....

WHAT YOU HAVE LEARNT

- Growth in living organisms results from increase in the number and size of a cell, organ or whole organism.
- Development is the whole series of qualitative and quantitative changes (growth, differentiation, maturation), which an organism undergoes throughout its life cycle.

- Growth of cells occurs in three successive stages i.e., cell division, cell enlargement, cell differentiation.
- Plants show three phases of growth - Lag Phase, Log Phase, Stationary Phase
- Auxanometer is a specially designed equipment used to measure the rate of growth of shoot length of plants.
- The external factors that affect the growth of the plant are light, temperature, Water and mineral nutrients.
- The internal factors responsible for plant growth are auxin, gibberellins, cytokinins, ethylene, and abscissic acid. These are substances produced in a small quantity in one part of plant body and capable of moving to other parts to influence the growth of that part.
- Seed germination is the return of metabolic activities and growth by the seed tissue to give rise to a new plant. The germination in seeds is mainly affected by factors like Water, temperature, oxygen, light, and hormone. Flowering plants show two types of germination, epigeal germination; and hypogeal germination.
- Photoperiodism is the biological response in growth, reproduction (flowering) of a plant to the duration of light, which falls on it per day.
- Florigen is a hypothetical plant hormone, which is responsible for initiation of flowering in plants.
- The method of accelerating the ability of flowering in plants by keeping them at low temperature for sometime is called vernalisation
- Senescence is a gradual process during which any plant part or the whole plant completely loses its function and ultimately dies.
- The process of detachment of any leaves, fruits, flower or any part of the plant from the main body after getting older is called abscission.
- Any change in the environmental conditions that may adversely affect the growth or development in plants is called biological stress. This stress occurs mainly due to temperature, water, salt, shade, light, and various pollutants.

TERMINAL EXERCISES

1. State the different stages of cellular growth.
2. Distinguish between growth and development.
3. What is a sigmoid growth curve? State the different phases of sigmoid curve.
4. Describe the various external factors that affect the growth of plants.
5. What is vernalisation?
6. Define the term Photoperiodism.
7. What is auxin? What is its role in the growth of plants?
8. State any two functions of Gibberellin?

9. Explain the role of Cytokinins and Ethylene in growth and development of plants.
10. Distinguish between epigeal germination and hypogeal germination.
11. What is meant by seed germination? Describe the various factors responsible for seed germination.
12. What is senescence?
13. State any two practical utilities of growth hormones.
14. What is biological stress? Describe the different types of biological stress.
15. What is apical dominance? Name the hormone responsible for it.
16. What is meant by plant movement? Describe any two types of movement of plants with example.

ANSWERS TO INTEXT QUESTIONS

20.1 1. Growth : Increase in number and size of a cell, organ organism.

Development : Series of qualitative & quantitative changes including growth, differentiation and maturation.

2. Process of change in cells, tissues or organs in order to carry out different functions.
3. Similar cells organise to form a group called tissue to perform a particular function

20.2 1. (i) Auxin, (ii) Ethylene (iii) Abscissic acid

2. (i) Cell elongation (ii) Delays fall of leaves (iii) suppresses growth of lateral bud (any two)
3. *Dedifferentiation:* Process by which precursor cells become distinct cell types to perform a specific function.

   Redifferentiation: Process by which the plant cells while undergoing dedifferentiation lose their capacity to divide once again but mature to perform specific functions.
4. Auxin and Cytokinin.

20.3 1. Movement induced by light – Phototropism

Movement induced by gravity – Geotropism

2. (i) Closure of leaves on fall of darkness

   (ii) dropping of leaves on touch

   (iii) closing leaves of venus fly trap to catch a landing insect (any two)

21

REPRODUCTION AND POPULATION CONTROL

The ability to reproduce is one of the essential characteristics of living beings. It involves the transmission of genetic material from the parental generation to the next generation, thereby ensuring that characteristics not only of the species but also of the parental organisms, are perpetuated. In this process, one generation of living organisms gives rise to another generation. The process by which a living organism produces its own kind is known as **reproduction**.

Organisms reproduce in two ways: (1) gametes are not produced and hence there is no fusion of gametes or fertillisation (asexual reproduction), and (2) by formation and the fusion of gametes (sexual reproduction). In this lesson, types of reproduction, reproduction in sponges, insects and humans are discussed. A section deals with problems of population explosion of humans.

OBJECTIVES

After completing this lesson, you will be able to:

- *define reproduction and differentiate between asexual and sexual reproduction;*
- *describe gemmule formation as one example of asexual reproduction.*
- *describe the organs for sexual reproduction in cockroach.*
- *state functions of each part of male and female reproductive systems in humans;*
- *draw labelled diagrams of male and female reproductive systems;*
- *describe the main events in the process of reproduction in humans starting from the production of gametes to pregnancy and childbirth;*
- *describe the process of exchange of nutrients and respiratory gases across embryo and mother;*
- *explain lactation.*
- *explain how twins are produced;*
- *highlight recent advances in the area of human reproduction;*
- *define the terms—population, demography, birth rate, death rate and growth rate, etc.;*

- *list the factors responsible for rapid rise of population in India;*
- *describe the disadvantages of enormously increasing population;*
- *explain the needs for controlling the population growth;*
- *list various methods of contraception for population control.*

Reproduction: Reproduction is the ability of living organisms by which they produce offspring of their own kind. Organisms reproduce by:

1. Asexual reproduction involves the production of an offspring from a single organism without the formation of gametes. It is a common process of reproduction in bacteria, protista, lower plants and lower animals.

2. Sexual reproduction is the production of offspring by the formation and subsequent fusion of gametes. At fertilization, the male and the female gametes unite to form a zygote which develops into a mature organism. Most animals and higher plants multiply by sexual reproduction.

Two examples of sexual reproduction are given here (i) insects (ii) in humans

21.1 A SEXUAL REPRODUCTION IN ANIMALS

There are various methods of sexual reproduction in lower animals and one example, is that of production of reproduction bodies called 'gemmules' in sponges (Phylum Porifera)

21.1a Gemmule

Gemmule is a reproductive body for asexual reproduction found in fresh water sponges and some marine sponges (*Gemma* in Greek means bud).

A full grown gemmule (Fig. below) looks like a tiny hard ball containing an inner mass of undifferentiated cells called **archaeocytes**. The archaeocytes are surrounded by a resistant covering which protects the inner cells. The covering is made up of chitin and may be strengthened by spicules. There is a small outlet called micropyle. Gemmules tide over the unfavourable conditions. For example when the pond dries up or during the freezing cold of winter when adult sponges die, it is the gemmules that remain viable. When the favourable conditions return, archaeocytes come out of the micropyle and develop and differentiate into a sponge.

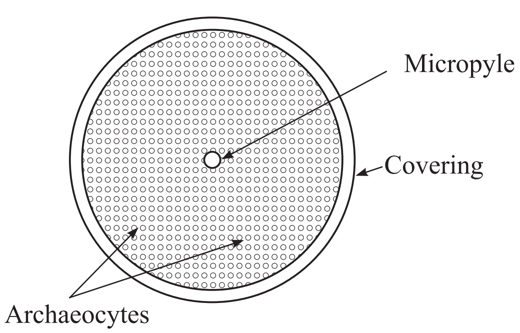


Fig. A gemmule of fresh water sponge *Spongilla*

21.1 REPRODUCTION IN HUMANS

The humans reproduce sexually. Reproduction in humans can be studied in two parts:

(a) Reproductive system, and

(b) Fertilization, pregnancy and development of the embryo.

Human Reproductive System

Maturity of human sex organs begins with puberty the name given to the **changes** that occur in boys and girls as they grow up. Mostly these changes occur between the age of 10 to 14 years, and these are brought about by certain hormones. During puberty the body grows rapidly, and both *primary and secondary reproductive organs* grow and become mature. Along with these changes, *secondary sex characters* also start appearing. It is also to be noted that in males, sexual maturity is attained at the age of 13–14 years and in females, at the age of 11–13 years. Puerty ultimately leads to a stage when the child becomes an adolescent.

Some Basic Facts

What is adolescence?

The term adolescence comes from the Latin verb *adolescere*, meaning '*to grow into maturity*'. In this sense, '*adolescence is a process rather than a time period, a process of achieving the attitudes and beliefs needed for effective participation in society*'. The World Health Organization (WHO) defines adolescence as the period from 10 to 19 years of age characterized by developments and changes in physical, psychological, and social areas.

During adolescance, the secondary sexual charaters that develop are as follows:

In males, these include deepening of voice, widening of shoulders, muscular body, appearance of beard and moustache, growth of axillary and pubic hair, enlargement of external genital organs.

In females, the changes include growth of axillary and pubic hair, widening of pelvis and hip, enlargement of breasts and initiation of the menstrual cycle.

Sexual maturation is a very significant stage in one's life, hence it is necessary to maintain the health and hygiene of the reproductive organs during this stage.

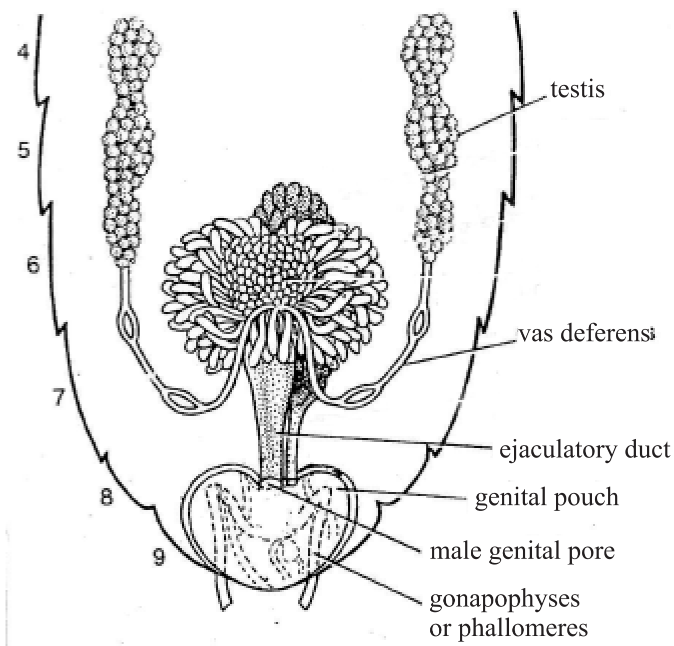
21.2a Reproductive System of Insects

Sexes are separate in most insects and reproduction is usually sexual, although in some groups of insects, eggs sometimes develop parthenogenetically (without fertilization). e.g. in aphids all generations are produced parthenogenetically and are all females.

The reproductive organs of cockroach are described here as a representative of insects.

Male Reproductive System

The male reproductive system consists of a pair of **testis** a pair of delicate ducts called the **vas deferens**, (plural: vasa deferentia) and a single median **ejaculatory duct**. The ejaculatory duct opens into a **genital pouch** through a **male genital pore**. Surrounding the male genital pore are the **gonapophyses** which help in copulation. **Seminal vesicles** are small white sacs at the anterior end of the ejaculatory duct. Seminal vesicles store the sperms. **Mushroom gland** and **phallic** or **conglobate gland** are accessory reproductive glands of male. (See figure below)



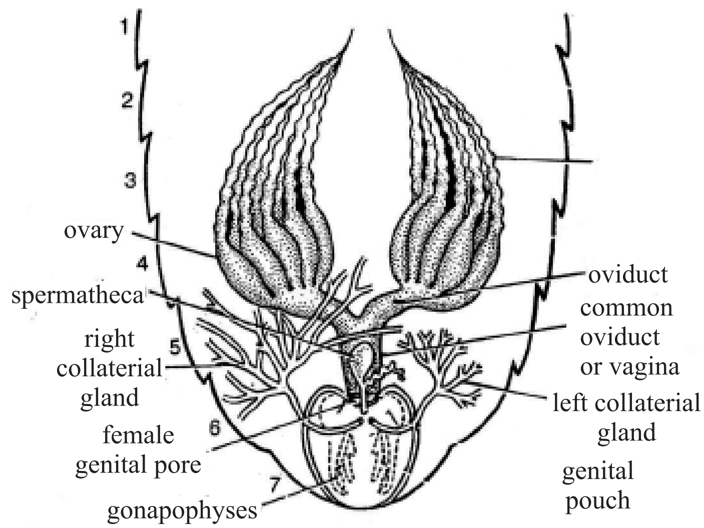
Periplaneta americana. Mate reproductive organs in dorsal view.

Female Reproductive System:

Female reproductive system consists of a pair of **ovaries**, one on either side of the hind gut embedded in the fat bodies. Each ovary consists of blind tubes called **ovarioles.** All the ovarioles unite posteriorly and open into a short lateral oviduct. The two lateral oviducts unite to form a short median **oviduct**. The posterior part of the oviduct is wide and is called the **vagina**. Vagina opens into the **genital pouch** through the female **genital pore** or **vulva**. A **receptaculum seminis** or **spermatheca** opens into the genital pouch. Spermatheca receives the sperms during copulation from the male. Three pairs of **gonapophyses** are present between the female genital pore and anus. They assist in copulation, in laying eggs and in the formation of oötheca (see Fig. below) or egg cover.

A pair of branched accessory glands called the **colleterial glands** open into the genital pouch. The secretion of these glands form the oötheca (hard egg case).

However, different insects may show a variation from this basic plan.



Periplaneta americana. Female reproductive organs in dorsal view.

Human reproductive organs are described and illustrated below.

Male reproductive system

The reproductive system in male consists of the following organs – a pair of **testes**, a pair of epididymis, a pair of vasa deferentia (singular : vas deferens), urethra, penis and accessory glands (Fig. 21.1) (Table 21.1).

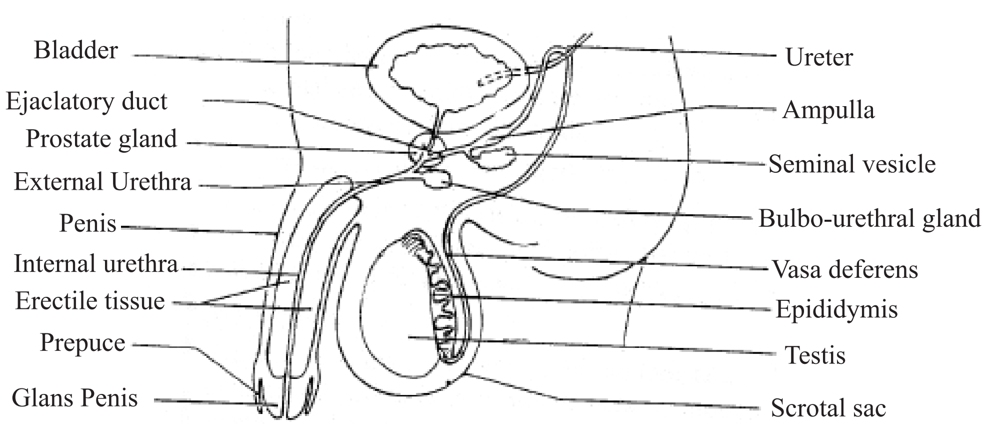


Fig. 21.1 Male Reproductive system

(i) Testes

Testes (singular: testis) as depicted in Fig. 21.2 are the male gonads. In an adult male, each testis is approximately 4-5 cm long and about 12 g in weight. Testes are **extra-abdominal,** that is, present outside the abdomen in a pouch made up of skin and connective tissue called **scrotal sac** or **scrotum** that hangs in the region between the legs.

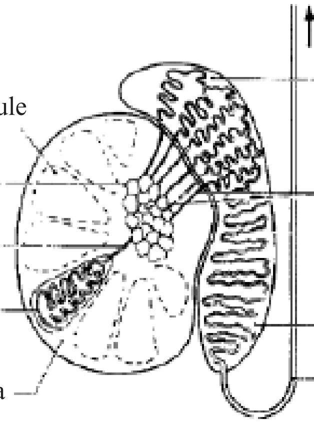


Fig. 21.2 Microscopic Structure of Testis

The scrotum acts as a thermoregulator. It helps in maintaining the temperature of testes at about 2-3°C lower than the body temperature. This temperature is suitable for the development of sperms.

Anatomically, each testis is encased in a capsule of white fibrous connective tissue called tunica albuginea. Each testis has several highly coiled tubules called **seminiferous tubules** (Fig. 21.2) where the sperms are produced. Between the seminiferous tubules is the connective tissue, which contains clumps of interstitial cells, also called **Leydig cells**. These cells secrete **testosterone** the male sex hormone. Testosterone maintains the primary and secondary sexual characteristics in males.

(ii) Epididymis

It is a long highly coiled tube which remains attached to the testis and lies within the scrotal sac. Epididymis stores spermatozoa (sperms) and serves as a passage for their transport from the testis.

(iii) Vas deferens (sperm duct)

Each epididymis continues as **vas deferens**. It enters the abdominal cavity, passes over the urinary bladder and joins the duct of seminal vesicle to form the **ejaculatory duct.** The ejaculatory duct opens into the urethra.

(iv) Urethra

The urethra in males is about 15-20 cm long and is differentiated into three parts—an anterior prostatic part which passes through the prostate gland; a middle membranous part; and a posterior penile part which passes through the copulatory organ, the penis. Urethra functions as a passage for both semen and urine.

(v) Penis

Penis is a cylindrical, spongy, muscular and a highly vascular (supplied with blood vessels) copulatory organ in males. The urethra runs through it centrally and serves as a common passage for urine and semen. During sexual excitement, the spongy tissue gets filled-up with blood, making it erect and stiff. Externally, the penis is covered by skin. The tip of the penis is soft and highly sensitive. It is called **glans penis**. It is covered by a loose fold of skin called prepuce which can be retracted. The functions of various male parts are given in table 21.1.

Table. 21.1 Important functions of male reproductive organs in humans.

Organ	Function
Seminiferous tubules in testes	Produce sperms
Epididymis	Stores sperms in a viable but immobile state
Sperm duct (vas deferens)	Contractions help in the passage of sperms into urethra during ejaculation
Seminal vesicles and prostate gland	Secrete fluid which activates and nourishes sperms
Urethra	Contractions expel semen from penis during ejaculation (urethra also carries urine to exterior)
Penis	Contains spongy tissue and serves as the copulatory organ

21.2 b (iii) Organs associated with human male reproduction system

Accessory glands

The accessory glands include seminal vesicles, prostate glands and Cowper's glands.

Seminal vesicles. A pair of seminal vesicles are present at the base of the urinary bladder. The seminal vesicles store sperms that descend from the testis and secrete seminal fluid. The seminal fluid is a viscous fluid which provides nourishment to the sperms. This secretion forms about 40-80 per cent of the ejaculate (semen thrown out of the penis).

Prostate gland. Prostrate gland surrounds the first part of the urethra. It secretes an alkaline fluid which is discharged into the urethra. This fluid keeps the sperms alive and helps them to swim vigorously. Secretion of prostrate gland forms about 5-30 per cent of the ejaculate.

Cowper's glands or Bulbo-urethral glands. These are paired glands that lie below the prostate gland and join the urethra at a short distance from that of the prostate gland. Cowper's glands secrete a white, viscous, alkaline secretion resembling mucous which acts as a lubricant.

21.2b (iii) Spermatozoa and semen

The process of formation of sperms is termed Spermatogenesis

The spermatozoa are male gametes produced by the testes. Structurally, human sperm has three main parts—head, neck and tail. The tip of a sperm is covered by a cap-like structure, **acrosome**, which helps the sperm to penetrate inside the egg during fertilization. The structure of a human sperm is shown in Fig. 21.3.

Notes

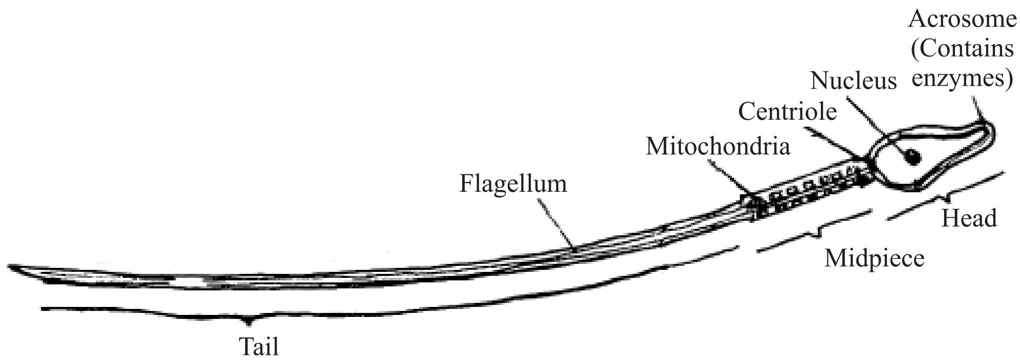


Fig. 21.3 Structure of human sperm.

Spermatozoa are immotile when stored in the epididymis but get activated and motile by the secretions from the accessory reproductive glands in males. The secretions of various accessory glands along with sperms form the **semen**. The sperms are released in millions. In one ejaculation about 200,000,000 (2×10^8) sperms are discharged. Sperms when introduced into the vagina of the female move with the speed of 2 mm/minute in side the body of the female.

Fig. 21.4 shows the course of sperms from their production in the testes to reach the urethra in penis.

Seminiferous tubules in testes produce sperms

↓

Sperms pass to vasa efferents through network of tubules

↓

Sperms are stored in epididymis in viable but immotile stage

↓

Vas deferens (sperm ducts)

↓

Urethra in penis

Fig. 21.4 The course of sperms in male.

21.2.2 Female reproductive system

The female reproductive system consists of the following organs :

A pair of ovaries, a pair of fallopian tubes, uterus, vagina and external genitalia (Fig. 21.5).

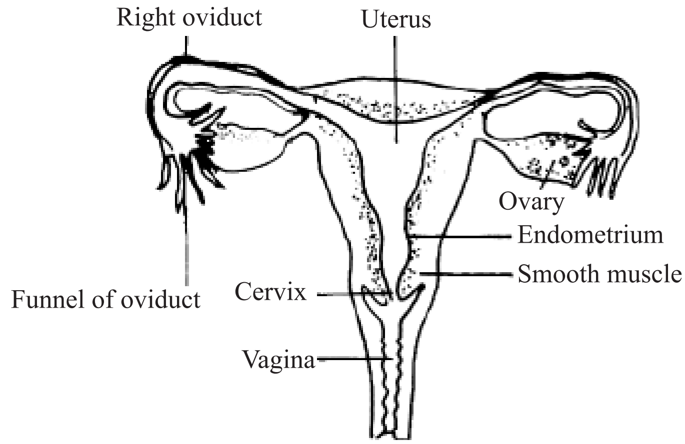


Fig. 21.5 Female reproductive system

(i) Ovaries

There is a pair of ovaries, which lie in the lower part of the abdominal cavity, one on each side of the body. Ovaries produce ova and also secrete female sex hormones, oestrogen and progesterone. The process of formation of egg in the ovary is known as **oogenesis**.

If a section of the ovary is cut, eggs at various stages of maturing can be seen. Each egg begins as a primary follicle. Follicular cells then cover the egg and a cavity called **antrum** is formed. This is the mature egg called **Graffian follicle**. The egg then gets released (ovulation) from the ovary leaving the empty follicle called **corpus luteum** (Fig. 21.6).

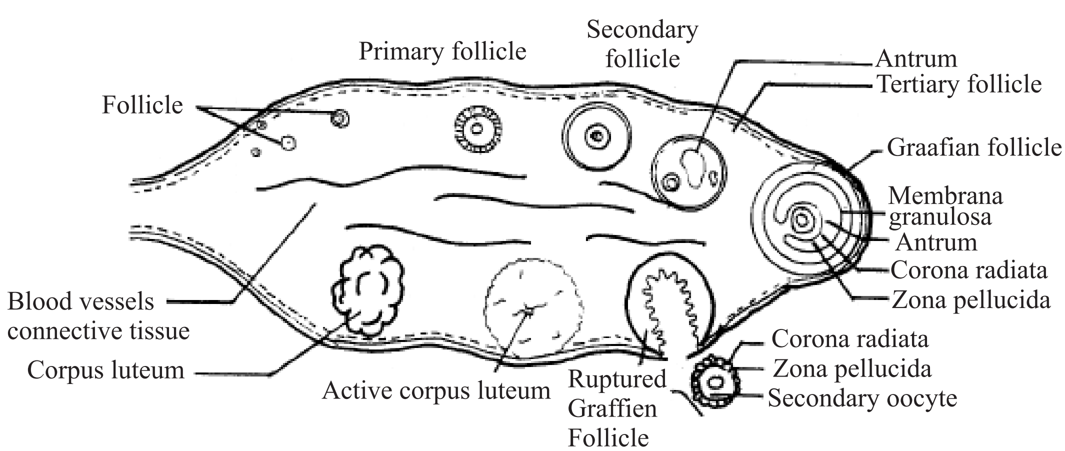


Fig. 21.6 Ovary showing microscopic structure

(ii) Fallopian tubes (oviducts)

There are two oviducts (or Fallopian tubes) in female reproductive system. Each oviduct is about 10-15 cm long. The proximal funnel-shaped end of each oviduct lies near the ovary and is called **infundibulum**. Its margin bears finger-like projections called **fimbrae**. Each infundibulum continues as a thin and coiled tube called oviduct or **Fallopian tube**. Both Fallopian tubes open into the uterus.

(iii) Uterus

The uterus is a pear-shaped, muscular, thick-walled organ. It is about 7 cm long, 5 cm broad, and 2.5 cm thick. The wall of the uterus comprises of three coats—the innermost **endometrium**, middle **myometrium**, and outermost **perimetrium**. The endometrium layer is richly supplied with blood vessels. There is a sphincter muscle that closes the lower end of the uterus where it joins the vagina.

(iv) Vagina

Vagina is the organ where the penis is inserted during coitus (sexual act) for the discharge of semen. It is a muscular tube about 7-10 cm in length. It serves as the birth canal during child birth and also acts as a duct for the passage of uterine secretions and menstrual flow.

The vagina opens to the outside by an opening. The opening of vagina is normally obstructed in a virgin female by a perforated membrane, the **hymen**. In a human female, the urethra and the genital duct have separate openings. Functions of various female reproductive parts are summarised in table 21.2.

Table 21.2. Important functions of female reproductive organs in humans.

Organ	Function
Ovary	Manufactures eggs
Oviduct (or Fallopian tube)	Site of fertilization; transfers fertilized egg/embryo to the uterus
Uterus	Inner lining receives, protects and nourishes embryo; contractions of muscular wall expel baby during birth
Cervix (neck of uterus)	Produces watery mucous that serves as a lubricant for the penis and as medium, in which sperms swim after ejaculation
Vagina	Receives penis during intercourse; passage for baby during birth
Clitoris (external sensual organ)	Equivalent to the male penis;

21.2.3 Menstrual Cycle in Human Females

In a human female, the fertility period extends from the age of puberty, i.e. about 12-13 years up to menopause, i.e. 45-50 years. The stage of puberty is marked by the appearance of secondary sexual characteristics.

Some Basic Facts

Does an irregular menstrual cycle cause any problems?

When a girl begins menstruating, it may take sometime for her periods to become regular. Also, sometimes her menstrual cycle may become irregular, and her periods may be delayed or may occur earlier than the expected date because of illness or mental tension such as stress or depression. Irregularities in the menstrual cycle are quite common among young girls who have just begun to menstruate. However, if one does not menstruate then it is important to consult a doctor or a health worker.

How does one maintain hygiene during the menstrual period?

- Daily bathing along with regular/daily washing of the genital area is essential.
- Sanitary pads and/or cloths used should be changed at least twice a day, if not more frequently.
- It is important to maintain menstrual hygiene in order to reduce the risk of contracting an infection of the female reproductive tract.
- If pads or napkins are not changed frequently, the old blood begins to smell. This may lead to social embarrassment.
- Home-made sanitary napkins should be washed thoroughly with hot water and soap, and should be dried in a sunny and airy place. They should be stored in a clean and dry place.
- Moderate exercise and sufficient rest are also important.

The onset of menstruation in a female is called **menarche**. It starts at an age of about 11-13 years. The permanent stoppage of menstruation in a female is called **menopause**. It occurs at an age of about 45-50 years. At the time of menopause, ovulation and menstruation stop and the reproductive organs decrease in size.

Between puberty and menopause, the female reproductive system passes through a regular monthly sequence of events called the **menstrual cycle**.

During **menstrual cycle** (Fig. 21.7), an ovum is matured and released once every 28 days. However, many a times, due to some reasons this period may increase or decrease. The menstrual cycle starts with the menstrual flow, during which the cellular lining of the uterus, with blood flow, is shed off. This process continues for 3-4 days. From the 5th upto the 13th day of the onset of menstrual cycle, growth and maturation of the Graafian follicle takes place. Graafian follicle is the final stage in the maturation of an ovum inside the ovary. It consists of an ovum and a mass of cells surrounding it. The Graafian follicle also produces a hormone, **oestrogen**, which stimulates the uterus to prepare itself to receive the ovum. The cells lining the uterus grow rapidly and develop a dense network of blood vessels.

Ovulation takes place 13-14 days after the onset of menstruation. The Graafian follicle ruptures to release the ovum. The cells of the ruptured follicle form the **corpus luteum** which secretes the hormone, **progesterone**. The ovum reaches the uterus via the fallopian tube on the 13th or 14th day and remains there up to the 16th day (for 48-72 hours). If the ovum does not receive any sperm during this period it starts degenerating. At the end of the 28th day this ovum is rejected along with the uterine lining. This marks the start of a slow disintegration of the thickened lining of the uterus and the next menstrual cycle.

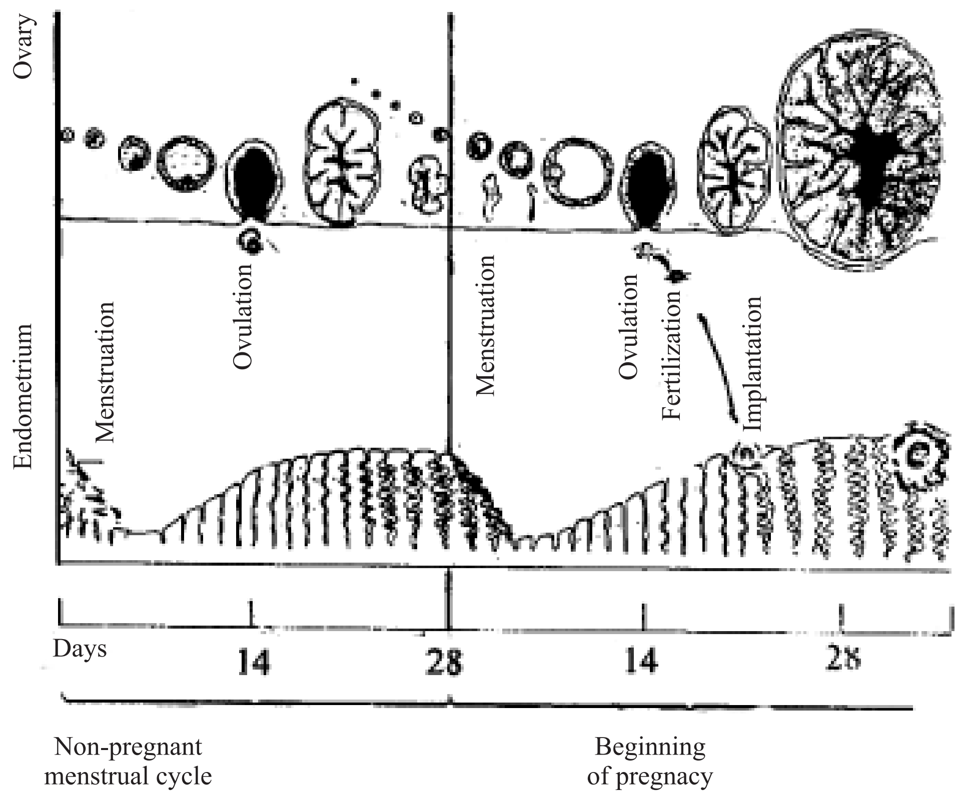


Fig. 21.7 Graphical representation of menstrual cycle

What happens to the menstrual cycle if the ovum receives sperm and fertilization occurs?

If the ovum receives sperm and gets fertilized, menstruation (and ovulation) cease for as long as the woman is pregnant. This is because progesterone is produced continuously first by the corpus luteum (which persists in the ovary) and later by the placenta.

INTEXT QUESTIONS 21.1

1. At what age do human males and females attain puberty?

   ....

2. Name the tubules present in the human testis.

   ....

3. Name the various parts of the following,

   (i) Human male reproductive system

   ....

   (ii) Human female reproductive system

   ....

4. Name the three types of accessory glands found in the human male reproductive system.

   ....

5. State the functions of the following.

   (a) Seminal vesicles ....

   (b) Prostate glands ....

   (c) Uterus ....

6. What is a gemmule? Explain its importance in the life of sponges.

7. State the functions of the following in insects:

   (a) seminal vesicles in male

   (b) spermatheca in female

   (c) testes in males

   (d) ovaries in females

21.2 FERTILIZATION, PREGNANCY AND DEVELOPMENT OF THE EMBRYO

21.2.1 Fertilization and implantation

Spermatoza remain viable in the female genital tract from 24 to 72 hours. For fertilisation, sperms are introduced into the female body. One sperm fuses with the ovum in the fallopian tube.

If the ovum happens to meet a sperm, the two unite to form a **zygote**. 13-14 days after onset of menstruation are most favourable for conception (pregnancy). The zygote immediately begins to divide and passes down the fallopian tube to the uterus and fixes itself to the wall of the uterus. This fixing of the embryo in the wall of the uterus is called **implantation** and the female is said to be pregnant. Implantation takes place about a week after fertilization.

21.2.2 Placenta

Placenta is an association between maternal and foetal tissue meant for some extermely important physiological exchange. The developing embryo is attached to the uterus by a tissue called **placenta** (Fig. 21.8). **Umbilical cord** is a tough structure that serves as the blood vascular connection between the foetus (developing embryo) and uterine wall. From the first few weeks of development, the embryo is enclosed in a sac called **amnion** which is filled with **amniotic fluid**. Amniotic fluid acts as a shock-absorber and helps to protect the embryo from damage.

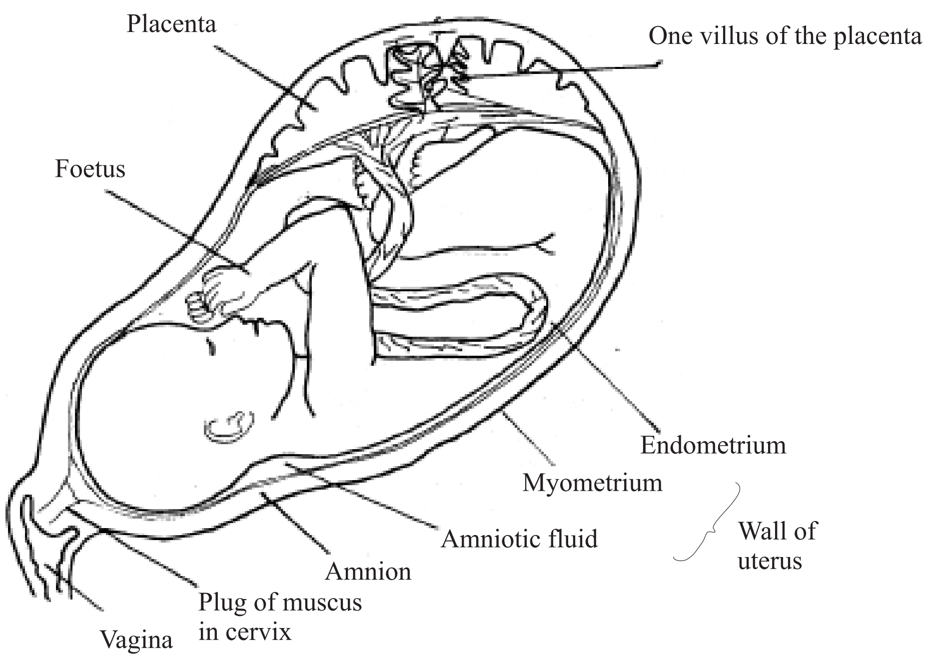


Fig. 21.8 Foetus and placenta

Placenta serves as a tissue through which oxygen and food are supplied from the maternal blood to the foetus. It also transports carbon dioxide and excretory waste from the foetal blood to the maternal blood.

Fig. 21.9 Summarises the steps in fertilisation of human egg, its inplantation and development in the uterus upto birth.

Sperms from male are deposited into the female reproductive system

↓

Egg released from the ovary

↓

Union of the sperm and egg in the fallopian tube

↓

Fertilization and formation of zygote (Day 1)

↓

Repeated division of zygote leading to formation of
a spherical mass of cells called morula (Day 4)

↓

Early embryonic stage is (called blastocyst) formed (Day 5)

↓

Blastocyst attaches to uterine wall
(i.e. Implantation occurs) (Day 6-7)

↓

The developing Embryo about the size
of a pea is formed (4 weeks)

↓

Embryo (now called foetus) with human features, limbs appear.
It floats in amniotic fluid (6 weeks)

↓

Birth of human infant (about 40 weeks)

Fig. 21.9 Development of human embryo

Placenta is permeable to respiratory gases, nutrients and antibodies. The membrane prevents harmful material from reaching the embryo. It does not allow the passage of germs from the mother to the foetus. However, if the mother is already infected with HIV, then HIV can pass through the blood to the embryo. Placenta produces the hormone progesterone. Egg-formation (ovulation) and menstruation also stop as pregnancy continues. However, these are resumed after child birth.

The hormone Oxytocin from posterior pituitary is responsible for uterine contractions for child birth.

21.2.3 What happens during childbirth?

- The uterus undergoes occasional contractions (labour).
- The amnion bursts and the amniotic fluid is discharged.
- The uterus contracts vigorously, expelling the baby.
- The baby's lungs start functioning and the baby takes its first breathe.
- The umbilical cord is tied and cut.

- After birth the placenta gets discharged.
- The breasts start producing milk.

21.2.4 Lactation

The secretion of milk from the mammary glands is called lactation and the period during which the mammary gland secretes milk is called **lactation period**. The first seeretion that comes out from the mammary glands of the mother, just after child birth, is called **colostrum.** It is rich in nutrients, fats and proteins. Colostrum also contains antibodies (Immunoglobulin A-IgA) that provide passive immunity to the new born infant.

The synthesis of milk from the mammary glands is stimulated by the hormone **prolactin** which is secreted by the anterior lobe of the pituitary gland. Another hormone called **oxytocin** secreted by the posterior lobe of pituitary gland stimulates the release of the milk from the mammary glands.

21.2.5 How twins are Produced

Usually, only one ovum is released by an ovary in every reproductive cycle. If this ovum receives sperm and gets fertilized, one baby is born to the mother. But sometimes two eggs may be released and fertilized by two different sperms. Such siblings are called **fraternal twins** who may be brother and sister, or brother-brother, or sister-sister. But in certain cases, only one egg is released and gets fertilized. After this, it divides into two, and the two cells then separate and start developing independently into two separate individuals. They are identical in all respects and called **identical twins**. They are always of the same sex.

Siamese twins

The twins produced from one egg which fail to separate are called Siamese twins. The first case of Siamese twins was of twin boys born to a Chinese mother in Siam, (now Thailand) in 1811. These were joined at the thoracic region. These twins lived up to an age of 65 years.

The Siamese twins can sometimes be surgically separated. However, it depends upon the extent of their joining.

21.3 NEW MEDICAL TECHNIQUES IN REPRODUCTION

There are many new medical techniques in the field of reproduction to help infertile males and females produce babies. Some of these are given here.

Test tube babies

In some women the oviducts (Fallopian tubes) are blocked. This prevents the ova from being fertilized. This problem can be overcome by the **test tube baby technique**. In this technique, one or more ripe ova are sucked from a woman's ovaries using a special syringe. These ova are placed in a dish containing sperms from her male partner under optimum conditions for a few hours. Sperms fertilize the ova which form an embryo. One embryo is then inserted into the woman's uterus where there is a chance it will implant and develop into a baby.

Artificial insemination

Human semen can be rapidly frozen using liquid nitrogen and stored in sperm banks for several years without losing its fertile condition. It is then thawed, and introduced into a woman by means of a syringe at a time when ovulation takes place. This is called **artificial insemination**.

Fertility drugs

In some women ovaries fail to develop the Graafian follicles needed to release ripe ova into their reproductive tract. It is now possible to artificially stimulate follicle production by injecting sterile women with a fertility drug containing FSH (follicle stimulating hormone) obtained from animals.

INTEXT QUESTIONS 21.2

1. State the main function of placenta.

   ....

2. Define the following terms.

   (i) Implantation ....

   (ii) Placenta ....

   (iii) Morula ....

   (iv) Amnion ....

3. Name the fluid surrounding the foetus in the uterus.

   ....

4. Write the function of:

   (a) Prolactin

   (b) Oxytocin

5. The first milk that comes out of the mammary gland of the mother is called .... Why is this first milk important for the child?

21.4 POPULATION–PROBLEMS AND CONTROL

21.4.1 Few terms to remember

- **Human population** : The sum total of human beings on earth.

- **Demography** : The scientific and statistical study of human population. It deals with population growth, its composition (age, sex ratio) and its distribution in space.
- **Population density** : The number of individuals per square kilometre (km^2) at any given time.
- **Birth rate (natality)** : The number of live births per 1000 individuals of population per year.
- **Death rate (mortality)** : The number of deaths per 1000 individuals of population per year.
- **Population growth rate** : The difference between the birth rate and the death rate.
- **Census** : The official data of registered number of people in a selected area.

21.4.2 Population growth in India

Did you know that India is the second most populous country in the world, next to China. India comprises more than 15% of world's total population. The population of India was about 24 crores in the year 1901. Except for a slight fall in 1911-21, the population of India has been steadily increasing for the last 100 years. As per the census of 2001, as on 1st March 2001, the population of India was 1,027,015,247, i.e. about 102.7 crores. This alarming rate of rise in human population is a cause of concern. Now in 2014, the population of India is:

Table 21.3 The population of India during last 100 years

Year	Approximate population (in crores)
1901	23.8
1911	25.2
1921	25.1
1931	27.9
1941	31.8
1951	36.1
1961	43.9
1971	54.8
1981	68.5
1991	84.6
2001	102.7

21.4.3 Factors responsible for population explosion in India

Advancement in agriculture : With the advancement in the agriculture sector, the availability of food has increased leading to less of starvation and malnutrition.

Advancement in medicine : With the advancement in medicine, various diseases can be controlled now. This has led to increase in life span. Thus, more and more people live longer, reach reproductive age and produce more children.

Religious and social customs : Because of prevailing social custom and beliefs many people do not accept family planning measures, leading to rise in population.

Industrialization : Advancement in industrialization helps in better storage and distribution of food, more employment opportunities and more prosperity.

Illiteracy : A sizeable number of our population is educated, and yet a large proportion is still illiterate. They are not aware of the functioning of reproductive system and hence the consequence of overpopulation.

Economic reasons : Children instead of attending school go to work and increase the income of the family.

Desire for a male child : Even after so much emphasis on gender equality, because of patriarchy in many families, the male child is considered to be essential for continuing the name of the family. The parents want to have at least one son and in this process they give birth to many children sometimes.

21.4.4 Problems posed by increasing population

The problems posed by increasing population are of two types:

1. Problems posed to large families, and
2. Problems posed to the Country.

1. Problems for large families

A large family having many children suffers many problems such as

(a) **Poor health of the mother :** Because of frequent pregnancies, the mother may suffer from ill-health.

(b) **Poor housing :** More family members need more space. The family may not be able to afford a good, clean and spacious house.

(c) **Economic pressure :** The large family will need more resources, leading to immense economic pressure on the parents and children affecting the quality of life.

(d) **Poor health :** The family members may not get enough food, leading to malnutrition and deficiency diseases. They will require constant medical support.

Also, because of medical facilities being expensive, it may not be possible to provide everyone adequate medical support.

(e) **Improper education :** Proper educational facilities for children may not be affordable.

Problems Posed to the Country

A high population growth has severe environmental implications like over-crowding, decrease in per capita income, depletion of food, land, fuel and consumer resources. Some such problems are listed below:

(a) **Urbanization and environmental degradation :** Due to increasing population, farmlands in the rural areas can no longer support additional people. Thus, a large number of people migrate to urban areas with the hope of finding jobs and a better life. This leads to an increase in the urban population.

The growth in urban population stresses the urban environment by increasing the number of squatter settlements, and slums with no proper sanitation facilities, thus causing air, water and soil pollution beyond permissible limits.

(b) **Increasing population and transportation :** Increase in population requires a corresponding increase in the means of transport. Increase in the number of automobiles as a consequence of phenomenal growth in population has increased the pollution load (air pollution, water pollution and solid waste pollution).

(c) **Increasing population and education :** Education is most important for economic and social upliftment. Although literacy rate is growing, we still have a very large number of illiterates in the country. The increasing population further adds up to the problems of providing education to all.

(d) **Increasing population, agricultural development and environmental degradation :** In order to meet the food requirement of the ever-increasing population of the country new agricultural techniques have been adopted. Some of these have proved to be detrimental to the environment.

(e) **Increasing population and food requirements :** Increasing population will need more food. For this purpose new agricultural land has to be created. So, forests have been cut down for cultivation. Due to deforestation, excessive irrigation and natural hazards, such as floods are frequent, land is being degraded and wasteland is increasing. The increased use of fertilizers and pesticides to boost agricultural productivity has immense adverse effects on land and water resources of our country. Agricultural land has been extensively polluted due to pollution from fertilizers and pesticides.

(f) **Increasing population and water :** The availability of water is limited. Increasing population needs more water for drinking, bathing, washing etc. Thus, availability of water is becoming scarce.

(g) **Increasing population and depletion of mineral reserves :** Our mineral reserves are limited, once finished they cannot be replenished (i.e. they are non-renewable). More population means more requirements of minerals, leading to fast depletion of mineral resources.

(h) **Increasing population and depleting energy sources :** Energy is needed for almost all our day-to-day activities whether for cooking, transportation, factories or at home. Presently we are largely dependent on fossil fuels such as coal and petroleum for energy. At the current rate of consumption, our fossil fuel reserves will be exhausted in a short time.

INTEXT QUESTIONS 21.3

1. List any **four** reasons for population explosion in India.

   ....

2. What is the inter-relationship between population, environment and development?

   ....

3. What is the effect of uncontrolled population growth on us and our nation?

   ....

4. How does population growth influence urbanization and environmental degradation?

   ....

5. Relate the indiscriminate increase in population with the standard of living in our country.

   ....

21.4.5 Population control and family planning

It is very necessary to control the overgrowing population. It is necessary to educate people to accept small family norms and create awareness about population explosion and its impact on the family, society and the nation. The government has taken many measures for providing family planning guidance and support, and family welfare measures.

There are various ways of preventing fertilization and hence to check the increase of population. Some of these are discussed here.

Education

The most effective method for control of population is to impart education to the masses about the consequences of population explosion and make them aware of various ways of fertility control. Education helps to make people aware of the advantages of a small family and the disadvantages of a large family.

Preventive methods for population control and family planning.

Following are some methods of birth control

(i) **Rhythm method –** The period in the menstrual cycle before ovulation phase is termed 'safe period' as no egg is available for fertilization by the sperm. This method, however, is not reliable.

(ii) **Use of condoms in males and diaphragms in females** prevent sperms from meeting the ovulated egg.

(iii) **Intrauterine devices** such as copper T are inserted in the female body so that implantation is not possible. This method requires advice and help from the medical doctor.

(iv) **Oral contraceptive pills** are tablets which have to be taken as per directions from a medical practitioner. These pills interfere with ovulation and in turn prevent fertilization.

(v) **Vasectomy and Tubectomy** are surgical methods. In males, the vas deferens through which sperms travel out of epididymis is ligated (tied) by the surgeon to prevent sperms from going out of the body. This method is temporary and can be reversed by the surgeon if required. For permanently preventing fertilization the vas deferens is cut and the open ends ligatured (tied by thread). Tubectomy is sterilization of the woman by cutting fallopian tubes and ligaturing them so that ovulated egg cannot pass down for fertilisation.

In case preventive measures fail or if the foetus is found to have a defect, the foetus may have to be aborted.

Abortion or Medical Termination of Pregnancy (MTP) is to remove the unwanted foetus from the mother's body. However, it is advised to always seek professional medical help for MTP.

WHAT YOU HAVE LEARNT

- A process by which a living organism is able to produce more of its own kind is known as reproduction.
- In asexual reproduction only one organism is involved, no gametes are produced and no fertilization takes place. Gemmules are reproductive bodies for asexual reproduction in sponges.
- In sexual reproduction both male and female gametes are produced and the process of fertilization takes place. The human reproduce sexually.
- The age of 13-14 years in human males and 11-12 years in human females is called puberty in human beings. At this age, sex organs get matured and several secondary sexual characteristics appear in them.

- The male reproductive system consists of a pair of testes, a pair of epididymis, a pair of vasa differentia, urethra, penis and accessory glands.
- The female reproductive system consists of a pair of ovaries, a pair of Fallopian tubes, uterus, vagina and external genitalia.
- Testes are extra-abdominal in human males.
- The fixing of the embryo in the uterine wall is called implantation.
- Placenta is an association between maternal and foetal tissues meant for exchange of material between pregnant mother and developing foetus.
- Loctation is the production of milk in a mother soon after delivering the baby.
- Twins are of two types—fraternal and identical twins.
- The scientific and statistical study of human population is called demography.
- Advancement in agriculture, medicine, industrialization, religious and social customs, illiteracy, economic reasons and desire for a male child are some factors responsible for the unchecked growth of population in India.
- The enormous increase of the population can be controlled by education, methods.
- In cockroach there are well developed sex organs in males and female as sexes are separate.

TERMINAL EXERCISES

1. Define the following terms.

   (i) Demography (ii) Vasectomy (iii) IUD

2. Mention if the following statements are True (T) or False (F) and rewrite the wrong statements in the correct form.

   (i) Fertilization occurs in vagina.

   (ii) Oxygen and nutrients diffuse from mother's blood into foetus's blood through amnion.

   (iii) Testes produce testosterone hormone.

   (iv) Pregnancy in women can be prevented by the method of vasectomy.

   (v) Tubectomy involves the cutting and tying of the vas deferens in male.

3. Choose the odd one in each of the following.

   (i) ovary; Fallopian tube; ureter; uterus

   (ii) epididymis; urethra; vas deferens; uterus

(iii) Graafian follicle; corpus luteum; Leydig cell

(iv) amnion; corpus luteum; amniotic fluid; umbilical cord

4. Match the terms of Column I with those of Column II and write down the matching pairs.

Column I	Column II
1. Acrosome	(a) Testis
2. Ovulation	(b) Luteinizing hormone
3. Villi	(c) Spermatozoa
4. Fertilization	(d) Progesterone
	(e) Placenta
	(f) Vagina
	(g) Fallopian tube

5. What is reproduction? List tile organs of the human male reproductive system.

6. What is placenta? How is the placenta beneficial to the mother and the foetus?

7. What is the significance of testes being located in scrotal sac outside the abdomen of human males?

8. Write in a sequence the region through which sperm travels from seminiferous tubules up to the urethral opening in human males.

9. How can the knowledge of process of reproduction help in reducing population growth? Give reasons.

10. How does increasing population affect environment?

11. Name the following.

(i) The organ in which the foetus develops in a human female.

(ii) The male gamete in humans.

(iii) The fluid surrounding the developing embryo.

(iv) Stage when menstruation and ovulation stops in females.

(v) The surgical method of contraception in human female.

12. Differentiate between the following.

(i) Implantation and pregnancy

(ii) Graffian follicle and corpus luteum

(iii) Identical twins and fraternal twins

(iv) Birth rate and death rate

(v) Vasectomy and tubectomy

13. Draw the outline of the cross section of the male reproductive system.

(i) Label the following parts.

(a) testis (b) epididymis

(c) seminal vesicles (d) vas deferens

(ii) Name the hormone produced by the testis.

(iii) Why are sperms produced in large numbers?

(iv) State the function of the seminal vesicles.

14. Write a note on:

(i) Lactation in humans

(ii) Gemmule (iii) Cockroah ovaries

ANSWERS TO INTEXT QUESTIONS

21.1 1. Male 13-14 years; Female 11-13 years

2. Epididymis

3. (i) Testes, epididymis, vas deferens, urethra, penis

(ii) Ovaries, fallopian tubes, uterus, vagina

4. Seminal vesicles, prostate glands, cowper's glands

5. (a) Stock sperms and provide them nourishment

(b) Secretes an alkaline fluid, thin fluid keeps the sperms alive and helps them to swim vigorously.

(c) Secretes a white viscous, alkaline secretion that acts as a lubricant.

(d) Inner lining receives, protects and nourishes embryo; contraction of muscular wall exits baby during birth.

6. Gemmule is a reproductive body for asexual reproduction in sponges.

Gemmules help sponges overome periods of drought and form new sponges when favourable conditions arise

7. (a) Seminal vesicles store sperms; (b) receives sperms during copulation

(c) generate sperms (d) produce eggs.

21.2 1. supplies oxygen and food from maternal blood to foetus and transports carbon dioxide and excretory waste from foetal blood to the maternal blood.

2. (i) the fixation of morula in the wall of uterus is called implantation

   (ii) Association between maternal and foetal tissue for physiological exchange, developing embryo is attached to the uterus by a tissue called placenta.

   (iii) Morula : The zygote begins to divide and form a mass of cells called morula.

   (iv) Amnion : From the first few stages of development, the embryo is enclosed in a sac called amnion.

3. Amniotic fluid

4. Prolactin stimulates synthesis of milk in mammary glands in women soon after delivering a body.

   Oxytocin stimulates uterine contration for child birth and squeezing of milk in mother for new born infant

5. Colostrum; rich in nutrients, fats and protiens. Provides passive immunity

21.3 1. (i) Advancement in agriculture (ii) Religous and social customs

   (iii) Illiteracy (iv) Desire for a male child

2. See text sub-section 21.4.4

3. See text sub-section 21.4.4

4. See text sub-section 21.4.4

5. See text sub-section 21.4.4

22

PRINCIPLES OF GENETICS

It is a common observation that seeds of mango trees germinate to grow into mango plants, and dogs give birth to puppies only and not into the young ones of any other animal. Humans give birth to human beings. The tendency of offsprings to inherit parental characteristics is termed as '**heredity**' and the study of science of heredity and the reasons governing the variation between the parents and their offsprings, is called '**Genetics**'. Genetics also seeks to answer questions like why two offspring of same parents look different, why some people have dark, and others have fair complexion. In other words, why is there **variation** among individuals of the same kind. This lesson deals with heredity and the reasons behind the variation among individuals of the same species. It also includes diagnostic techniques to find out the bases for types of sex determination, inheritance of blood groups in humans, hereditary disorders and gives an insight up the human genome as amniocentesis.

OBJECTIVES

After completing this lesson, you will be able to :

- *explain the terms heredity and Genetics;*
- *describe Mendel's experiments on garden pea and the principles derived;*
- *define the terms hybridization, alleles, trait, dominance, recessive, homozygous, heterozygous, genotype, phenotype;*
- *explain incomplete dominance, polygenic inheritance, pleiotropy and lethal genes with examples.*
- *explain the chromosome theory of heredity;*
- *define and give examples of linkage, crossing over and cris-cross inheritance;*
- *explain sex determination in honey bees, birds and humans.*
- *justify mitochondrial inheritance as a case of maternal inheritance;*
- *describe the human karyotype;*
- *list and describe the causes and symptoms of some common genetic disorders e.g. Colour blindness, haemophilia, Down's syndrome, Turner's syndrome, Klinefelter's syndrome;*

- *describe the inheritance of Rh factor and explain its significance during pregnancy;*
- *explain inheritance of human blood groups;*
- *explain the diagnostic technique of amniocentesis and give its significance;*
- *give a brief idea of genomics and human genome.*

22.1 HEREDITY AND VARIATION

Whenever an infant is born in a family, the relatives begin to wonder about the resemblance of the infant's eyes, facial features, complexion, colour of hair with those of the parents, siblings and grandparents. The source of such resemblances and differences are in the "genes" that are passed down form parents to children and so on generation after generation. This inheritance of genes is termed '**heredity**' the study of reasons of heredity is '**Genetics**'. New individuals develop features according to the genes inherited by them from their parents.

The transmission of characters from one generation to the next, that is from parents to offsprings is known as heredity.

It is further observed that siblings from same parents are unique and differ from each other except the identical twins. Such differences are termed **variations**.

Variation means differences between parents and their offsprings or between offsprings of same parents or between members of the same population.

Variation in a population is very important. It has survival value for the population. This is because if the environment changes, some individuals (variants) may be able to adapt to new situations and save the population from dying out. Variation arises due to **mutation** or sudden change in the genes. Variation also arises because genes get shifted and exchanged during meiosis at the time of formation of gametes, giving rise to new gene combinations (Recall from lesson 8 on cell and cell division about chiasma formation and lesson no. 20 on reproduction in animals for gamete formation and fertilization). At fertilization, there is random mixing of paternal and maternal chromosomes with different gene combinations. Such a source of variation which is most common is called genetic **recombination**.

Heritable Variations generally arise because of mutation and recombination.

22.2 MENDEL'S EXPERIMENTS ON THE GARDEN PEA AND PRINCIPLES OF INHERITANCE

Sir Gregor Johann Mendel (1822 to 1884) was Austrian monk who used garden pea (*Pisum sativum*) for his experiments on plant breeding and published his results in 1865. His work, however, was independently rediscovered in 1900, long after Mendel's death, by Tschermak, Correns and DeVries. But since Mendel was the first to suggest principles underlying inheritance he is regarded as the founder or **father of genetics**.

22.2.1 Mendel's Experiments

Mendel designed his experiments in such a way that a pure tall variety of pea plants could be crossed to a pure dwarf variety. The anthers from flowers of tall plants were removed and their stigmas dusted with pollen from flowers of dwarf plants. The reverse experiment was also carried out, that is anthers of flowes borne on dwarf plants were removed and their stigmas were dusted by pollen from flowers of tall plants.

In the following spring, seeds from the new plants were collected and sown. Mendel found that all the plants of this generation called **first filial generation** or F_1 grew to be tall plants. He allowed them to self pollinate. Again he collected the seeds. The following year, after the seeds had been sown, he found that three quarters of these plants were tall and the rest dwarf. He repeated the experiment several times and found that the ratio of tall to dwarf plants was 3 : 1 (Fig. 22.1).

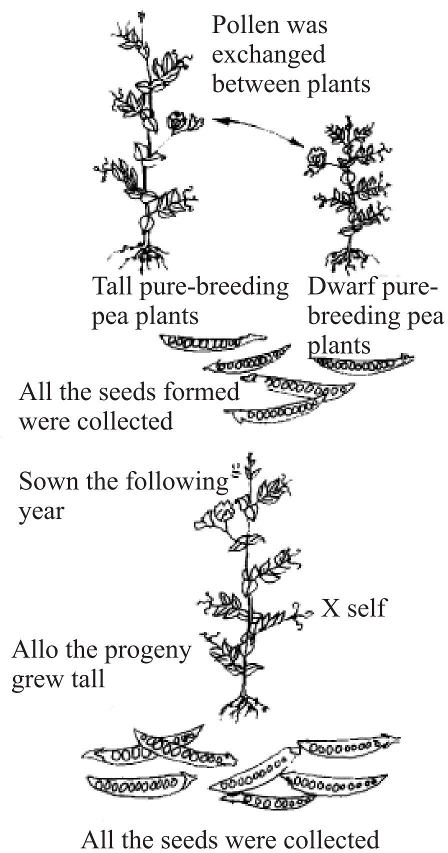


Fig. 22.1 Mendel's experiment with tall and dwarf plants.

In this way he tried to cross pea plants differing in seven such contrasting characters or **traits**. These were 1. red flowered and white flowered plants; 2. axillary flowered (flower arising in the axial of the leaf) and terminal flowered (flower arising at tip of stalk); 3. yellow seeded versus green seeded; 4. round seeded versus wrinkled seeded; 5. green pod versus yellow pod 6. plants with inflated pods versus those with constricted pod and 7. pure tall plants versus pure dwarf plants. Plants with these contrasting characters existed in varieties that were 'self pollinating' so that generation after generation they expressed only one type of feature (Fig. 22.2).

Crosses involving plants differing in the inheritance of **one contrasting feature only** are called **monohybrid crosses**. Mendel also tried crosses involving two contrasting features, such as tall and red flowered plants crossed with dwarf and white flowered plants. Such crosses are termed **dihybrid crosses**.

22.2.2 Mendel's Principles (laws) of inheritance

Based on the results of his experiments, Mendel postulated the following laws of heredity.

1. **Law of segregation or purity of gametes.** At formation of gametes, the two chromosomes of each pair separate (segregate) into two different cell which form the gametes. This is a universal law and always during gamete formation in all sexually reproducing organisms, the two factors of a pair pass into different gametes. Each gamete receives one member of a pair of factors and the gametes are pure.

   Mendel's factors later came to be known as genes.

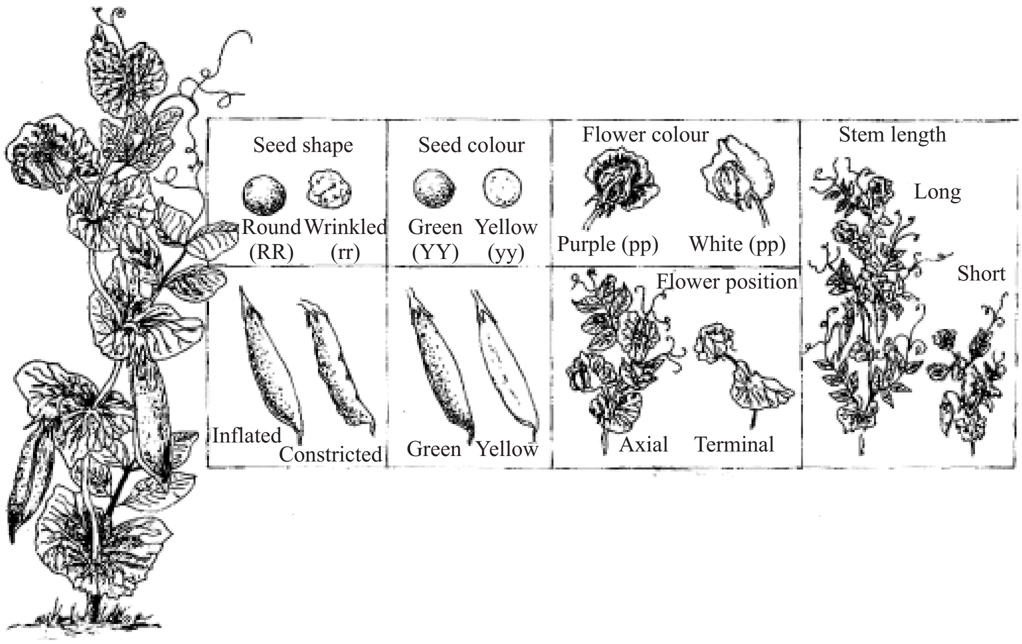


Fig. 22.2 Seven traits studied by Mendel

2. **Law of dominance.** During inheritance of many traits (e.g. eye colour, flower colour, seed shape) is controlled by **one pair of genes**. When the two genes of a pair are of the same kind (e.g. brown colour of eyes, red colour of flower) the condition is termed as **homozygous**. When a pair of chromosomes has the gene controlling the same feature (flower colour) in two different forms (red flower gene on one chromosome and white flower gene on another member of the pair (termed its **homologue**) the condition is termed **heterozygous.** The factors or genes for red and white flower olour are alternative forms of the same gene, that is, the gene for flower colour. Suh alternative forms of the same gene are termed as **Alleles**.

   The second law of inheritance maintains that when the two genes of a pair, represent contrasting characters **the expression of one is dominant over that of the other**. Thus if both genes of an allele are for tallness (represented as TT) that is **homozygous** or one gene is for tallness and another for dwarfness (Tt), that is **heterozygous**, the pea plants will be tall. The opposite of dominant gene is termed **recessive gene**. The recessive feature (e.g. dwarfness of the plant) is expressed only when both the genes of allele are in the homozygous condition (tt).

The law of dominance was found to be true in both monohybrid and dihybrid crosses in cases of all the seven characteristics studied by Mendel in the garden pea.

3. **Law of independent assortment** meaning whereby that in the inheritance of two features (each feature controlled by a pair of genes), genes for the two different features are passed down into the offspring **independently** (Fig. 22.3) i.e. the segregation of one pair of factors is independent of the segregation of the factors belonging to any other pair of factors or allelic pair.

	Red Tall		White Dwarf	
Parents	TTRR	×	ttrr	
gametes	TR		tr	
F_1	Tt		Rr	Tall, red (self)

F_2 progeny worked out below.

Genes in male and female gametes	TR	Tr	tR	tr
TR	TTRR Tall red	TTRr Tall red	TtRR Tall red	TtRr Tall red
Tr	TTRr Tall red	TTrr Tall white	TtRr Tall red	Ttrr Tall white
tR	TtRR Tall red	TtRr Tall red	ttRR Dwarf red	ttRr Dwarf red
tr	TtRr Tall red	TtRr Tall white	ttRr Dwarf red	ttrr Dwarf red

Fig. 22.3 Dihybrid phenotypic ratio

9 Tall Red : 3 Tall White : 3 Dwarf red : 1 Dwarf white

In Fig. 22.3 results show independent assortment in two pairs of genes. R stands for red flower colour, r for white flower colour, T for tallness and t for dwarfness.

You would have noticed that the composition of genes termed **genotype** controls the outside expression which we can see, that is the **phenotype**. The ratio of progeny in the crosses is therefore, the **phenotypic ratio**.

However, as more and more scientists began to devise genetic experiments, it became clear that Mendel's laws do not hold true in all cases. We shall learn about the deviations from Mendel's laws such as incomplete dominance, codominance and polygenic inheritance.

22.2.3 Reasons for Mendel's success

1. **Mendel succeeded in postulating laws of inheritane because of his choice of experimental plant** garden pea which has a short life cycle, has self pollinated bisexual flowers so that cross-pollination is not allowed and the true breeding behaviour of parents could be maintained. Because of the property of self pollination in garden pea plants, a large number of pure line of plants with several pairs of contrasting characters could be obtained in the same field.

2. **His selection of traits :** All the seven pairs of contrasting characters of pea plants considered by Mendel in his experiments showed complete dominance that helped Mendel to postulate the law of dominance and the law of segregation.

3. The factors for all the seven traits selected by Mendel for his experiments were either present on separate homologous chromosomes or if they were present on the same chromosome, they were apart so that the factors segregated independently & were not inherited together so that Mendal failed to discover linkage and crossing over.

4. **Mendel's methodology:** His technique of experimentation also helped him in discovering the Laws of Heredity :

   (i) Homozygous pure line plants with contrasting characters were crossed.

   (ii) Self pollination was prevented by removing stamens to bring about cross-pollination between the desired parents.

   (iii) Female plants were dusted with pollen grains from another plant with the contrasting feature and were tied in a bag to prevent any further pollination.

   (iv) Seeds were collected from plants of different generations and sown in time.

   (v) The results of different generations were maintained, and analysed statistically, by counting the individuals exhibiting different traits.

   (vi) He considered the inheritance of one character at a time, then he considered inheritance involving individuals differing in two contrasting characters.

   (vii) He performed reciprocal crosses and test crosses to confirm the results. (see section 22.3 for definition of these terms), and formulated the basic laws of heredity.

22.3 IMPORTANT TERMS IN GENETICS

- **Factor :** The unit of inheritance and expression of a particular character is controlled by inheritable units called factor (gene) which are present in pairs in parental cells and singly in the gametes.

- **Gene :** A segment of DNA molecule which determines the unit of inheritance and expression of a particular character.

- **Alleles or Allelomorphs :** Two or more alternative forms of a gene are called **alleles**. For example in pea plant, the gene for producing seed shape may occur in two alternative forms: smooth (S) and wrinkled (s). Genes for smooth wrinkled seeds are alleles of each other, and occupy same locus on homologous chromosomes.
- **Trait :** is the morphologically or physiologically visible character, e.g. colour of flower, and shape of seed.
- **Dominant trait :** Out of the two alleles or allelorrorphs of a trait, the one which expresses itself in a heterogygous organism in the F_1 hybrid is called the dominant trait (dominant allele) and the one that remains masked in F_1 individual but gets expressed in the next generation (F_2), is called **recessive**. Thus, if the allelic combination in an organism is Tt, and T (tallness) expresses itself but t (dwarfness) cannot, so T is the dominant allele, and tallness is dominant on dwarfness represented by "t'.
- **Recessive trait :** Out of the two alleles for a trait, the one which is suppressed (does not express) in the F_1 hybrid is called the recessive trait (recessive allele). But the Recessive allele does express itself only in the homozygous state (e.g. tt).
- **Genotype :** A class of individuals recognised based on its genetic constitution and breeding behaviour is called the genotype, e.g., the genotype of pure smooth seeded parent pea plant is SS and it will always breed true for smooth-seeded character, but plants having Ss on selfing would give rise to a population represented by 3 : 1 ratio for smooth seeded plants and wrinkled seeded plants.
- **Phenotype :** A class of individuals recognised based on outward appearance of a trait in an individual is the phenotype, e.g. Smooth-seeded shape or wrinkled shape of seeds represent two different phenotypes.
- **Homozygous :** An individual possessing identical alleles for a trait is termed homozygous e.g. SS is homozygous condition for smooth seeded character in garden-pea.
- **Heterozygous :** An individual with dissimilar alleles for a trait is termed heterozygous for e.g. Ss represents the heterozygous condition for smooth seeded character in garden pea.
- **Parent generations :** The parents used for the first cross represent the parent (or P_1) generation.
- **F_1 generation :** The progeny produced from a cross between two parents (P_1) is called **First filial** or **F_1 generation**.
- **F_2 generation :** The progeny resulting from self pollination or inbreeding of F_1 individuals is called **Second Filial** or F_2 generation.
- **Monohybrid cross :** The cross between two parents differing in a single pair of contrasting characters is called monohybrid cross and the F_1 offspring is the

Monohybrid. The phenotypic ratio of 3 dominants : 1 recessive obtained in the F_2 generation from the monohybrid crosses by Mendel was mentioned as 3:1 **monohybrid ratio**.

- **Dihybrid cross :** The cross in which two parents differing in two pairs of contrasting characters are considered simultaneously for the inheritance pattern is called dihybrid cross. The phenotypic ratio obtained in the F_2 generation from a dihybrid cross is called Mendelian dihybrid ratio (9 : 3 : 3 : 1), and the F_1-individual is called dihybrid (Ss Tt).
- **Hybridisation :** Crossing organisms belonging to different species for getting desirable qualities in the offspring.
- **Test cross :** is the Crossing of the F_1 progeny with the homozygous recessive parent. If F_1 progeny is heterozygous, then test cross always yields the ratio of 1 : 1 between its different genotypes and phenotypes.
- **Reciprocal cross :** Is the cross in which the sex of the parents is reversed. That is if in the first cross father was dwarf and mother tall, then in the reciprocal cross, dwarf parent will be female and tall parent male.

INTEXT QUESTIONS 22.1

1. Name the founder of genetics and state why he is called so.

   ....

2. State one difference between

   (i) homozygous and heterozygous individuals

   ....

   (ii) dominant and recessive traits

   ....

   (iii) genotype and phenotype

   ....

   (iv) monohybrid and dihybrid crosses.

   ....

3. Define heredity and Genetics.

   ....

4. Give the monohybrid and dihybrid phenotypic ratios for Mendelian inheritancce.

   ....

5. Mention two sources of variation.

   ....

22.3 DEVIATION FROM MENDEL'S LAWS INCOMPLETE DOMINANCE

In the four O'clock plant *Mirabilis jalapa* and Snapdragon or *Antirrhinum* law of dominance does not hold good. Thus when a homozygous red flowered plant (RR) is crossed to a homozygous white flowered plant (rr), all flowers in the F_1 are pink while when F_1 plants are self pollinated, the phenotypic ratio in the next generation is found to be 1 : 2 : 1.

Parents	RR × rr
Gametes	R, R × r, r
F_1	Rr Pink
F_2	1 Red : 2 Pink : 1 White
	1 RR : 2 Rr : 1 rr

You will find that the heterozygous (Rr) plants have an intermediate colour pink. You must have also noticed that the genotypic ratio 1 RR : 2 Rr : 1 rr and phenotypic ratio 1 Red : 2 Pink : 1 white are the same, that is, 1 : 2 : 1.

Multiple alleles and codominance

Height and flower colour in peas and eye colour of humans have only two **alleles** (T and t; R and r; B and b (alleles for Brown blue eyes in humans). Most genes, however, may have more than two alleles or **multiple alleles**, controlling the same Trait. An example of multiple alleles is inheritance of blood group in man.

The four blood groups of humans are determined by combination of different alleles. The alleles I^A for A group, I^B for B blood group are both dominant. Therefore person with alleles I^A and I^B have the blood group AB as both the genes I^A and I^B are **co-dominant**. The gene i^o when homozygous (i^oi^o) gives the blood group O. Genotype and phenotype of blood groups in humans are given in Table 22.1.

Table 22.1 Genotypes and Phenotypes of human blood groups

Genotype	Blood group
I^AI^A and $I^A\ i^o$	A
$I^B\ I^B$ and $I^B\ i^o$	B
$I^A\ I^B$	AB
i^oi^o	O

Lethal genes

Have you ever seen a yellow mouse? Probably not. The yellow coat colour in mice is due to the presence of the gene (y) which is also responsible for killing the mouse in homozygous (yy) condition at the zygotic stage indicating thereby that the mice homozygons for dominant "Y" allele (that is, true breeding for yellow oat colour) are never borne. Such a combination of genes (y) are termed **lethal genes**, and the phenomenon is called **lethality**. Some lethal genes kill an individual only in the homozygous condition and are **recessive lethals.** .

Pleiotropy

While a gene may have multiple alleles and thus give multiple genotypes, one gene may control several phenotypes. For example the recessive gene for white eye in *Drosophila* when present in the homozygous condition affects several other features such as wing shape and shape of abdomen. Thus, a white eyed *Drosophila* is also born with vestigeal wings and curled abdomen.

Polygenic or quantitative inheritance

When a trait (feature or character) is controlled by a single gene representing an allelic pair it is termed **monogenic inheritance**. However, many traits or features are controlled by a number of different genes present at different loci on the same chromosome or different chromosomes. For example, the height and skin colour of humans and the kernel colour of wheat results from the combined effect of several genes, none of which are singly dominant. Polygenes affecting a particular trait are found on different locion many chromosomes. Each of these genes has equal contribution and cumulative effect. Three to four genes contribute towards formation of the pigment in the skin of humans. So there is a continuous variation in skin colour from very fair to very dark. Such an inheritance controlled by many genes having additive or cumulative effect in terms of expression of the phenotypic character, is termed as **quantitative inheritance** or **polygenic** (poly meaning or due to many genes) **inheritance**.

$R_1R_1R_2R_2$ Red × $r_1r_1r_2r_2$ White

$R_1r_1R_2r_2$ Pink

	R_1R_2	R_1r_2	r_1R_2	r_1r_2
R_1R_2	$R_1R_1R_2R_2$ Red	$R_1R_1R_2r_2$ Dark Pink	$R_1r_1R_2R_2$ Dark Pink	$R_1r_1R_2r_2$ Pink
R_1r_2	$R_1R_1R_2r_2$ Dark Pink	$R_1R_1r_2r_2$ Pink	$R_1r_1R_2r_2$ Pink	$R_1r_1r_2r_2$ Light Pink
r_1R_2	$R_1r_1R_2R_2$ Dark Pink	$R_1r_1R_2R_2$ Pink	$r_1r_1R_2R_2$ Pink	$r_1r_1R_2r_2$ Light Pink
r_1r_2	$R_1r_1R_2r_2$ Pink	$R_1r_1r_2r_2$ Light Pink	$r_1r_1R_2r_2$ Light Pink	$r_1r_1r_2r_2$ White

1 Red : 4 Dark Pink : 6 Pink : 4 Light Pink : 1 White

INTEXT QUESTIONS 22.2

1. Define : (i) An allele (ii) Codominance (iii) Polygenes (iv) Lethal genes
2. Name the kind of inheritance in terms of expression of
   (i) blood groups of humans

   ....

(ii) wheat kernel colour ....

....

(iii) human skin colour? ....

....

3. State the phenotypic monohybrid ratio in case of incomplete dominance.

....

22.4 CHROMOSOMAL THEORY OF INHERITANCE

Sutton and Boveri in **1902** observed that

> Chromosomes from two parents come together in the zygote as a result of the fusion of two gametes and again separate out during meiosis at the time of formation of gametes. You have already learnt that chromosomes are filamentous bodies present in the nucleus and seen only during cell division. Gametes have half (n) number of chromosomes or are haploid and zygote is diploid or has (2n) or double the number of chromosomes when compared to chromosome number in the gametes.

The observations proved that there is a remarkable similarity between the behaviour of Mendelian factors or genes during inheritance and that of chromosomes during meiosis.

This led Sutton and Boveri to propose '**chromosomal theory of inheritance**' and its salient features are as follows.

1. The somatic or body cells of an organism, which are derived by the repeated division of zygote have **two identical sets of chromosomes** i.e. they are **diploid.** Out of these, one set of chromosomes is received from the mother (maternal chromosomes) and one set from the father (paternal chromosomes). Two chromosomes of one type (carrying genes controlling the same set of characters) constitute a **homologous pair**. Humans have 23 pairs of chromosomes.
2. The chromosomes of homologous pair separate out during meiosis at the time of gamete formation.
3. The behaviour of chromosomes during meiosis indicates that Mendelian factors or **genes are located linearly on the chromosomes.** With progress in molecular biology it is now known that a **chromosome is made of a molecule of DNA and specific sets of segments of DNA are the genes.**

22.5 LINKAGE AND CROSSING OVER

Bateson and Punnett performed a dihybrid cross with true breeding varieties of sweet pea (*Lathyrus sativus*) and instead of 9 : 3 : 3 : 1 ratio in F_2 generation they got the ratio 7 : 1 :1 : 7. It means that the characters controlled by the two genes chosen for the experiment do not follow the principle of independent assortment as postulated by Mendel. Instead they tend to be inherited together or are **linked** together. Thus genes present on the same chromosome tend to be inherited together and are said to be **linked**. This phenomenon is called **linkage**.

All the genes present on the same pair of chromosomes and with a tendency to be inherited together forms a linkage group.

In the above experiment some recombinant type of individuals were also produced. How did that happen ? They are produced by another phenomenon called **crossing over**.

Crossing over is the physical exchange of parts of the non sister chromatids of the chromosomes of a homologous pair (Fig. 22.4).

Crossing over occurs during prophase I at meiosis I of the time of gamete formation. The point where crossing over occurs is called **chiasma**. (plural : chiasmata) See Fig. 22.3. Linked genes get separated from each other by crossing over.

Because of linkage and crossing over a heterozygous individual can produce four types of gametes as shown in Fig. 22.4. The figure 22.4 shows linked genes of the parents and **recombinants** due to crossing over.

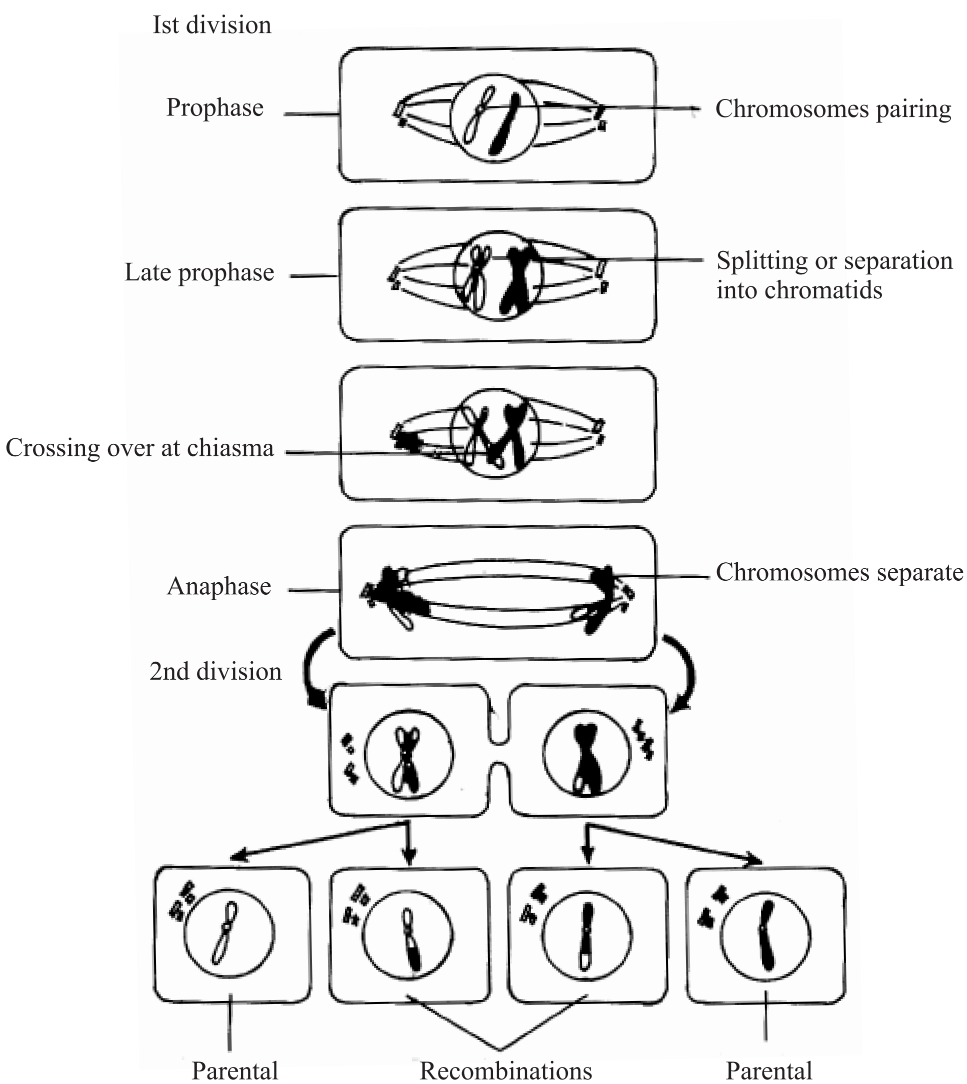


Fig. 22.4 Schematic diagram showing recombination by crossing over

22.6 CHROMOSOMES AND SEX DETERMINATION

Sex of the unborn individuals is determined in different ways in different kinds of organisms. You will learn about sex determination in humans, birds and honey bees in this section.

In some diploid organisms, specific chromosomes have a role in sex determination. Such chromosomes are called **sex chromosomes** and the rest of the chromosomes of a set are called **autosomes**.

- If sex chromosomes are morphologically similar (i.e. XX) in an individual, the individual is termed **homogametic**. Such individuals, produce only one kind of gametes (containing X). For example : all eggs of the human female contain an X chromosome and autosomes. So human female is termed as homogametic.

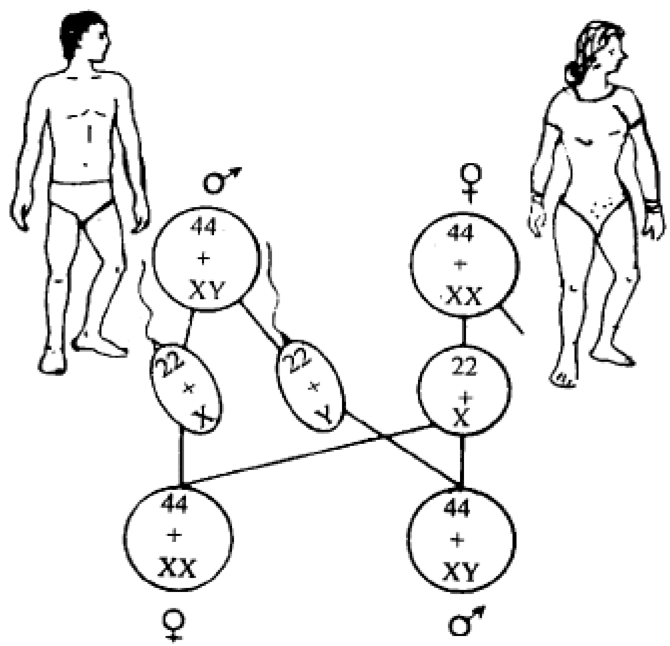


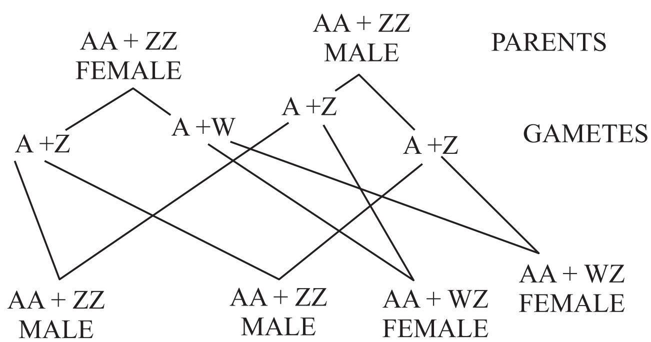
Fig. 22.5 Chromosomal basis of sex determination in humans.

22.6.1 Sex Determination in Human

- Sex chromosomes in males are morphologically dissimilar (i.e. XY). Such individuals produce two types of gametes (one containing X and the other containing Y) and are called heterogametic. For example : human male produces two kinds of sperms, X bearing and Y bearing sperms. When the human egg is fertilised by an X bearing sperm a girl is born, and if human egg is fertilized by a sperm having "Y" chromosome, a boy is born (Fig. 22.6). Whether the unborn will be a male or female is purely a matter of chance and no parent can be blamed for the sex of the progeny.

22.6.2 Sex Determination in Birds

You have just studied the XX-XY type of sex determination in humans. This type of sex determination is found in other mammals and most insects. However, the method of sex determination in birds is a little different. In birds both sexes (male and female) possess two sex chromosomes but unlike human beings the female has the heteromorphic morphologically different sex chromosomes (ZW) while the males bear homomorphic (condition, the sex chromosomes (ZZ). Thus, the females are heterogametic and produce two types of eggs: A+Z and A+W ('A' stands for autosomes). The male gamete is only of one type: A+Z. This type of sex determination is called ZW-ZZ type or WZ-ZZ type of sex determination. The letters Z and W are used to distinguish these types of sex chromosomes from X and Y chromosomes found in the X-Y type of sex determination.



ZW - ZZ Type of Sex Determination in birds AA - Autosomes

22.6.3 Sex Determination in Honey Bees

Honey bees have a unique method of sex determination. In honey bees, fertilised eggs emerge as females and unfertilised eggs develop into males. Since fertilised eggs and also females are diploid and unfertilised eggs and males haploid, sex determination in honey bees is referred to as **haplodiploidy**-sometimes also called **arrhenotoky**.

The sex is determined by the number of sets of chromosomes an individual receives. The male, which is called a drone, is produced from **unfertilized haploid eggs**. And thus, male honeybees contain a single set of chromosomes. The female honeybees, which are worker bees and queen bees, are produced from fertilized eggs and therefore are diploid. They contain two sets of chromosomes. In this case, only females are produced by sexual reproduction.

It is very interesting in honey bees that males have no father and cannot have sons but have a grandfather and can have grandsons.

22.7 CRIS-CROSS INHERITANCE X-LINKED INHERITANCE

We already know that genes are located on chromosomes. The genes which are located on X chromosome (sex chromosome), are called **sex linked genes**. These genes show cris-cross inheritance as shown in Fig. 22.6.

When a male has a defective sex linked gene located on **X** chromosome he transmits the defective **X** chromosome to his **daughter only during reproduction,** . The female who has this gene transmits it to her son and daughter both in equal probability. So the male passes on his recessive sex linked trait to 50% of his grandsons through his daughter. The sex linked trait being recessive is not expressed in female but is expressed in males. Therefore males suffer from the genetic defect due to the presence of faulty gene on the single X-chromosome while females are only **carriers** of these defective genes as they have the other X which masks the effet of faulty gene. The trait shows up in females only both X chromosomes from mother and father have faulty gene.

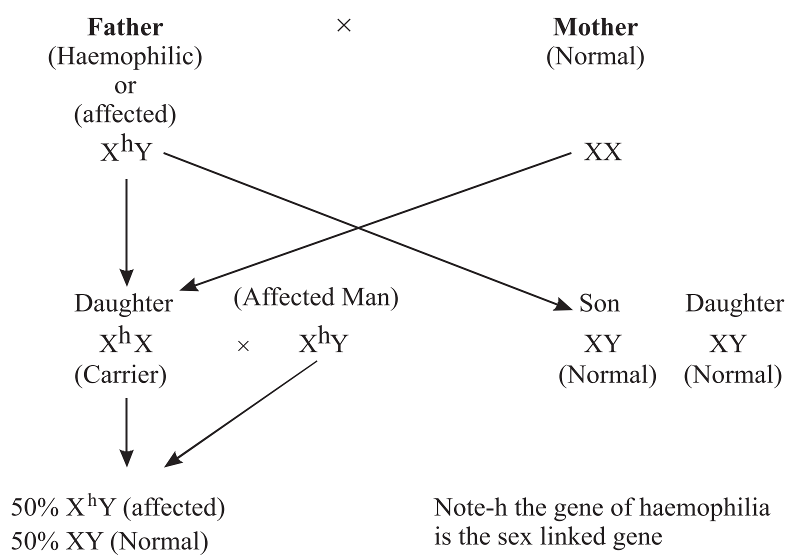
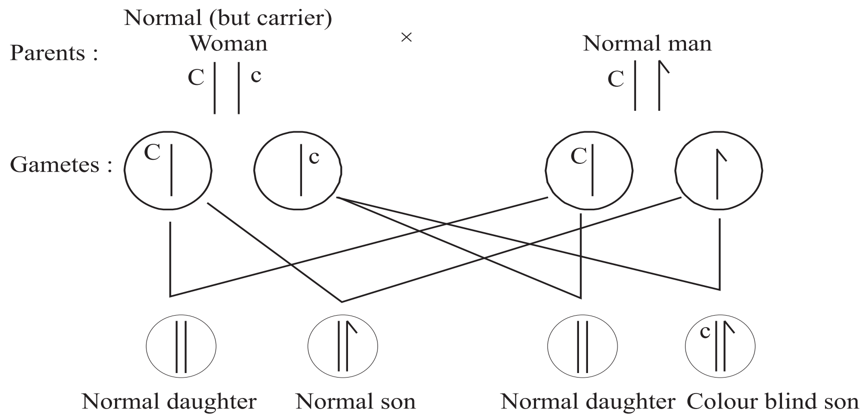


Fig. 22.6 Criss cross inheritance or X-linked sex linked inheritance

> This type of inheritance of recessive sex linked character from father to daughter and then from the daughter to her sons is known as **cris-cross inheritance or sex linked or X-linked inheritance.**

Criss Cross Inheritance in humans : Red green colour blindness and Haemophilia are examples of sex linked inheritance in humans. The defective gene is located on **X** chromosome. Thus a single defective gene causes disease in male while two defective genes (homozygous condition) only can cause the disease in female. Females in heterozygous condition are apparently normal but actually the carriers of the disease. Carrier females pass this defective gene to 50% of her sons. The disease is expressed only in males because male does not have the partners of the genes on **Y** Chromosome to mask the effect of the faulty gene. See Fig. 22.7 (a), and (b).



(C = gene for normal colour vision and c = gene for colour blindness)

Fig. 22.7 (a) Progeny of carrier female for colour blindness and a man with normal colour vision.

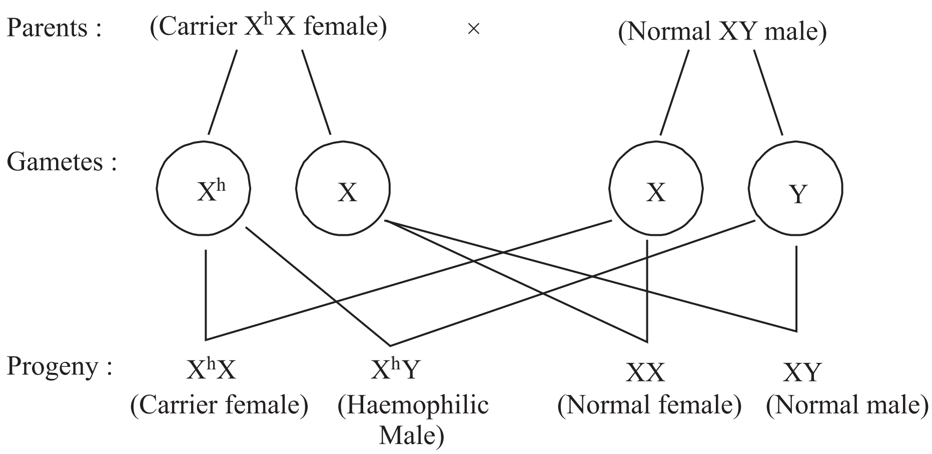


Fig. 22.7 (b) Progeny of a haemophilic carrier female and normal male

INTEXT QUESTIONS 22.3

1. What are genes and where are they located?

   ....

2. State the names of the scientists who proposed the chromosomal theory of inheritance.

   ....

3. Define (i) linkage and (ii) crossing over.

   ....

4. When does gene exchange through chiasma formation occur between homologous chromosomes?

   ....

5. Why is the human female called the homogametic sex?

6. A colour blind man married a normal woman whose father and mother both had normal colour vision. Will any of their sons be colour blind? If not why not.

7. With the help of flow chart explain the difference in sex determination in birds and mammals.

8. Name an insect in which all males are produced parthenogenetically.

9. In honey bees “males have no father and cannot have sons but have a grandfather”. Justify the statement.

10. Which sex in birds is heterogametic?

11. Why is sex determination in honeybees called haplodiploidy

22.8 MITOCHONDRIAL INHERITANCE AS A CASE OF MATERNAL INHERITANCE

Apart from the nucleus, mitochondria and chloroplasts also possess DNA and you have just learnt that genes are segments of DNA. Till now you have studied that genes are present on the chromosomes present in the nucleus. Since mitochondria come into the zygote from the egg, inheritance of mitochondrial DNA is said to be a case of **maternal inheritance**.

In fact, certain diseases and therefore the genes responsible for them are due to defects in mitochondrial DNA and can be traced to the mother’s family.

22.9 HUMAN KARYOTYPE

Human karyotype is the arrangement of human chromosomes in seven groups according to the types of chromosomes and their size. It is prepared by arranging chromosomes seen at mitotic metaphase in descending order with the longest pair of chromosomes drawn first, and the sex chromosomes are drawn the last :

(i) Total no. of chromosomes or 2n = 46 (23 pairs).

(ii) Number of autosomes = 44 (22 pairs).

(iii) Sex chromosomes 2 = X and Y

(iv) Depending on size, location of centromere, and bands obtained by special staining methods, human chromosomes are grouped into 7 groups, A to G as shown in Fig. 22.8.

Sex determination in humans, as you have already learnt is as follows :

Normal male has 22 pairs of autosomes + one X chromosome and one Y chromosome

Normal female has 22 pairs of autosomes + two X chromosomes

Presence of Y is necessary for maleness.

Absence of Y chromosomes, makes the individual a female with some defective characters.

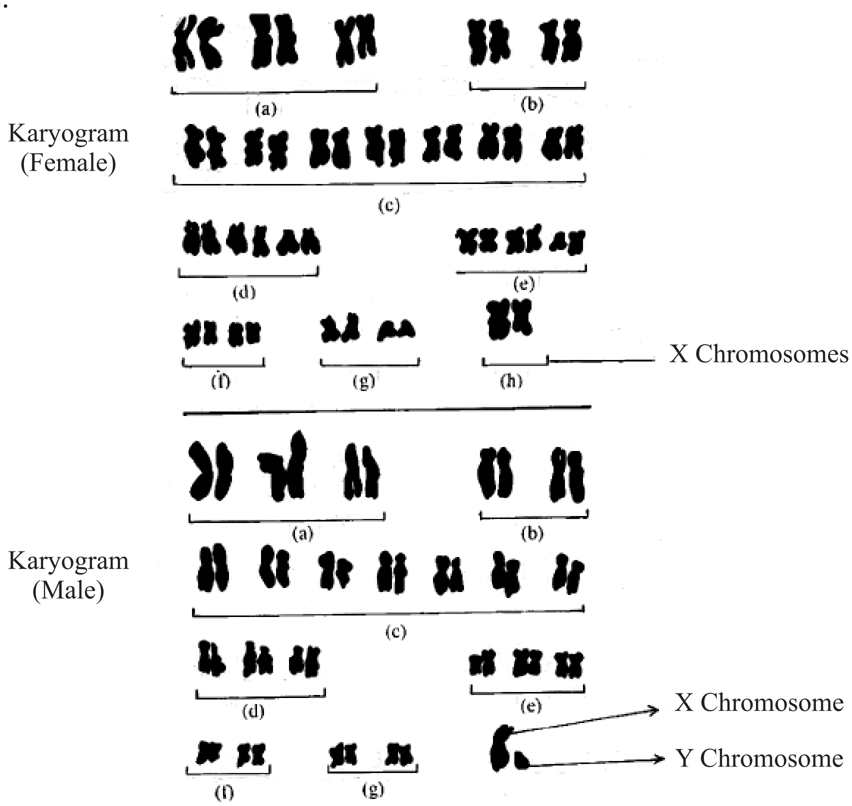


Fig. 22.8 Karyotype showing chromosomes of normal male. Female has the same autosomes but two X-chromosomes instead of XY

22.10 CHROMOSOMAL ABNORMALITIES AND GENETIC DISORDERS IN HUMANS

Any change from the normal number or structure of chromosomes causes abnormalities. Following are some examples of human genetic disorders :

1. Mongolism or Down's syndrome

The individual has 47 chromosomes because of one extra chromosome in the 21st pair (Trisomy of chromosome 21). The outcome of this defect are the following characters or features :

- mentally retarded
- have a thick tongue
- and a drooping (false expression of pleasure) face. Fig. 22.9.

The possibility of giving birth to a mongolian child is far greater in pregnant mothers above the age of forty.

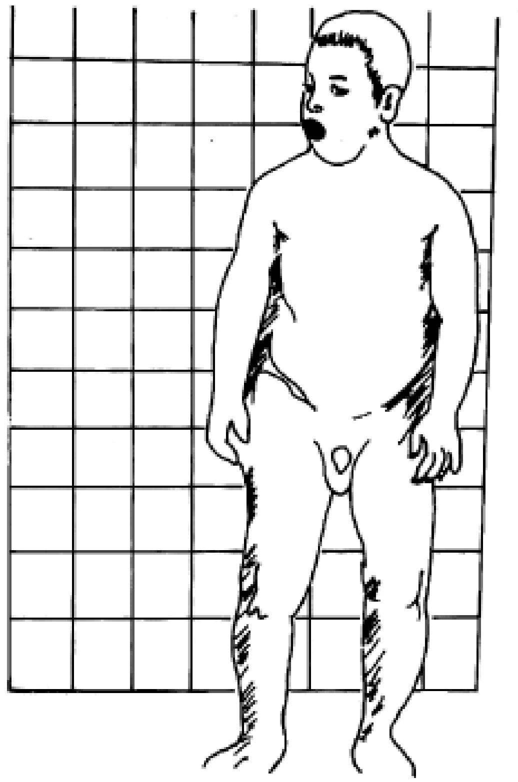


Fig. 22.9 Mongolism or Down's syndrome

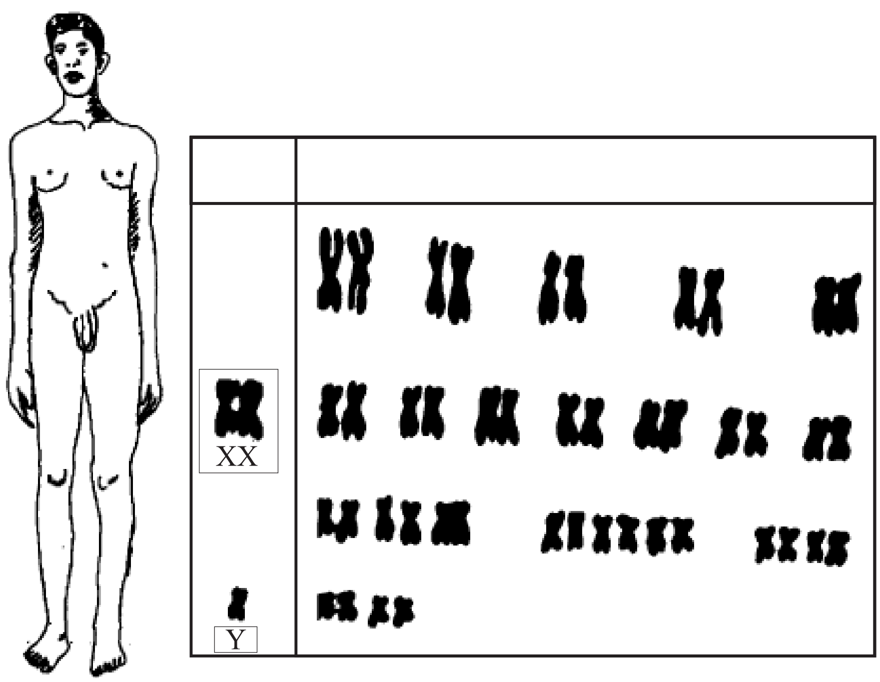


Fig. 22.10 Man showing Klinefelter's syndrome

2. Klinefelter's syndrome

Individual is a male with 47 chromosome with one extra X chromosome. (44 autosomes + XXY). Typical features of Klinefelter's syndrome are :

- Tall, mentally retarded male;
- Sterile and shows breast development or **gynaecomastia** (gynae : female; massere : mammary glands). Fig. 22.10.

3. Turner's syndrome

Individual is a female with 45 chromosomes and with only one X, chromosome (22 pairs of autosomes +XO). The characteristic features of this syndrome are

- Mentally retarded
- web like skin on neck.
- incompletely developed breasts. Fig. 22.11.

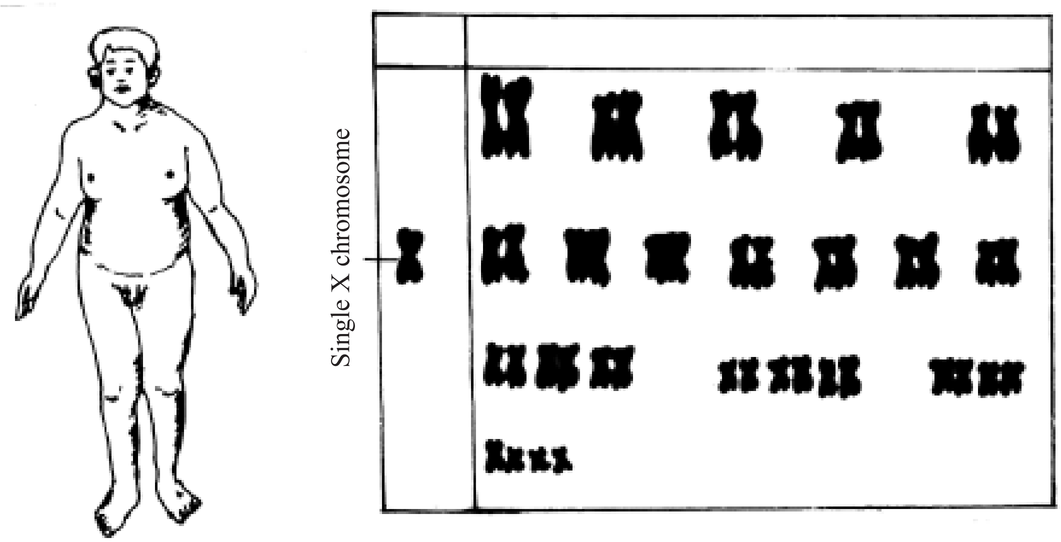
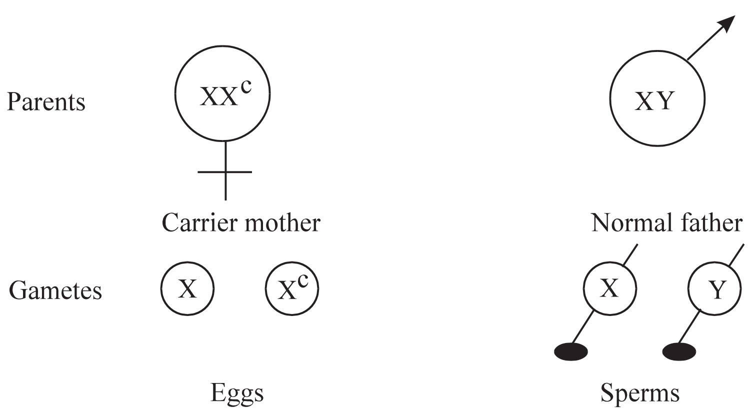


Fig. 22.11 A woman suffering from Turner's syndrome.

4. Colour blindness and Haemophilia (Bleeder's diseases)

Both these defects are sex linked disorders. (See figures 22.6 and 22.7)



The inheritance is as follows :

♀ Gametes \ ♂ Gametes	X	Y
X	XX Normal daughter	XY Normal son
X^c	X^cX Carrier daughter	X^cY Colour blind son

Note : X = *normal allele*; X^C = *recessive mutant*

Fig. 22.12 Inheritance of colour blindness

See also 22.7

In male, the single X-chromosome is received from the mother.

Hence a defective, gene (for colour blindness or haemophilia) on X chromosome of the mother, is passed on to the son and expressed as a defect.

The daughter receives one X-chromosome from the mother and the other X from the father. In a carrier daughter the defective gene received from the mother is masked chromosome received from normal father by normal allele on the other X (Fig. 22.12).

Colour blind males are unable to distinguish between red-green colours. In haemophilia afflicted male, blood does not clot easily and the patient may bleed to death. Its mode of inheritance is exactly like that of colour blindness.

5. Thalassemia

It is an autosomal disorder in which normal haemoglobin is not synthesised. So, frequent blood transfusions are required for survival.

The defective gene is recessive and present on an autosome in the heterozygous Parents may not show the disorder. The child who gets the defective genes 'from both the parents (homozygous recessive) suffers from Thalassemia.

6. Sickle Cell Anemia

This is another hereditary abnormality due to mutation of a single autosomal gene in which red blood corpuscles lose their shape and become sickle shaped because of defective Haemoglobin. Individuals possessing two defective genes (homozygous recessive), cannot survive. In the heterozygous individuals, one gene is normal and so half the number of total red blood corpuscles are normal containing normal haemoglobin while the others are defective. For heterozygous individuals with sickle cell gene, it is a boon in disguise against malaria for children with one defective haemoglobin gene can survive as they are less affected by malarial because the malarial parasite cannot thrive inside the defective RBCs.

7. Rh factor

Rh factor is an antigen (a protein) present on the surface of red blood corpuscles. About 15% of all women do not have the gene for Rh antigen. They are Rh-negative. Men can also be Rh-negative. But the problem which this trait creates is in Rh-negative women.

A pregnant Rh-negative woman whose husband is Rh + may bear a the child who may have inherited the Rh + gene from the father. If the foetal blood of the Rh + foetus enters mother's body stream, her immune system produces antibodies against Rh antigen which may cause minor problems in first pregnancy. Antibodies remain in the mother's blood and in the subsequent pregnancies, the mother's antibodies against foetal Rh antigen may enter the foetal blood stream and destroy its red blood corpuscles causing severe anemia which may even be fatal (erythroblastosis foetalis) for the foetus.

Now-a-days Rh-negative mother of a Rh-positive foetus is treated immediately after delivery, to destroy Rh antigens in her blood stream. (Fig. 22.13)

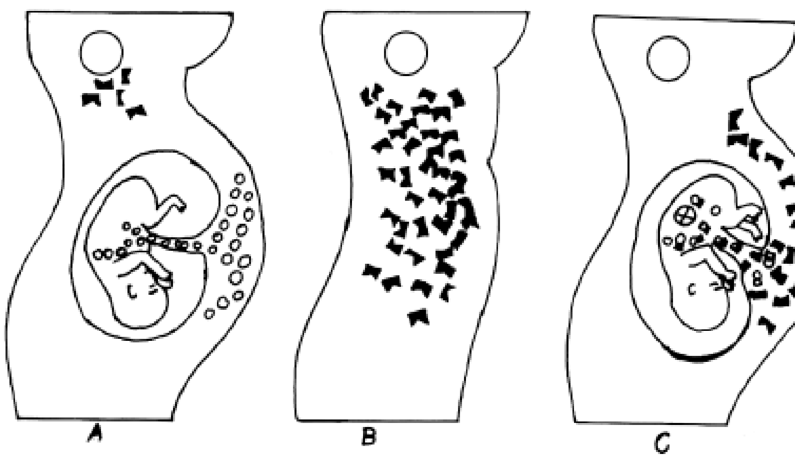


Fig. 22.13 The mechanism of Rh inheritance

(a) shows the first pregnancy where the mother is Rh (-) and foetus Rh (+). Antigens (empty circles) of the foetus stimulate the production of anti bodies (black blocks) in the mother's blood.

(b) shows the retention of anti bodies in the mother's body.

(c) shows the Rh (+) foetus in the womb of the same mother during the second pregnancy. The anti factors from the mother's body destroy the infant's red blood cells.

22.11 AMNIOCENTESIS

Amniocentesis in a technique by which hereditary disorders due to defects in genes can be detected. In this technique (Fig. 22.14)

(i) a small sample of amniotic fluid which surrounds the foetus is syringed out.

(ii) This fluid has cells which break off from the skin of the foetus.

(iii) Foetal cells are picked up and cultured.

(iv) Chromosomes in the dividing cells are analysed for genetic defects.

If incurable genetic defects are detected, pregnancy can be terminated.

It is illegal to use amniocentesis for detecting the sex of the unborn.

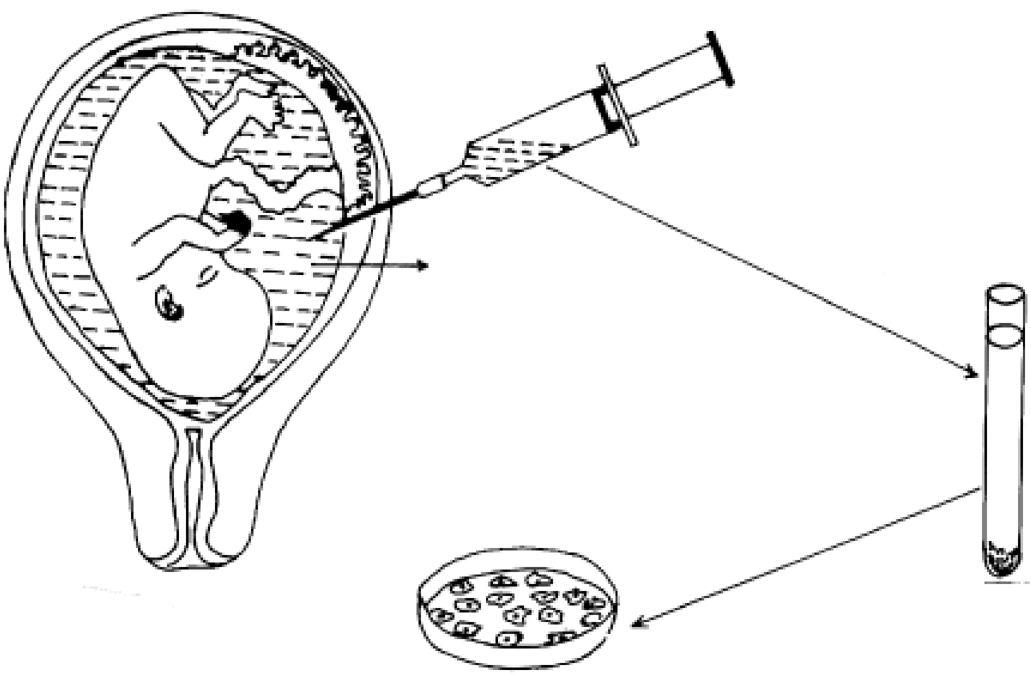


Fig. 22.14 Techniques of Amniocentesis

22.12 THE HUMAN GENOME

In the last over hundred years genetics and molecular biology have gone far ahead and the progress has been very rapid.

You have just read about genetic disorders and today there is hope for cure through gene therapy. This is because in 2003, most of the genes on human chromosomes have been mapped or located on the 23(n) chromosomes. The genes responsible for inheritance of various structural features, that control various enzymes that catalyse the various biochemical reactions in the body, and genes responsible for genetic disorders have been located. **Genome means genes of a particular organism on its haploid set of chromosomes and study of genome is Genomics**. Since genes are present in pairs (one inherited from mother and other from the father), all kinds of genes present in a particular type of organism are present in its haploid set (n). Thus human genome may be defined as all the genes present in the haploid set of chromosomes in humans. There are an estimated 20,000 to 25,000 genes and 3 billion base pairs in the total human DNA. Each human chromosome has apart from protein coding genes, regulating base sequences, non coding DNA, promoter sequences (TATA box) in between genes that code for proteins. There are genes that code for the production of ribosomal RNA and the many tRNAs.

It is estimated that only 1.5% of the human genome has protein coding sequences.

INTEXT QUESTIONS 22.4

1. Why is mitochondrial inheritance treated as a case of maternal inheritance?

   ....

2. Into how many groups have human chromosomes been grouped in the human karyotype?

   ....

3. State the chromosomal abnormality in Klinefelters, Turners syndrome and in Mongolism.

   ....

WHAT YOU HAVE LEARNT

- Heredity means the transmission of characters from parents to offsprings.
- Variation pertains to differences between siblings or members of same species.
- Mendel was the first to explain that heredity involves transmission of certain factors from reproductive cells of parents to offsprings.
- Hugo de Vries, Correns and Tschermach rediscovered Mendel's Laws of inheritance nearly 35 years after Mendel's death.
- Mendel selected seven varieties of garden pea differing in seven pairs of contrasting characters.
- According to his 'law of segregation' the factors segregate at the time of gamete formation, and come together after fertilization.
- Mendel's 'law of dominance' states when partents differing in a pair of contrasting characters are crossed, the factor that expresses itself in the F-1 is called **dominant**, and the factor which is masked by **dominant** factor, is called **recessive**.
- Law of independent assortment states that the inheritance of factors controlling one character does not depend on inheritance of any other factor controlling any other character.

- There are deviations from Mendelian inheritance and these patterns of inheritance are incomplete dominance, codominanace, multiple alleles, polygenic inheritance and pleiotropy.
- Sutton and Boveri (1902) proposed the chromosome theory of heredity. It states that Mendelian factors or genes are located on chromosomes.
- Genes are located on chromosomes in a linear fashion and are held together in linkage group. Linked genes get segregated through chiasma formation or crossing over.
- Organisms with separate sexes have a pair of sex chromosomes called sex chromosomes. In humans, XX are responsible for homogametic female and XY for heterogametic male. In birds it is the opposite—male is ZZ or homogametic and female is ZW or heterogametic.
- In honey bees, males arise from unfertilised eggs and are therefore, haploid or with half the number of chromusomes while females develop from fertilised eggs and are diploid.
- Human males inherit an X chromosome from female parent and Y from the male parents. Y chromosome bears genes for maleness.
- Females receive two X chromosomes one each from either of the two parents.
- Any change in normal number and structure of chromosomes of an individual causes abnormalities.
- A normal karyotype shows 23 pairs of humans chromosomes bearing thousands of genes, controlling different characters.
- Down's syndrome patients have 47 chromosomes exhibitting tri-somy of chromosome 21.
- Klinefelter's syndrome patient has 44 autosomes and XXY.
- Turner's syndrome, has 44 autosomes + XO
- Colour blindness and Haemophilia are X-linked and sex-linked disorders.
- Thallessemia and Sickle cell anaemia are due to a single autosomal defective gene.
- Rh +ve foetus in a Rh negative mother poses problems in which antibodies are produced in mother's blood against antigens of the foetus.
- The human genome has been mapped.
- Amniocentesis is a technique for detecting genetic disorder in foetus.

TERMINAL EXERCISES

1. State the three Mendel's laws of inheritance. Which one of these laws is universal?

2. Consider a hypothetical case of a cross between a tall plant (TT) and a dwarf plant (tt). Work out the phenotypic and genotypic ratios of the F_2 progeny if the cross were to show
   (a) dominance (b) incomplete dominance
3. What will be the blood group of the progeny of parents with AB and O groups.
4. Write notes on :
   (a) recessive lethal genes (b) pleiotropy
   (c) linkage groups (d) mitochondrial inheritance
   (e) human karyotype (f) human genome
5. Why do we find so many different complexions among humans?
6. State the chromosome theory of inheritance.
7. Work out the following crosses and mention the phenotypic ratio of their progeny.
   (a) A colour blind man marries a carrier woman
   (b) A man with normal colour vision marries a carrier woman.
8. Why is X-linked inheritance termed cris-cross inheritance?
9. Give an account of genetic disorders caused by abnormal chromosomal number.
10. What is amniocentesis? How and for what is it carried out?
11. In what way is chromosomal sex determination of humans different from that of birds?
12. From which kind of eggs do males and females of honeybees emerge.

ANSWERS TO INTEXT QUESTIONS

22.1 1. Gregor John Mendel, was the first to suggest principles underlying heredity

2. (i) homozygous = bearing identical alleles controlling a trait; heterozygous = bearing dissimilar alleles controlling a trait.

   (ii) Dominant allele = expressing in both heterozygous and homozygous conditions.

   Recessive = expressing only in homozygous condition.

   (iii) Genotype = genetic constitution of an individual, represented with the help of symbols.

   Phenotype = class of individuals recognised based on externally/ internally visible characters.

(iv) monohybrid = cross between two parents differing in a single pair of contrasting character; dihybrid corss = cross of two parents differing in two pairs of contrasting characters.

3. Heredity : is the study of transmission of characters from one generation to next generation.

   Variation: Differences between individuals of same species.

4. Monohybrid ratio = 3 : 1, Dihybrid ratio = 9 : 3 : 3 : 1.

5. Mutation, Recombination.

22.2 1. (i) Alleles are diffrerent forms of a gene.

(ii) Both alleles express as dominant phenotype.

(iii) Many genes controlling same trait.

(iv) Presence of which kind of genes in an individual proves to be fatal?

2. (i) Codominance and multiple alleles

(ii) Incomplete dominance

(iii) Polygenic inheritance

(iv) Polygenic inheritance

3. 1 : 2 : 1

22.3 1. Genes are segments of DNA. They are located in chromosomes.

2. Sutton and Boveri

3. (i) Linkage is the tendency of genes residing on the same chromosome to be inherited together.

   (ii) Breakage and exchange of genes between two chromatids of a homologous pair is termed crossing over.

4. During prophase I of meiosis

5. Human female produces only one kind of gametes (homo = same)

6. No. Because gene for color blindness on X chromocomes is a recessive gene so it gets marked by renual gene from mother.

7. Female

8. Because males develop from unfertilised or haploid eggs and females from fertilised or diploid eggs.

22.4 1. Because mitochondia are inherited from the mother through the ovum.

2. Seven

3. Kline felter : 2n = 47; XXY

   Turner : 2n = 45; XO

   Mongolism : 2n = 47; Trisomy of chromosome 21

23

MOLECULAR INHERITANCE AND GENE EXPRESSION

A cell contains the nucleus. Nucleus contains chromosomes, Chromosomes bear genes. Genes carry the hereditary information. A zygote has the information for development and differentiation of the embryo in its genes. Cells of an individual have the genes for maintaining their structure and function. What are these genes and how do they function? Genes are made of segments of the DNA. This lesson deals with the study of DNA as the genetic material, its structure and functioning at the molecular level.

OBJECTIVES

After completing this lesson, you will be able to :

- *discuss the concept of one gene one enzyme hypothesis;*
- *give the history of discovery of DNA as geneticc material;*
- *describe the general structure of DNA by referring to the terms nucleotides, nucleosides, purincs and pyrimidines;*
- *list the differences between DNA and RNA;*
- *mention the various categories of RNA and explain their functions;*
- *describe the modes of gene transfer, transformation, transduction and conjugation;*
- *explain the steps of DNA replication;*
- *explain the concept of central dogma;*
- *describe the sequence of steps during transcription and translation during protein sysnthcsis;*
- *trace the major steps in regulation of gene expression;*
- *define house-keeping genes and explain their role;*
- *categorise various types of mutations;*
- *define mutagen and list their different categories;*
- *highlight the useful and harmful effects of mutation.*

23.1 THE CONCEPT OF THE ONE GENE ONE ENZYME HYPOTHESIS

The British biochemist and physician Archibald Garrod had mentioned in his book named "Inborn errors of metabolism" that there are inherited genetic disorders such as **phenylketonuria** and **alkaptonuria** which are caused by the absence of particular enzymes. Beadle and Tatum working with the mutants of the fungus *Neurospora* showed that the absence of a gene in a mutant leads to absence of an enzyme in a metabolic pathway (chain of biochemical reactions) midway. Thus was proposed that **one gene was responsible for the production of one enzyme** and this was called the **one gene one enzyme hypothesis**. Later, it was found that an enzyme (a protein) may be made of more than one polypeptide and one gene controlled production of one polypeptide (chain of amino acids in a protein).

In the following sections you will learn about the nature of the genetic material, DNA, and its role in the synthesis of proteins. You will also learn about gene mutation because of which a normal protein is not manufactured in the body and results in genetic disorders.

23.2 DISCOVERY OF DNA AS THE GENETIC (HEREDITARY) MATERIAL

That genes, located on chromosomes, are the hereditary material was known to scientists in the early twentieth century. That genes are segments of DNA became evident from the work of Griffith on **bacterial transformation.**

Bacterial transformation

The bacterium *Streptococcus pneumoniae* when grown in the lab forms smooth colonies and when injected into mice kill them. A mutant of this bacterium forms rough colonies and is harmless to mice. In 1928, Frederick Griffith found that if the *smooth virulent* form of *Streptococcus* is killed and mixed with the *harmless rough* form of *Streptococcus* the latter becomes virulent (killer). This change (or transformation) of the bacteria from harmless to virulent is termed **bacterial transformation.** (Fig. 23.1).

In 1944, Avery, Mcleod and McCarty extracted DNA from the virulent smooth *Streptococcus* and mixed it with the non-virulent rough variety. The non-rough variety became *virulent* and had a *smooth coat*. This did not happen when DNA of the virulent form was digested with the enzyme DNase and then mixed. Thus it became clear that **DNA was the transforming principle.**

Later Hershey and Chase in 1952 used T_2 bacteriophage, a virus which infects bacteria for their experiments. They labelled the protein coat of the virus with radioactive isotope of sulphur ^{35}S. When the virus was introduced into the bacteria, no radioactivity was found inside the bacteria as the viral coat was left outside. When they labelled viral DNA with $^{52}P_{32}$ or radioactive phosphorus, radioactivity was found inside the bacteria. It bacame clear that new generations of the virus were reproduced inside bacteria because of viral DNA (Fig. 23.2).

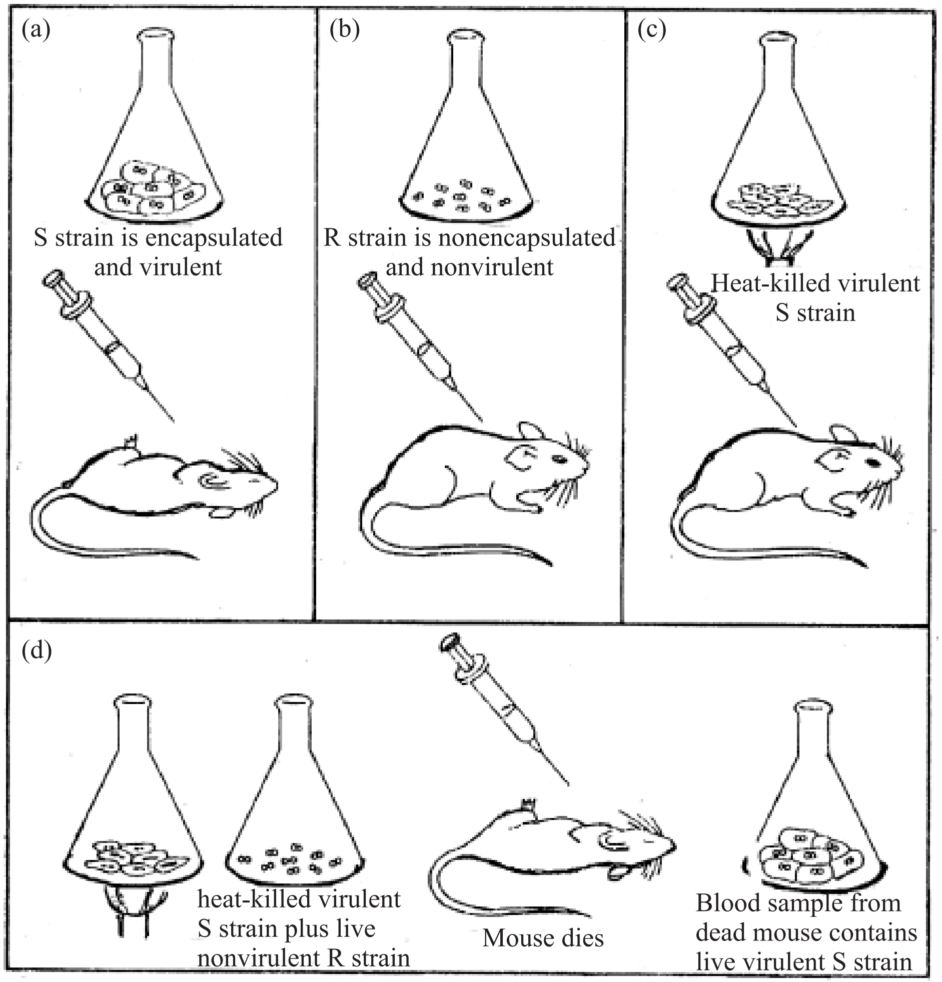


Fig. 23.1 Griffith's bacterial transformation experiment.

These experiments confirmed that DNA is the genetic material and genes are made of Deoxyribonucleic Acid or DNA.

23.3 STRUCTURE OF DNA, THE GENETIC (HEREDITARY) MATERIAL

23.3.1 Chemical nature of DNA or Deoxyribonucleic acid

DNA is a polynucleotide, a macromolecule (macro = large) made of units called **nucleotides.**

Each nucleotide consists of three subunits.

(i) a pentose (5 carbon) sugar called **deoxyribose**

(ii) 4 nitrogenous bases Adenine (A), and Guanine (G) are purine bases and Thymine (T) and Cytosine (C) are pyrimidine bases

(iii) a phosphate group (PO_4) positioned on the sugar (Fig. 23.3)

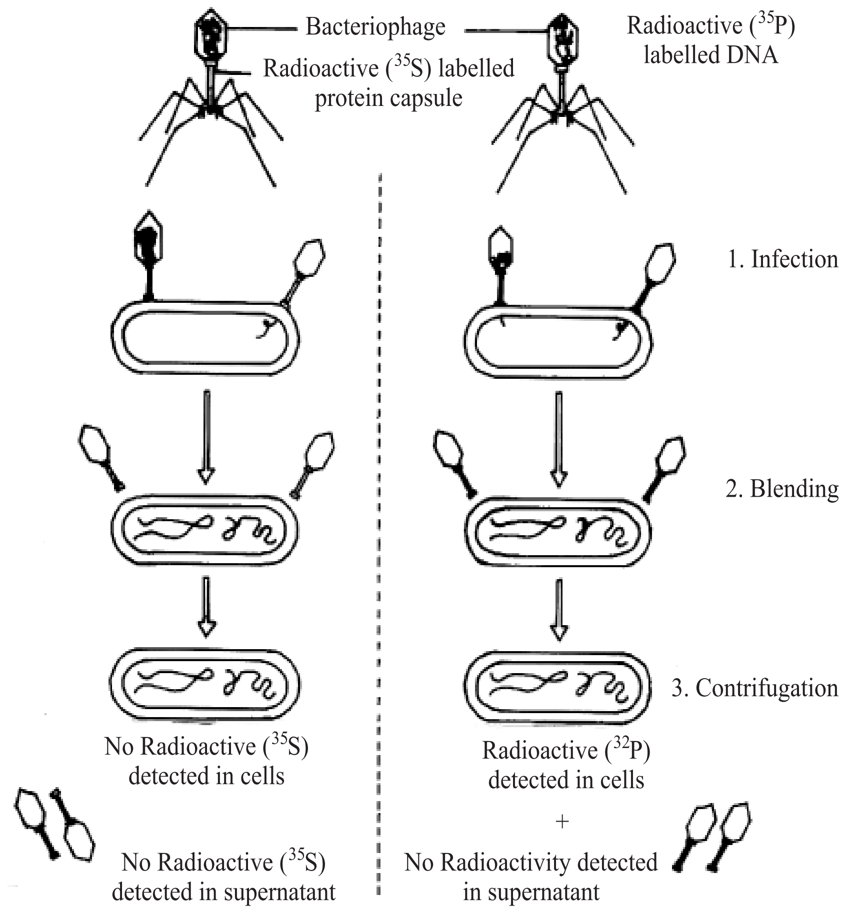
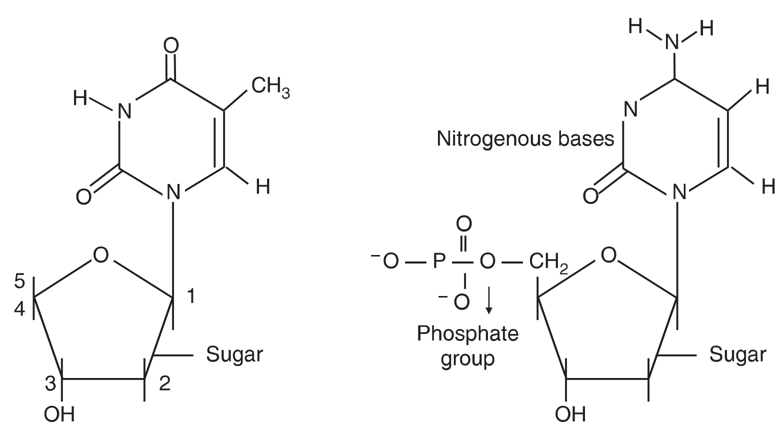


Fig. 23.2 The Hershey Chase experiment



(a) (Base + Sugar = Nucleoside)

(b) (Base + Sugar + Phosphate = Nucleotide)

Fig. 23.3 Component of nucleoside and nucleotide

A base and a sugar combine to form a nucleoside, while it becomes a **nucleotide** when a phosphate group gets attached to the **nucleoside**.

Base + sugar = nucleoside

Base + sugar + Phosphate = nucleotide

So there are **four nucleotides** in DNA formed of sugar and nitrogenous base and phosphate.

Chargaff's rule

The four nucleotides are not present in equal amounts in a DNA molecule. But the amount of purines (A + G) and that of pyrimidines (T + C) is always equal. In other words, A = T and G = C. This is called Chargaff's rule.

23.3.2 Physical structure of DNA– The DNA double helix

A DNA molecule is **three dimensional** and made of **two strands** helically coiled around each other. Franklin and Wilkins first showed through X-ray diffraction studies of DNA that it is a double helix.

In 1953, James Watson and Francis Crick were awarded the Nobel Prize for working out the structure of DNA.

According to the Watson and Crick model

- DNA molecule is a **double helix** consisting of two strands of DNA
- The arrangement of the two strands is **antiparallel**, which means that the sequence of nucleotides goes up in 5′ to 3′ direction in one strand and other strand comes down in 3′ to 5′ direction. (3′ and 5′ refer to the carbon atom to which the phosphate group is attached) see Fig. 23.4.

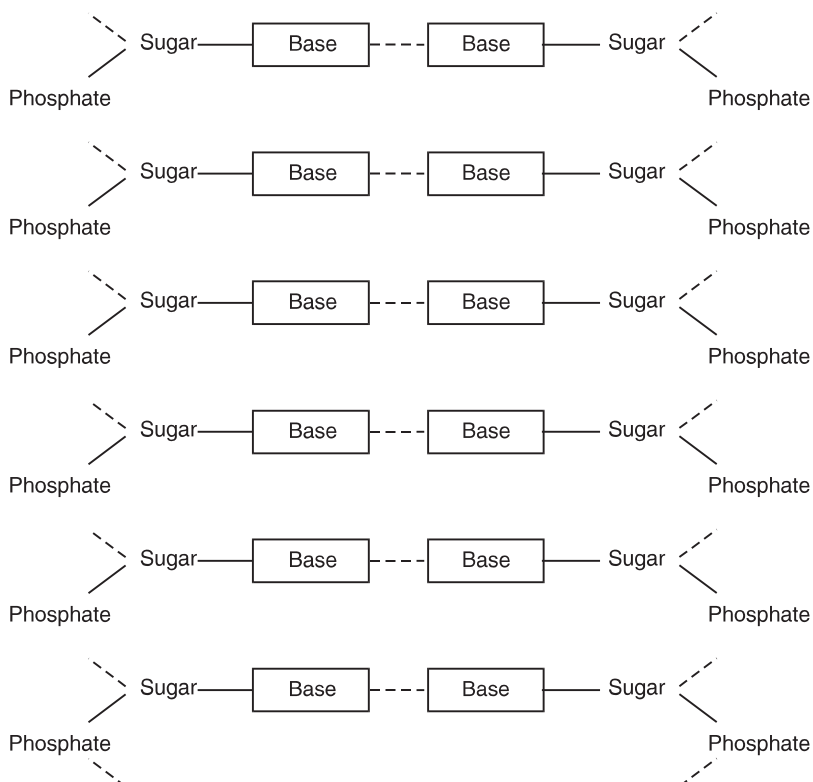


Fig. 23.4a Components of a DNA double helix

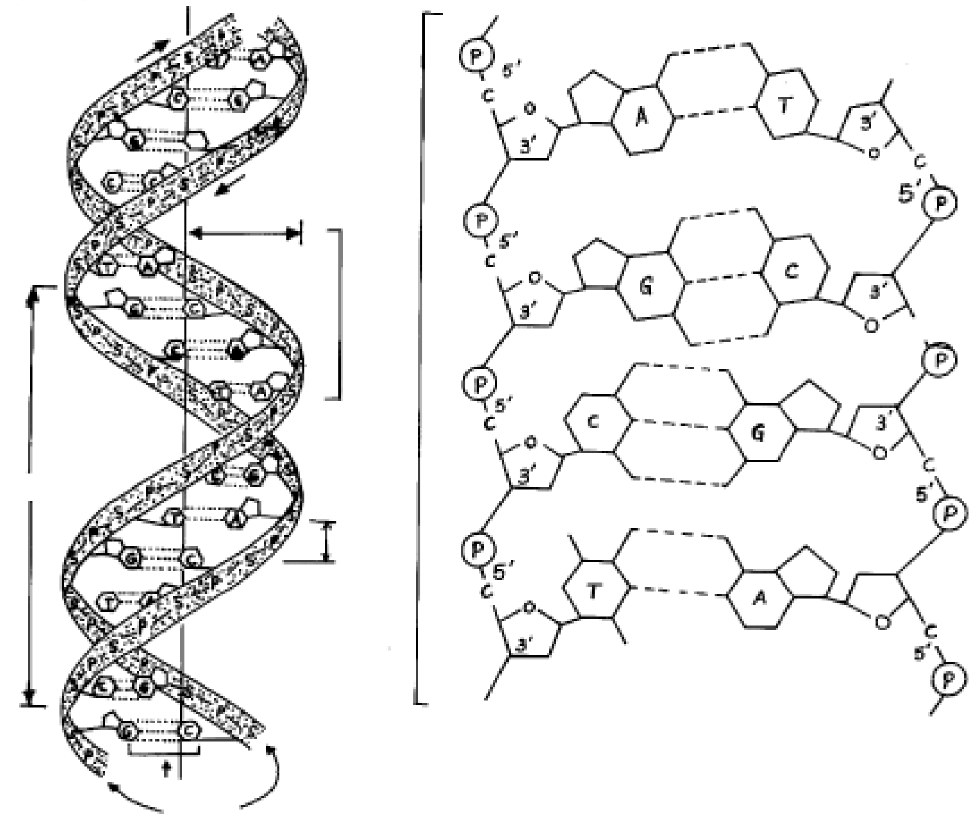


Fig. 23.4b-c DNA double helix

- The **backbone** of the helix is made of **sugar and phosphate.** Nitrogenous bases are linked to the **sugar**. (Fig. 23.4a and 23.4b)
- The bases of the two strands are linked by hydrogen bonds.
- Base pairing is very specific as per Chargaff's rule. Adenine, a purine base always pairs with thymine, a pyrimdine base. The purine base Guanine pairs with the pyrimidine, Cytosine. These pairs of bases are called **complementary bases.**

There are **two** hydrogen bonds between A and T and **three** hydrogen bonds between G and C. A and T are complementary bases and so are G and C.

In the DNA helix, a complete helical turn occurs after 3.4 nm (or 34Å). This complete turn encloses 10 base pairs. Each base pair lies 0.34 nm (3.4 Å) apart. The diameter of the double helical DNA molecule is 2.0 nm (Fig. 23.4c).

Watson and Crick model explains well how the two strands of a DNA molecule may separate at replication and transcription and then rewind.

The hereditary material must be capable of (i) replication (ii) storage of information (iii) transmission of information (iv) expression of information and (v) regulation of gene expression.

Packaging of DNA in Eukaryotic chromosome

In the bacteria (prokaryotes), ***only one double stranded DNA molecule*** constitutes the chromosome. Eukaryotes have many chromosomes and also many genes. One chromosome, however, is made up of one long double stranded DNA molecule. So how does this long molecule get accommodated in the chromosome seen as small mircoscopic entities during cell division? Fig. 23.5 shows how a long DNA molecule is packaged.

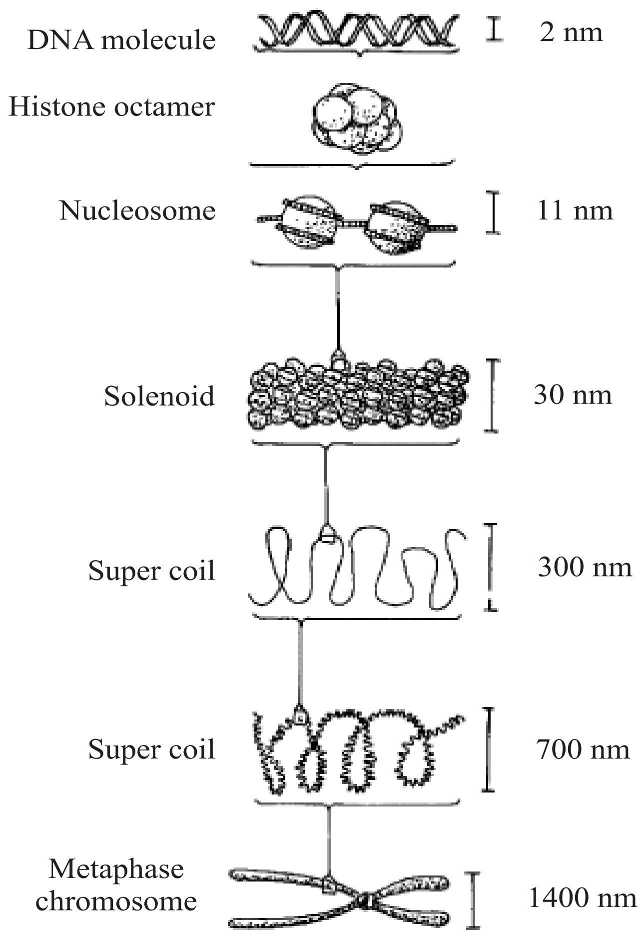


Fig. 23.5 Packaging of the DNA molecule.

- At intervals DNA molecule is coiled around a "core particle" which is an **octamer**, that is made of 8 histone proteins forming a ball like structure.
- Each core particle with DNA around it is called a **nucleosome.** Under the electron microscope the eukaryotic chromosome looks like a string of beads (string being the DNA molecule and beads the nucleosomes).
- The string is then coiled to form a **solenoid** and the solenoid is coiled again (**supercoiling**) ultimately to form the chromosome.
- In this way the long DNA molecule becomes thicker and thicker and shorter and shorter as shown in the figure.

23.4 RNA OR RIBONUCLEIC ACID

Apart from DNA, RNA or Ribonucleic acid is the other important nucleic acid present inside the cell. Table 23.1 gives the differences between DNA and RNA.

Table 23.1 Differences between DNA and RNA

DNA	RNA
1. *Double* stranded molecule	1. Single stranded molecule
2. Contains **deoxyribose** sugar	2. contains **ribose** sugar.
3. Pyrimidine base complementary to Adenine is **Thymine**	3. Pyrimiine base complementary to adenine is **Uracil** No thymine in RNA
4. DNA has only one function, that is to bear hereditary in formation	4. Many species of RNA such as mRNA, tRNA, rRNA with different functions. RNA is the genetic material in retroviruses.
5. DNA can duplicate **on its own**	5. RNA is synthesized **on a DNA template**

Functions of various type of RNA

mRNA or messenger RNA

mRNA or messenger RNA is transcribed in the nucleus to carry information for the protein to be synthesized, from DNA to site of protein synthesis in the cytoplasm.

mRNA is transcribed as a strand of complementary bases of one of the DNA strands and carries the information for the synthesis of a particular protein or polypeptide.

tRNA or transfer RNA

tRNA or transfer RNA, also called soluble RNA has a clover leaf structure (Fig. 23.6) with loops. One loop recognises the ribosome, the top loop has an 'anticodon' to recognise the codon (triplet nucleotide sequence coding for an amino acids) on mRNA. tRNA "transfers" the amino acids to their respective positions during synthesis of protein.

There are many t-RNAs which differ in their anticodon. Each tRNA is specific for an amino acid and can carry that amino acid to the ribosome during protein synthesis.

The 3' end of every t RNA ends in the bases CCA and the 5' end of the tRNA end in G. Amino acid is carried at 5' end.

tRNA contains unusual bases like inosine, dihydrouridine etc.

rRNA or ribosomal RNA

rRNA is a component of ribosome which are ribonucleoprotein particles containing RNA and proteins. rRNA is synthesized from the information in ribosomal genes in a chromosome. rRNA has a role in protein synthesis

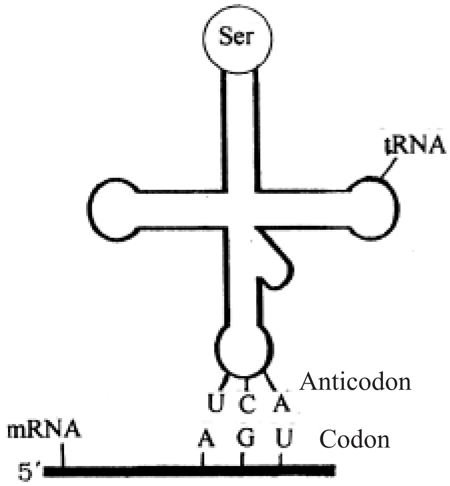


Fig. 23.6 RNA showing anti codon and codon pairing.

23.5 MECHANISMS OF DNA TRANSFER IN BACTERIA

Bacteria are prokaryotes and possess a single DNA molecule as their single chromosome. The DNA molecule is double stranded and helically coiled. Among bacteria, genes may be transferred from one bacterium to the other. DNA transfer or gene transfer can occur among bacteria by any one of the three processes, 1. Conjugation, 2. Transformation and 3. Transduction

Conjugation

Two bacteria may come together for **conjugation**. In conjugation, a plasmid containing a few genes passes from one bacterium into the other. The transfer (also called horizontal gene transfer) may also happen through a break in the single strand of the chromosome of **donor bacterium** and then that broken one strand is transferred to the **recipient bacterium**. The single strand left behind in the donor as well as the single strand donated to the recipient cell then become double stranded by adding a strand with complementary bases. The transferred DNA gets integrated into recipient chromosome. This is called **recombination.** Conjugation occurs between two strains of bacteria F^+ and F^-. The transferred DNA is from F^+ called F factor. Since F factor from F^+ is integrated into bacterial chromosome, there is high frequency of recombination, hence the strain is now known as H fr strain.

Transformation

Recall from the earlier part of this lesson (21.2) that DNA from one bacterium may integrate into DNA of another bacterium as in case of *Streptococcus pneumoniae*. Transformation is defined as the **ability of extracellular DNA to enter a bacterial cell** and recombine with the bacterial genome. The bacterial genome acquires new properties on account of the foreign DNA that had entered.

Transduction

Transduction refers to transfer of DNA from one bacterial cell into another bacterium through the agency of a virus (bacteriophage). A phage may undergo **lysogeny**, that is the virus enters the bacterium and divides along with bacterial genome. So a number of viral particles can form. Meanwhile viral DNA integrates and becomes part of bacterial DNA which is now a new **recombinant DNA**. Sometimes the viral genome may become independent and carry host bacterial genes to another new host bacterium and recombine into its genome. This process of gene transfer is called **transduction.**

INTEXT QUESTIONS 23.1

1. Expand the abbreviation DNA.

   ....

2. Name the scientists who confirmed that DNA was the genetic material in bacterial transformation.

   ....

3. Name the sugar and the nitrogenous bases found in DNA

   ....

23.6 DNA REPLICATION

DNA duplicates itself with complete fidelity for passing on genetic information to the next generation of cells. Replication may thus be defined as a mechanism for transmission of genetic information generation after generation.

You have learnt in the lesson on 'cell' that the cell passes through the cell cycle and DNA replication or DNA duplication takes place during S-phase.

Mechanism of replicaiton

Replication occurs through the following steps :

1. Unwinding of DNA double helix

The two strands of the replicating DNA molecule separate by the action of the enzyme **Helicase. Topoisomerase** enzyme keeps it open. The opened part is the replicaiton fork as shown in Fig. 23.7a.

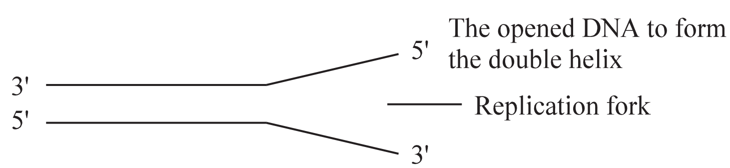


Fig. 23.7a Replication fork

2. Synthesis of the primer

Primer is a short RNA molecule of about 5 to 10 bases. It is formed in the presence of the enzyme **primase**. The primer provides a 3'-OH group for attachment of the new DNA strand.

3. Synthesis of new DNA strand

The opened strands of DNA form the template. New strands complementary to template get synthesized. At the replication fork, a new DNA strand begins to synthesise, attaching itself to the primer, in the presence of the enzyme **DNA polymerase**. It begins synthesis from its 5' end and a DNA strand complementary to one of the unwound parental DNA strand gets synthesized. The new strand of DNA **continues to be synthesized uninterrupted** and is termed as the **leading strand.**

Synthesis of the other new DNA strand

DNA synthesis always takes place along 5' to 3' direction. Therefore, the other new DNA strand gets synthesised in the direction opposite to the leading strand. This new strand called **Lagging strand** builds up in small pieces as shown in the figure, in the presence of enzyme **DNA polymerase**. Thus, the synthesis of the lagging strand is **discontinuous** (Fig. 23.7b). The new pieces of DNA are termed **Okazaki fragments**. In the presence of the enzyme **ligase** and the energy source ATP, the okazaki pieces get joined together to form a DNA strand

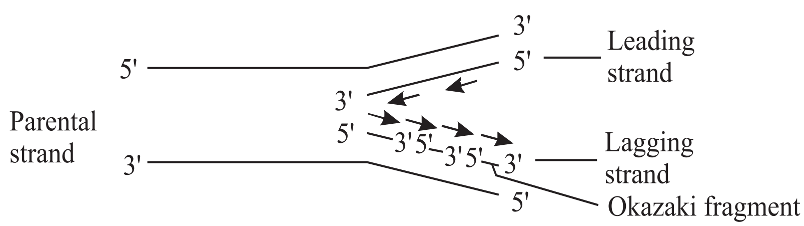


Fig. 23.7b Formation of new DNA strands

- DNA replication is remarkably accurate so that the parental DNA molecule gets an exact duplicate copy. Any mistake gets chipped and repaired. This is at the end of DNA replication and is called DNA **proof reading**.
- After **DNA replication,** two identical DNA molecules are formed which are identical to the parent molecule.
- DNA replication is thus **semidiscontinuous**, that is, one strand of the new DNA molecule builds up continuously and the other in pieces.
- DNA replication is **semiconservative**, since in the two new molecules formed, one parental strand is conserved and the other strand is newly synthesised The semiconservative mode of DNA replication was experimentally proven by Messelson and Stahl.

INTEXT QUESTIONS 23.2

1. In which direction does DNA polymerase proceed to catalyse DNA replicaiton 5′ to 3′ or 3′ to 5′?

   ....

2. What is a primer .... a DNA molecule or an RNA molecule?

   ....

3. Name the four enzymes needed for DNA replication.

   ....

4. Which enzyme joins the okazaki pieces to form a complete DNA strand?

   ....

23.7 GENES AND PROTEIN SYNTHESIS

The genes of an individual is the **genotype**, and the expression of genes results in the **phenotype**. This you have already learnt in the previous lesson. There are different **structural proteins** e.g. Haemoglobin in blood, enzymes e.g. pepsin, almost all of which are proteins. There are **carrier proteins** in the cell membrane about which you have learnt in lesson 1, on cell. So there are various proteins and the information for the formation of these proteins is present in the genes, which you know are sequences of bases in the DNA molecule.

For the study of protein synthesis you have to first understand the following

1. Central dogma
2. Genetic code

23.7.1 Central Dogma

Genes are in the nucleus and proteins are synthesised in the cytoplasm of the cell. **The transfer of information from genes to the site of protein synthesis constitutes the Central Dogma.** The central dogma operates in the following sequence. Information flows from DNA (particular gene) to the particular protein through RNA.

$$\text{DNA} \xrightarrow{\text{Transcription}} \text{RNA} \xrightarrow{\text{Translation}} \text{Protein}$$

For protein synthesis, first the information coded in DNA is copied as a complementary messenger RNA molecule. This is termed as **Transcription**. Messenger RNA carrying information moves out of nucleus into the cytoplasm, attaches to the ribosomes to translate the information in the form of a protein. This is termed **Translation** as shown.

In retroviruses, the genetic material is RNA. Therefore, during protein synthesis it is first ‘transcribed into a DNA molecule in the presence of the enzyme **Reverse Transcriptase** and then the path of central dogma is followed as shown below.

$$\text{RNA} \xrightarrow[\text{transcription}]{\text{Reverse}} \text{DNA} \longrightarrow \text{mRNA} \longrightarrow \text{Protein}$$

(genetic material
of retrovirus)

23.7.2 Genetic Code

The information for the synthesis of proteins is present in the DNA in a sequence of nucleotides. This coded information was discovered by Nirenberg, Mathais and Ochoa.

The genetic code refers to the information in DNA responsible for the amino acid sequence of a particular protein to be synthesised. The information is coded as sequence of nitrogen bases in the DNA molecule. The particular gene or fragment of DNA which carries the code for synthesis of a complete polypeptide (protein) is termed a **cistron**.

The genetic code has the following characteristics:

1. Genetic code is a **triplet** code. This means that sequence of 3 bases called **codon** has the information of a particular amino acid. The **sequence of** codons determine the sequence of amino acids in a protein.

2. Genetic code is **unambiguous,** that is a particular codon can code for only one amino acid.

3. Genetic code is **commaless** and **non-overlapping**. This means that it is read continuously from beginning to end.

4. Genetic code is **degenerate**. There are 20 amino acids only that form the various proteins of living beings. But if 3 out of 4 nucleotides (each containing one of the four bases) form a codon, there can be $4^3 = 64$ codons. Hence more than one codon codes for a particular amino acid that is, the code is degenerate. In fact as you can see from the table 23.1 first two bases of the codons for the same amino acid are common and the third one changes or wobbles. This is called **Wobble hypothesis**.

5. The genetic code is read on the transcribed mRNA during protein synthesis.

6. AUG codon, codes for Methionine and is the **initiation** codon as it is the first one to be transcribed from a cistron.

7. UAA, UAG and UGA are stop codons and anticodons of one of these three codons is present at the end of every cistron to terminate protein synthesis.

8. Genetic code is universal and common for almost all organisms on earth. (Table 23.1).

23.7.3 Transcription in Prokaryotes (Bacteria)

The flow of genetic information from cistronic DNA to mRNA is called Transcription. It occurs in the following steps–

1. Cistronic DNA which carries the information for the protein to be synthesised unwinds in the presence of enzymes helicase and topoisomerase.

2. RNA polymerase begins to catalyse synthesis of mRNA signalled by a protein called **sigma** factor.

3. mRNA is synthesised complementary to cistronic DNA and a Rho factor signals RNA polymerase to complete transcription.

4. The strand of DNA which bears the code for transcription of the specific protein is called **sense strand of DNA** opposed to the **antisense strand** which is not transcribed. (Fig 23.8)

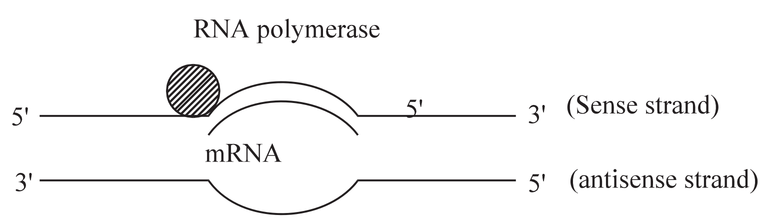


Fig. 23.8 Transcription in prokaryotes

In Eukaryotes a large molecule of RNA called hn RNA is synthesised in the nucleus when its sense strand is exposed. Catalysed by enzyme RNA polymerase, hn RNA is processed to form mRNA which gets a cap at 5' end and a poly A tail, before leaving the nucleus.

Processsing of mRNA

hnRNA is large because eukaryotic genes contain coding sequences called **exons** and non coding sequences called introns (I) in between exons. Both introns and exons (E) are transcribed in mRNA. During processing of mRNA, introns are cut off and exons join to form mRNA.

- A nucleoside (recall from section 23.3) called methyl guanosine comes and attaches at the 5' end of mRNA. This is called capping.
- A small piece of RNA having only nucleotides containing the base Adenine is attached at the 3' end. This is called the poly A tail.
- The m RNA with cap and tail moves out of the pores in the nuclear membrane.

The process of formation of functional mRNA from hnRNA is termed **RNA processing** (Figs. 23.9)

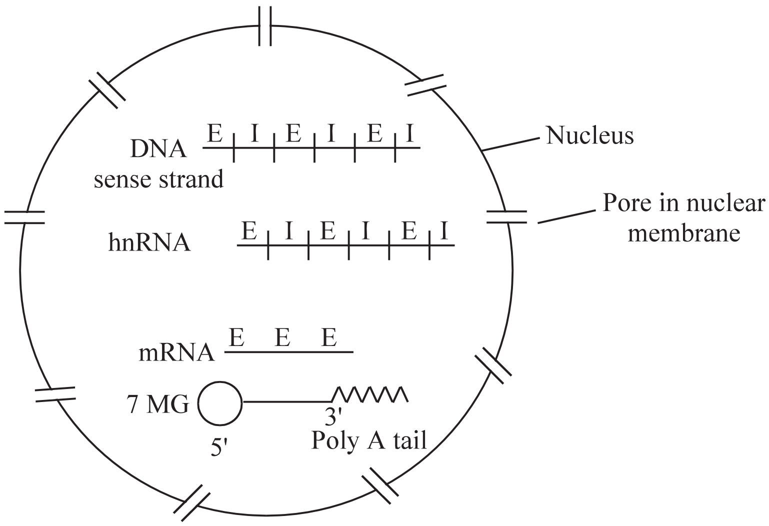


Fig. 23.9 Schematic drawing showing transcription and processing of hnRNA in eukaryotes

23.7.4 Translation

A series of events follows transcription in which the language of nucleotides transcribed (copied) in mRNA is **translated** into the language of amino acids to form a protein. These events are

1. Activation of amino acid
2. Formation of mRNA ribosome complex and chain initiation
3. Chain elongation
4. Chain termination

Activation of amino acid

A specific t RNA attaches to specific amino acid in the presence of the enzyme **amino acyl-tRNA synthetase** in two steps given below. This requires energy

$$\text{Amino acid} + \text{ATP} \xrightarrow[\text{tRNA synthetase}]{\text{aminoacyl}} \underset{\text{(Amino acyl adenylate)}}{\text{aa} \sim \text{AMP}} + \underset{\text{(Inorganic phosphate)}}{\text{Pi}}$$

$$\text{aa}\sim\text{AMP} + \text{tRNA} \xrightarrow[\text{tRNA synthetase}]{\text{aminoacyl}} \underset{\text{(Amino acid attached to its tRNA)}}{\text{aa} \sim \text{tRNA}} + \text{AMP}$$

Formation of mRNA ribosome complex and chain initiation

- mRNA binds to small ribosomal subunit

- Larger subunit of ribosome attaches to complete the ribosome.
- The mRNA ribosomal complex contains two codons so that at a time two amino acids can be accommodated in the ribosome.
- In the presence of some proteins called **initiation factors** methionine (an amino acid is carried to the mRNA ribosome complex and enters at the A site in the large subunit of ribosome. Recall that tRNA has an **anticodon** a sequence of three bases complementary to the codon for methionine.

Chain elongation

The second amino acid is carried by its tRNA to the ribosome according to the second codon on at the P site in large ribosomal unit. Peptidyl transferase enzyme then helps to establish a bond between the first two amino acids. The first amino acid loses its tRNA which moves out. Ribosome then moves over the m-RNA towards 3' end. The dipeptide made of the two amino acids shifts towards 5' end such that the second amino acid occupies the A site with methionine attahed to it. The third amino acid then enters through P site carried by its tRNA according to third codon. In the presence of peptidyl transferase, a peptide bond is formed between second and third amino acids and tRNA of second amino acid becomes free. In this way the peptide chain is synthesized. (Fig. 23.10).

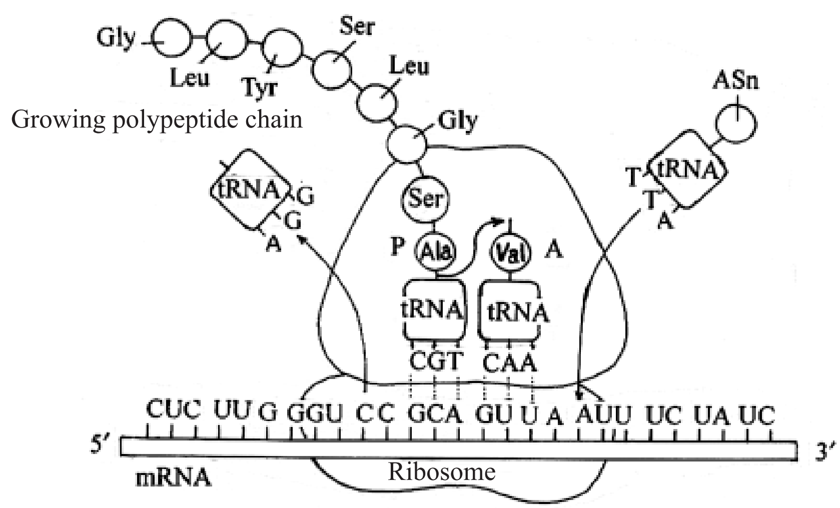


Fig. 23.10 Translation of mRNA Polysome assembly

- **Polysome assembly**

  When mRNA has shifted ahead such that about ten amino acid long peptide is synthesised, a second ribosome attaches to form ribosome mRNa complex. Thus at one point of time a number of ribosomes are seen attached to mRNA one molecule of the polypeptide continues synthesis in each ribosome till the termination codon is reached (Fig. 23.10).

Chain termination

When the stop codon on mRNA is reached, the polypeptide is synthesised. It leaves the ribosome and the ribosome dissociates into its two subunits.

INTEXT QUESTIONS 23.3

1. What is central dogma in molecular Biology?

   ....

2. Which molecule is synthesised during transcription?

   ....

3. What is a codon? What is meant by 'code is degenerate'?

   ....

4. Where in the cell does translation occur?

   ....

5. Name the three types of RNA that participate in protein synthesis.

   ....

23.8 HOUSE KEEPING GENES

In multicellular organisms, all cells contain all genes but only those genes function which are required to be active. In other words the expression of genes is regulated by switching on and switching off genes when required.

Certain genes, however, bear the code for proteins needed in the cell all the time. These are the genes needed for survival and maintenance of the cells and need to be expressed all the time. Such genes which are expressed all the time in all cells are termed **housekeeping genes. Inducible genes** are the genes which are switched on when a particular substance is present in the environment. **Repressible genes** are those which are shut off in the presence of a specific substance in the environment.

23.9 REGULATION OF GENE EXPRESSION

In Prokaryotes, the Lac-operon is an excellent example of control of gene expression in prokaryotes (bacteria). It is an inducible system and is switched on in the presence of the substrate **lactose**. Enzymes for metabolising lactose are galactosidase, permease and transacetylase and genes that code for them get switched on. In the absence of lactose, they remain switched off.

Jacob and Monod received the Nobel prize for showing that bacterium *Escherichia coli* has a set of genes forming an "operon" which regulate expression of genes coding for enzymes needed to breakdown lactose. The operon includes certain genes lying close together on the chromosome next to the regulator gene i, and includes promoter gene p which RNA polymerase identifies at the time of transcription; operator gene, o which switches on structural genes z, y, a coding for the enzymes, Galactosidase, Permease and Transacetylase.

The working of the operon system is given in Fig. 23.11a-b.

In absence of the substrate lactose

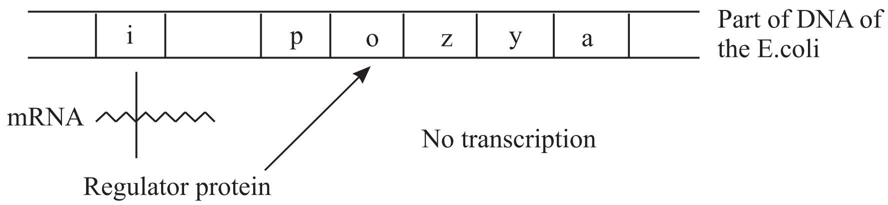


Fig. 23.11a Lac operon switched off

Regulator protein blocks o, RNA polymerase cannot find p and z, y, a remain switched off.

In the presence of lactose

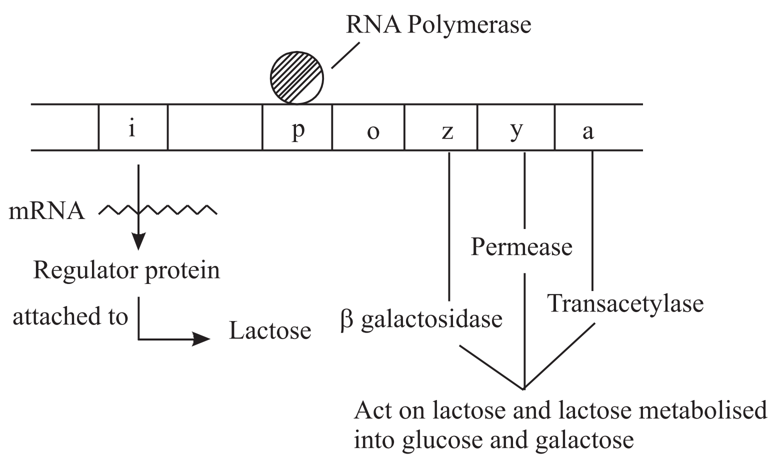


Fig. 23.11b Lac operon switched on

Regulator protein is attracted to lactose, o site opens; RNA polymerase finds promoter; genes z, y, a switched on, transcription begins and the three enzymes are synthesized inside the cell.

The above is an example of inducible system. Repressible systems are also found in prokaryotes.

Gene regulation in eukaryotes is more complex, Gene expression can be regulated at level of transcription or processing of hnRNA into mRNA or at translation or post translation. (Fig. 23.12).

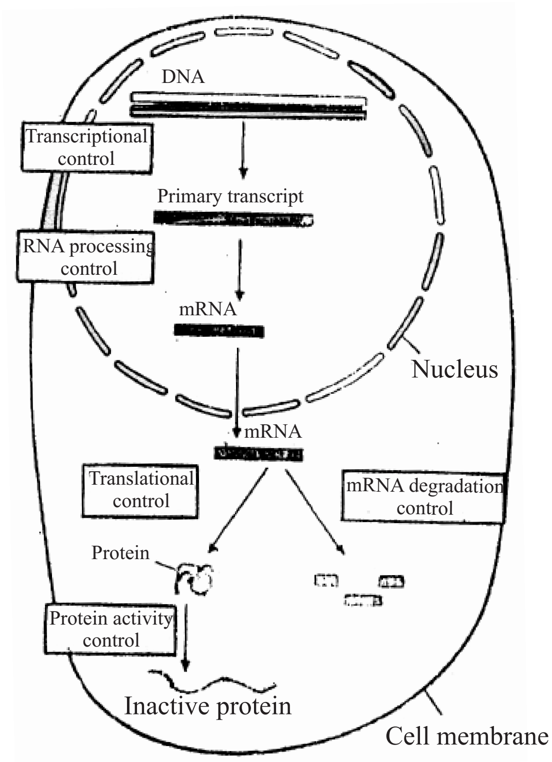


Fig. 23.12 Levels of gene control in eukaryotes

A heritable change in the structure, content and organization of the genetic material that can be passed down to the next generation is termed **mutation**. Mutation may occur in **one gene** when it is termed **point mutation** or may affect a number of genes on a part of chromosome when it is termed **chromosomal mutation**.

Chromosomal mutation

Involves a number of genes. It is of two types, (1) Change in number of chromosomes and (2) Change in structure of chromosomes.

The number of chromosomes in individuals of a species is fixed. For example humans have 2n = 46 chromosomes. But sometimes one or more chromosomes may be lost or added and such a change in number is termed **Aneuploidy** when 2n = 45 or 2n = 47 is found is an individual. Sometimes the whole set of chromosomes may be duplicated so that instead of 2n, an individual way possess 3n or 4n chromosomes. This is **polyplocdy**.

Chromosomal change in structure is also termed as **chromosomal aberration**. It is of four types 1. **Deletion**, in which a piece of a chromosome may be lost. 2. **Inversion**, a piece of a chromosome breaks off and rejoins in the reverse direction. 3. **Duplication** A part of the chromosome may get represented twice and 4. **Translocation** a piece from another chromosome may get attached.

Genes mutation or Point Mutation

A change which affects only one gene is called gene mutation or point mutation. You already know that gene is a segment of DNA and is made of a sequence of nucleotides. Whenever one nucleotide is changed within a gene, it may cause a change in the phenotype.

Gene mutation is of the following types :

1. Transition : When a purine base is replaced by another purine base or a pyrimidine base by another pyrimidine

   ATGCATGC ⟶ A**G**GC AGGC

2. Transversion : When a purine base is replaced by pyrimidine base and similarly a pyrimidine base by a purine

   ATGC ATGC ⟶ ATG**T** ATGC

3. Frameshift : Sometimes due to loss or gain of one nucleotide the reading frame of the genetic code for an entire protien changes

   CAT CAT CAT CAT ⟶ CAT ATC ATC ATC

   when C gets lost after CAT

4. Missense : A change in the genetic code due to replacement of a nucleotide (base) may give rise to a different protein e.g. sickle cell haemoglobin.

5. Nonsense : If a genetic code changes such that it becomes a stop codon mid way, no protein is formed e.g.

   GAAGAAGAA ⟶ GAA**UAA**AA

   synthesis stops as UAA in stop condon

6. Silent : When the changed nucleotide does not bring about any phenotypic change because it also codes for same amino acid.

Mutagens

Agents that cause mutation in the genetic material are called **mutagens**. Mutagens belong to two categories

1. Radiations : x-ray, UV rays, α radiations.
2. Chemical : Mustard gas, Actinomycin D

INTEXT QUESTIONS 23.4

1. Name the components of an operon.

   ....

2. What is mutation? When is a mutation called a transition mutation?

   ....

3. Why is "silent mutation" called so?

....

4. What are mutagens?

....

5. Name a chemical which causes mutation in the heredity material.

....

WHAT YOU HAVE LEARNT

- One gene was found to be responsible for the production of one enzyme, and this was called one gene one enzyme hypothesis.
- The transformation of the bacteria from harmless to virulent is termed bacterial transformation.
- DNA is a polynucleotide, made up of nucleotides. Each nucleotide consists of three subunits (i) deoxyribose sugar (ii) any one of 4 nitrogenous bases (Adenine, Guanine, Thymine and cytosine (iii) a phosphate group.
- RNA is the other important nucleic acid present inside the cell. RNA has pentose sugar ribose and base uracil instead of cytosine. Many species of RNA such as mRNA, tRNA, rRNA have different functions.
- Transformation means the ability of extracellular DNA to enter a bacterial cell and recombine with the bacterial genome.
- Transduction refers to transfer of DNA from one bacterial cell into another bacterium through the agency of a virus.
- Replication may be defined as a mechanism for transmission of genetic information generation after generation.
- The transfer of information from genes to the site of protein synthesis constitutes the central dogma.
- The information for genetic coded was discovered by Nirenberg, Mathair and Ochoa.
- The flow of genetic information from cistronic DNA to mRNA is called transcription.
- A single triplet (three bases) is called codon.
- Mutation is a sudden change in genes or chromosomes resulting in alteration of protien/phenotype.

TERMINAL EXERCISES

1. How did Hershey and Chase prove that DNA is the hereditary material?
2. Explain (i) Transduction and (2) Lysogeny
3. Describe the Watson and Crick model of DNA.
4. Explain how replication takes place.
5. Write a note on Central Dogma
6. State the properties of the genetic code.
7. Explain transcription in Eukaryotes and processing of hnRNA.
8. What do you mean by regulation of genes?
9. Explain how the lac operon gets switched on in the presence of lactose in *E.coli*.
10. Name three levels at which regulation takes place in a eukaryotic cell.
11. Write notes on :
    (i) Types of mutations
    (ii) Okazaki fragments
    (iii) Chain termination during translation.

ANSWERS TO INTEXT QUESTIONS

23.1
1. Deoxyribonucleic acdi
2. Avery, Mcleod and McCarty
3. Deoxyribose, Adenine, Guanine, Thymine, Cytosine

23.2
1. In 5'-3' direction
2. RNA molecule
3. Helicase, DNA polymerase, DNA ligase, Topoisomerase
4. DNA ligase

23.3
1. The transfer of information from genes to the site of protein synthesis constitutes the central dogma.
2. Cistronic DNA
3. Sequence of three bases in the genes.
4. Nucleus
5. mRNA, tRNA, hnRNA

23.4
2. A heritable change in the structure, content and organization of genetic material when in a DNA sequence a purine is replaced by purine and pyrimidine is replaced by pyrimidine.
3. A silent mutation ina gene does not bring about a change in the synthesis of the coded protien.

24

GENETICS AND SOCIETY

You have already learnt that genetics is the science of heredity and variation. After Mendel's work was rediscovered in 1900, genetics progressed very rapidly in the 20th century. Today we find many applications of the knowledge of genetics in the fields of agriculture, medicine and forensic science. Some technologies related to genetics such as gene cloning, recombinant DNA technology, DNA fingerprinting, raising genetically modified crops will be dealt with in this lesson. Biopiracy, biosafety and biopatents related to GMOs and Bt crops have also been touched upon

OBJECTIVES

After completing this lesson, you will be able to :

- *highlight human curiosity and consciousness for healthy progeny;*
- *define the term gene cloning;*
- *explain the usefulness of gene bank;*
- *enumerate the various steps of recombinant DNA technology in a sequence;*
- *define genetic engineering and mention its utility;*
- *define transgenic organism, explain the steps in its production and cite examples of transgenic animals, plants and microbes;*
- *critically evaluate the advantages* and disadvantages of growing Bt crops;
- *describe steps of polymerase chain reaction and mention its (PCQ) use;*
- *list the steps of DNA fingerprinting and mention its usefulness;*
- *explain the term genomics;*
- *justify the importance of genetic counselling.*
- *express concern regarding biosafety and awareness regarding biopiracy and biopatents*

24.1 GENETICS THROUGH AGES

The history of genetics can be traced to prehistoric times and can be classified into three eras as given below :

Early ideas

Primitive art such as drawings in ancient tombs and caves, bones and skulls show that human activities included selecting, breeding and domesticating plants and animals. Between 8000 and 1000 BC, horses, camels oxen and dogs had been domesticated. Between 7000 to 5000 BC corn, rice, wheat and datepalm were being cultivated.

Between the 17th and 19th century many theories regarding inheritance had been proposed but could not be proved. These were **epigenesis, preformationism, blending inheritance** and **pangenesis**. But this clearly shows that humans were always curious to know how traits are passed down the generations.

Modern Genetics

Gregor Johann Mendel, whose principles (laws) of inheritance you have learnt in earlier lessons of the unit is regarded as the founder of modern genetics. Between 1902 and 1904, the **chromosome theory of inheritance** was accepted and chromosomes, which could actually be seen under the microscope during cell division were regarded as the 'bearers of hereditary characters (genes)'. **Mutations** were recognised as source of **genetic variation.**

With the acceptance of Darwin's theory of natural selection, geneticists studied the inheritance of traits in populations (**Population genetics**).

Molecular Genetics

By the mid 20th century, **DNA** was established as the genetic material and structure and chemical nature of DNA was understood [recall the double helical structure of DNA as proposed by J. Watson and F. Crick]

The **central dogma** of molecular biology holds that genetic information resides in DNA, but its expression is in the form of proteins which are synthesized according to genetic information carried by mRNA from DNA.

In the last two decades of the twentieth century more has been understood about the **nucleic acid molecules** and **protein molecules** and also about the **genetics of bacteria**. The knowledge gained has led to the invention of technologies of **genetic engineering, gene cloning, organismal cloning, DNA finger printing**. Even more recent are the fields of **genomics** and **bioinformatics**. The entire genetic make up (genome) of an organism can now be cloned, sequenced and functions of the various genes explored. Knowing the human genome has opened up the possibilities for handling genetic disorders through **gene therapy.**

24.2 GENE CLONING AND GENE BANK

The term **clone** is a collective term for **genetically identical** individuals. You have probably heard about the sheep named "Dolly", which possessed the same genes as did her mother as she was cloned from her mother.

> In the Roslin Institute in Scotland, Ian Wilmut cloned "Dolly" the sheep from Dolly's mother in 1996. The nucleus from a cell from Dolly's mother's udder (mammary glands) was introduced into the egg of another ewe (female sheep) whose nucleus was removed. This cell divided to give more cells which formed an embryo that could be implanted into the uterus of another ewe (surrogate mother).

The production of large quantities of identical genes is called **gene cloning**. Since any gene is a segment of DNA having a **particular sequence** of the four nitrogen bases (A, T, G, C), multiple copies of a particular gene may be obtained by means of **recombinant DNA technology**, popularly known as **genetic engineering**. You will learn more about genetic engineering later in this lesson.

Gene bank

Various clones of bacteria carrying the **desired genes** in their DNA can be stored and preserved at very low temperatures for their future use, in a gene bank. A gene bank or a gene library or a DNA library is, thus, a collection of bacterial or bacteriophage (virus) clones. Each clone carries specific DNA segment (gene) from another organism. For example, human gene coding for the hormone insulin may be inserted through genetic engineering into a bacterium. When the bacterium multiplies it forms a clone of bacteria carrying the gene for insulin and may be preserved in the '**gene bank**'. Thus, clones from a gene bank may be used for producing large quantities of certain enzymes, hormones and vaccines.

INTEXT QUESTIONS 24.1

1. Name any two recent techniques in genetics.

   ....

2. Define gene cloning

   ....

3. What is a gene bank ?

   ....

24.3 RECOMBINANT DNA TECHNOLOGY

One of the major applications of genetics is in "genetic engineering" which is also called recombinant DNA technology. In this technique the desired gene which is a DNA segment carrying a particular sequence of nucleotides, is added to the DNA of another organism (usually a bacterium) with the help of a transferring agent or **vector**. The modified DNA molecule carrying DNA from two different sources is called **recombinant DNA** or **rDNA.** The joining of two pieces of DNA is termed **DNA splicing** (Splicing in Latin means marriage).

The steps in the production of rDNA is as follows (Fig. 24.1) :

- The desired piece of DNA is cut from the cells (e.g. human cells) with the help of enzymes called **restriction endonucleases** or restriction enzymes. These enzymes are found in different bacteria. They recognise **specific nucleotide sequences** in a DNA molecule and cleave (cut) them.
- The same restriction enzyme cuts the same specific nucleotide sequence in a plasmid. A plasmid is a ring shaped DNA molecule present in a bacterium. It is **not** part of the chromosome of the bacterium. It is used as a vector for transferring the foreign DNA into the host cell.
- The desired DNA fragments are then mixed with the cleaved plasmids. These plasmids pick up the foreign DNA pieces with the same base sequence to replace their lost parts. These become the recombinant plastids and the DNA is rDNA or **recombinant DNA**
- The recombinant plasmids are now introduced into or mixed with their bacteria which pick up the recombinant plasmids.
- The r-plasmids in the bacteria multiply along with the host bacteria. Soon a **clone of bacteria with** rDNA is obtained. Such a bacterial clone containing copies of the desired gene can be preserved for future use. For example, as already mentioned, human insulin gene can be inserted into bacterial plasmid and insulin obtained from the bacterial clone when needed.

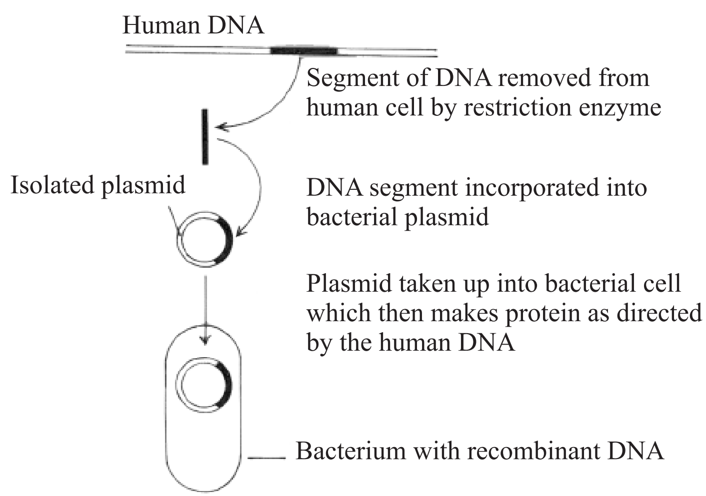


Fig. 24.1 Major steps in genetic engineering.

24.4 IMPORTANCE OF GENETIC ENGINEERING

Genetic engineering or rDNA technology can be used for various purposes:

- To manufacture important compounds like vaccines, hormones, vitamins, antibodies etc. The production of these substances is by inserting genes responsible for them in the bacteria and then getting clones of these bacteria to produce the desired substances.
- To manufacture enzymes used for making cheese.
- To breakdown pollutants through recombinant bacteria (bioremediation).
- To clone particular genes with the help of rDNA technology and build up a gene bank or a gene library.
- To use rDNA for gene therapy for curing genetic disorders.
- To raise useful plants (transgenic plants) resistant to herbicides (chemicals used to kill weeds) or insect pests by inserting genes in the plants through rDNA technology.

INTEXT QUESTIONS 24.2

1. What is the popular term for recombinant DNA technology?

   ....

2. What is meant by DNA splicing?

   ....

3. What is a plasmid and why is it called a vector for genetic engineering?

   ....

24.5 TRANSGENIC MICROBES, PLANTS AND ANIMALS

Also called genetically modified organisms (GM organisms), transgenic organisms contain in their genetic make up, foreign genes, that is, genes from another species or another kind of organism. **Transgenics are raised through recombinant DNA technology.**

24.5.1 Transgenic microbes

Bacteria are easiest to be genetically modified by adding foreign gene into their plasmids through rDNA technology as you have already learnt in this lesson. Transgenic bacteria with insulin gene and human growth hormone gene have been cloned to provide these hormones for human use.

Other uses of transgenic bacteria are in decomposing pollutants and extracting metals such as copper and gold.

24.5.2 Transgenic plants

Some genetically modified plants are herbicide and pest resistant. A genetically modified tobacco plant contains a gene from the firefly and emits green light.

Bt CROPS

Bt crops are genetically modified crops and are therefore also called **transgenic crops**. The name Bt crops is because the transgene or the foreign gene is transferred into the crop by the soil bacterium *Bacillus thuringiensis* (Bt).

The transferred gene or transgene is not harmful to the host crop into whose genotype the gene has been added. It codes for a protein called ***cry* protein**.

The bacteria Bt lives in the soil. In its genotype there is a gene called *cry* gene which produces an insecticidal (insect killing) protein. A Bt crop produces this protein. When an insect pest eats the Bt crop, cry protein is converted into a toxic substance by the enzyme present in the stomach of the pest. This toxic substance kills the pest.

The cry gene has been isolated and transferred into many crops, eg cotton, maize, brinjal, tomato and tobacco and tested in the fields. They are resistant to insect attacks. Use of Bt crops reduces the need for spraying insecticides to kill insect pests. Insecticides are harmful to humans and other animals.

However, Bt crops can only be cultivated after permission from Government of India, under Environment Protection Act (EPA). This is because entomologists worry that:

- Since Bt crops make the toxin throughout their growing season, pests may evolve which are Bt resistant
- Non-target species like the butterflies may die if they feed on Bt pollen.
- Genetically modified crops may be harmful for the environment as they may pass the gene into a close relative plant which may be useless for humans but perpetuate as super weeds.

24.5.3 Transgenic animals

The gene for growth hormone from cattle have been inserted through genetic engineering to produce large fish, pigs and some other animals.

Transgenic goats can produce a blood clotting protein in their milk. This may be useful for children suffering from disorders such as haemophilia in which blood does not clot.

> Genetic engineering offers a wide scope for transferring genes from one organism to another, such as plants to microbes, animals to microbes. Such gene transfers are not possible by other techniques like hybridisation. However, rDNA technology is not without problems. One danger is that accidentally or intentionally pathogens may be produced and misused as in biological warfare. Hence strict guidelines have been laid down for research in genetic engineering.

24.5.4 Biosafety

There is public concern about possible hazards of using genetically modified (GM) organisms as food. You already know that a GM organism is one that contains genes from another species. For example, Bt brinjal, a GM brinjal has genes added to genome of brinjal from another species by genetic engineering which helps it to protect itself from one of its pests. The salmon fish has been genetically modified by adding a more active salmon growth hormone gene.

But the concern is about safety of GM foods to humans and other animals and also to the environment. Hence, in early 2000, several countries agreed to a Biosafety protocol by which the safety of using GM foods is first ascertained before using them. In our country, Department of Biotechnology, in compliance with rules of Environment Protection Act (EPA) has to be consulted granting permission for research and use of any GM organism only after testing its safety to humans, other animals and the environment.

24.5.5 Biopiracy

Piracy means theft. Biopiracy means patenting or exploiting a biological resource of another country without being authorised or giving adequate compensation. For example, a rich developed country may patent a bioresource such as medicinal plant or traditional knowledge regarding a bioresource of a developing country. Sometimes a useful biomolecule extracted from a plant growing in another country may be patented and used for commercial benefits. Even genes from foreign plants and animals may be patented, eg U.S granted a patent for the germplasm of basmati rice grown in India.

24.5.6 Biopatent

A patent is an official document. Possession of this document permits the holder to use or sell his/her invention. The duration of a patent is 20 years and the patent holder has to obtain a license on certain reasonable terms and conditions. The Indian Patent Act (1970) provides patents for invention to be used as food, medicine/ drugs, alloys, semiconductors etc. In India, duration of patent is for 14 years except for food and pharmaceuticals which is only for 7 years.

The patent is granted to the inventor so that the invention is not used by others for commercial purposes. A patent may be granted for (i) an invention or discovery (ii) improvement of an earlier invention (iii) process of generating a patent (iv) a concept or design.

INTEXT QUESTIONS 24.3

1. Use the example of Bt crops to state importance of transgenic crops.

   ....

2. What is a cry protein?

   ....

3. Exploiting a biological resource of another country without being authorised is called ....
4. When and why was the biopatent act adopted in India?
   ....
5. What is the duration of a patent for pharmaceutical products in India?
   ....

24.6 POLYMERASE CHAIN REACTION

You have learnt in the lesson no 22, that DNA polymerase is the enzyme responsible for DNA replication or making a copy of a DNA molecule.

In the technique called **polymerase chain reaction (PCR),** DNA polymerase enzyme is used repeatedly for making many copies of a small fragment of DNA. Thus polymerase chain reaction or PCR helps in making many copies of a small amount of DNA.

The steps in PCR are,

- Double helical DNA molecule is heated so that it breaks up into two strands
- Primers are added and the DNA is cooled.
- DNA polymerase is added and in its presence the two single strands acquire complementary strands and so two molecules of the DNA are formed. (Fig. 24.2).

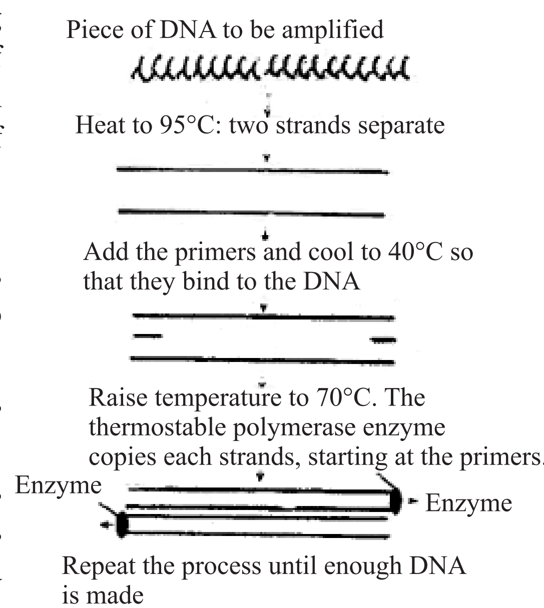


Fig. 24.2 Polymerase chain reaction

These steps are repeated to get multiple copies of DNA. These days DNA polymerase from a bacterium living in hot springs called Taq polymerase is used in PCR machines. DNA amplified by PCR can be used for various techniques.

24.7 DNA FINGER PRINTING

Like our fingerprints, the repeated sequences in our DNA are unique. You must have heard that the police lifts fingerprints from the scene of crime to identify the culprit in case of rape, theft or murder.

In 1984, Alec Jeffreys, a geneticist invented a technique which could distinguish the DNA of a person from that of another and called this technique **genetic fingerprinting** or **DNA fingerprinting**. This technique is now used for scientific investigation of crime. For example identifying correctly the accused in rape or murder or to solve paternity disputes (find out who the actual father of a child is).

DNA fingerprinting can be done from very small amounts of DNA which are taken out of a tiny drop of blood, semen, hair follicle, tooth pulp etc. picked up from the scene of crime. The steps in the technique are:

- DNA is isolated from blood, semen etc.
- Its quantity is increased through PCR
- The lengths of these DNA pieces vary from person to person because of certain repeated sequences of nucleotides in DNA which vary.
- The DNA pieces are separated from each other according to size and charge with the help of a technique called **electrophoresis.**
- The pattern as you can see in the figure given below is unique for each person.

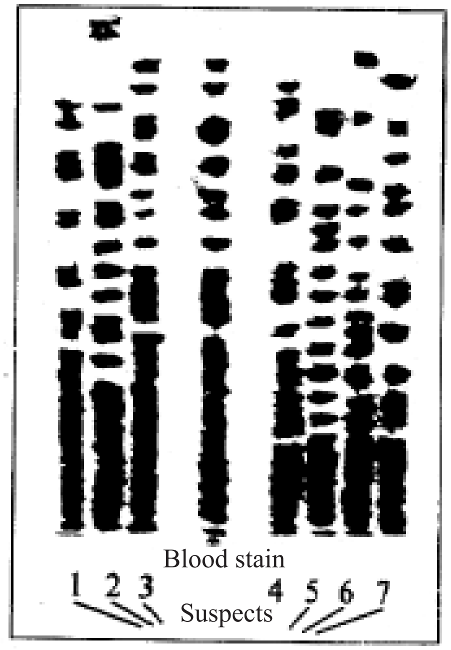


Fig. 24.3 DNA fingerprinting (Match and see that culprit is suspect No : 3)

In a crime, there may be three or four suspects. Their DNA fingerprinting is carried out and compared with that of the DNA picked up from the scene of crime. The one that matches the DNA print of one of the suspects is the actual culprit. (Fig. 24.3).

24.8 GENOMICS

Genome is a collective term for a full set of genes in an organism. Genes are paired and so genome means all the genes present in a haploid (n) set of chromosomes. Genomics is the analysis of the genome data, that is, finding out the functional nucleotide sequences (genes) in the DNA of an organism.

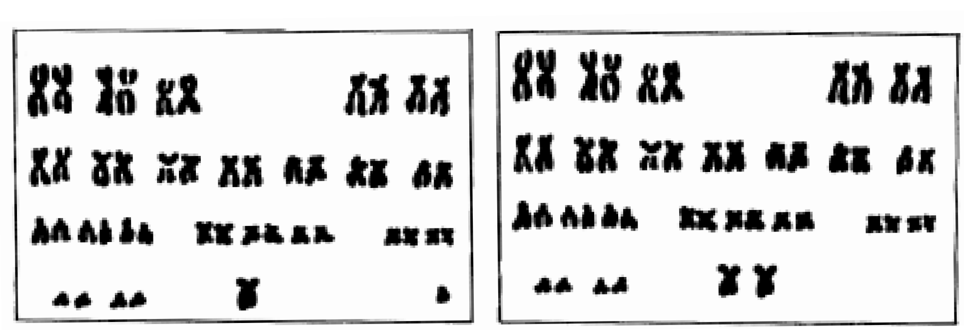


Fig. 24.4 Karyotypes showing Chromosomes of (a) male, and (b) female humans

The genome of *E. coli* bacterium, the yeast **Saccharomyces** and some other kinds of organisms is already known *e.g. Arabidopsis Drosophila.*

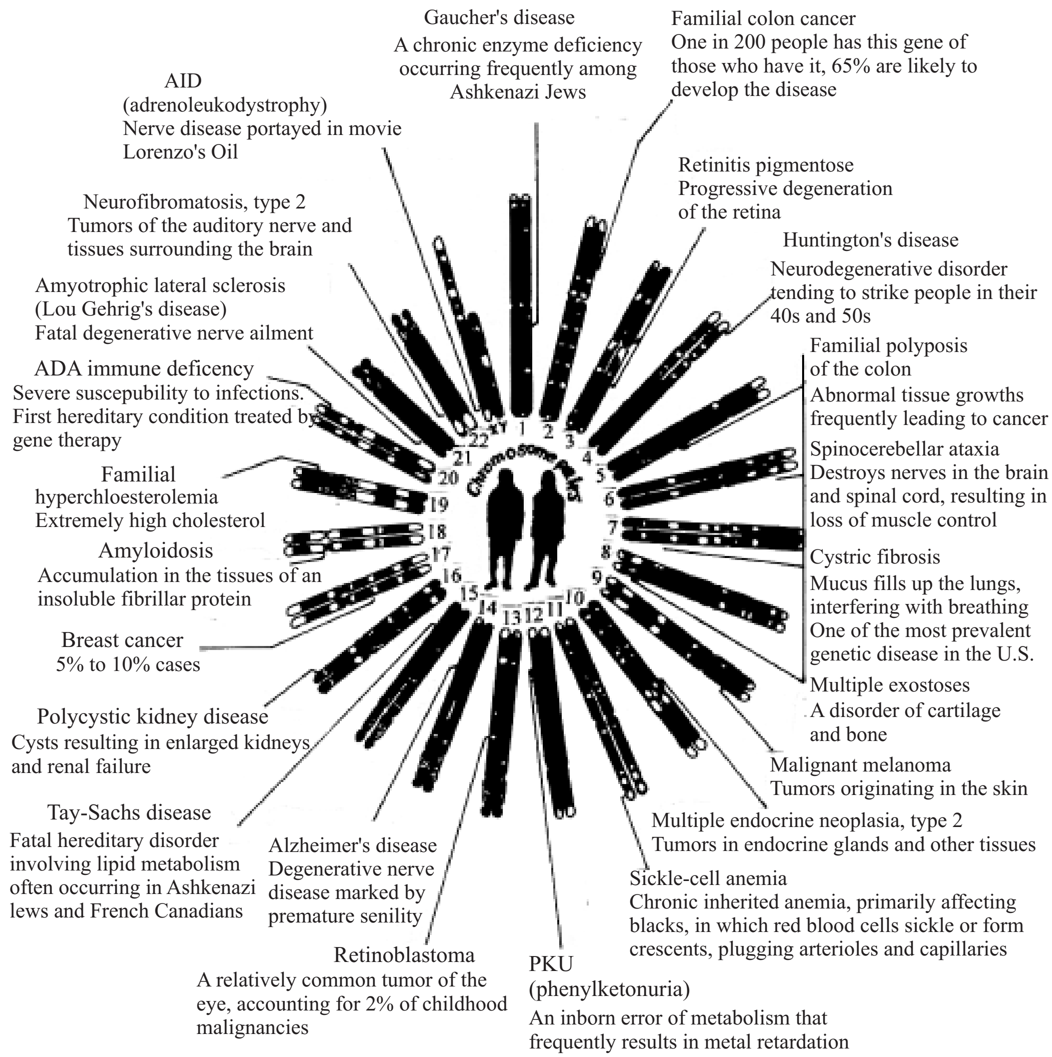


Fig. 24.5 Human genome showing location of some defective genes.

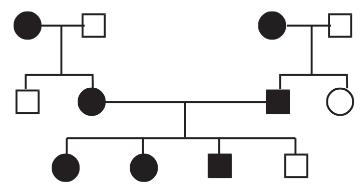
The human genome has been mapped in 2003. Humans have 23 pairs of chromosomes (2n = 46) and the human genome has 3×10^9 nucleotide base pairs and if the sequence of nucleotides (genes) is known, it will be possible to pinpoint (i) defective genes (as shown in the figure in the box) and (ii) identify genes for correction of genetic disorders (gene therapy) and genetic counselling.

24.9 GENETIC COUNSELLING

You have earlier learnt about dominant and recessive genes. If a child receives a dominant gene from one parent and its recessive from the other parent (heterozygous condition) the recessive gene does not express itself. Recessive genes get expressed only when they are in the homozygous condition, that is, both genes of a pair inherited from the parents are recessive.

You can probably appreciate why marriages between closed relations (termed consanguineous marriage) are discouraged. Being related, both parents may pass down the defective gene which may be present in a family. Most defective genes that cause genetic disorders are recessive. When both genes of a pair in the child are defective, the child is born with a genetic disorder. So if a couple wishes to know the chances of their child getting a particular disorder present in their family, they have to go to a **genetic counsellor. Genetic counselling** means advise given regarding a genetic disorder so that the couple knows whether to have any more children if their first child is suffering from a genetic disorder. The genetic counsellor has a very good knowledge of human genetics and can predict the chances of a genetic defect in a family.

The pattern of inheritance of a particular trait (feature) among humans is identified by the method of **pedigree analysis**. Pedigree is a diagrammatic representation of relationships showing a particular trait in a family. The genetic counsellor prepares a pedigree chart and can then advise accordingly. See the pedigree chart (Fig. 24.6) and study the squares and circles as explained.



The circles are females and the squares are males; filled in circles and squares are affected individuals, empty circles and squares are normal individuals

Fig. 24.6 Pedigree chart

INTEXT QUESTIONS 24.4

1. Define genome.

   ....

2. What is genomics?

   ....

3. What is the use of genomics?

   ....

4. Why should a genetic counsellor have good knowledge of genetics?

   ....

5. Expand the abbrenation PCR.

   ....

6. Why is the tehinque DNA fingerprinting named so?

   ....

Notes

WHAT YOU HAVE LEARNT

- From prehistoric times, humans have had a curiosity to know how traits (features) are inherited.
- Domestication of animals and cultivation of crops like rice, wheat, maize and date palm can be traced to earlier then 5000 BC.
- Modern genetics began after Mendel's laws of inheritance were accepted. Soon after it become clear that genes are carriers of hereditary features and they are present on chromosomes. That genes mutate also became known.
- The last fifty to sixty years have been an era of Molecular Genetics when it was confirmed that DNA is the genetic material and the mechanism of DNA replication and protein sysnthesis in a cell were discovered.
- In the last few years, many techniques such as rDNA technology, DNA fingerprinting have been put forth.
- Gene cloning means producing and preserving desired genes in a clone of bacteria through recombinant DNA technology. A gene bank is one where several clones of bacteria carrying different desired foreign genes (for example genes of humans) are preserved for future use of products of these genes.
- Genetic engineering, also called recombinant DNA technology uses specific restriction endonuclease from different bacteria to cut genes, that is, particular DNA sequences from DNA molecules of an organism (e.g. humans) and similar sequences from plasmids and join the foreign DNA to the plasmid and introduce the plasmid with foreign DNA into its host bacterium and raise a bacterial clone.
- Genetic engineering is useful for creating genetic libraries, gene therapy and genetically modified organisms.
- Genetically modified organisms are also called transgenics. Transgenic microbes, plants and animals carry in their genetic make up, gene or genes of another kind of organism. Transgenic bacteria are used for extracting metals and decomposing pollutants. Transgenic plants are herbicide and pest resistant. Transgenic animals are larger in size and transgenic goats may carry a human gene responsible for a particular protein which is then released in its milk.
- PCR or polymerase chain reaction is a technique to make many copies of a small amount of DNA.

- DNA fingerprinting is a technique to identify the DNA of a particular person. It is used to scientifically investigate a crime and identify the real criminal.
- Genomics is the analysis of a complete set of genes found in an organism. The complete set of genes is called a genome.
- Genetic counselling is the advise given by an expert on the chances of an unborn baby getting a genetic disorder.

TERMINAL EXERCISES

1. Name the three eras in the history of genetics.
2. Define gene cloning. What is the usefulness of a gene bank?
3. Give the various steps of recombinant DNA technology.
4. What are the benefits of genetic engineering?
5. What are transgenics? Give examples of a transgenic microbe, plant and animal.
6. Define genomics
7. Draw and explain a pedigree chart.
8. What is genetic counselling and why is it important?
9. What is DNA fingerprinting? Justify that it is the foolproof tecnique for sorting out paternity issues.
10. List the steps of Polymerase chain reaction.
11. What are Bt crops? What are the benefits and fearns related to their use?
12. Write notes on (i) Biopatent (ii) Biopiracy and (iii) Necessity for a biosafety protocol.

ANSWERS TO INTEXT QUESTIONS

24.1

1. Genetic engineering or recombinant DNA technology, gene cloning, DNA fingerprinting (any two).
2. A technique of producing many identical copies of a particular gene.
3. A collection of all the genes of any human or genes of any other organisms in various clones of bacteria.

24.2

1. Genetic engineering.
2. Joining of two pieces of DNA belonging to different species.
3. Plasmid is a separate round piece of DNA found in bacteria. It is used to carry desired gene from a particular organism into bacteria.

24.3
1. Transgenic crop like Bt crops reduce the need for use of insecticides which are toxic to humans and other animals.
2. Due to worries of (i) Bt crop evolving resistance (ii) non target species feeding on Bt crops may die (iii) production of super weeds.
3. *Cry* protein produced by Bt crop causes toxicity or poisoning when it enters the pest stomach killing the pest
4. Biopiracy
5. 1970
6. 20 years

24.4
1. Collective term for the full set of genes of an organism.
2. Science of analysis of genes in the DNA of an organism relating each gene to its function.
3. Helps to identifying defective genes so that correction may be possible by gene therapy.
4. Because the counsellor has to advise regarding the possibility of genetic disorder in the next generation.

MODULE - IV
ENVIRONMENT AND HEALTH

25

PRINCIPLES OF ECOLOGY

Earth is the only planet in the solar system that supports life. This is because of the three physical systems on it that is, soil, water and air which provide material essential for life. All the living beings differ from each other but they are all interdependent and interact with each other as also with, their environment directly or indirectly. In this lesson we study the earths own life support system, the organisational levels of living beings and their characteristics.

OBJECTIVE

After completing this lesson, you will be able to:

- *define environment, ecology and biosphere;*
- *list the various components of the environment;*
- *name the biotic and abiotic components of the environment;*
- *mention the various levels of organisation of life.*
- *define terms related to environment or ecology like habitat, niche, population community, an biome.*
- *discuss inter-relationship between plants and animals in an ecosystem;*
- *describe food chain and food web;*
- *trace the path of energy flow through the food chain;*
- *differentiate between food chain and food web;*
- *pinpoint the position of human beings in a food chain;*
- *define biome;*
- *list the various biomes and their characteristics (flora and fauna);*
- *describe the biogeochemical cycles such as Carbon, Phosphorus and water cycles.*

25.1 ENVIRONMENT, ECOLOGY AND BIOSPHERE

25.1.1 Environment

The term environment denotes all the physical, chemical and biotic conditions surrounding and influencing a living organism. Favourable environmental conditions are required to sustain life on earth.

The environment can be divided into two main components : Non Living and Living

1. **Abiotic or Non-living components include** the physical (climatic), edaphic (nature of soil) and chemical. For example temperature, light, pressure, humidity, precipitation, wind, mineral elements of soil and composition of air. Some of these environmental factors serve as **resources** (air, soil and water) while others act as **regulatory factors** (light, temperature and pressure etc).
2. **Biotic or Living components include** All living organisms found in the environment including plants, animals and microorganisms.

25.1.2 Ecology

Ecology is the scientific study of the relationship and interactions between organisms and their environment. The term ecology is derived from a Greek word *Oekologie* where "*oikos*" meaning "household"and "*logos*" means "the study of".

25.1.3 Organisation of Life

Various levels of organization exist in the living systems starting from the molecules such as DNA (genes) to the whole **biosphere**. The **levels of organization** are as follows :

Genes $\rightarrow$ Cell $\rightarrow$ organ $\rightarrow$ organism $\rightarrow$ Species Population $\rightarrow$ Community $\rightarrow$ Ecosystem $\rightarrow$ Biome $\rightarrow$ Biosphere

25.1.4 Levels of biotic organizations show direct impact of the environment

- An organism is a self reproducing system capable of growing and maintaining itself and is directly influenced by the surrounding environment.
- A population is an assemblage of similar organisms belonging to the same species, living together at one place at a given time. A population always lives a specific place known as its *habitat*. Habitat is thus the physical environment in which an organism lives. The environment provides for its needs. For example, the environmental requirement of an elephant would be a forest and not the ocean. Many different species with similar requirements may share a habitat. For example, a single ocean as a habitat may support a whale, a sea-horse, seal, phytoplankton, sea weeds and many other kinds of organisms. Forest, ocean, river etc. are some examples of **'habitat'** which in common language are the

'addresses' of organisms. The features of the habitat can be represented by its structural components (Fig. 1), namely:

1. Space
2. Food
3. Water
4. Cover or Shelter

Earth has four major habitats-(1) Terrestrial (2) Freshwater (3) Estuarine (where rivers meet the ocean) and (4) Oceanic. The human gut is the habitat of a tapeworm and the rotting log, a habitat of a fungus.

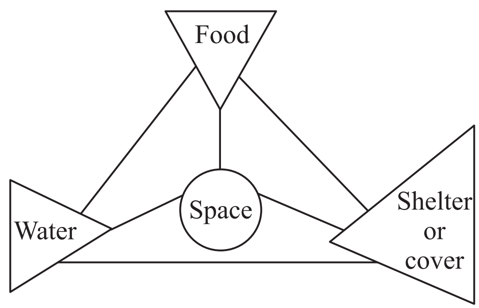


Fig. 25.1: Structural components of a habitat

Niche and Organism

In nature, many species occupy the same habitat but they perform different functions. The functional characteristics of a species in its habitat is referred to as "**niche**"**.** While habitat of a species is like its 'address' (i.e. where it lives), niche can be thought of as its "profession" (i.e. activities and responses specific to the species). The term **niche means the sum of all the activities and relationships of a species by which it uses the resources in its habitat for its survival and reproduction.**

A niche is unique for a species (Fig. 25.2) while many species may share the same habitat. No two species in a habitat can have the same niche. This is because, if two species occupy the same niche they will compete with one another until one is displaced. For example different species of insects may be pests of the same plant but they can co-exist as they feed on different parts of the same plant that is because their niches are different (Fig. 25.3).

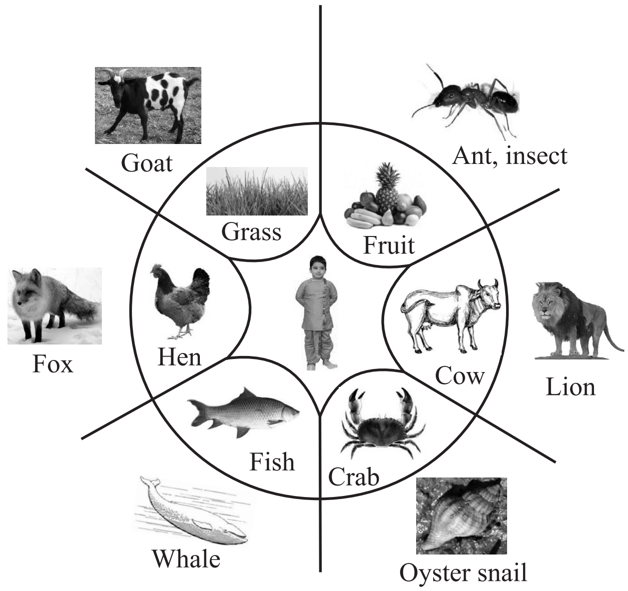


Fig. 25.2: The ecological niche of human being

Another such example is the vegetation of the forest. The forest can support a large number of plant species as they occupy different niches: the tall trees, the short trees, shrubs, bushes and grasses. Their heights vary and they differ in their requirements for sunlight and nutrients and so they can all survive together (Fig. 4)

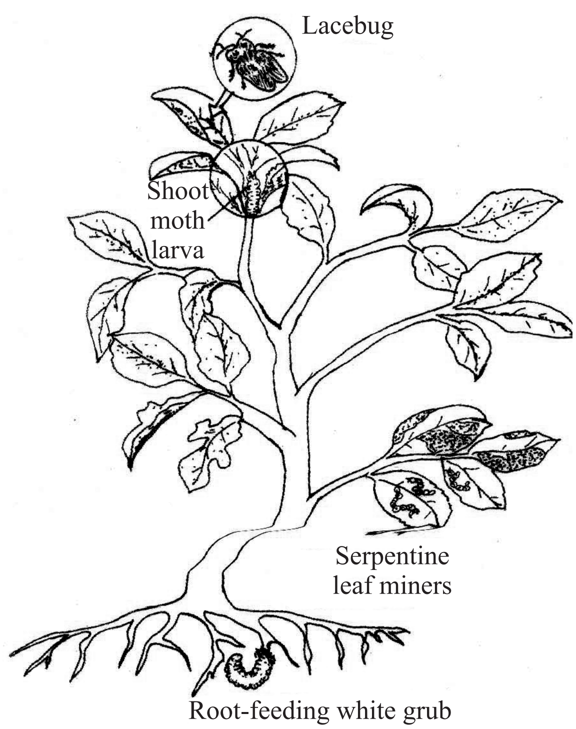


Fig. 25.3: Different species of insects feeding on different parts of the same plant

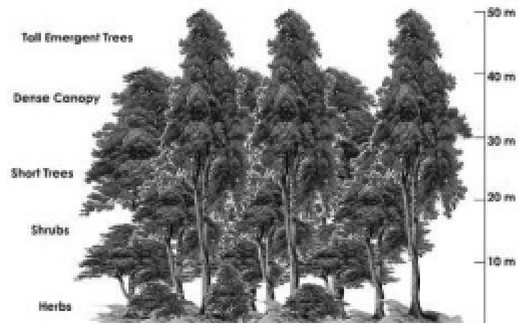


Fig. 25.4: Stratification a Tropical Rain Forest (Forest Ecosystem)

The most important resources available in the niches of animals are food and shelter while in case of plants, they are moisture and nutrients (phosphorus and nitrogen).

Adaptation

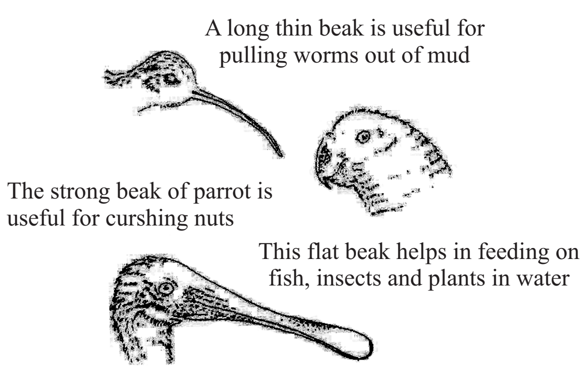
Every organism is suited to live in its particular habitat. You know that coconuts are adapted for growing in water while a camel is adapted for life in the desert.

An adaptation is thus, "the appearance or behaviour or structure or mode of life of an organism that allows it to survive in a particular environment".

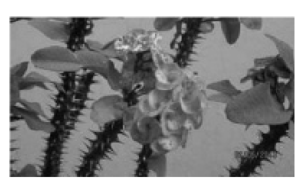
Presence of gills and fins are examples of adaptation of fish to aquatic habitat. In aquatic flowering plants, absence of wood formation and highly reduced root system are adaptations to aquatic environment. Adaptations can be observed in structure or behaviour or physiology of an organism. Adaptations have a genetic basis and have been evolved and perfected through the evolutionary process.

Following are examples of basic adaptations that help animals and plants to survive in their respective environments.

- Shape of bird's beak suited to the kind of food it needs to procure. (Fig. 25.5a)
- The thickness or thinness of fur depends on the elimate in which the animal lives.
- Presence of feathers and wings in birds for movement in air.
- Presence of thorns on leaves and stems for protection, from herbivores (Fig. 25.5b).



(a)



(b)

Fig. 25.5: (a) Adaptation in the types of beaks in birds: The beaks of different birds are adapted for feeding on different kinds of food (b) Plant with thorns for protection

INTEXT QUESTIONS 25.1

1. Name the various levels of organizations.

   ....

2. Define the term ecology.

   ....

3. What are the three physical systems that support life on earth?

   ....

4. Name the major components of the environment.

   ....

5. Enumerate the various physical factors of the environment

   ....

6. Why is habitat called the address of organisms and its niche 'the profession'? Justify.

   ....

7. What do we mean by 'fins are an adaptation of fish to aquatic life'? Explain.

   ....

Species

If you bring the sunfish from two different ponds and put them together in one pond, they can interbreed. So both the populations of sunfish belong to one species. *A **species** is defined as a group of organisms which can interbreed and reproduce successfully. These organisms may be separated in space and time into smaller groups called **populations***. For example human populations live in different geographical areas but all belong to the species, *Homo Sapiens*.

25.4 POPULATION

'Population' is defined as a group of freely interbreeding individuals of the same species present in a specific geographical area at a given time.

A population has traits of its own which are different from those of the individuals forming the population. For example (i) An individual is born and dies but a population continues. Population may change in size depending on birth and death rates of the population. (ii) An individual is either female or male, young or old but a population has a sex ratio which means, the ratio of male to female in the population which also has (iii) age structure, which means the various age groups into which the population may be divided.

The **characteristics of any population** depends on the following factors.

(i) density of the population, (ii) natality (birth rate), (iii) mortality (death rate), (iv) dispersal, (v) biotic potential (vi) age distribution (vii) dispersion and (viii) growth form.

Density: The number of individuals per unit area at a given time is termed population density which may vary from time to time and place to place.

For example, you may notice more plant and animal species in the garden during the monsoon season.

Density of a particular organism in a region is determined by selecting random samples from an area of particular dimension (size) called quadrat from that region.

In case of large mobile animals like tigers, leopards, lions, deer etc, the density may be determined by counting individual animals directly or by the pugmarks (foot imprints) left by the animals in a defined area (Fig. 25.6).

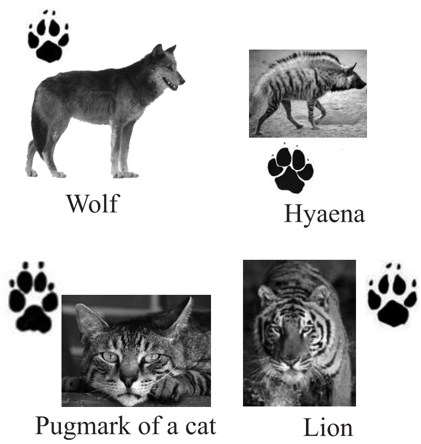


Fig. 25.6: Pugmarks (Foot prints of soft padded feet) of wild animals

Counting of human population is called **census** and is carried out by the Indian government every 10 years. In census however each individual is physically counted.

Birth Rate or Natality: The rate at which new individuals are born and added to a population under given environmental conditions is called natality.

In case of humans, natality or birth rate is usually expressed in terms of births per thousand per year.

Death Rate or Mortality: Loss of individuals from a population due to death under given environmental conditions is called mortality.

Mortality rate in human population may be expressed in terms of number of persons dead per thousand per year.

Dispersal: The movement of individuals of a population out of a region on a permanent basis is termed **emigration**. **Immigration** refers to the movement of individuals into a new area. Dispersal includes both emigration (going away permanently from an area) and immigration (influx of new individuals into the area).

The density of a population thus basically depends on four factors: (i) natality, (ii) mortality, (iii) immigration and (iv) emigration (Fig. 25.7)

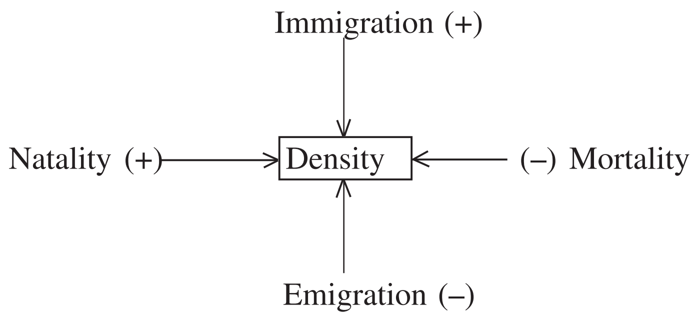


Fig. 25.7: Parameters of population.

Age distribution: Natural populations include individuals of all age groups. **Age distribution refers to the proportion of individuals of different age groups in a population**.The population may be broadly divided into three age groups:

- **pre-reproductive group**: comprising of juvenile individuals or children,
- **reproductive group**: consisting of individuals capable of reproduction ,
- **post-reproductive group**: contains aged individuals who are incapable of reproduction.

A rapidly growing population will usually contain a large proportion of individuals in the reproductive age group; a stationary population (where there is no increase or decrease in population) contains an even distribution of all age groups, and a declining population contains a large proportion of old or individuals of post-reproductive age.

Sex ratio: Sex ratio is an important aspect of population. It refers to the ratio between female and male individuals in a population.

Population Growth

The growth, stability or decline in number of individuals in a population is influenced by its relationship with the environment. Populations have characteristic patterns of growth with time, which is depicted by population growth curves. Two basic forms of population growth curves can be identified:

(i) 'J'shaped growth curve

(ii) 'S' shaped or sigmoid growth curve.

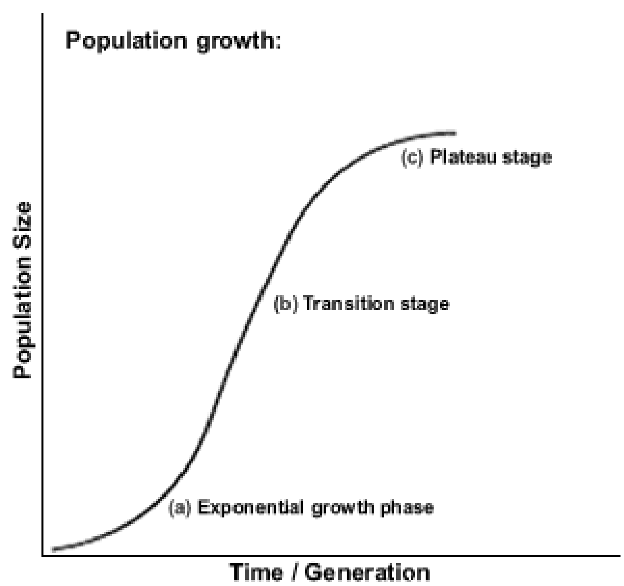


Fig. 25.8

The 'J' shaped growth curve is typical of the species which reproduce rapidly and which are greatly affected by seasonally fluctuating environmental factors such as light, temperature and rainfall. In this type of curve, population density increases rapidly in exponential (geometric) progression (total number doubles at regular intervals of time). **This type of exponential growth occurs in nature when a population has abundant supply of resources**. After reaching a peak there is a sudden crash or decline due to environmental or other factors. Such type of growth may be exhibited by insect populations which show explosive growth during the monsoon season and then abruptly disappear at the end of the season.

S-shaped curve or sigmoid growth curve has a lag phase, growth phase and a stable phase as shown in the figure, when few organisms occupy a hitherto unoccupied area reproduction occurs after some time (lag phase). Natality and mortality remain small. When growth phase begins, rapid increase in size of population occurs as there is plenty of food and no competition. Eventually, food or water or some source (e.g. nutrients in soil for plants) becomes limiting and population enters stable phase (plateau). Natality and mortality then become almost equal.

INTEXT QUESTIONS 25.2

1. A population with equal number of births and deaths will show:
   - (a) Acceleration phase of growth
   - (b) Plateau phase
   - (c) Exponential growth phase
   - (d) Initial phase of growth
2. When population reaches carrying capacity:
   - (a) Mortality rate = Birth rate
   - (b) Mortality rate > Birth rate
   - (c) Mortality rate < Birth rate
3. Human population shows:
   - (a) S-shaped growth curve
   - (b) J-shaped growth curve
   - (c) Z-shaped growth curve

- **Biological community** refers to the populations of different species occupying a common place of living. For example all the living organisms in a pond belong to one community. A biological community along with its nonliving environment of energy and matter makes an **ecosystem** (Fig. 25.9). Ecosystem can range in size from a puddle of water to a stream or a patch of wood to entire forest or desert.

The study of groups of organisms in relation to their environment is called ***synecology****.*

Biosphere

A thin layer on and around the earth which sustains life is called **biosphere**. Life exists in the diverse forms of living organisms. All these living organisms of the biosphere are directly or indirectly dependent on one another as well as on the physical components of the earth. The three physical components of the earth are **atmosphere, lithosphere** and **hydrosphere** (air, land and water).

The **atmosphere** is a gaseous envelope surrounding the earth's surface, It is made up of nitrogen, oxygen, carbon dioxide and many other gases in very small amounts.

Hydrosphere is all the water supply to the earth which exists as liquid, vapour or frozen form of fresh and salt water.

Lithosphere comprises the soil and rock of the earth's crust.

Recently the term ecosphere is being used more commonly. It is used to denote biosphere (living components) along with its three abiotic components –atmosphere, hydrosphere and lithosphere of the earth as one entity (unit).

Ecosphere = Biosphere + Lithosphere + Hydrosphere + Atmosphere)

25.3 ECOSYSTEM

Ecosystem is a self sustaining unit of nature. It is defined as a functionally independent unit (of nature) where living organisms interact among themselves as well as with their physical environment. In nature two major categories of ecosystems exist : **terrestrial** and **aquatic**.

Forests, deserts and grasslands are examples of terrestrial ecosystem.

Ponds, lakes, wet lands and salt water are some example of aquatic ecosystem. Crop lands and aquarium are the example of man made ecosystems.

The interaction between the living organisms and their environment can be studied in a puddle of water or a hole in a tree, which are very small ecosystems or in large ecosystems such a forest, river or ocean. Irrespective of their sizes all ecosystems share many common characteristics. Let us study moderate sized pond ecosystem to understand its structural and functional components.

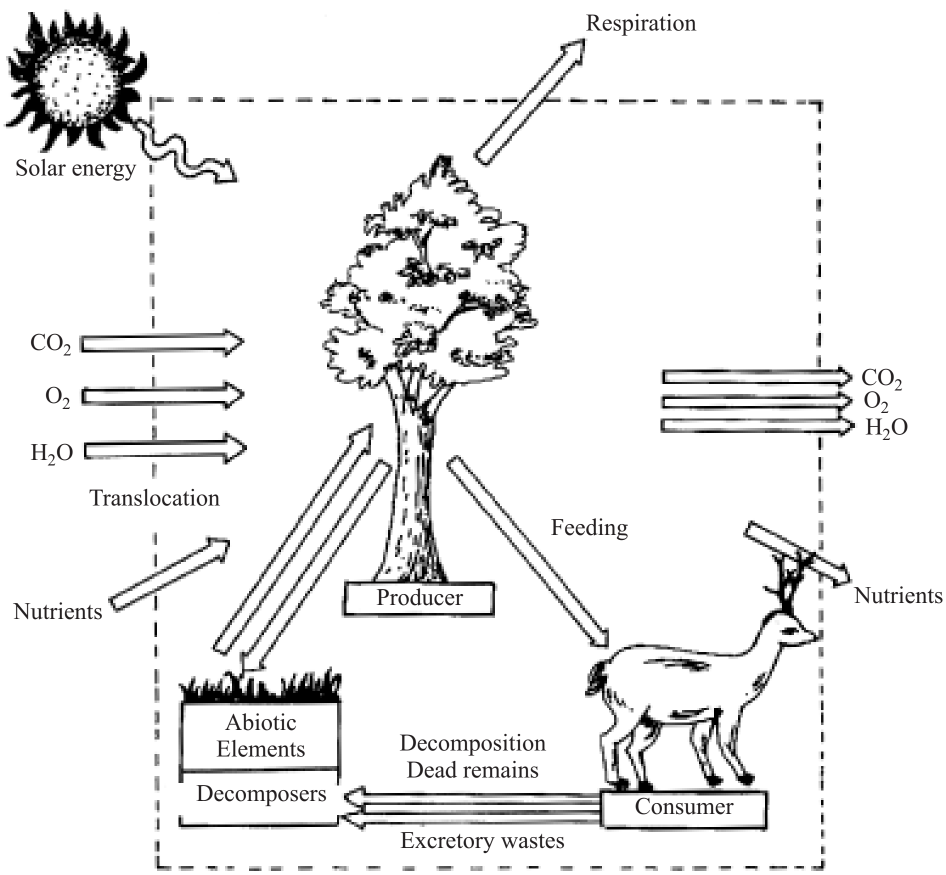


Fig. 25.10: Components of an ecosystem.

In the Fig. 25.2 (pond ecosystem), you can see that it is a shallow body of water. Sun's light can penetrate into it. It has sediment as a substrate at the bottom that is a source of nutrition for living organisms. The living organisms in it are small floating plants, submerged vegetation and rooted plants. There are animals of various sizes ranging from microscopic to large fishes. All these components of the pond ecosystem can be arranged to give it a definite structure.

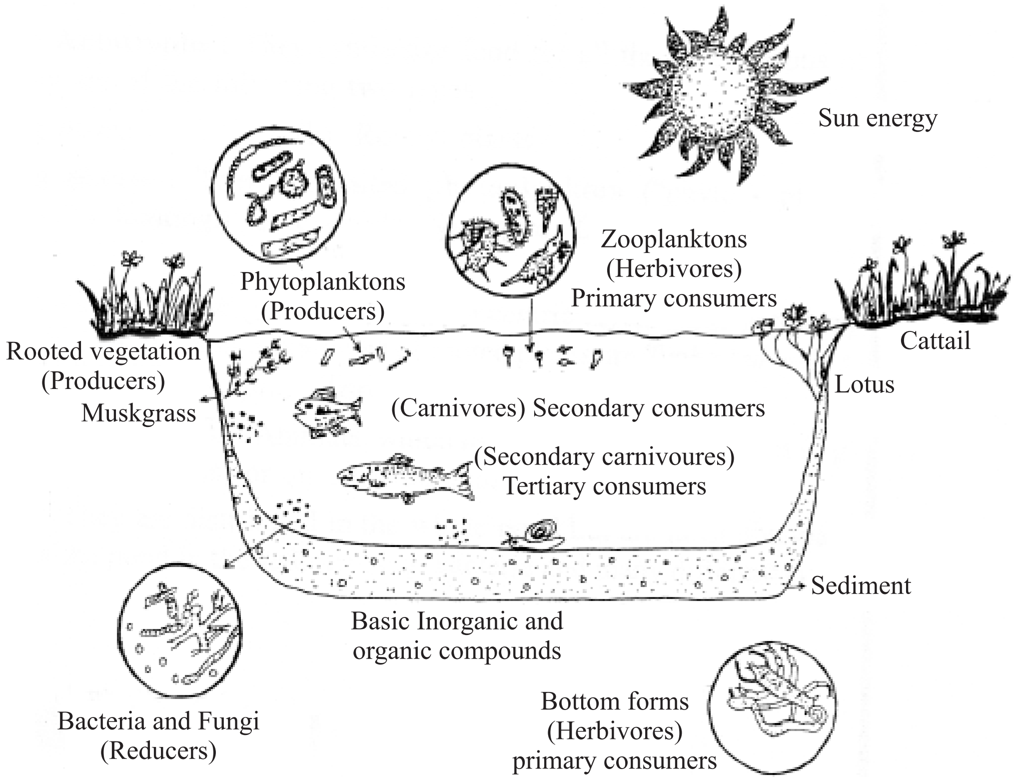


Fig. 25.11: Pond ecosystem

25.3.1 Structure of Pond Ecosystem

Abiotic Components

1. **Physical or climatic regime :** Pond receives solar radiation, which provides it heat and light energy to sustain life.

   (a) **Light :** In case of shallow ponds with clear water sun light can penetrate up to the bottom . In deep ponds penetration of light depends on the transparency of water The amount of dissolved/suspended particles, nutrients and number of animals and plants determine the transparency of water and control the penetration of light in it.

   (b) **Temperature :** Heating effect of solar radiation leads to diurnal (day and night) or seasonal temperature cycles. In the tropical regions there are not much temperature variations. At higher latitudes there are remarkable seasonal temperature variations.

2. **Inorganic substances :** These are water, carbon, nitrogen, phosphorus, calcium and a few other elements like sulphur or phosphorus depending on the location of the pond. O_2 and CO_2 are in the dissolved state in water. All animals and plants depend on water for their food and exchange of gases.

3. **Organic compounds :** The commonly found organic matter in the pond is amino acids and humic acids and the breakdown products of dead animal and plant tissues. They are partly dissolved in water and the remaining are accumulated in sediment.

Biotic Components

1. **Producers or Autotrophs :** They synthesize food for all the heterotrophs of the pond. They are of the following two types.

   (a) Floating plants (b) Rooted plants

   (a) **Floating plants :** They are called **phytoplankton** ("phyto"- plants, "plankton" - floating.) for example, *Spirogyra*, *Ulothrix*, diatoms and *Volvox*.

   (b) **Rooted plants :** These plants occur in concentric layers from periphery to the deeper zones. Some examples of rooted plants are *Typha bulrushes*, *Sagittaria*, *Hydrilla*, *Rupia*, *Chara.*

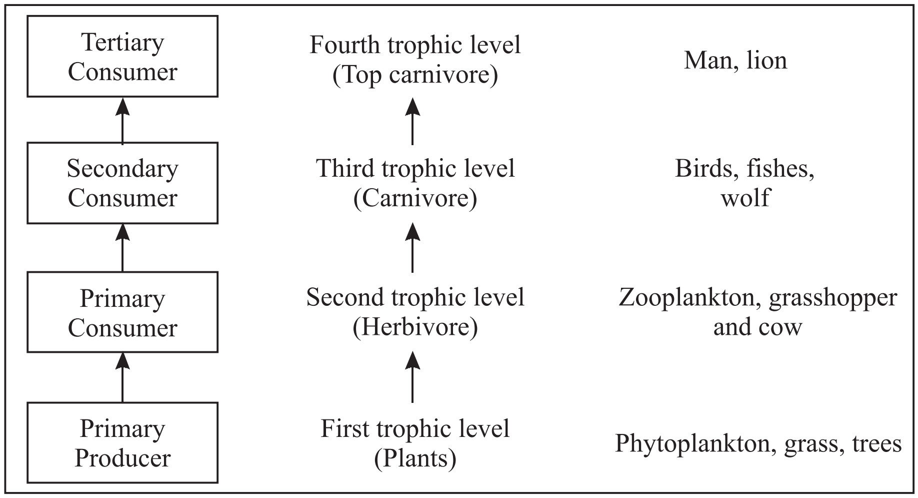
2. **Consumers or Heterotrophs :** Animals, which feed directly on autotrophs (e.g. insect larvae, tadpole, snails) or on other animals (sunfish and bass)

3. **Decomposers :** They are distributed in the whole pond but are most abundant at the bottom of the pond in the sediment e.g. bacteria and many different types of microbes.

25.4 ECOSYSTEM : STRUCTURE AND FUNCTION

You have already learnt that ecosystems are capable of persisting as independent units of nature. In the following part of the lesson you will learn about the structure and functions of ecosystem. Interaction between biotic and abiotic components results in a physical structure characteristic of each type of ecosystem. The important structural features are **species composition** (types of plants and animals) and **stratification** (vertical and horizontal distribution of various species occupying different levels). Another way of looking at the structural components is through food relationships of producers and consumers. Several **trophic levels** exist in the ecosystem. These feeding relationships can be studied as food chain, food web and standing crops. These structural components function as a unit and produce certain functional aspects of ecosystem. Some of these aspects are :

- Productivity, energy flow, nutrient cycle



Diagrammatic representation of trophic levels in an ecosystem

25.4.1 Species Composition

A community is an assemblage of many populations that are living together at the same place and time. For example a tropical forest community consists of trees, vines, herbs and shrubs along with large number of different species of animals. This is known as species composition of tropical forest ecosystem. Each ecosystem has its own species composition depending upon the suitability of its habitat and climate. If you compare animal and plant populations of a forest they are entirely different from those of a grass land. Not only are the types of species different in these two ecosystems but even their total number and biomass varies. A forest ecosystem supports much larger number of species of plants and animals than a grassland. The total number and types of species in a community determine its stability and **ecosystem balance** (ecosystem equilibrium).

25.4.2 Stratification

The vertical and horizontal distribution of plants in the ecosystem is called **ecosystem stratification**. You would have observed that the plants are of different heights in forests. Tallest trees make the top canopy. This is followed by short trees and shrubs and then the forest floor is covered with herbs and grasses. Some burrowing animals live underground in their tunnels or on the roots of the plants. Each layer from the tree top to the forest floor has its characteristic fauna and flora. This is termed as vertical stratification of forest ecosystem. On the other hand desert ecosystem shows low discontinuous layers of scant vegetation and animals with some bare patches of soil showing a type of horizontal stratification.

25.4.3 Food Chain

Transfer of food from the plants (producers) through a series of organisms with repeated eating and being eaten is called a food chain e.g.

Grasses	→ Grasshopper	→ Frogs	→ Snakes	→ Hawk/Eagle
1	2	3	4	5

1. Each step in the food chain is called trophic level. In the above example grasses are first and eagle represents the fifth trophic level.
2. Some more examples of food chain are given in Fig. 25.13.

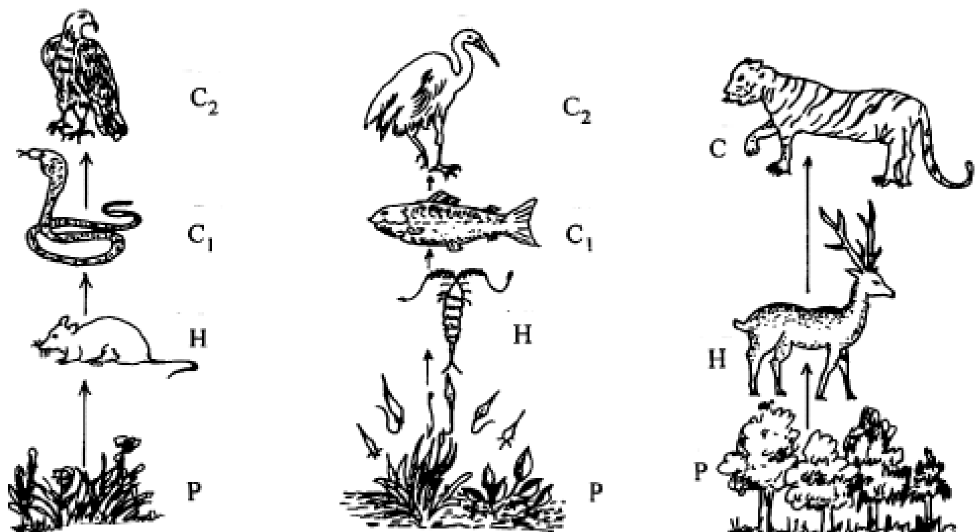


Fig. 25.13: Some examples of food chain.

Three important features that you can note in these chains are :

- Weaker organisms are attacked by the stronger organisms
- Number of organisms is reduced at each higher level but the size of organisms is increases.
- The number of steps in a food chain is limited to 4-5.

A. A food chain consists of the following trophic levels :

(i) **(Producers) Autotrophs :** They produce food for all other organisms of the ecosystem. Autotrophs represent the first trophic level. They are largely green plants they convert inorganic substances by the process of photosynthesis into food (organic molecules) in the presence of sun light. The total rate at which the radiant energy is stored by the process of photosynthesis in the green plants is called Gross Primary Productivity (GPP). This is also known as total photosynthesis. A part of the gross primary productivity is utilized by the plants for their own metabolism, maintenance and reproduction. Energy required for all these functions is produced by the process of respiration. The remaining is stored by them as Net Primary, Productivity (NPP) and is available to the heterotrophs or consumers, (The next trophic level)

$$GPP = NPP + R \quad \text{or} \quad GPP - R = NPP$$

Productivity in the biological system is a continuous process but it is different in different ecosystems.

(ii) **Primary consumers Herbivores** : These are animals which feed directly on the plants. They are first level consumers and therefore they are also known as primary consumers and make the second trophic level in the food chain e.g. grasshopper in the above example. Other examples are insects, birds, rodents and ruminants. Herbivores are capable of converting energy stored in the plant tissue into animal tissue and therefore they are also known as key industry. They can digest high cellulose diet.

(iii) **Secondary consumer Carnivores :** Carnivores are the animals that feed on other animals or its tissues. Therefore they are secondary, tertiary or quaternary level consumers. Frog is secondary level consumers as it feeds on herbivorous grasshopper. Snake is tertiary level consumer since it consumes other carnivore that is frog. Frog, snake, dog, cat and tiger are all carnivores. Generally the size of the carnivore/ increases at each trophic level.

(iv) **Decomposers :** They make up the final trophic level in a food chain. Decomposers are the organisms that feed on dead organic matter called detritus of all the trophic levels and help in recycling the nutrients. Examples of decomposers are bacteria, fungi, mites, millipedes, earthworms, nematodes, slugs, crabs and molluscs.

Special feeding groups (Consumers)

(i) **Scavengers** : These are the animals that feed on the dead plants and animals. e.g. termites and beetles feed on the decaying wood, and many marine invertebrates. Vultures, gulls and hyena are other examples of scavengers.

(ii) **Omnivores :** Omnivores consume both plants and animals as source of their food e.g. human beings. Some of the omnivores like the red fox feeds on berries small rodents as well as on dead animals. Thus it is a herbivore, carnivore and also a scavenger.

(iii) **Parasites :** They live and feed on/in other living organisms called *host*. Parasites not only feed on their host but they also cause lethal or nonlethal disease in it.

B. Position of human beings in the food chain ; Human beings are consumers and may occupy

Primary, secondary or tertiary levels. Vegetarian people are 'primary consumers; when they consume small fish chicken or goat meat they are 'secondary' consumers and when they consume big fishes they are 'tertiary' consumers. Can you explain why big fishes feed upon small fishes and other smaller aquatic animals?

25.4.4 Food Web

In nature the food chains are not isolated sequences but they are interconnected with one another. *A net work of food chains which are interconnected at various trophic levels of the food chain to form a number of feeding connections is called a food web*. In a food web one trophic level may be connected to more than one food chain. A snake can feed on frog or rat or any other small rodent. In the figure given below sunfish consumes zooplanktons as well as bloodworms.

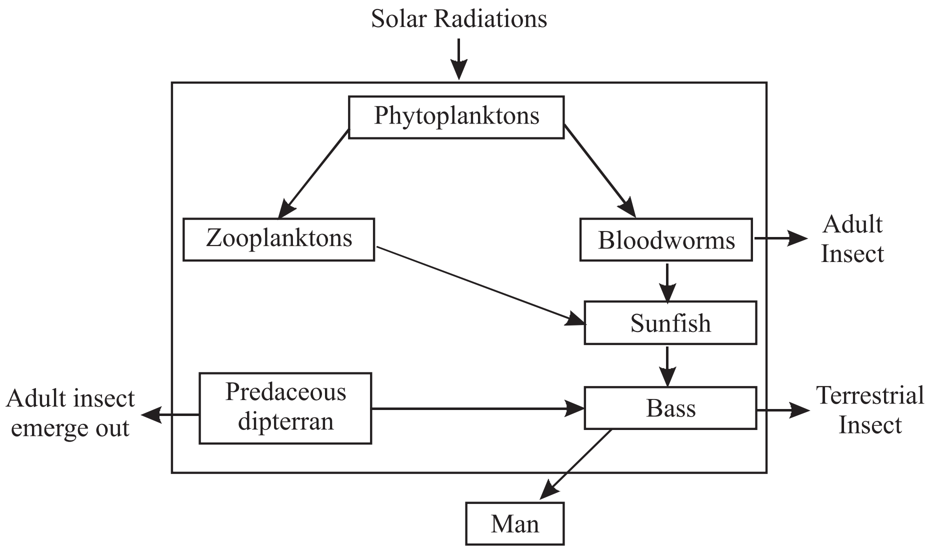


Fig 25.14: Simple food web in a pond ecosystem.(modified from Odum)

INTEXT QUESTIONS 25.3

1. Define an ecosystem.

   ....

2. What are the main components of an ecosystem?

   ....

3. Give reason, why are decomposers necessary in an ecosystem?

   ....

4. What is the role of decomposers in nature?

   ....

5. Why are plants called autotroph and animals called heterotrophs?

   ....

6. Give one example of food chain.

   ....

7. Name the trophic level frog belongs to.

   ....

8 Snake can be both a secondary as well as tertiary consumer Justify.

   ....

25.4.5 Energy flow through an ecosystem

The energy enters into the ecosystem in the form of solar radiation and is converted into food (plant biomass) by the producers. Food stored by the plants and their biomass (matter) is the chemical form of energy. From the producers this chemical form of energy passes through various trophic levels in the food chain. *This process of transfer of energy through various trophic levels of the food chain is known as flow of energy.*

All the functions of ecosystem depends on the flow of energy through it. In figure 25.5, boxes represent the trophic level and the pipes depict the energy flow in and out of each trophic level. The quantity of energy flowing through the successive trophic levels decreases as indicated by the reduced size of the boxes and thickness of pipes in the figure. This is because all the energy entering at each trophic level is not used for production of biomass due to the following two reasons.

- Firstly a part of the energy (not utilized) as and lost as heat.
- Secondly a part of it is used up by the organisms and lost as heat for their own metabolism through the process of respiration.

If herbivores consumes 1000 kcal. of plant energy in the form of food, only 100 kcal. is converted into herbivore tissues, and 10 kcal. into first level carnivore and only 1 kcal into second level carnivore. This is known as 10% law (or ecological rule of thumb) where by only 10% of the energy is transferred to the next higher trophic level.

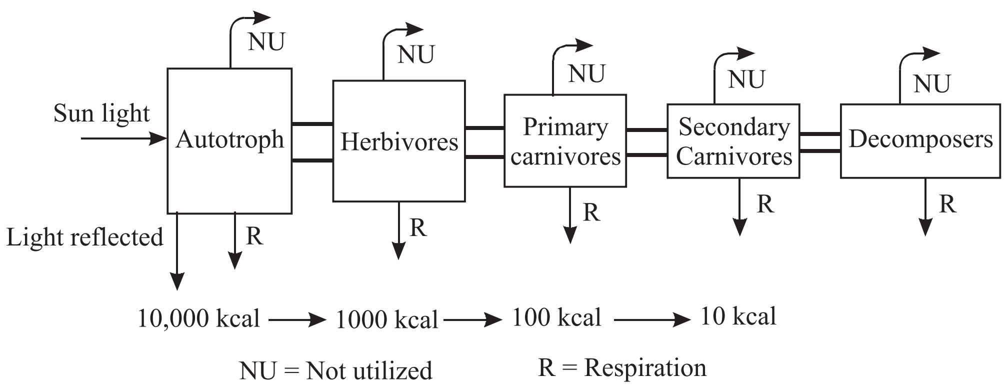


Fig. 25.15: Energy flow in a ecosystem. Boxes indicate the standing crop biomass and pipes indicate the energy flowing

The entire process of energy flow can be summarized in the following four steps:

- The flow of energy in an ecosystem is always linear or one-way.
- At every step in a food chain the energy received by the organism is also used for its own metabolism and maintenance. The left over is passed to next higher trophic level. Thus energy flow decreases with successive trophic levels.
- It follows the ecological thumb rule of 10%.
- The number of steps is limited to four or five in a food chain for the transfer of energy.

25.4.6 Ecological Pyramids

Standing crop is the amount of biomass or energy present in different trophic levels at any given time. This is another important characteristic of an ecosystem. It can be expressed in terms of

- biomass,

Notes

- number or
- total energy fixed at each step at each trophic level.

These three parameters give a definite trophic structure to the ecosystem. It is represented with the producers at the base and the subsequent trophic levels as the tiers. This gives a gradually sloping pyramidal shape.

This graphical representation of the standing crop expressed as number, biomass or energy is called pyramid of number, pyramid of biomass and pyramid of energy respectively. Collectively they are known as ecological pyramids. Some examples

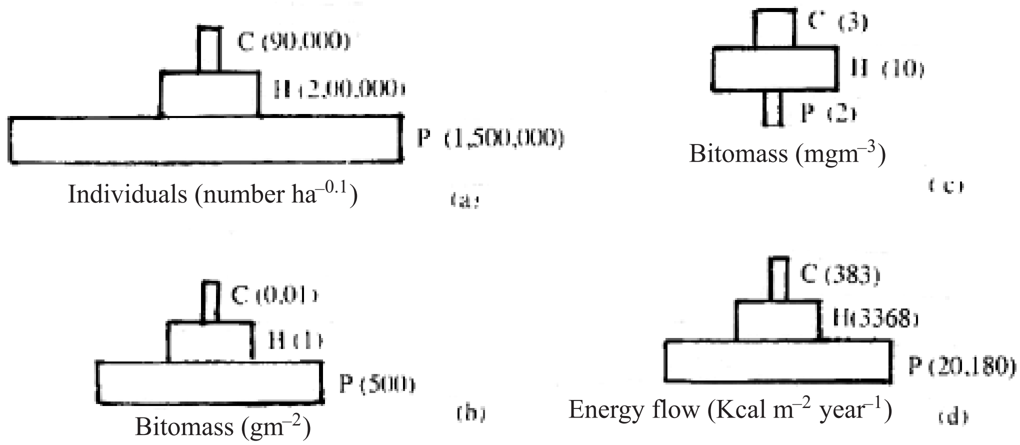


Fig. 25.16: Ecological Pyramids (P = producer; C1 Herbivores; C2 Primary carnivores; C3 secondary carnivores)

INTEXT QUESTIONS 25.4

1. What can be the maximum number of steps in a food chain?

   ....

2. Why is energy flow linear in ecosystem?

   ....

3. Define : (a) biomass (b) pyramid of number.

   ....

4. What is meant by community stratification?

   ....

25.5 TYPES OF ECOSYSTEMS – NATURAL AND HUMAN MODIFIED

You have already learnt about the components, structure and functions of an ecosystem. Now you can easily identify and study a few ecosystems around you. Ecosystems are classified as natural and human modified depending upon whether they are fully dependent on the solar radiation and other natural sources of energy or on fertilizers and fossil fuels. Natural ecosystems are such as ponds, lakes, meadows, marshlands, grasslands, desert and forests. They are our natural resources and provide us food, fuel, fodder and medicines. Human modified ecosystem are made and managed by human beings for their better living. Urban ecosystem, rural ecosystem, agro-ecosystems, aquaculture and spaceship aquarium terrarium, are some examples of the human modified ecosystems.

BIOTIC INTERACTIONS IN ECOSYSTEMS

The biological community in an area or ecosystem is a complex network of interactions.

The interaction that occurs among different individuals of the same species is called **intraspecific interaction** while the interaction among individuals of different species in a community is termed as **interspecific interaction.**

Interactions between organisms belonging to the same trophic level often involve **competition**. Individuals of a population may compete for food, space and mates. For example if a mouse has been eaten by a cat, other cats competing for this resource would have one less mouse to prey on. The snake another predator of the mice would also have fewer mice to eat during the night if the cat has succeeded. Direct competition, though, between the cat and snake is not much as they prey at different times. They also eat a variety of different foods. So competition may be intraspecific as well as interspecific.

Interspecific relationship may be direct and close as between a lion and deer or indirect and remote as between an elephant and a beetle. This is because interactions between two species need not be through direct contact. Due to the connected nature of ecosystems, species may affect each other through intermediaries such as shared resources or common enemies. Specific terms are applied to interspecific interactions depending upon whether the interaction is beneficial, harmful or neutral to individuals of the species. The various possible interactions between two species are given in Table 1

Table 1: Possible biological interactions between two species

S.No.	Type of interaction	Result of one species on the other	Effects of interaction
I.	**Negative Interactions**		
(i)	Amensalism	0	One species is inhibited while the other species is unaffected
(ii)	Predation	+	Predator-prey relationship: one species (predator) benefits while the second species (prey) is harmed and inhibited.

(iii)	Parasitism	+		Beneficial to one species (parasite) and harmful to the other species (host).
(iv)	Competition	0		Adversely affects both species
II.	**Positive Associations**			
(i)	Commensalism	+	0	One species (the commensal benefits, while the other species has neutral Interactions)
(i)	Neutralism	0	0	Neither species affects the other(the host) is neither harmed nor inhibited
(ii)	Mutualism	+	+	Interaction is favourable to both species
III.	**Neutral Interactions**			
(i)	Neutralism	0	0	Neither species affects the other

+ = beneficial; – = harmful; 0 = unaffected neutral

Interactions may be of various kinds

1. **Amensalism**: This is a negative association between two species in which one species harms or restricts the other species without itself being adversely affected or harmed by the presence of the other species. Organisms that secrete antibiotics and the species that get inhibited by the antibiotics, together form example of amensalism. For example the fungus called bread mould or *Pencillium* produces penicillin, an antibiotic, which inhibits the growth of a variety of bacteria. *Pencillium* benefits apparently by having greater availability of food when in the competition bacteria are removed.
2. **Predation**: In this type of interaction, predator captures, kills and eats an animal of another species called the prey. The predator naturally benefits from this relationship; while the prey is harmed. Predators like leopards, tigers and cheetahs use speed, teeth and claws to hunt and kill their prey.
3. **Parasitism**: In this type of interaction, one species is harmed and the other benefits. Parasitism involves small sized organisms or parasites living in or on another living species called the host from which the parasite gets its nourishment and often shelter.

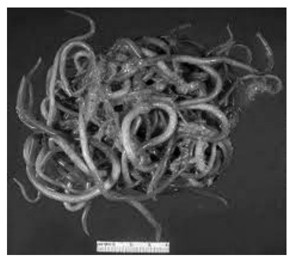
   The parasite is benefited and the host is harmed. Many organisms like, bacteria and viruses are parasites of plants (Fig. 10a) and animals (Fig. 10b). Plants like dodder plant (*Cuscuta*) (Refer again to Fig. 10a) and mistletoe (*Loranthus*) are parasites that live on flowering plants. Tape worm, round worm, malarial parasite, many bacteria, fungi, and viruses are common parasites of humans.

(a) (i)

Dodder, a parasitic plant is eating up a bush

(ii)

Dodder, a leafless parasitic plant, growing on the leaf of a grass tree



(b) *Ascaris lumbricoides* infections. A mass of large round worms from a human infestatic

Fig. 25.16: Parasite-host relationship (a) Plant parasite: Dodder (*Cuscuta)* plant is a parasitic weed that obtains moisture and nourishment by attaching to a green, living plant. (b) Animal parasite: *Ascaris* or round worms are internal parasites found in the human intestine

4. **Competition**: This is an interaction between two populations in which both species are harmed to some extent. Competition occurs when two populations or species, both need a vital resource that is in short supply. The vital resource could be food, water, shelter, nesting site, mates or space. Such competition can be: (i) **interspecific competition**-occurring between individuals of two different species occurring in a habitat and (ii) **intraspecific competition**-occurs between individuals of same species.

   Intraspecific competition occurs between members of the same species and so it is very intense.

5. **Commensalism:** In this relationship one of the species benefits while the other is neither harmed nor benefited. Some species obtain the benefit of shelter or transport from another species. For example sucker fish, remora often attaches to a shark by means of its sucker which is present on the top of its head. This helps remora get protection, a free ride as well as a meal from the left over of the shark's meal.The shark does not however get any benefit nor is it adversely affected by this association. Another example of commensalism is the relationship between trees and epiphytic plants. Epiphytes live on the surface of other plants like ferns, mosses and orchids and use the surface of trees for support and for

obtaining sunlight and moisture.The tree gets no benefit from this relationship nor are they harmed.

6. **Mutualism**: This is a close association between two species in which both the species benefit. For example the sea anemone, a cnidarian gets attached to the shell of hermit crab for benefit of transport and obtaining new food while the anemone provides camouflage and protection by means of its stinging cells to the hermit crab (Fig. 11).

Fig. 25.17: Sea anemone, attached to a shell inhabited by a hermit crab

However, some examples of mutualism are such that the interacting species can no longer live without each other as they depend totally on each other for survival. Such close associations are termed **symbiosis**. An example of such close mutualistic association is that of termite and their intestinal flagellates. Termites can eat wood but have no enzymes to digest it. However, their intestine contains certain flagellate protists (protozoans) that have the necessary enzymes to digest the cellulose of the wood eaten by termites and convert it into sugar. The flagellates use some of this sugar for their own metabolism while enough is left for the termites. Both termite and flagellates cannot survive without each other. Another familiar example of symbiosis is seen in pollination of flowers where flowering plants are cross pollinated by the bees which benefit by getting nectar from the plants. Both cannot survive without the other.

INTEXT QUESTIONS 25.5

1. Fill in the blanks
   (a) The relationship between two organisms where one receives benefits at the cost of other is known as ....
   (b) A group of several species living together with mutual tolerance or adjustment and beneficial interactions in a natural area is known as ....
   (c) A force that acts against maximum population growth is ....
   (d) Association between insect polinated flowers and pollinating insect is an association termed as ....

25.6 BIOMES

When you travel long distances in a train from one part of the country to the other you enjoy watching outside. Your train passes through the thick forests, grasslands deserts, croplands and some times mountains. If you look at the earth from a distance it shows beautiful kaleidoscopic patterns. All these patterns are because of the different types of plants that grow in these regions. The plant growth is determined by physical, edaphic and geographical characteristics of a place. These are the natural broad biotic zones of the biosphere called, **Biomes**. Each biome is characterized by uniform life form of vegetation such as grass, desert plants, deciduous trees or coniferous trees. A Biome is a large ecosystem which is embracing the large land scape, characterised by specific flora and fauna. Biomes can be classified as :

A. Terrestrial : These are the biomes found on land e.g,, Tundra, forest, deserts, grasslands

B. Aquatic. These are the biomes found in water. These can be :

(i) Fresh waters, such as pond, lake and river

(ii) Marine as oceans, shallow sea

25.6.1 Terrestrial Biomes

A. Forests : Forests are one of the largest plant formations, densely packed with tall and big trees. Forests are of many different types, depending on the climatic regime in which they are found. Three main forest types are:

1. Tropical rain forests
2. Temperate deciduous forests
3. Boreal or north coniferous forests

1. Tropical Rain (Evergreen) Forest : These are in the tropical region of very high rain fall. Such forests are well developed over the western coast of India and North eastern Himalayas and scattered in south east Asia, west Africa and north cost of South America.

Main characteristics

- Temperature and light intensity are very high
- Rain fall is greater than 200 cm. per year.
- Soil of these regions is rich in humus,
- The rate of **turnover** of the nutrients is very high leading to high productivity and have highest standing crop and biomass.

- The vegetation includes broad evergreen trees of about 200 feet like bamboos, ferns, shrub etc. Epiphytes and woody wines (liannas) are also abundant. Many tree species show buttresses (swollen stem bases) and leaves with drip tips.

These forests have rich invertebrate and vertebrate fauna. Snails, centipedes, millipedes and many insect species are common near the forest floor. *Rhacophorus* (flying frog), aquatic reptiles, *Chameleon* and many birds are common in these forests. Mammals of these forests are sloths , monkeys, ant eaters, leopards, jungle cats and giant flying squirrels.

2. **Temperate Deciduous Forests :** Trees of deciduous forests shed their leaves in autumn and a new foliage grows in spring. They occur mostly in northwest, central and eastern Europe, eastern north America, north China, Korea, Japan, far eastern Russia and Australia.

   Climate : These forests occur in the areas of moderate climatic conditions such as

   - Annual rainfall is 75 to 150 cm
   - Winter lasts for four to six months.
   - Temperature ranges between 10 to 20°C.
   - Soil is brown and rich in nutrients.

   Flora and fauna : Commonly found trees in this ecosystem are oak, birch heath, chest nuts, pitch pine, cyprus. Invertebrate fauna comprises green oak moth, bark beetle, green flies, aphids, sapflies, moths and butterflies. Prominent grazers are grass eating rodents, deer and bison. Rodents play a very important role in these forests. They feed on the seeds, fruits and leaves of the trees and consume much more food than the large sized grazers. Common carnivores in temperate forests are wild cat, wolves, foxes, tawny owl and sparrow hawk. Black bear, raccoons and skunks are the omnivorous animals of these forests.

3. **Coniferous forests :** Coniferous forests are also known as **Taiga** or **Boreal** forests. They extend as a continuous belt across north America and north Eurasia below the arctic tundra. In the Himalayas, these are distributed above 1700 to 3000 metre altitude. They also occur at high altitude below the alpine tundra and tree line.

   Climate : Climate is cold.

   - Long and harsh Winters is for more than six months. Mean annual temperature is below 0°C,
   - Soil is poor in nutrients and acidic in nature.

   Flora and fauna : Coniferous forests are characterized by conifers (gymnosperms). They are evergreen, drought resistant and woody. In many species the canopy is cone shaped. The common species of trees of these forests are Spruce, fir and pine trees. The productivity is much less than other ecosystem. There are very few animals in these forests. The herbivores are red squirrel, deer, goat, mule, moose etc. The carnivores are timber wolves, lynxes, wolverine, weasels mink and bear. Some common birds are cross bill, thrushes, warblers, flycatchers, robin and sparrow.

B. Grasslands

Distribution : Grasslands are dominated by the grasses. They occupy about 20% of the land on earth's surface. They occur in both tropical and temperate regions where environmental conditions are better than that of the desert but rainfall is not enough to support the growth of trees. Grasslands represent an **ecotone** (a zone in between two ecosystems) and are found between forest on one side and deserts on the other. They are subjected to greater variation of temperature, moisture, wind and light intensity of the sun.. Grasslands are known by various names in different parts of the world. For example they are called prairies, steppes, savannas and pampas.

Tropical grasslands are commonly called Savannas. They occur in eastern Africa South America, Australia and India. Savannas form a complex ecosystem as they contain grasses with groups of trees. Soil of grassland is rich and fertile.

Flora and fauna : Grasses are the dominating plants with scattered drought resistant trees in the tropical grasslands. Trees are less than 10 m in height. Animals are much reduced in grasslands because there is no shelter. The large herbivores of this biome are bison, proghorn (North America) wild horse, ass, saiga (Eurasia) , zebra and antelope (South Africa). Carnivores are quite small in number and size They are coyotes, weasels, badgers foxes and ferrets . Hawks, lark sparrows, warblers, Great Indian Bustard and peafowl are the common birds found in grassland. Grasslands are very rich in reptilian and insect fauna.

C. Deserts

Distribution : Deserts are waterless barren regions of the earth. They occupy about one-seventh of the land on earth's surface. Deserts form an extreme condition in sequence of ecosystems with respect to the climatic condition . They occur in two belts that encircle the northern and southern hemispheres roughly centered over the tropics of Cancer and Capricorn. Sahara deserts of Africa are the largest Indian Thar deserts are an extensions of Sahara deserts through Arabian and Persian deserts.

Climate:

- Annual rain fall is very little. It may be less than 25 cm per annum. At some places if it is high it is unevenly distributed.
- Temperature may be very high in subtropical deserts and very low in cold deserts e.g. Ladakh.
- Winds have high velocity.

Flora and fauna : Cacti, *Acacia, Euphorbia* and prickly pears are some of the common desert plants. Desert animals are insects, reptiles, and burrowing rodents. Desert shrew, fox, kangaroo, wood rat, rabbit, armadillo are common mammals in desert. Camel is known as the ship of the desert as it can travel long distances without drinking water for several days.

D. Tundra

The word tundra means a "barren land" since they are found in those regions of the world where environmental conditions are very severe. There are two types of tundra **arctic** and **alpine**.

Distribution

- **Arctic tundra** extend as a continuous belt below the polar ice cap and above the tree line on the northern hemisphere. It occupies the northern fringe of Canada Alaska, European Russia, Siberia and island group of arctic ocean.
- **Alpine tundra** occur at high mountain peaks above the tree line. Since mountains are found at all latitudes therefore alpine tundra show day and night temperature variations

Climate

- A permanently frozen subsoil called **permafrost** is found in the arctic and antarctic tundra. The summer temperature may be around 15°C and in winter it may be as low as –57°C in arctic tundra A very low precipitation of less than 400 mm per year
- A short vegetation period of generally less than 50 days between spring and autumn frost
- Productivity is low

Flora and fauna : Typical vegetation of arctic tundra is cotton grass, sedges, dwarf heath, willows birches,and lichens. Animals of tundra are hurepian reindeer, musk ox, arctic hare, caribous, lemmings and squirrel. Their body is covered with fur for insulation, Insects have short life cycles which are completed during favourable period of the year.

INTEXT QUESTIONS 25.6

1. Define alpine tundra ecosystems.

   ....

2. Give two examples of plants of tundra.

   ....

3. Give two common characteristics of tundra and desert biome.

   ....

4. Names of three main types of forests.

....

5. Where are savannas found?

....

6. What are deciduous trees?

....

25.6.2 Aquatic Biomes

Aquatic ecosystems are constituted by water bodies . Water covers about one third of the earth's surface. Origin of life took place in aquatic ecosystem. Therefore, these ecosystems make an important component of our biosphere. Aquatic ecosystems are classified on the basis of salinity into following two types:

1. Freshwater 2. Marine

1. Fresh Water Ecosystem

Water on land which is continuously cycling and has low salt content is known as fresh water. The study of fresh water ecosystem is known as **limnology**. Fresh waters are classified into two types:

(i) Standing or still water **(Lentic)** e.g. pond, lake, bogs and swamps.

(ii) Running water **(Lotic)** e.g.. springs, mountain brooks, streams and rivers.

Commonly found flora in ponds and lakes include

(i) Phytoplankton (freely floating microscopic plants) such as algae, diatoms

(ii) Floating plant : *Pistia,* water hyacinth, *Lemna, Azolla*

(iii) Rooted plant : Hydrilla, *Vallisnaria*, trapa and water lily.

The common animals in ponds and lakes include

(i) Zooplankton (freely floating microscopic animals) such a protozoans and crustaceans;

(ii) Actively swimming fishes, frogs, tortoises.

(iii) Bottom dwellers like hydra, worms, prawns crabs, snails.

(iv) Birds such as herons, water fowls and ducks occurs in and around water.

Wetlands are between aquatic and terrestrial ecosystem *They show an **edge effect** and form a **ecotone**. Ecotone is a transitional zone between two ecosystems.* Examples of wet zone are swamps, marshes and mangroves.

2. Marine Ecosystem

Distribution : Marine ecosystem covers nearly 71 % of the earth's surface with an average depth of about 4000 m. Fresh water rivers eventually empty into ocean. Salinity of open sea is 3.6 percent and is quite constant Sodium and chlorine make up nearly 86 percent of the sea salt and the rest is due other elements such as sulphur, magnesium, potassium and calcium

Temperature : The range of temperature variation is much less in sea than on the land although near the surface it is considerable from –2°C in antarctic ocean to 27°C in the warmer waters of pacific ocean. In the deeper layers temperature is constant at about 2°C.

Light : The light reaches upto a certain depth only. Deeper regions are permanently dark.

Pressure : Pressure increases with depth in oceans. It is 1 atmosphere near the surface and 1000 atmosphere at greatest depth.

Tides : The gravitational pulls of the sun and the moon cause tides in oceans. At the time of full moon and new moon tides are high and are called **spring tides**. At quarter moon the tides are exceptionally low and are known as low tide or **neap tides**

Flora and fauna : Life in the oceans is limited but its biodiversity is very high as compared to terrestrial ecosystems. Almost every major group of animals occur somewhere or the other in the sea. except for insects and vascular plant which are completely absent in marine ecosystem.

INTEXT QUESTIONS 25.7

1. What are plankton?

   ....

2. Name two phytoplanktons and two bottom dwellers in fresh water ecosystem.

   ....

3. What is the maximum pressure in ocean.

   ....

4. Give an example of (a) wet land (b) lotic type of ecosystem.

   ....

25.7 ECOLOGICAL SUCCESSION

Biotic communities are dynamic in nature and change over a period of time. **The process by which communities of plant and animal species in an area are replaced by another over a period of time is known as ecological succession**. Both the biotic and abiotic components are involved in this change. This change is brought about both by the activities of the communities as well as by the physical environment of that particular area.

The physical environment often influences the nature, direction, rate and optimal limit of changes. During succession both the plant and animal communities undergo change. There are two types of successions (i) Primary succession and (ii) Secondary succession.

Primary Succession

Primary succession takes place over bare or unoccupied areas such as rock outcrop, newly formed deltas and sand dunes, emerging volcano islands and lava flows as well as glacial moraines (muddy area exposed by a retreating glacier) where no community has existed previously. The plants that invade the bare land, where soil is initially absent for the first time are called **pioneer species**. The assemblage of pioneer plants is collectively called **pioneer community**. A pioneer species generally shows high growth rate but short life span (Fig 8)

Primary succession is much more difficult to observe than secondary succession because there are relatively very few places on earth that do not already have communities of organisms. The community that initially inhabits a bare area is called **pioneer community**. The pioneer community after some time gets replaced by another community with a combination of different species. This second community gets replaced by a third community. This process continues sequence-wise in which a community is replaced by another community.

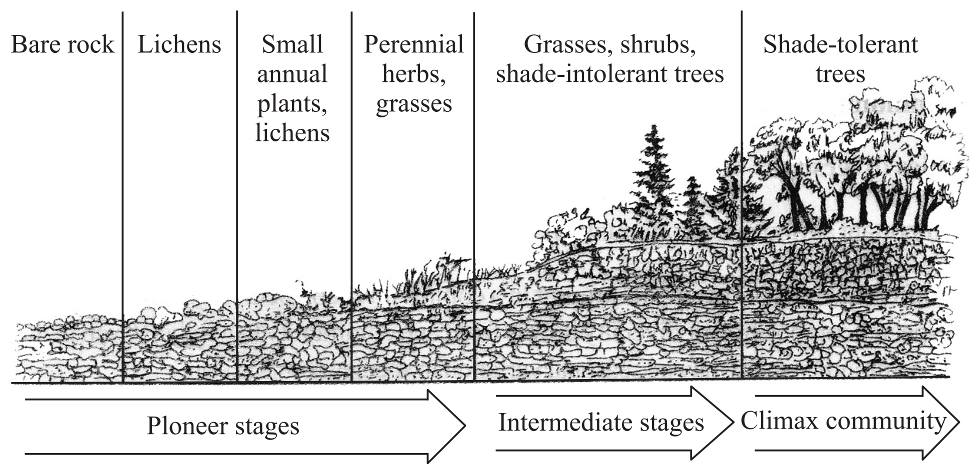


Fig. 25.18: The orderly sequence of primary succession

Each transitional (temporary) community that is formed and replaced during succession is called a stage in succession or a **seral community** (Fig. 9). The terminal (final) stage of succession forms the community which is called **climax community**. A climax community is stable, mature, more complex and long lasting. The entire sequence of communities in a given area, succeeding each other, during the course of succession is termed **sere** (Fig 9).

Notes

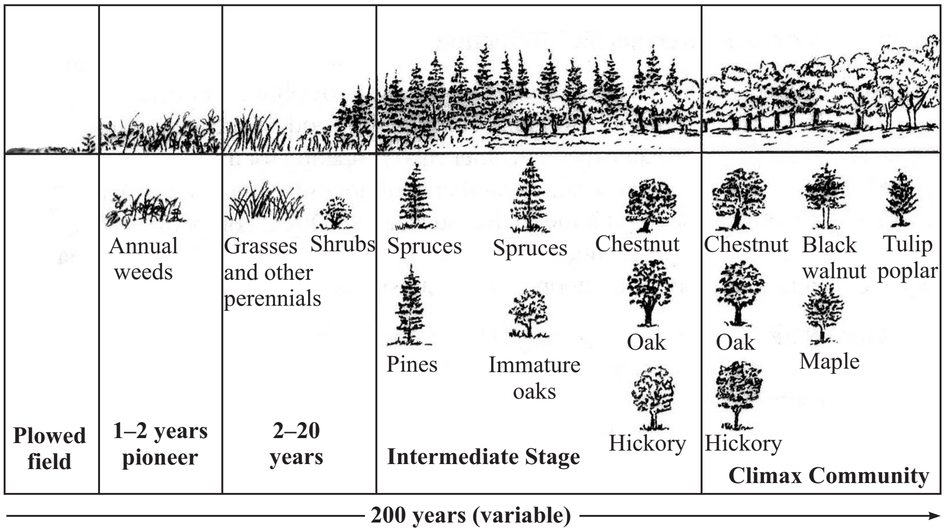


Fig. 25.19: Secondary succession on land

The animals of such a community also exhibit succession which to a great extent is determined by plant succession. However, animals of such successional stages are also influenced by the types of animals that are able to migrate from neighbouring communities. A climax community as long as it is undisturbed, remains relatively stable in dynamic equilibrium with the prevailing climate and habitat factors. Succession that occurs on land where moisture content is low such as on bare rock is known as **xerarch**. Succession that takes place in a water body, like ponds or lake is called **hydrarch**.

Secondary Succession

Secondary succession is the development of a community which forms after the existing natural vegetation that constitutes a community is removed, disturbed or destroyed by a natural event like hurricane or forest fire or by human related events like tilling or harvesting land.

A secondary succession is relatively fast as the soil has the necessary nutrients as well as a large pool of seeds and other dormant stages of organisms.

INTEXT QUESTIONS 25.8

1. What does the following sequence represent:

   Blue green algae ⟶ Crustose lichens
   ↓
   shrubs ⟵ mosses ⟵ Foliose lichens
   ↓
   Dicotyledonous trees

(a) Ecological succession

(b) Genetic drift

(c) Phylogenetic trend

(d) A food pyramid

2. A community which starts succession in a habitat is:

(a) Pioneer community

(b) Social community

(c) Biotic community

(d) Ecosere

3. In ecological succession, beginning from pioneer and ending in climax community, the biomass shall

(a) decrease

(b) increase and then decrease

(c) decrease and then increase

(d) Increase continuously

25.7 BIOGEOCHEMICAL CYCLES

You have already learnt that living organisms required several chemical elements for their life processes. There may be used as part of their structural component or as parts of enzymes which influence various life processes unlike energy which flows unidirectionally, nutrients are continuously exchanged between the organisms and their physical environment.

("Bio" - living, "Geo" - rock, "Chemical" - element). The cycling of the nutrients in the biosphere is called **biogeochemical or nutrient cycle**. It involves movement of nutrient elements through the various components of an ecosystem. There are more than 40 elements required for the various life processes by plants and animals. These elements are continuously cycling in the ecosystem through the biogeochemical cycles and the planet earth has no input of these nutrients. The nutrients (matter) from the dead remains of organisms are recovered and made available to the producers by decomposers. Thus the nutrients are never lost from the ecosystems.

A. Carbon cycle

Atmospheric carbon dioxide is the source of all carbon in both living organisms as well as in the fossils (used as fossil fuel). It is highly soluble in water. Oceans also contain large quantities of dissolved carbon dioxide and bicarbonates.

The carbon cycle Fig. 25.17 comprises the following processes

Photosynthesis

Terrestrial and aquatic plants utilize CO_2 for photosynthesis. Through this process the inorganic form of carbon is converted into organic matter in the presence of sunlight and chlorophyll. The carbon dioxide is thus fixed and assimilated by plants. It is partly used by them for their own life processes and the rest is stored as their biomass which is available to the heterotrophs as food.

Respiration

Respiration is a metabolic process reverse of photosynthesis in which food is oxidized to liberate energy (to perform the various life processes) and carbon dioxide and water. Thus the carbon dioxide of the atmosphere is recovered through this process.

Decomposition

After the death of the organisms the decomposers break down the remaining dead organic matter and release the left over carbon back into the atmosphere.

Combustion

Fossil fuel such as crude oil, coal, natural gas or heavy oils on burning releases carbon dioxide and carbon monoxide into the atmosphere. Forests make a large amount of fossil fuel. *Fossil fuel is product of complete or partial decomposition of plants and animals as a result of exposure to heat and pressure in the earth's crust over millions of years*.

Forests also act like carbon reservoirs as carbon fixed by them cycles very slowly due to their long life. They release CO_2 by forest fires.

Impact of human activities

Carbon dioxide is continuously increasing in the atmosphere due to human activities such as industrialization, urbanization and increased use of automobiles. This increase in atmospheric CO_2 is bading to green house effect and global warming.

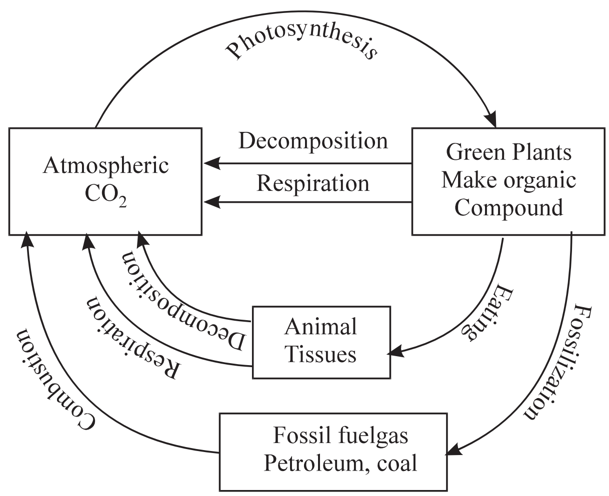


Fig. 25.18: Carbon cycle

(Arrows indicate the processes of the carbon cycle and compartments are the sites of these processes or the store houses of carbon in the reservoir pool and ecosystem)

B. Water cycle

This is also known as hydrologic cycle. You have already studied that earth is a watery planet of the solar system but a very small fraction of this is available to animals and plants. Water is not evenly distributed throughout the surface of the earth. Major percentage of the total water on the earth is chemically bound to rocks and does not cycle. Out of the remaining, nearly 97.3% is in the oceans and 2.1% exists as polar ice caps. Thus only 0.6% is present as fresh water in, the form of atmospheric water vapors, ground and soil water. The ice caps and the water deep in the oceans form the reservoir.

Solar radiation and earth's gravitational pull are the main driving forces of water cycle.

Evaporation, condensation and precipitation are the main processes involved in water cycle these processes alternate with each other

Water from oceans, lakes, ponds, rivers, streams and soil surface evaporates by sun's heat energy. Plants also transpire huge amounts of water through their leaves. Water remains in the vapour state in air and forms clouds, which drift with the wind. Clouds meet with the cold air in the mountainous regions above the forests and condense to form rain, which falls due to gravity.

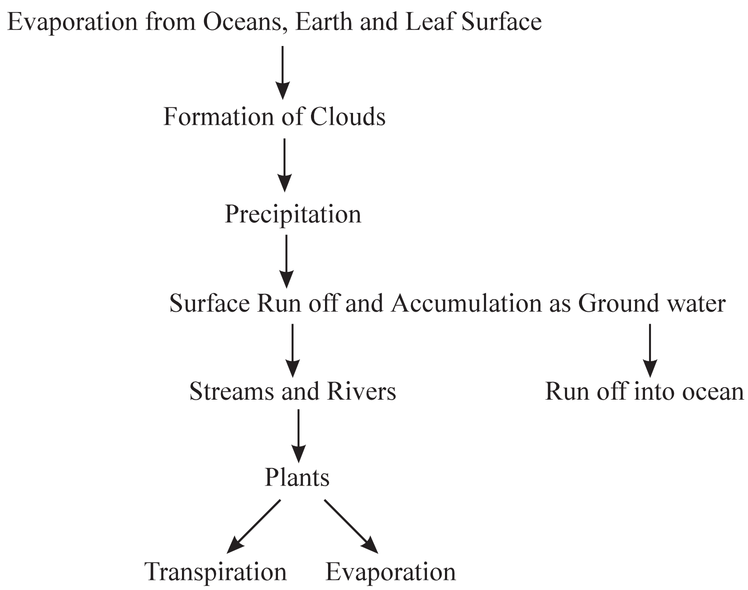


Fig. 25.8 Water cycle

On an average 84% of the water is lost from the surface of the oceans by evaporation. While 77% is gained by it from precipitation. The remaining 7% of the ocean evaporation is balanced by water run off through the rivers from the land.

C Phosphorus Cycle

We all know that phosphorus is a necessary and important constituent of the protoplasm in the living organisms. The reservoirs of phosphorus are the rocks or other deposits that have been formed in the past geological ages. The erosion of these deposits release phosphates in the ecosystem. However, much of it escapes into the sea where part of it is lost to the deep sediments and some of it deposited in the shallow marine sediments. Plants take up inorganic phosphate as orthophosphate ions. Animals (consumers) that feed on these plants in turn take up phosphate from them. After the death of the plants and animals, the decomposers act on them and the phosphate is returned in the ecosystem in the dissolved form. The excreta of the animals also return some phosphorus to the cycle. Bones and teeth of animals are resistant to weathering and this accounts for some loss of phosphorus. Sea birds play an important role in bringing back phosphorus to the cycle through their guano deposits. Marine fishes also return some of the phosphorus to the cycle. A study of phosphate cycle reveals that the return of phosphate to the cycle is inadequate to compensate the loss. It is human beings who have hastened the rate of loss of phosphorus.

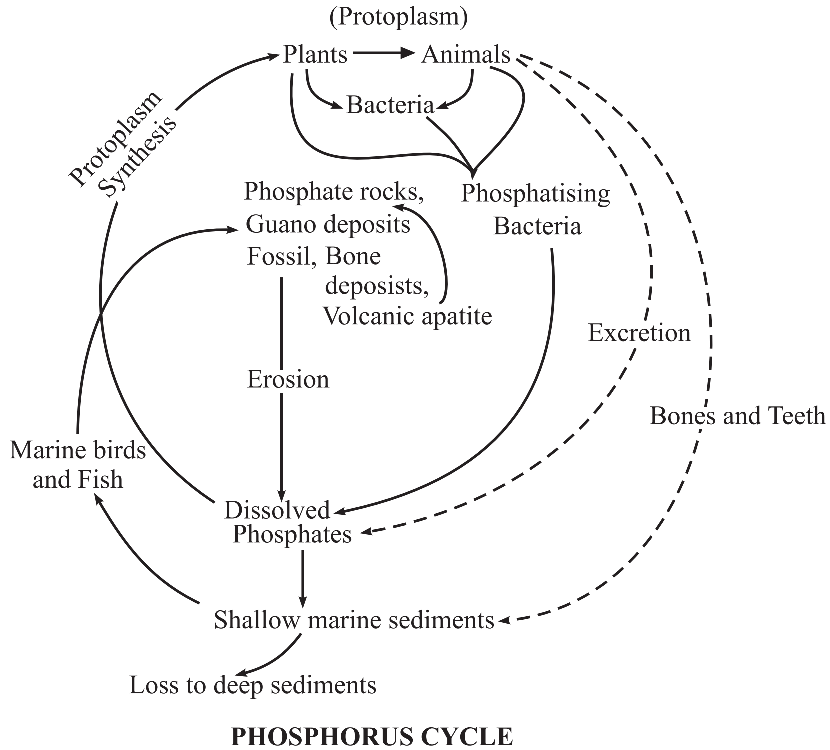


Fig. 25.9 Phosphorus Cycle

INTEXT QUESTIONS 25.9

1. Define nutrient cycle.

   ....

2. Where are the bulk of nutrient stored in an ecosystem?

   ....

3. Name the nutrient cycle where atmosphere acts as the main reservoir.

   ....

4. List any two human activities that have led to increase in atmospheric CO_2.

   ....

5. Name the reservoirs for water cycle.

   ....

6. How do humans affect the phosphorus cycle?

   ....

7. How do the sea birds contribute to the phosphorus cycle?

   ....

WHAT YOU HAVE LEARNT

- Earth is the only planet to support life. Earth provides soil, water and air to support it.
- Environment is defined as the physical, chemical and biotic conditions that surround and influence on living organisms.
- The abiotic components of environment are temperature, light, humidity, precipitation, wind minerals and the composition of air.
- Biotic components include plants, animals and microorganisms.
- Ecology is defined as the study of relationship between organisms and their environment. Ecology deals with various form of interaction between the organisms and their environment.
- The levels of organisation in the living system starting from genes to community.
- The three physical components of earth are atmosphere, lithosphere and hydrosphere.
- Ecosystem is defined as functionally independent unit of nature where living organisms interact among themselves as well as with their physical environment.
- Terrestrial and aquatic ecosystems are the two categories of natural ecosystems. Croplands and aquarium are the examples of artificial ecosystem.
- Light, temperature, inorganic and organic compounds constitute the abiotic components of ecosystem whereas produces consumers and decomposers are its biotic components.
- These biotic components of ecosystem interact with each other to give a physical character. These represent structural features of an ecosystem to an ecosystem.
- The important structural features of an ecosystem may be represented by its species composition, stratification, food relationship (trophic level food chain an food web).
- The structural components interact in a unit and produce certain functional aspects of an ecosystem such as productivity, energy flow and nutrient cycle etc.
- Humans occupy both primary and secondary levels of consumers.
- Transfer of food from the plants (producers) through a series of organisms with repeated eating and being eaten is called food chain.
- A network of a connected food chains interrelated form a food web.

- The process of transfer of energy through various trophic levels of the food chain is known as flow of energy.
- The quantity of energy flowing through the successive trophic level decreases. This is because a part of the energy is lost as heat and a part of energy used by the organism for its metabolism.
- Only 10% of the energy that enters the trophic level is transferred to the next trophic level. This is known 10% law. The flow of energy in an ecosystem is always linear.
- The number of trophic level in a food chain is limited in number (4 or 5).
- The graphical representation of standing crop expressed as number biomass or energy is called pyramid of number. Pyramid of biomass and pyramid of energy respectively. These are collectively known as ecological pyramid.
- A biome is a large ecosystem which is embracing the large landscape. Each biome is characterised by a specific flora and fauna.
- The cycling of the nutrients in the biosphere is called biogeochemical or nutrient cycle. Carbon cycle and water cycle are two such example.
- Photosynthesis, respiration, decomposition and combustion are the important processes in carbon cycle.
- Evaporation, condensation and precipitation are the important processes in water cycle.

TERMINAL EXERCISES

1. What are the three physical life support systems on the planet earth?
2. Name the various biotic and abiotic components of the environment
3. Give differences between natural and human modified ecosystem
4. Why is the number of trophic levels restricted to four or five in a food chain?
5. Give only two differences between fresh water and marine biome.
6. What will happen if all the floating animals are removed from a lake ecosytem?
7. What are the benefits of natural ecosystems?
8. Give two differences between energy flow and biogeochemical cycle in an ecosystem.

ANSWERS TO INTEXT QUESTIONS

25.1
1. Ernst haeckel
2. Genes → Cell → Organ → Organism → Population → Community
3. Study of animals and plants in relation to their habit and habitat.
4. Atmosphere, lithosphere and hydrosphere

25.2 1. (i) Abiotic (ii) Biotic

2. light, temperature, humidity, precipitation, pressure and soil profile

3. Helps in recycling of nutrients in the environment.

4. Plants are capable of capturing solar energy and transforming it into food energy. Thus they produce their own food. Animals depend upon plants or other animals for food as they cannot produce their own food.

25.3 1. Ecosystem is a unit to study ecology/functionally independent unit to stud. The interrelation between biotic and abiotic components.

2. Main components

Biotic	Abiotic
(Producers)	light
Consumers	Temperature
Decomposers	Inorganic substances
organic compounds	

3. to breakdown products of dead animals and plants tissue.

25.4 1. Grass → Grasshopper → Frog → Snake → Hawk/eagle

2. Secondary level consumer

3. Snake can feed on a rat and then it is a secondary consumer. It can also feed on a frog and then it is a tertiary consumer.

25.5 1. Upto five (5)

2. Energy from solar radiation is fixed in the form of food by the producer. This energy is passed on to the consumers of different trophic level. At each trophic level energy is used by the member for metabolism and only left over energy is passed on each trophic level (10%).

3. See text

4. Vertical and horizontal distribution of plants in the ecosystem.

25.6 1. Its an ecosystem that occurs high mountain peak above the tree line. Environmental conditions are very severe and show day and night temperature variation.

2. Cotton grass, sedges, dwarf leath, willows, birches and lichens (any two).

3. 1. both of them have very harsh climatic conditions.

2. Scarce vegetation.

4. 1. Tropical rain forest temperature.
   2. Deciduous boreal or north.
   3. Coniferous rain forest.
5. Eastern Africa, South America, Australia and India (any two).
6. Trees which shed their leaves in autumn and grow new foliage during spring.

25.7 1. Free floating microscopic organisms
2. diatoms, algae, prawn, crabs, snail (any two)
3. 1000 atmosphere
4. (a) swamps, marshes and mangroves (any one)
   (b) streams, rivers, springs (any one)

25.8 1. Movement of nutrient elements through the various components of an ecosystem is called nutrient cycle.
2. In the Reservoirs pool
3. Gaseous cycle
4. Industrialization, urbanization, increased used of automobiles (any two)
5. Polar ice caps and water present deep in the oceans.

26

CONSERVATION AND USE OF NATURAL RESOURCES

Nature provides us with the basic needs for our survival such as food, shelter, clothes, etc. We use air, water, soil, minerals, coal, petroleum, animals, plants etc. in our daily life ? But do you ever think, how long these precious materials of nature will last ? The growing population, rapid industrialisation and– urbanisation have created heavy demand on natural resources. This lesson deals with means of conservation of natural resources through prevention of resource ever exploitation and sustainable development.

OBJECTIVES

After completing this lesson, you will be able to:

- *explain the term natural resources;*
- *familiarise with the traditions practised in India for conservation of nature;*
- *describe the reasons for degradation of natural resources and suggest measures to prevent these;*
- *define biodiversity and describe the need to conserve biodiversity;*
- *list the various endangered species of animals and plants;*
- *state the various environmental laws passed to conserve the natural resources;*
- *explain sustainable development and justify its need; and*
- *describe the various conventional as well as non-conventional sources of energy.*

26.1 NATURAL RESOURCES

The term "natural resource" means any thing that we use from our environment to achieve our objective. For example, we require bricks, cement, iron, wood etc. to construct a building. All these items are called resources for construction of building. **A resource can be defined as 'any natural or artificial substance, energy or organism, which is used by human being for its welfare.** These resources can be two types:

(a) Natural resources

(b) Artificial resources.

All that nature has provided such as soil, air, water, minerals, coal, sunshine (sunlight), animals and plants, etc., are known as **natural resources**. The resources, which have been developed by human beings during the growth of civilization, are called **artificial resources**. For example, biogas, thermal electricity, plastics. These man-made resources are generally derived from some other natural resources. For example, plastics from the natural resource, petroleum.

26.1.1 Classification of Natural Resources

The air we breathe and the light we get from the sun are available in unlimited quantity. But what about coal, forest, and petroleum? The stock of these resources is limited and is depleting day by day.

- Resources
  - Natural (e.g. coal)
    - Exhaustible (Petroleum)
      - Renewable (e.g. wind, water, forests)
      - Non-renewable (e.g. coal, petroleum, iron, biological species)
    - Inexhaustible (e.g. solar energy, wind, rainfall, tidal energy)
  - Artificial (e.g. electricity)

- **Inexhaustible Resources**

The resources which cannot be exhausted by human consumption are called **inexhaustible resources.** These include energy sources like solar radiation, wind power, water power (flowing streams) and tidal power, and substances like sand, clay, air, water in oceans, etc.

- **Exhaustible Resources**

On the other hand, there are some resources, which are available in limited quantities and are going to be exhausted as a result of continuous use. These are called **exhaustible resources**. For example, the stock of coal in the earth is limited and one day there will be no more coal available for our use.

- **Renewable Resources**

Some of the exhaustible resources are naturally regenerated after consumption and are known as **renewable resources.** e.g. Forest trees and plants that make a forest may be destroyed but new ones gow in their place. But if forest is totally cut down to get land for constructioni of buildings, it is lost forever. Some other examples are fresh water, fertile soil, forest (yielding wood and other products), vegetation, wildlife, etc.

- **Non-renewable Resources**

The resources, which cannot be replaced after the use, are known as **non-renewable Resources.** These include minerals (copper, iron etc.) fossil fuels (coal, oil etc.). Even wildlife species (rare plants and animals) belong to this category.

INTEXT QUESTIONS 26.1

1. Given below are certain wrong statements. Identify the mistake and write the correct statement below each.

   (i) Plastic is a natural resource.

   ....

   (ii) Forest is an exhaustible non-renewable resource.

   ....

   (iii) The exhaustible resources, which are not replaced after consumption are known as renewable resources.

   ....

2. Classify the following under the three respective categories of natural resources: Air, iron, sand, petroleum, wind, clay, fish, forest, gold, pearls.

Inexhaustible	**Renewable**	**Non- renewable**
....	....	....
....	....	....

26.2 CONSERVATION OF NATURAL RESOURCES

Consumption of natural resources is increasing with growing population. With the increasing industrialisation and urbanisation, we need to conserve natural resources for thier destruction will also upset the ecological balance.

Conservation is the proper management of a natural resource to prevent its exploitation, destruction or degradation.

Conservation is the sum total of activities, which can derive benefits from natural resources but at the same time prevent excessive use leading to destruction or degradation.

26.2.1. Need for Conservation of Natural Resources

We know that nature provides us with all our basic needs but we tend to over exploit. If we go on exploiting nature, there will be no more resources available in future. Hence there is an urgent need to conserve nature for the following reasons. Some of the needs are :

- to maintain ecological balance for supporting life.
- to preserve different kinds of species (biodiversity).
- to make the resources available for present and future generations.
- to ensure survival of human race.

26.2.2. Coservation of Natural Resources and Traditions of India

The need for conservation of natural resources was felt by our predecessors and in India, there was a tradition of respecting and preserving nature and natural resources. Natural resources were conserved in the form of sacred groves/forests, sacred pools and lakes, sacred species etc e.g. the river ganges. In our country the conservaton of natural forests is known from the time of Lord Ashoka. Sacred forests are forest patches of different dimensions dedicated by the tribals to their deities and ancestral spirits. Cutting down trees, hunting and other human interferences were strictly prohibited in these forests. This practice is widespread particularly in peninsular, central and eastern India and has resulted in the protection of a large number of plants and animals. Similarly, several water bodies, e.g., Khecheopalri lake in Sikkim was declared sacred by people, thus, protecting aquatic flora and fauna. **Worshipping** certain plants like banyan, peepal, tulsi etc. has not only preserved them but also encouraged their plantation. History recalls numerous instances where people have laid down their lives for protecting trees.

Recent Chipko movement in India is one of the best examples. This movement was started by women in Gopeshwar village in Garhwal in the Himalayas. They stopped the felling of trees by hugging them when the lumbermen arrived to cut them. This saved about 12000 square kilometers of sensitive water catchment area. Similar movements also occurred in some other parts of the country.

INTEXT QUESTIONS 26.2

1. Why should we conserve natural resources? State any two reasons.

   (i) ....

   (ii) ....

2. Given below are certain incomplete words. Complete them by taking clues from the statement given below for each. Each blank space represents one letter only.

   (i) __ __ __ p k __

   (A movement started by women to stop the felling of trees by hugging them)

   (ii) T__ __ __ i

   (A sacred plant worshipped in India)

   (iii) Kh __ ch __ __ pa__ __ i

   (A lake in Sikkim that was declared sacred by the people)

26.3 SOIL

Soil is a very important natural resource and an abiotic component of the environment. Soil is the uppermost layer of earth's crust, which supports growth of plants. It is a complex mixture of (i) mineral particles (formed from rocks), (ii) humus (organic material formed from decaying plant remains), (iii) mineral salts, (iv) water, (v) air, and (vi) living organisms (larger ones like earthworms and insects and microorganisms like the bacteria and fungi).

Humus

A brown or black organic substance consisting of partially or wholly decayed vegetable or animal matter that provides nutrients for plants and increases the ability of soil to retain water.

Soil is both a renewable as well as non-renewable resource.

- Soil is renewable because its productivity can be maintained with fertilizers and manures rich in humus.
- If the soil has been removed from a certain place by erosion, it is practically non-renewable because formation of new soil may take hundreds and thousands of years.

26.3.1. Soil Erosion

Erosion literally means "to wear away". You might have noticed that in summer, when wind blows it carries away sand and soil particles. Similarly flowing water removes some amount of soil along with it. **This removal of top layers of soil by wind and water is called soil erosion.** The top layers of soil contain humus and mineral salts, which are vital for the growth of plants. Thus, erosion causes a significant loss of humus and nutrients, and decreases the fertility of soil.

26.4.2. Causes of soil Erosion

There are several causes of soil erosion.

(a) Natural causes; and

(b) Anthropogenic causes (human generated causes)

(a) Natural Causes of Soil Erosion

Erosion of soil takes places due to the effect of natural agents like wind and water. High velocity winds over lands, without vegetation, carry away the loose top soil. Similarly in areas with no or very little vegetation, pouring raindrops carry away the soil.

(b) Anthropogenic Causes of Soil Erosion

Besides the natural agents, there are some human activities, which cause soil erosion. Let us know about them.

1. **Deforestation:** If the forests are cut down for timber, or for farming purposes, or construction then the soil is no longer protected from the effect of falling rains. Consequently, the top soil is washed away into the rivers and oceans.

2. **Poor farming methods:** Improper tillage and failure to replace humus after successive crops and burning the stubble. The short, stiff stalks of grain or hay remaining on a field after harvesting of weeds reduce the water-holding capacity of the soil. So the soil becomes dry and can be blown away as dust.
3. **Overgrazing:** Overgrazing by flocks of cattle, buffaloes, goats and sheep leave very little plant-cover on the soil. Their hooves make the soil dry and soil can be blown away easily.

26.4.3 Conservation of Soil

Soil conservation means checking soil erosion and improving soil fertility by adopting various methods.

1. **Maintenance of soil fertility:** The fertility can be maintained by adding manure and fertilizers regularly as well as by rotation of crop.
2. **Control on grazing:** Grazing should be allowed only on specified areas.
3. **Reforestation:** Planting of trees and vegetation reduces soil erosion.
4. **Terracing:** Dividing a slope into several flat fields to control rapid run of water. It is practised mostly in hilly areas.
5. **Contour ploughing:** Ploughing at right angles to the slope allows the furrows to trap water and check soil erosion by rain water.

INTEXT QUESTIONS 26.3

1. How do the following cause soil erosion?

   Wind : ______________________

   Overgrazing : ______________________

   Water : ______________________

2. Match the items of column A with those of Column B.

Column-A	Column-B
(i) Terracing	(a) Decayed vegetable or animal matter
(ii) Erosion	(b) Cutting down forests
(iii) Deforestation	(c) Practised in hilly areas
(iv) Humus	(d) To wear away

26.4 WATER – A PRECIOUS RESOURCE

Water is essential for survival of all living organisms. It is the most important component of all life forms and necessary for sustaining life. Water also regulates climate, generates electricity and is also useful in agriculture and industries.

About 97% of the water on earth is saline in nature, found in seas and oceans. The remaining 3% is fresh water, most of which is stored in ice caps and glaciers, and just about 0.36% is distributed in lakes, rivers, ponds, etc. as 'fresh water'.

Sea water supports marine life and contributes to the production of fish and sea foods and several other commercial products (iodine, agar, coral, pearls, etc.). Fresh water is needed by humans for their personal use (drinking, cleaning, sewage disposal), It is also used by other animals, in agriculture, and in industries. Fresh water is a renewable resource as it is continuously being produced through hydrological cycle (evaporation, condensation and precipitation). A from lesson 24.

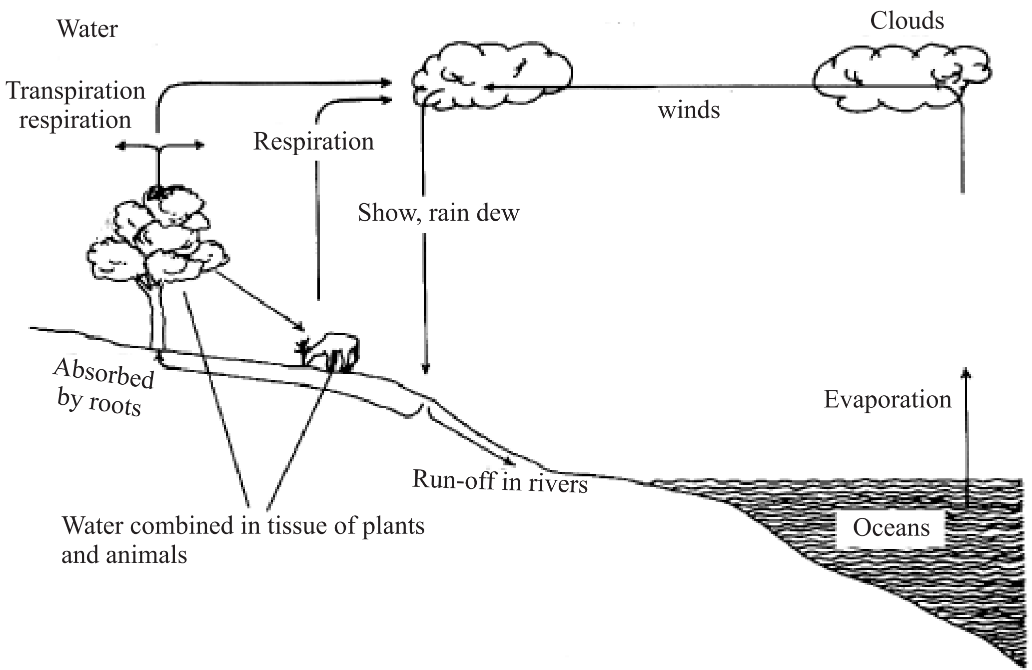


Fig. 26.1 Hydrological cycle

26.4.1.Degradation of Water

With increase in population and industrial growth, water is being degraded day by day. The main reasons for the degradation of water are:

1. to meet the need of increasing population, surface water (water from ponds, lakes, rivers, etc) and ground water are overdrawn, depleting volume of water.
2. sewage i.e., waste water from domestic and municipal use makes fresh water unfit for use by human beings and animals.
3. waste water, from all industries flows down into the surface water bodies and ground water bodies and they get polluted.

4. agricultural wastes containing manures, fertilizers and pesticides enter the water bodies and degrade the quality of water.
5. the continuous decrease of ground water level along coastal regions often cause movement of saline sea water into freshwater wells, thus, spoiling their water quality.

26.4.2. Conservation of Water

Conservation and management of water are essential for the survival of mankind, plants and animals. This can be achieved adopting the following methods:

1. **Growing vegetation** in the catchment areas, which will hold water in the soil and allow it to percolate into deeper layers and contribute to formation of ground water.
2. **Constructing dams and reservoirs** to regulate supply of water to the fields, as well as to enable generation of hydroelectricity.
3. **Sewage** should be treated and only the clear water should be released into the rivers.
4. **Industrial wastes (effluents)** should be treated to prevent chemical and thermal pollution of fresh water.
5. **Judicious use** of water in our day-to-day life.
6. **Rainwater harvesting** should be done by storing rainwater and recharging groundwater.

INTEXT QUESTIONS 26.4

1. Why do we consider fresh water as a renewable resource?

   ....

2. Give three methods of water conservation.

   ....

26.5 BIODIVERSITY

When we observe our surroundings, we find different types of plants, ranging from small green grasses to large trees, large variety of animals, from tiny insects to human beings and many other big animals. Besides these there are micro-organisms in the soil, air and water that we can't see through our naked eyes. These varieties of plants, animals and microbes together form the biological diversity or biodiversity of your surroundings.

So **biodiversity can be defined as the flora and fauna i.e. variety of all plants, animals and microbes of a region.**

26.5.1 Importance of Biodiversity

Biodiversity is essential for maintenance of ecosystem. It maintains gaseous composition of atmosphere, controls climate, helps in natural pest control, pollination of plants by insects and birds, soil formation and conservation, water purification and conservation, geo-chemical cycles etc.

Some of the uses of biodiversity are given below :

- Food : All kind of food is derived from plants and animals.
- Drugs and Medicines : Around 25% of drugs are obtained from plants e.g. quinin used for treatment of malaria is obtained from *Cinchona officinalis*. All antibiotics are derived from microbes.
- Cultural and Aesthetic value : You enjoy watching butterflies, animals, birds and flowers. Eco-tourism is a source of income.
- Religious values : Plants like tulsi, peepal, banyan and animals like cows, ox, elephant are worshiped.
- Biodiversity conservation is essential for maintenance of ecosystem.
- It is also required for disposal and pollinaiton in plants, formation and conservation of soil and purification and conservation of water.

Hot Spots of Biodiversity

Biodiversity is not uniformly distributed across the geographical regions of the earth. Certain regions of the world are very rich in biodiversity. We call such areas as "**mega diversity zones**". We also refer to them as "**hot-spots**". For example, India accounts for only 2.4 % of the land area of the world; but it contributes approximately 8% species to the global diversity due to existence of such pockets. The hot spots are the richest and the most threatened reservoirs of biodiversity on the earth. The criteria for determining an area as a hot spot are:

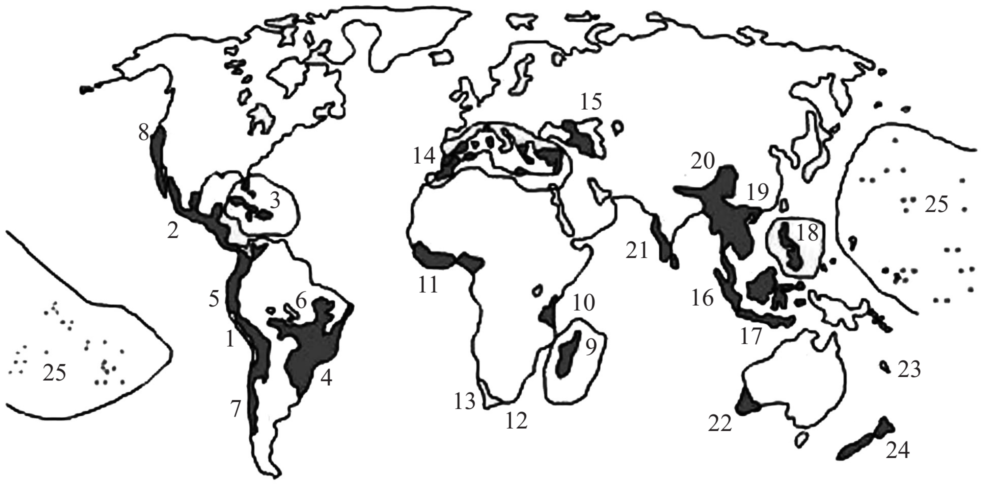
(i) The area should support >1500 endemic species,

(ii) It must have lost over 70 % of the original habitat

Twenty-five biodiversity hot spots have been identified in the world. These hot spots are characterized by supporting exceptionally high biodiversity.

Among the 25 hot spots of the world, two are found in India namely **Western Ghats** and the **Eastern Himalayas**. These two areas of the country are exceptionally rich in flowering plants, reptiles, amphibians, butterflies and some species of mammals.

The eastern Himalayan hot spot extends to the north – eastern India and Bhutan. The temperate forests are found at an altitude of 1780 to 3500 m. Many deep and semiisolated valleys are exceptionally rich in endemic plant species.



1. Tropical Andes, 2. Mesoamerica, 3. Caribbean, 4. Brazil's Atlantic Forests, 5. Chico/Darien/Western Equador, 6. Brazil's Cerrado, 7. Central Chile, 8. California Floristic Province, 9. Madagascar, 10. Eastern Arc and Coastal Forests of Tanzania/Kenya, 11. West African Forests, 12. Cape Floristic Province, 13. Succulent Karoo, 14. Mediterranean Basin, 15. Caucasus, 16. Sundland, 17. Wallacea, 18. Phillipplnes, 19. Indo-Burma, 20. South Central Chaina, 21. Western Ghats/Sri Lanka, 22. Southwest Australia, 23. New Caledonia, 24. New Zealand, 25. Polynesia/Micronesia.

Fig. 12.1a: The terrestrial biodiversity hot spots

CASE STUDIES

There are many amongst us humans who are motivated to solve societal problems, however difficult. There are several success stories of which three are mentioned below regarding water management in water starved areas:

Case Study 1

Rajasthan for many years suffered as 'land without water'. Geared by an urge to solve the water crisis, Rajinder Singh, a devout follower of Mahatma Gandhi and Jaiprakash Narayan, gave up a lucrative job to serve the people. With the help of villagers, he dug 'johads', which means 'dug out ponds' as water conservation structures where rain water began to collect year after year. Rajendra Singh's initiative worked wonders and today there are 3500 'people made' water conservation structures and no water scarcity.

Case Study 2

In Gandhigram, a coastal village in Kutch district, the villagers had been facing a drinking water crisis for the past 10 to 12 years. The groundwater table had fallen below the sea level due to over extraction and the seawater had seeped into the ground water aquifers. The villagers formed a village development group, Gram Vikas Mandal. The mandal took a loan from the bank and the villagers contributed voluntrary labour (Shramdan). A check dam was built on a nearby seasonal river, which flowed past the village. Apart from the dam, the villagers also undertook a micro-watershed project. Due to these water retention structures, the villages now have sufficient drinking water.

Case Study 3

Rainwater harvesting – another success story: The area surrounding the River Ruparel in Rajasthan is a good example of proper water conservation. The site receives very little rainfall, but proper management and conservation have ensured water availability throughout the year. The water level in the river began declining due to extensive deforestation and agricultural activities along the banks and, by the 1980s, a drought-like situation began to spread. Under the guidance of local people, the women living in the area were encouraged to take the initiative in building johads (round ponds) and dams to hold back rain water. Gradually, water began coming back as proper methods of conserving and harvesting rainwater were followed. The revival of the river has transformed the ecology of the place and the lives of the people living along its banks.

26.5.2. Threat to Biodiversity

Though biodiversity is so important for our survival, we are destroying it knowingly or unknowingly. It is under threat due to the following reasons:

(i) Destruction of habitat by cutting down trees, filling up the wetland, ploughing of grassland or burning a forest.

(ii) Population explosion has increased demand for food and shelter. It has led to culture of single crop (monoculture) that will result in disappearance of some other crops.

(iii) Industrialisation and urbanisation has changed and destroyed the natural habitat of plants and animals.

(iv) Pollution of soil, air and water changes the habitat quality and may reduce or eliminate sensitive species.

(v) Mining activities add to the pollution of air and water and threaten the survival of the animals in the nearby areas.

(vi) Construction of dams, roads and railways destroys huge patches of forests, grassland etc. thus, disturb the biodiversity.

(vii) Indiscriminate killing of animals for different purposes has resulted in their reduction.

(viii) Introduction of exotic/foreign species in an area threaten the survival of existing natural biodiversity; e.g., water hyacinth clogs rivers and lakes and threatens the life of many aquatic species in our country.

26.5.3 Conservation of Biodiversity

There are two basic strategies for conservation of biodiversity:

(i) **In-situ** conservation

(ii) **Ex-situ** conservation

(i) **In-situ (on site)** conservation includes the protection of plants and animals within their natural habitats or in protected areas. Protected areas are areas of land or sea dedicated to protection and maintenance of biodiversity. For example: e.g., National Parks, Wildlife Sanctuaries, Biosphere Reserves, etc.

(ii) **Ex-situ (off site)** conservation is the conservation of plants and animals outside their natural habitats. These include Botanical Gardens, Zoo, Gene Banks, DNA Banks, Seed Banks, Pollen Banks, Seedling and Tissue Culture etc.

INTEXT QUESTIONS 26.5

1. Some of the following words/terms are related to conservation of biodiversity and some are threat to biodiversity. Identify the points relating to conservation by mentioning 'C' and threat to biodiversity by mentioning 'T' against the points.

   (i) Wildlife sanctuaries (......................)

   (ii) Population explosion (......................)

   (iii) Industrialisation (......................)

   (iv) Zoo (......................)

   (v) Tissue culture (......................)

   (vi) Pollution (......................)

26.6 ENDANGERED SPECIES

You have already learnt about the various reasons due to which our biodiversity is under constant threat. You also learnt about the strategy to protect the biodiversity. Let us know about some of the plants and animals which have already become extinct or are going to be extinct from the earth surface.

The species, which have already disappeared, are called the **extinct** species and the phenomenon of disappearance is known as extinction. Another category of species called **endangered species are those which have been reduced in number to a critical level and facing a high risk of extinction in the near future.**

The World Conservation Union, formerly International Union for the Conservation of Nature and Natural Resources (IUCN) has enlisted endangered plants and animals in the **Red Data Book.** Few endangered plants and animals are listed below:

Endangered Animals

1. Asiatic Lion,
2. Green sea turtle, loggerhead turtle,
3. Tortoise
4. Marsh crocodile and gharial
5. Tiger
6. Rhinoceros
7. Asiatic Elephant, Indian Python
8. Great Indian Bustard, butterflies

Endangered Plants

1. Pitcher plant
2. Indian belladona
3. Orchids
4. Nilgiri Lily
5. *Ginkgo biloba* (Maiden hair tree)

26.7 WILDLIFE

Now we shall learn about an important resource of nature called wildlife. At home you may have a pet dog or a cat, even some of you may have cows, buffalos, sheep, goats etc. In your garden you may grow different types of vegetables and flowering plants. In addition to these, there are other plants and animals, which are not cultivated by you. **The plants, animals and microorganisms other than the cultivated plants and domesticated animals constitute wildlife.**

Animals and plants living in their natural habitat constitute **wildlife**. Wildlife forms an important resource as it plays a major role in maintaining ecological balance. It is used in research as experimental material and also used for recreational purposes. Like other resources it is also facing severe threat. So it should be conserved and maintained for the use of future generation.

26.7.1 Need for Conservation of wildlife

Wildlife needs to be conserved for :

- maintaining ecological balance for supporting life.
- preserving different kinds of species (biodiversity).
- preserving economically important plants and animals.
- conserving the endangered species.

26.7.2 Methods of Conservation of Wildlife

After knowing the need for conservation of wildlife, let us discuss how to conserve it. We can protect it by adopting various means, like:

- Establishing biosphere reserves, national parks and sanctuaries.
- Afforestation (Tree planting programme).
- Special schemes for preservation of threatened species.
- Improvement of natural habitats of wildlife.

- Educating people about the need and methods of conservation of wildlife.
- Formulation of Acts and Regulations to prevent poaching (killing animals) for sports and money.

> Wildlife week is being observed in India in the month of July every year since 1955. It aims at creating awareness among people about the importance of wildlife and to highlight the conservational and management needs of wildlife.

INTEXT QUESTIONS 26.6

1. What is Red Data Book?

   ....

2. Define the term Wildlife.

   ....

3. Below are certain incomplete words. Complete them by taking clues from the statement given below for each. Each blank represent the letter only.

   (i) A __ __ or __ __ __ at __ on

   (Tree planting programme)

   (ii) Be __ __ ado __ __ a

   (An endangered Indian plant)

   (iii) Rh __ no __ __ r __ __

   (An endangered animal)

26.7.3 Wildlife Reserves in India

Many National Parks and Sanctuaries have been established to preserve wildlife in their natural environment. Some of them are given below along with the important species found in these.

- Kaziranga sanctuary (Assam) – one-horned rhinoceros
- Manas sanctuary (Assam) – wild buffaloes
- Gir forest (Gujarat) – lions, chital, sambar, wild bears
- Kelameru bird sanctuary (Andhra) – pelicans and marine birds
- Dachigam sanctuary (Jammu and Kasmir) – Kashmir stags, Himalayan tahr, wild goats, sheep, antelopes
- Bandipur sanctuary (Karnataka) – Indian bison, elephants, langurs
- Periyar sanctuary (Kerala) – elephants, barking deer, sambar

- Kanha National Park (Madhya Pradesh) – tiger, leopards, wild dogs
- Similipal National Park (Orissa) – mangroves, marine turtles lay eggs
- Bharatpur bird sanctuary (Rajasthan) – ducks, herons
- Corbett National Park (Uttaranchal) – tigers, barking deer, sambar, wild bear, rhesus monkey
- Jaladpara sanctuary (West Bengal) – rhinoceros

26.7.4 Agencies Dealing with Conservation of Wildlife

There are various agencies both at national and international levels which take care of conservation of wildlife. Some of them are given below

(i) Indian Board for Wildlife (IBWL) advises state government on wildlife protection.

(ii) Constitution of India includes forest and wildlife protection.

(iii) World Wildlife Fund for nature (WWF) : It is an international organisation formed in the year 1961 and is engaged in protection of wildlife. India became a member of it in 1969 and has its headquarter in Mumbai. It has supported the well-known "Project Tiger".

(iv) International Union for Conservation of Nature and Natural resources (IUCN), World Conservation Union (WCU) is engaged in protection of wildlife and their habitats.

(v) Convention of International Trade in Endangered Species (CITES) is an international organisation to check trade products from endangered animals. India became a party to CITES in 1976.

26.8 LEGISLATION FOR CONSERVATION

Various acts and laws have been passed in Indian constitution for conservation of natural resources. Some of them are:

- Environment Protection Act, 1986
- Forest (Conservation) Act, 1980
- National Forest Policy, 1988
- Wildlife Protection Act, 1972 and amended in 1991

INTEXT QUESTIONS 26.7

1. Expand the following.

   (i) WWF ....

   (ii) CITES ....

   (iii) IUCN ....

2. Match the items of column A with those of Column B.

	Column – A		Column – B
(i)	Periyar sanctuary	(a)	Rajasthan
(ii)	Kanha National Park	(b)	Orissa
(iii)	Similipal National Park	(c)	Uttaranchal
(iv)	Bharatpur bird sanctuary	(d)	Kerala
(v)	Corbett National Park	(e)	Madhya Pradesh

26.9 SUSTAINABLE DEVELOPMENT

However, these industries, factories, cities, towns, roads, railways, dams etc. for development, the governors of all countries build have replaced the natural habitats of plants and animals. Natural resources have been dedpleted gradually and a day will come when many natural resources will not be available for our future generation. So it is high time to think about maintaining a balance between environment and development so that both present and future generations can derive proper benefits out of these resources. This can only be achieved by the process of sustainable development.

Sustainable development is the development that meets the needs of the present generation and conserves resources for the future generation.

Sustainable development should include –

- reducing excessive use of resources and enhancing resource conservation.
- recycling and reuse of waste materials.
- scientific management of renewable resources, especially bio-resources.
- planting more trees.
- green grassy patches to be interspersed between concrete buildings.
- using more environment friendly material or biodegradable material.
- use of technologies, which are environmental friendly and based on efficient use of resources.

INTEXT QUESTIONS 26.8

1. A and B are two friends. In their daily life both have different opinion on certain matters. Considering the necessity of sustainable development give your suggestions in the given space.

   A says - Polythene bags should be used to carry vegetables.

   B says – Jute bags should be used to carry vegetables.

   Who is right and why?

   ....

2. Mention any two activities which will help in sustainable development.

....

26.10 ENERGY RESOURCES

We have always been using different forms of energy obtained from various sources for our daily activities like cooking, heating, ploughing, transportation, lighting, etc. For example, heat energy required for cooking purpose is obtained from firewood, kerosene oil, coal, electricity or cooking gas. LPG (liquefied petroleum gas) We use animal power (horse, bullock, etc.) for transportation and for running minor mechanical devices like the Persian wheel for irrigation or for running a "kolhu" for extracting oil from oilseeds. Different forms of these energies are obtained from various sources. We will discuss about them in detail.

26.10.1 Types of Energy Sources

There are two main categories of energy sources:

(i) **Conventional Sources of Energy,** which are easily available and have been in usage for a long time.

(ii) **Non-Conventional Sources of Energy,** that are other than the usual, or that are different from those in common practice.

The table 26.2 below summarises the list of both the above categories of energy resources.

Table 26.2 Various types of energy sources

Sources of Energy		
Conventional Energy		**Non-Conventional Energy**
Conventional Non-renewable Energy (Mostly fossil fuels found under the Ground) Examples: Coal, Oil, Natural gas etc.	**Conventional Renewable Energy** (Mostly non-fossil fuels seen above the Ground) Examples: Firewood, Cattle Dung, Farm Vegetable Wastes, Wood charcoal, etc	• Solar Energy • Hydel Energy • Wind Energy • Nuclear Energy • Hydrogen Energy • Geothermal Energy • Biogas • Tidal Energy • Bio-fuel

26.10.2 Conventional Sources of Energy

Conventional sources of energy have been in used since ancient times. Most important among them are the fossil fuels.

Fossil Fuels

Fossil fuels are the fossilised remains of plants and animals, which over millions of years have been transformed into coal, petroleum products and natural gas.

Coal is the most abundant fossil fuel. It is widely used for combustion in cooking and industrial activities. There are different types of coal products such as coal gas, coal tar, benzene, toluene, etc., which are used for various purposes.

Oil and Natural gases are formed from plants and animals which once lived in the tropical seas. Oil (or petroleum) is a source of countless products. Apart from petrol, diesel and other fuels, petroleum products include lubricants, waxes, solvents, dyes, etc. Petroleum reserves are supposed to last for another 100 years or so.

Natural gas is often found with petroleum. The gas mainly contains methane. Apart from serving as fuel in several industries, it is being increasingly used as domestic fuel in many countries including India. United States of America is the largest producer as well as consumer of natural gas.

Now-a-days in big cities and towns it is being supplied through pipelines which is called Piped Natural Gas (PNG). The natural gas is also used as a fuel to run vehicles. It is known as Compressed Natural Gas (CNG). It is accepted as an economical and less polluting fuel for transport.

The Liquefied Petroleum Gas (LPG) is the common cooking gas used in Indian homes. It is a mixture of propane and butane gases kept under pressure in liquid form, but they burn in gaseous form. This gas is made available in a specific container for domestic as well as industrial uses. It is a byproduct of petrolium refineries

INTEXT QUESTIONS 26.9

1. Coal is a non-renewable source of energy whereas wood charcoal is renewable. Why ?

   ....

2. How are the following useful in our day to day life?

   (i) CNG ....

   (ii) PNG ....

   (iii) LPG ....

3. A and B are two friends. In their daily life both have different opinion on certain matters. Considering the necessity of sustainable development give your suggestions in the given space.

   A says – Coal should be used as a fuel to cook our food

   B says – LPG should be used as a fuel to cook our food.

   Who is right and why?

   ....

26.10.3 Non-Conventional Sources of Energy

We have already learnt known about conventional sources of energy, whether renewable or non-renewable (coal, oil, etc.), which are fast depleting and will not last long. Therefore, greater utilisation of non-conventional sources of energy (solar, wind, hydro, geothermal, etc) will have to be used.

1. Solar Energy

Solar energy is the ultimate source of all energy on earth. Firewood, coal, oil or natural gas are the products of plants and other organisms, which had used solar energy for the synthesis of organic molecules during photosynthesis. Even today it will turn out to be the most important answer to problems of energy except nuclear energy. The solar energy has the following advantages:

(i) It is abundant

(ii) It is everlasting

(iii) It is available almost everywhere.

(iv) It is free from political barriers.

Various technologies in which solar energy can be, and is being utilised are as follows:

(i) Solar cookers

(ii) Solar hot water systems

(iii) Solar dryers (used for drying crop yields)

(iv) Solar air heaters

(v) Solar kilns

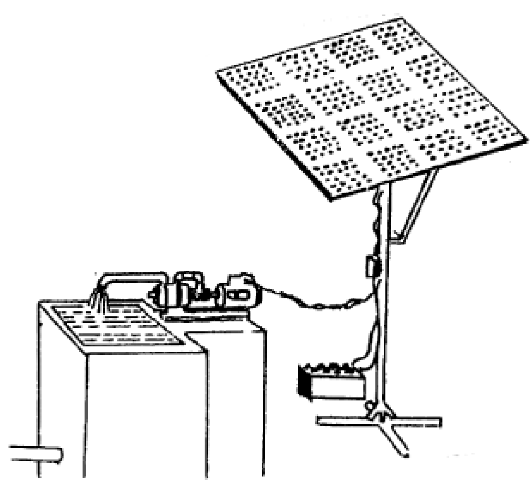


Fig. 25.2 Solar battery that can run a water pump or put to any other use.

(vi) Solar desalination systems

(vii) Solar batteries (Fig. 26.2).

2. Hydel /Hydro Energy

The generation of electricity by using the force of falling water is called hydro-electricity or hydel power. It is cheaper than thermal or nuclear power. For its generation dams are built to store water, which is made to fall to rotate turbines that generate electricity.

3. Wind Energy

Wind as an energy can be utilised in our daily life by converting it into mechanical energy. This mechanical energy is used to generate electricity, raise water from wells and rivers for irrigation and other purposes. Windmills have been in use since early times to provide power for grinding grains. It is also used for grain cutting and shelling. In India a large number of windmills are being constructed on the sea beach and hilly areas. (Fig. 26.3).

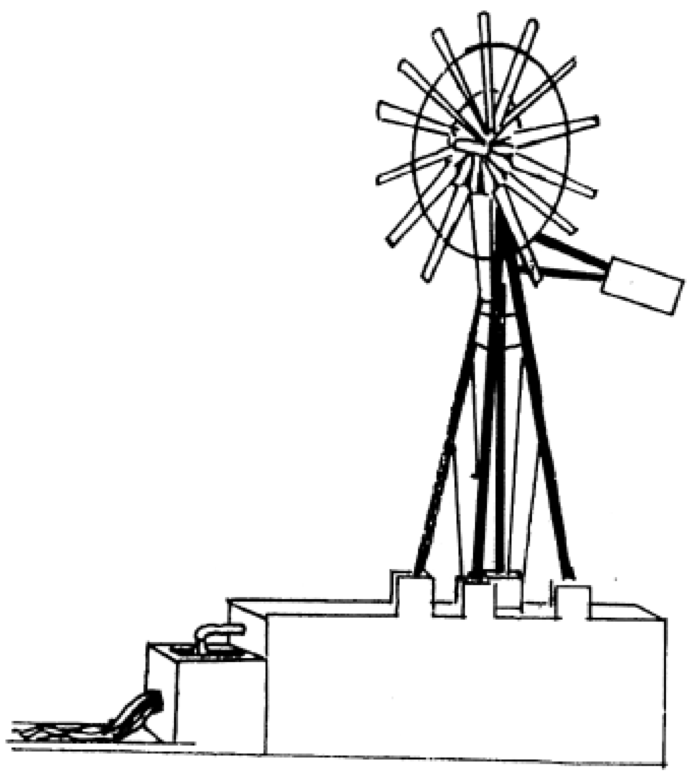
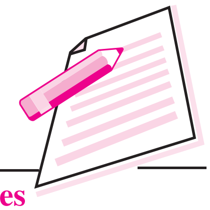


Fig: 26.3 Windmill

Minimum wind speed required for operating the windmill is 7 km/hour. A windmill can draw water upto a maximum depth of 55 feet and the output is 4000-9000 litres (of water) per hour.



4. Tidal Energy

Tidal energy is one that is produced by making the use of water movement from a high tide to a low tide. Ocean waves and tides can be made to turn a turbine and generate electricity. Areas where rivers flow into the sea experience waves and tides and electricity can be generated there. It has much potential. As you know we have a large coastline and major river systems in our country, electricity can be generated on a large scale from waves and tides.

5. Nuclear Energy

Radioactive elements like uranium and thorium disintegrate spontaneously releasing large quantities of energy. This energy can be trapped to produce electricity. 25% of world's thorium reserve is found in our country, which can be utilised to generate electricity. Most advanced countries have nuclear power stations. We too have some in India, for example, Tarapur (Maharashtra), Kalpakkam (Tamil Nadu), Narora (Uttar Pradesh), Kota (Rajasthan). Approximately 3% of India's electricity comes from nuclear power and about 25% is expected to come by 2050.

Installation costs of nuclear power stations are very high, but maintenance costs are relatively low. If not carefully maintained, these also have an inherent risk of causing radioactive pollution.

6. Hydrogen Energy

Hydrogen is the primary fuel for the hydrogen based fuel cells and power plants. Power can be generated for industrial, residential and transport purposes by using hydrogen.

7. Geothermal Energy

This is the energy derived from the heat in the interior of the earth. In volcanic regions, springs and fountains of hot water called "geysers" are commonly found. These eruptions of hot steaming water can be used to turn turbines and produce electricity in geothermal power plants. In this method cold water is allowed to seep through the fissures in the rocks till it reaches the hot rocks in the lower layers. Water gets heated and gets converted into steam which forces out to the surface to be used in power generation. Besides the superheated steam of hot springs can also generate electricity. There are 46 hydrothermal areas in India where the water temperature normally exceeds 150 degree centigrade. Electricity can be generated from these hot springs.

8. Biogas

Another form of non-conventional energy is **biogas**. It is produced by the microbial activity on cattle dung in a specially designed tank called digester. A mixture of water and cattle dung is poured in this digester where anaerobic decomposition takes place and biogas is generated. This gas contains 55 – 70 percent methane, which is inflammable and it is generally used as cooking gas and for generation of electricity. The "waste" left in the tank after the generation of biogas is used as manures. Thus, biogas plant provides us both the fuel and the manure. Biogas plants are becoming very popular in rural India.

There are two types of biogas plants:

(a) Family type gas plants- These are small and are used individually by a family.

(b) Community type gas plants- These are large and are used by larger rural populations.

9. Bio-fuel

You know it very well that fossil fuels have been the main source of energy for transportation and industries for more than a century. Their rapid consumption has depleted the reserves of fossil fuels. Their fast depletion and non-renewable nature has sent an alarm to look for alternative fuel. Among the fuels, consumption of liquid fuels is the highest. So there are attempts to identify potential plant species as sources of liquid hydrocarbons, a substitute for liquid fossil fuels. The hydrocarbons present in such plants can be converted into petroleum hydrocarbons. This liquid hydrocarbon is the bio-fuel and the plants producing it are called petro-plants. The plant species, *Jatropha curcus* is the most suitable one, which yields bio-diesel. The Indian Oil Corporation is carrying out experiments for preparation of bio-diesel from various vegetable oils extracted from rice bran, palm, karanjia, sunflower etc.

Advantages of Bio-diesel

Bio-diesel has several advantages; some of them are given below-

- It is an agriculture based fuel substitute.
- It can be made from both vegetable oil and animal fats.
- It can be used without major modifications in engines.
- It does not need separate infrastructure for storage and delivery.
- Handling bio-diesel is safer.
- Planting of *Jatropha curcus* will utilise wasteland in our country.
- It's combustion emits less carbon monoxide, sulphates, unburnt hydrocarbons and particulate matters, thus reduces air pollution.

26.10.4 Conservation of Energy Sources

We have already leant about the different types of sources of energy and how they are useful to us. Now you think about your daily activities and the types of energy you are using in each activity. Make a list of the sources, which produce these energies. Everyday you and your family members are using four to five sources of energy. Similarly other people, industries and different establishments are using energy everyday. The demand for energy is increasing day-by-day and exploitation of the energy sources is on the rise. Thus, energy sources are depleting gradually. There is an urgent need to conserve energy, else adequate energy will not be available in future. Some methods to conserve energy are:

- Minimise exploitation of non-renewable energy resources.
- Emphasis on use of renewable sources of energy.
- Stop wastage of energy.
- Creating awareness among people regarding wise and judicious use of energy.
- Make more use of bio-mass based energy.

INTEXT QUESTIONS 26.10

1. Why do we consider sun as the best source of energy?

   ....

2. What is meant by 'radioactive pollution'?

   ....

3. What are the advantages and disadvantages of nuclear energy?

   ....

4. The following table contains the different sources of energy and their uses. Put a tick mark under the source against the appropriate use(s).

	Geothermal	Bio gas	Bio-diesel
(i) Generation of Electricity			
(ii) Fuel for Cooking			
(iii) Fuel for Vehicles			

5. Mention any three ways of conservation of electric energy at your home.

   (i) ....

   (ii) ....

   (iii) ....

Notes

WHAT YOU HAVE LEARNT

- Any natural or artificial substance, energy or organism, which is used by human being for its welfare is called a resource. Two types of resources are, (a) Natural resources; and (b) Artificial resources.
- Natural resources are classified into (i) inexhaustible- air, water (in oceans), solar energy etc. and (ii) exhaustible- soil, forest, fresh water, minerals, fossil fuels, etc. Exhaustible resources may be non-renewable such as metals fossil fuels, and renewable such as water, wood, natural pastures, forests, etc.
- Conservation is the sum total of activities, which can derive benefits from natural resources but at the same time prevent excessive use leading to destruction or neglect.
- Soil is the uppermost layer of earth's crust, which supports growth of plants. It is both a renewable and non-renewable resource.
- Water is the most important component of all life forms. It regulates climate, generates electricity and is also useful in agriculture and industries. With increase in population and industrial growth, water is degraded day by day. Conservation and management of water are essential for the survival of mankind, plants and animals
- The variety of all plants, animals and microbes of a region is termed biodiversity. Biodiversity is essential for maintenance of ecosystem.
- Though biodiversity is important for our survival, it is under threat due to the various human activities. So we should protect biodiversity by strategies like, (i) In situ conservation, and (ii) Ex situ conservation.
- The endangered species are those, which have been reduced in number to a critical level and facing a high risk of extinction in the near future.
- The plants, animals and microorganisms other than the cultivated plants and domesticated animals constitute wildlife. Wildlife forms an important resource for maintaining ecological balance. Conserve it by establishing biosphere reserves, national parks and sanctuaries etc.
- Sustainable development is the development that meets the needs of the present generation and conserves it for the future generation.
- There are two main categories of energy sources: (i) conventional sources of energy; and (ii) non-conventional sources of energy. Conventional sources of energy may be (a) **conventional non-renewable energy** (Mostly fossil fuels found under the ground like coal, oil and natural gas etc.); and (b) **Conventional renewable energy** (firewood, cattle dung, charcoal etc.)

- The Non-Conventional Energy includes Solar energy, Hydel energy, Wind energy, Nuclear energy, Hydrogen energy, Geothermal energy, Biogas energy, Tidal energy, Bio-fuel, etc.
- The demand for energy and exploitation of the energy sources is increasing day-by-day. Energy sources are depleting fast. There is an urgent need to conserve energy; else adequate energy will not be available in future.

TERMINAL EXERCISES

1. Define conservation.
2. What is meant by soil erosion?
3. Define the term biodiversity.
4. State the meaning of sustainable development.
5. Mention any two methods of conservation of energy resource.
6. Why should wildlife be conserved?
7. Why is soil considered as both renewable and non-renewable resource?
8. State any three reasons for degradation of water.
9. Distinguish between *in-situ* and *ex-situ* conservation strategies.
10. Describe natural gas as conventional source of energy.
11. Describe the natural and the anthropogenic causes of soil erosion.
12. Describe the various methods of conservation of soil.
13. Future generations of mankind will depend more and more on non-conventional sources of energy. Discuss.
14. Explain any five methods of conservation of water.
15. Describe any three non-conventional sources of energy.

ANSWERS TO INTEXT QUESITONS

26.1 1. (i) Plastic is an artificial resource.

(ii) Forest is an exhaustible renewable resource.

(iii) The exhaustible resources, which are not replaced after consumption are known as non-renewable resources.

OR

The exhaustible resources, which are replaced after consumption, are known as renewable resources

2.

Inexhaustible	Renewable	Non- renewable
Air	Fish	Iron
Sand	Forest	Petroleum
Wind	Pearls	Gold
Clay		

26.2 1. (i) To maintain ecological balance for supporting life.
(ii) To preserve different kinds of species.

2. (i) Chipko
(ii) Tulsi
(iii) Khecheopalri

26.3 1. Wind : Carries away the loose top soil
Overgrazing : Removes the protective vegetation, thus help in erosion by wind and water
Water : Rain drops carry away the soil not covered by vegetation.

2.

Column – A		Column – B	
(i)	Terracing	(c)	Practised in hilly areas
(ii)	Erosion	(d)	To wear away
(iii)	Deforestation	(b)	Cutting down forests
(iv)	Humus	(a)	Decayed vegetable or animal matter

26.4 1. It is produced continuously through hydrologic cycle.

2. (i) Constructing dams and reservoirs
(ii) Rainwater harvesting
(iii) Judicious use

26.5 1. (i) C (ii) T (iii) T (iv) C (v) C (vi) T

26.6 1. It is published by IUCN that gives information on endangered plants and animals.

2. The plants, animals and microbes other than the cultivated plants and domesticated animals constitute the wildlife.

3. (i) Afforestation
(ii) Belladonna
(iii) Rhinoceros

26.7 1. (i) World Wildlife Fund
(ii) Convention of International Trade in Endangered species
(iii) International Union for Conservation of Natural Resources

2. (i) (d), (ii) (e) (iii) (b)(iv) (a)(v) (c)

26.8 1. (i) B is right; because jute bags are biodegradable and eco-friendly. Though science has invented the bio-degradable polythene bags, all are not bio-degradable, hence cause pollution.

(ii) see text

26.9 1. Coal cannot be regenerated after consumption. But wood charcoal is obtained from wood and wood can be obtained continuously from trees/ forest.

2. CNG : Cooking, Transportation

PNG : Cooking

LPG : Cooking, Lightening, Transportation

3. B is right LPG causes less pollution than coal.

26.10 1. It is available free of cost and in ample quantity, everlasting. It has no boundaries and is also free from political barriers.

2. The radioactive elements when not disposed off properly cause disintegration in the soil and water and thus cause pollution.

3. India has sufficient Thorium to generate electricity cause pollution.

4.

	Geothermal	Bio-gas	Bio-diesel
(i) Generation of Electricity	√	√	√
(ii) Fuel for Cooking		√	
(iii) Fuel for Vehicles			√

5. (i) Judicious use of electricity

(ii) Use of florescent lamp instead of incandescent lamp

(iii) Create awareness about the proper use of electricity, or any other.

27

POLLUTION

You have already learnt about the environment and its components in the earlier lessons. You have also studied the importance of maintaining a life-supporting environment. However, the environment has undergone many changes over the period of time. Population explosion in recent times has resulted in a number of environmental problems. The population of India has crossed the figure of 2 billion and the world population is estimated to have touched the 7 billion mark. To meet the demands of food, housing and energy, environmental resources are being exploited at a fast pace. Over-exploitation of resources and human activities have resulted in many environmental problems, such as deforestation, destruction of wild life, air, water, land and noise pollution, diminishing fossil fuels (oil, coal and natural gas), concentration of pesticides in alarming proportions in the bodies of organisms, and depletion of ozone layer and global warming.

In this lesson, you will learn about various kinds of environmental polluton, their causes effects and control.

OBJECTIVES

After completing this lesson, you will be able to :

- *define pollution;*
- *list various types of pollution and mention their sources;*
- *describe effects of air, water and soil pollution on flora and fauna;*
- *describe methods of control of air, water and soil pollution;*
- *describe methods of nuclear and solid waste management*
- *describe the causes and effects of sound pollution;*
- *describe the causes and effects of radiation pollution;*
- *discuss rates of entry and translocation of pollutants in the human body.*

27.1 POLLUTION

We perform a number of daily activities such as bathing and washing of clothes with soaps and detergents. By doing so we add some chemical residue to water and change its quality. This water may mix with the water in ponds and rivers due to ignorance and carelessness. Cooking of food by using firewood may release smoke in the air. Agricultural activities may dump fertilizers and pesticides in the environment. **The addition of unwanted substances in a concentration that has an adverse effect on organisms and environment, is called pollution.**

> An undesirable change in the physical, chemical and biological characteristics of the environment especially air, water and land that may adversely affect human population and the wild life, industrial processes, cultural assets (building and monuments), is called **pollution.**
>
> The agents that pollute the environment or cause pollution are called **pollutants.**

27.2 TYPES OF POLLUTION

Depending upon the area or the part of environment affected, pollution may be of the following types :

- Air pollution
- Water pollution
- Land pollution
- Noise pollution

27.2.1 Air pollution

We all breathe in air, we can feel, and even smell the air and say whether it is fresh or stale. The pollution in air may not be noticed until we see smoke coming out from some source. All human activities from cooking at home to activities in highly mechanized industries contribute to air pollution.

27.2.1a Sources of air pollution

The sources of air pollution can he divided into two categories (i) natural, and (ii) human-made

(i) Natural sources

(i) Ash from burning volcanoes, dust from storm, forest fires

(ii) Pollen grains from flowers in air are natural sources of pollution

(ii) Anthropogenic (human-made) sources

(i) Power stations using coal or crude oil release CO_2 in air

(ii) Also furnaces using coal, cattle dung cakes, firewood, kerosene, etc.

(iii) Steam engines used in railways, steamers, motor vehicles, etc. give out CO_2.

(iv) So do Motor and internal combustion engines which run on petrol, diesel, kerosene. etc.

(v) Vegetable oils, kerosene, and coal as household fuels

(vi) Sewers and domestic drains emanating foul gases

(vii) Pesticide residues in air

Major air pollutants

Some major air pollutants are discussed here.

• Carbon dioxide

Carbon dioxide is one of the major gases which contributes towards air pollution. It is mainly produced during the combustion of fuel in factories, power stations, household etc. The increasing CO_2 in the atmosphere is likely to have the following effects:

(i) **A rise in atmospheric temperature or global warming due to greenhouse effect. Also causes climate change.**

(ii) **Reduced productivity of the marine ecosystem**. This is due to the fact that water in the oceans would be more acidic due to increased concentration of CO_2 in the air, which dissolves in the water.

(iii) **Due to Global warming,** the increased surface temperature would cause **melting of continental and mountain glaciers** and thus would cause **flooding of coastal areas** of some countries.

• Sulphur dioxide

It is produced by the burning of coal in powerhouses and automobiles (car, trucks etc.). It causes **chlorosis** and **necrosis** of plants, irritation in eyes and injury to the respiratory tract (asthma, bronchitis) in humans responsible for discoloration and deterioration of buildings. High concentration of sulphur dioxide in the atmosphere dissolves in rain drops to form sulphuric acid which causes **acid rain**.

• Carbon monoxide

Carbon monoxide is produced as a result of incomplete combustion of fossil fuels like coal, petroleum and wood charcoal. Automobiles using diesel and petroleum are the major sources of carbon monoxide which gets added to the atmosphere. Carbon monoxide is more dangerous than carbon dioxide. It is a poisonous gas which causes respiratory problems. When it reaches the blood stream, it replaces oxygen due to its high affinity for haemoglobin. It also causes giddiness, headache and interferes with normal function of the heart.

• Fluorides

Upon heating,, rocks, soils and minerals that contain fluorides, give out hydrogen fluoride gas. This is an extremely toxic gas, which causes serious injury to livestock and cattle.

• Oxides of nitrogen

A few oxides of nitrogen, such as nitric oxide (NO), nitrous oxide (N_2O) and nitrogen dioxide (NO_2) are produced by natural processes as well as from thermal power stations, factories, automobiles and aircrafts (due to burning of coal and petroleum). They reduce the oxygen carrying capacity of blood, may cause eye irritation and skin cancer in human beings.

Smog

Smog is a mixture of smoke, dust particles and small drops of fog. Smog may cause necrosis and develop a white coating on the leaves (silvering) of plants. In human beings and animals, it may cause asthma and allergies.

Aerosol spray propellants

Suspended fine particles in the air are known as aerosols. Aerosols contain chlorofluoro carbons (CFCs) and fluorocarbons used in refrigerants and aerosol cans. They cause depletion of the ozone layer.

Domestic air pollutants

Smoke from cigarettes, *biri*, cigar and other such objects using burning tobacco, burning of coal, firewood, cow dung cakes, kerosene oil and liquefied gases are major domestic pollutants. The common pollutant gases emitted during the domestic burning of coal, kerosene oil, firewood, cow dung cakes, etc. are carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2), etc. The pollution due to these pollutants causes suffocation, eye and lung diseases and low visibility.

27.2.1b Effects of air pollution

Major effects of air pollution on human health, plants and other animals is given in table 27.1.

Table 27.1: Some major air pollutants, their sources and effects

Pollutant	Source	Harmful effect
Carbon compounds (CO and CO_2)	Automobile exhausts burning of wood and coal	• Respiratory problems • Green house effect global warning and climate change
Sulphur compounds (SO_2 and H_2S)	power plants and refineries Volcanic eruptions	• Respiratory problems in humans • loss of chlorophyll in plants (chlorosis) • Acid rain
Nitrogen Compound (NO and N_2O)	Motor vehicle exhaust, atmospheric reaction	• Irritation in eyes and lungs • Low productivity in plants • Acid rain damages material (metals and stone)
Hydrocarbons (benzene, ethylene)	Automobiles and petroleum industries	• Respiratory problem • Cancer causing properties

SPM (Suspended Particulate matter) (Any Solid or liquid particles suspended in the air, (fly ash, dust, lead)	Thermal power plants. construction activities, metallurgical processes and automobiles	• Poor visibility, breathing problems • Lead interferes with the development of red blood cells and causes lung diseases and cancer • Smog (smoke+fog) formation leads to poor visibility and aggravates asthma in patients
Fibres (Cotton, wool)	Textile and carpet weaving industries	• Lung disorders

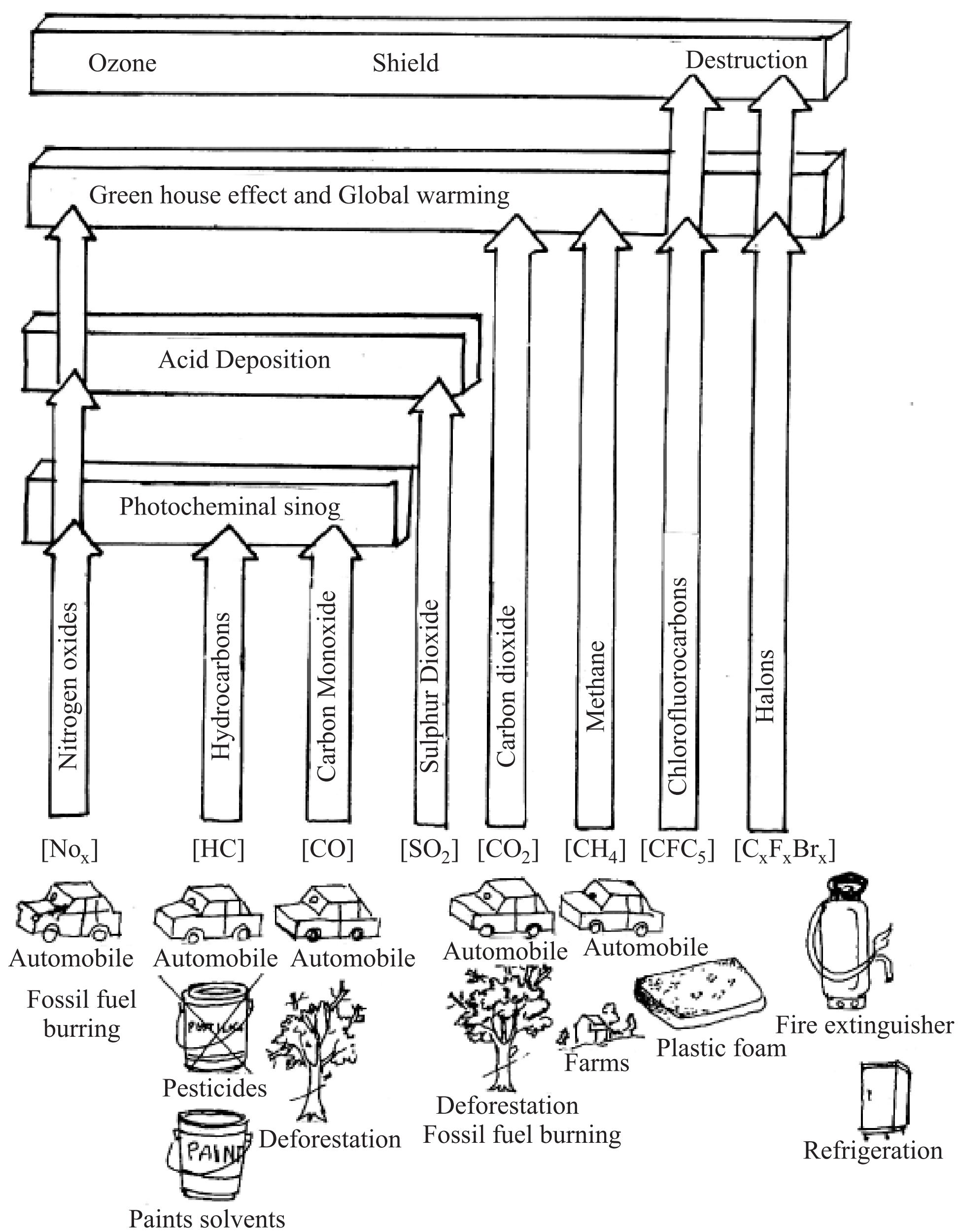


Fig. 27.1 Major effects of air pollution

27.2.1c Prevention and control of air pollution

There are two types of air pollutants—gaseous and particulate.

Methods of controlling gaseous air pollutants

(i) **Combustion.** This technique is used for controlling those air pollutants that are in the form of organic gases or vapours. In this technique, the organic air pollutants are subjected to flame combustion technique (also known as catalytic combustion). In this technique, organic pollutants are converted into less harmful products and water vapour.

(ii) **Absorption.** Absorption is a process in which a substance penetrates into another substance like scrubbers. In this technique, gaseous pollutants are passed through absorbing material like scrubbers. These scrubbers contain a liquid absorbent. This liquid absorbent removes the pollutants present in gaseous effluents. Thus the air coming into scrubber is free from pollutants and it is discharged into atmosphere.

(iii) **Adsorption.** Adsorption is a process in which a substance sticks to the surface of another substance (called absorbent). In this technique, gaseous effluents are passed through porous solid absorbent kept in containers. The gaseous pollutants stick to the surface of the porous material and clean air passes through. The organic and inorganic constituents of gaseous effluents are trapped at the interface of solid adsorbent by physical adsorbent.

Methods to control particulate air pollutants

The particulate air pollutants such as dust, soot, fly ash etc. can be controlled by using fabric filters, electrostatic precipitators, wet scrubbers and mechanical devices etc.

(i) ***Fabric filters.*** In this technique, gaseous emission containing dust, soot and fly ash is passed through porous fabric filters made of fabric (cloth) (woven or filled fabric). The particles of pollutants get trapped in this fabric and are collected in the filter and the gases free from the pollutant particles are discharged.

(ii) ***Mechanical devices.*** There are many mechanical devices that clean the air of pollutants either due to (i) gravity in which the particles settle down by gravitational force; or by (ii) sudden change in the direction of gas flow in which particles separate out due to greater momentum.

(iii) ***Electrostatic precipitators.*** In this technique, a gas or air stream containing aerosols in the form of dust, mist or fumes, is passed between the two electrodes of the electrostatic precipitator. During this process, the aerosol particles get precipitated on the electrodes.

27.2.1d Prevention and control of air pollution

(i) At domestic level, burning of wood and dung cakes can be replaced by use of cleaner fuel and biogas (formed by the decomposition of animal and plant wastes in a biogas plant).

(ii) Automobile pollution can be reduced by :

- pooling of transport or use of public transport.
- use of unleaded petrol and CNG (Compressed Natural Gas).
- regular tuning and servicing of the engines, and
- switching off the engine at red lights or when not in use.

(iii) Following measures can reduce industrial pollution:

- installation of tall chimneys,
- installation of devices that do not allow pollutants to be released in the environment, such as filters, electrostatic precipitators, scrubbers etc.,

INTEXT QUESTIONS 27.1

1. Define pollution.

   ....

2. Name four types of pollution.

   ....

3. Name one effect on plants and one on human caused by excess SO_2 in the air.

   ....

27.2.2 Water pollution

Addition of undesirable substances in water is called **water pollution**. Water pollution could be due to natural or human activities.

Natural sources of water pollution are soil erosion, leaking of minerals from rocks, and decaying of organic matter, while **human-made sources** include domestic, agricultural and industrial activities. Many water sources have become a dumping ground for wastes. Water pollution is one of the main causes of human diseases in India.

> Any physical, biological or chemical change in water quality that adversely affects living organisms or makes water unsuitable for desired use is called water pollution.

27.2.2a Sources of water pollution

There are two sources of water pollution on the basis of origin of pollutants:

(i) point sources. and (ii) non-point sources.

(i) ***Point sources.*** Those sources which discharge water pollutants directly into the water are known as point sources of water pollution. Oil wells situated near water bodies, factories. power plants, underground coal mines, etc. are point sources of water pollution.

(ii) **Non-point sources.** Those sources which do not have any specific location for discharging pollutants, in the water body are known as non-point sources of water pollution. Run-offs from agricultural fields, lawns, gardens, construction sites, roads and streets are some non-point sources of water pollution.

Water pollutants

River, lake and sea water may be polluted in many ways.

- **Domestic sewage** discharged into rivers from areas located on its banks
- **Industrial wastes** effluents from urban areas containing high concentration of oil, heavy metals and detergents
- **Minerals, organic wastes and crop dusting** from agricultural fields with phosphate and nitrogen fertilizers that reach lakes, rivers and sea (water becomes deoxygenated and poisonous, thus, cannot support aquatic life)
- **Chemical fertilizers, pesticides, insecticides, herbicides and plant remains**
- Industrial waste water containing several **chemical pollutants,** such as calcium, magnesium, chlorides, sulphide, carbonates, nitrates, nitrites, heavy metals and radioactive waste from nuclear reactor.
- **Excretory wastes of humans and animals in water bodies**
- **Disposal of urban and industrial waste matter into water bodies**

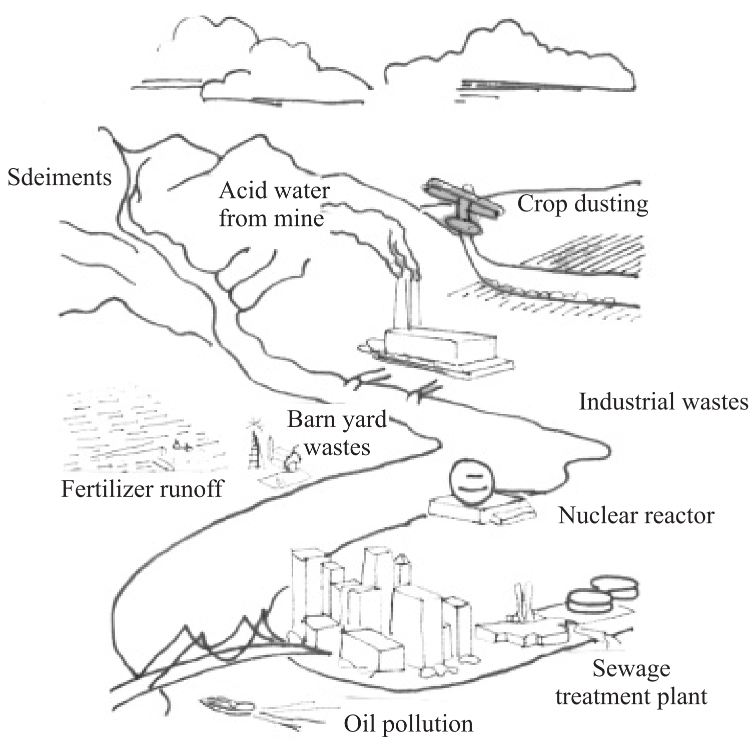


Fig. 27.2 Water pollution due to human activities.

27.2.2b Effects of water pollution

- Water pollution **adversely affects the fish and other aquatic life.**
- The presence of acids/alkalis in water **destroys micro-organisms**, thereby disturbing the self purification process in rivers.
- The toxic materials in water **cause serious health hazards** in human beings and other animals.
- Polluted water causes **spread of epidemics**, such as cholera, tuberculosis, jaundice, dysentery, typhoid and diarrhoea in human beings.
- The use of polluted water from lakes, ponds and rivers for irrigation of agricultural fields, damages crops severely and **decreases agricultural production.**
- The use of water contaminated with salts **increases alkalinity of the soil.**
- Heavily polluted water **affects the soil, decreases its fertility** and kills soil micro-organisms and even certain useful bacteria.
- Contamination of sea water due to oil slicks caused by the leakage of crude oil from oil tankers causes **ecological disasters** which results in the death of sea organisms including fishes.

The sources and effects of certain water pollutants have been given in the following table 27.2

Table 27.2: Some major disturbances in the ecosystem due to water pollution

Pollutant	Sources	Cause	Effect
Nitrates, phosphates, ammonium salts	Agricultural fertilizers, sewage, manure	Plant nutrients	Eutrophication
Animal manure and plant residues	Sewage, paper mills, food processing wastes	Oxygen deficiency	Death of aquatic animals
Heat	Power plants and industrial cooling	Thermal discharge	Death of fish
Oil slick	Leakage from oil ships	Petroleum	Death of marine life due to non availability of oxygen dissolved in water

Fertilizers and pesticides are widely used in agriculture. Their excessive use for increasing agricultural yield has led to the phenomenon of **eutrophication** and **biomagnification.**

Eutrophication

With the use of high yielding varieties of crops, the use of fertilizers and pesticides has increased a lot. Excess fertilizers may mix with surface water and may get drained into water bodies (surface runoff). The enrichment of water with nutrients such as nitrates and phosphates that triggers the growth of green algae is called **eutrophication.** (Fig. 27.3) This fast growth of algae followed by decomposition depletes the water body of its dissolved oxygen. As a result aquatic animals die of oxygen shortage.

Sewage and/or fertilizer run off from fields
↓
Enriched nutrient content in lakes (Eutrophication)
↓
Algae multiply to produce an 'algal bloom'
↓
Algae use up oxygen and begin to die
↓
Decomposers (bacteria) multiply and use more oxygen
↓
Organisms (such as fish) die due to lack of oxygen

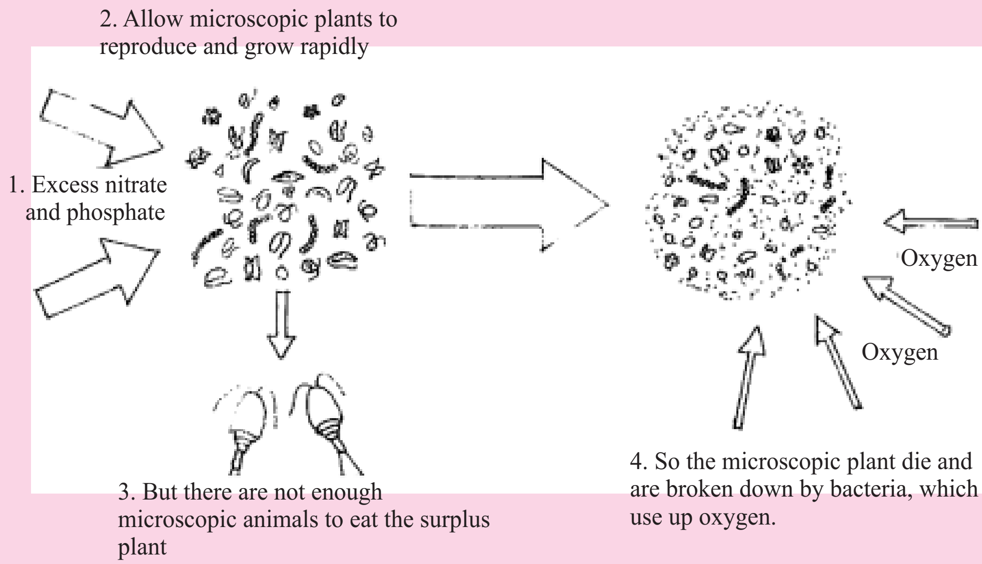


Fig 27.3 Sequence of events that may occur as a result of eutrophication

Biomagnification

Non-biodegradable pesticides, such as DDT are widely used for crop protection. Once they enter the food chain, their concentration keeps on increasing with each trophic level (steps of a food chain). As a result, accumulation of these compounds takes place in the body of top consumers over a period of time.

Entry of harmful non-biodegradable chemicals in small concentrations and their accumulation in greater concentrations in the various levels of food chain is called **biomagnification**.

Consider the following food chain. Is there any difference in the concentration of DDT in water and that in the body of the Pelican bird?

Water $\rightarrow$	Algae $\rightarrow$	Fish $\rightarrow$	Pelican bird (top consumer)
0.2 ppm	77 ppm	500-600 ppm	1700 ppm

(ppm = parts per million)

DDT used in small quantities to kill mosquitoes can enter the food chain and may get concentrated in large concentration due to its non-biodegradable nature in the body of birds (top) consumer. This causes adverse effects, such as weak egg shells, resulting in decreased population. (Fig. 27.4).

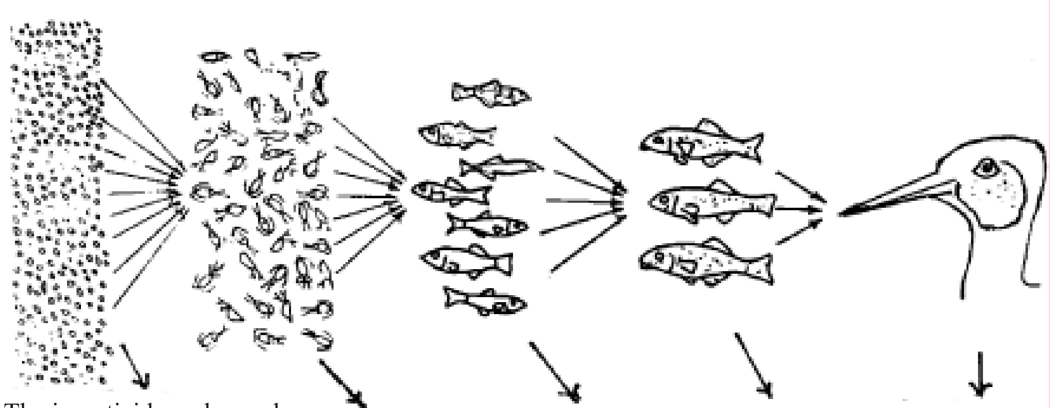


Fig. 27.4 How pesticides affect food chain

Table 27.3 and 27.4 show respectively the industrial sources of water pollution and sources and effects of some water pollutants.

Table 27.3 Sources of industrial pollution

Type of Industry	Inorganic pollutants	Organic pollutant
Mining	Chlorides, various metals, ferrous sulphate, sulphuric acid, hydrogen sulphide, ferric hydroxide surface wash offs, suspended solid, chlorides and heavy metals	
Iron and Steel	Suspended solids, iron cyanides, thiocyanate, sulphides, oxides of copper, chromium., cadmium and mercury.	Oil, phenol and naphtha.
Chemical Plants	Various acids and alkalies, chlorides, sulphates, nitrates of metals, phosphorus, fluorine, silica and suspended particles	Aromatic compounds
Pharmaceuticals		Protein, carbohydrates, organic solvents intermediate products, drugs and antibiotics.

Soap and Detergents	Tertiary ammonium compound alkalies.	Fats and fatty acids, glycerol, phosphates, polysulphonated hydrocarbons.
Food processing		Highly putrescible (easily rots) organic matter and pathogens.
Paper and Pulp	Sulphides and bleaching liquors	Cellulose fibre, bark, wood sugars organic acids,

Table 27.4 Some water pollutants, their sources and effect on human health

Pollutant	Source	Diseases in humans
Lead	Industrial waste	Nervous disorders, Kidney failure. blood poisoning
Tin	Industrial dust	Affects central nervous system (CNS) Affects, vision
Mercury	Industrial discharge	Affects central nervous system and peripheral nervous system, kidney failure, Numbness of lips, muscles and limbs, Blurred vision
Arsenic	Industrial discharge	Respiratory and skin cancer. Nervous disorder
Nickel	Aerosols, industrial dust	Pulmonary disorders, dermatitis
Cadmium	Industrial discharge	Kidney disorders, Pulmonary and skeletal diseases
Uranium, thorium cesium	Radioactive waste	Leucoderma, skin cancer

27.2.2c Prevention and control of water pollution

Water pollution can be controlled by

- **Treating industrial effluents** before discharging into rivers, separate channels for river and sewage water
- **Avoid contamination of rivers,** lakes and ponds by washing clothes, bathing. etc.
- **Not throwing waste,** food materials, paper, biodegradable vegetables and plastic **into open drains.**
- Setting up **sewage water treatment plants**
- Use of **septic tanks in houses** to avoid direct outlet of faecal matter and other wastes
- Effluents from distilleries and solid waste containing organic matter diverted to **biogas plants to generate energy**

- **Maintenance or safety standards** for the effluents discharged into the water system

27.2.2d Treatment of sewage

The sewage can be treated by a modern technique involving three steps— primary treatment, secondary treatment and tertiary treatment.

In **primary treatment** sewage is passed through a grinding mechanism. This is then passed through several settling chambers and lime is added to neutralise it. The neutralised sewage still contains a large number of pathogenic and non-pathogenic organisms and sufficient amount of organic matter.

In the **secondary treatment**, these neutralised effluents are passed through a reactor called UASB (Upflow anaerobic sludge blanket). In this reactor, the anaerobic bacteria degrades the biodegradable material into neutralised effluents. In this process, the foul odour and methane are released and the sewage is converted into clean water. This water is sent to aeration tanks where air and bacteria are added to it. This process is called biological or secondary treatment.

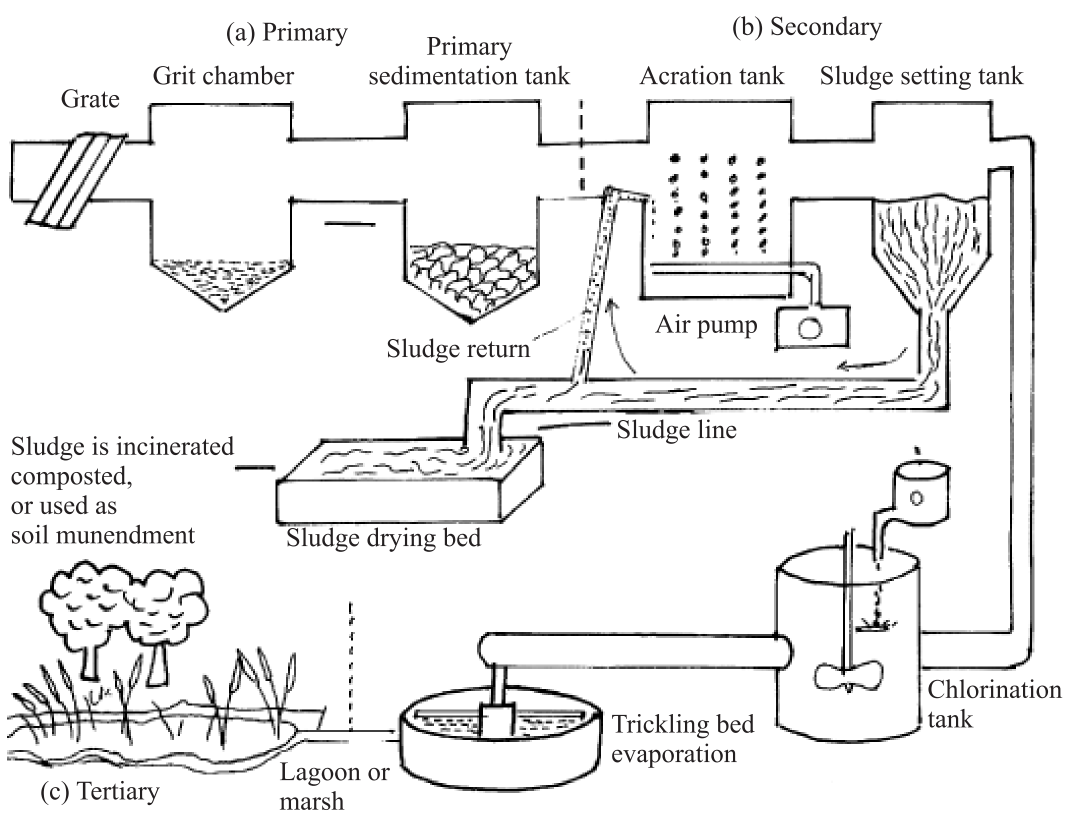


Fig. 27.5 Treatment of sewage

The water obtained as a result of secondary treatment is still unfit for drinking and needs further purification. This is done by **tertiary treatment.** In this treatment, which is a disinfecting process, final traces of disinfecting bacteria and any dissolved organic solids arc removed. Then, the chlorination, evaporation and exchange absorption methods arc employed to obtain clean water.

INTEXT QUESTIONS 27.2

1. Give two examples of natural sources of water pollution.
   (i) ....
   (ii) ....
2. What is biomagnification?
   ....
3. Give the technical term for enrichment of water bodies with nutrients coming from fields.
   ....
4. Give one source of and one disease caused by from the following pollutants
   (i) lead ....
   (ii) Tin ....
   (iii) Nickel ....

27.2.3 Soil Pollution

Addition of substances that change the quality of soil by making it less fertile and unable to support life is called **soil pollution.**

27.2.3a Sources of soil pollution

Soil pollution is caused due to :

- Domestic sources : plastic bags, kitchen waste, glass bottles, and paper
- Industrial sources : chemical residue, fly ash, metallic waste, and
- Agricultural residues : fertilizers and pesticides.

Harmful effects of soil pollution

- Decrease in irrigated land thereby reduction in agricultural production.
- Decrease in soil productivity.
- Carry over of pollutants into the food chain.
- Damage to landscape

27.2.3b Control of Soil Pollution

- Judicious use of chemical fertilizers and pesticides.
- Proper and appropriate irrigation practices
- Conversion of farm wastes into compost and much use of bio fertilizers and manure in farming.

- Ensure use of pollution free or treated waste water only for irrigation.
- Recycling of waste material for example plastic, metal and glass are recyclable and incineration of non recyclable, wastes.

27.2.3c Soil Erosion

The process of detaching and removal of loosened soil particles by water (running water, ground water, rain, sea waves) and wind is known as soil erosion. Soil may be eroded by water and wind, each contributing towards a significant amount of soil loss every year in our country.

Types of soil erosion

Wind erosion

Erosion of large quantity of fine soil particles and sand from deserts by wind is known as wind erosion. It is spread over the cultivated land and thus, destroys fertility of that land.

Sheet erosion

When water moves over the land surface as a sheet, it takes away the topmost thin layer of soil. This phenomenon occurs uniformly on the slopes of hilly areas, riverbeds and areas affected by floods. This type of erosion is known as **sheet erosion**.

Gully erosion

When water moves down the slope as a channel, it scoops out the soil and forms gullies which gradually multiply and spread over a large area. This type of soil erosion is known as **gully erosion.**

Effects of soil erosion

Soil erosion may have several adverse effects such as,

- The top layer of productive land may be washed away.
- Roads, fences, bridges, trees and houses may get damaged.
- Fine soil may be transported far away.
- Crops and pasture lands may be destroyed either by being washed out or by getting covered with mud.
- Flooded fields may take a long time to recover and fertilizers may also be washed out leading to reduction in agricultural yield.
- Organic matter of the soil, residues or any applied manure, is relatively light-weight and can be readily washed off the field. Crop emergence, growth and yield are directly affected by the loss of natural nutrients and fertilizers in the soil. Seeds and plants can get disturbed or completely removed from the eroded soil.
- Soil erosion changes the composition of soil leaving infertile rock behind. Soil quality, structure. stability and texture may also be affected.

- The breakdown of aggregates and the removal of smaller particles or entire layers of soil or organic matter can weaken the structure and even change the texture. Textural changes can in turn affect the water-holding capacity of the soil making it more susceptible to extreme conditions, such as drought.
- Sediment which reaches streams or water-courses due to soil erosion clog drainage and stream channels, deposit silt in reservoirs and reduce quality downstream water.

Causes of Soil Erosion

(i) Natural Sources

Water Erosion: During rainfall, drops of rain can break down soil aggregates and disperse them. The loosened soil particles are transported with the runoff water. If vegetation is depleted by drought, raindrops are free to hit the soil, causing erosion during rainfall.

Wind Erosion: Wind can move large amounts of soil. Wind erosion is a serious means of soil erosion. Blowing soil not only leaves a degraded area behind but can also bury and kill vegetation where it settles. Winds blow away the fine particles of soil during drought.

(ii) Anthropogenic (Produced by humans)

- Extensive cutting down of forests and trees exposes the ground surface to the direct impact of rain and wind. For example, in the absence of proper vegetation cover there is no interception of rainfall and the falling rain strikes the soil surface directly resulting in the throwing up of loose soil particles in the air which are washed away by rainwater.
- Construction work, mining, digging canals and ditches change the structure of soil. This accelerates soil erosion due to high-speed winds as well as rainwater.
- While making roads. soil is cut and massive digging of earth takes place. This leads to soil erosion by water or wind.
- Excessive use of plough, machines, fertilizers and irrigation may damage the land.
- In many areas, trees and grasses are depleted because of overgrazing by animals. This makes the soil susceptible to erosion.

Prevention of soil erosion

Some methods to control soil erosion are discussed below.

- The roots of the trees hold soil material together. Therefore, we should protect our forests and trees from being cut down. Afforestation means planting trees in place of cut-down forest trees. Planting of trees along river-side, waste lands and mountaineous slopes reduces excessive erosion of soil that takes place in these regions. It is also effective in controlling wind erosion.

- Grazing by domesticated animals in a planned way reduces soil erosion by protecting vegetation cover specially on the hill slopes which are more prone to soil erosion.
- Protected channels for water movement must be provided to stop soil erosion. 1f the waterways are properly maintained the speed of water gets reduced and soil erosion decreases. Dam should be constructed on rivers to control flooding and consequently soil erosion. This can also be done by diverting water to dry areas through canals, in a planned way.
- Obstructions known as bunds should be constructed in lands affected by gully erosion.
- Terracing is a method of farming to conserve the thin soil layer on the mountain slopes. This helps in controlling soil erosion and using water resources of these areas more economically and effectively for growing crops on these terraces.
- Ploughing and tilling of land along the contour levels in order to cause furrows to run across the land slopes is known as the contour ploughing. This method is most suited to areas that have a rolling landscape.
- Windbreaks which means planting trees to protect bare soil from the full force of wind also help in preventing soil erosion by wind. Windbreaks reduce the velocity of wind thereby decreasing the amount of soil that it can carry away.

INTEXT QUESTIONS 27.3

1. What is soil erosion?

   ....

2. Name the various types of soil erosion.

   ....

3. Name any two natural factors responsible for soil erosion.

   ....

4. How does terracing prevent soil erosion?

   ....

Biodegradable and non-biodegradable waste material

The waste generated from various sources can be categorized into two types:

(i) **Biodegradable waste** includes substances that can be degraded by microbes into harmless and non-toxic substances. Sewage, kitchen waste, agricultural and animal wastes like leaves, twigs. hay, dung, etc. are biodegradable waste.

(ii) **Non-biodegradable waste** cannot he easily degraded. Aluminium cans, plastics, glass, DDT, etc, are examples of non-biodegradable wastes. Radioactive wastes produced during nuclear reactions take a long time to decay and are harmful to human beings.

If a waste material is processed by some means and converted to a product, we call the process **recycling**. Recycling helps in efficient management of wastes and also reduces the load on natural resources.

Use of cow dung for the production of biogas is a good example of recycling of waste for the production of energy.

27.2.4 Noise pollution

Noise can be simply defined as "unwanted sound". It is generally higher in urban and industrial areas than in rural areas. Workers using heavy machinery are exposed to high noise levels for long period of work hours every day. Intensity of sound is measured in a unit called **decibel** or **dB.** *The lowest intensity of sound that human ear can hear is 20 dB.*

27.2.4a Sources of noise pollution

The major sources of noise pollution are :

- Use of loud speakers, loud music system and television at public places
- Means of transport i.e. automobiles, railways, aircrafts, etc.
- Heavy machines in industries fireworks

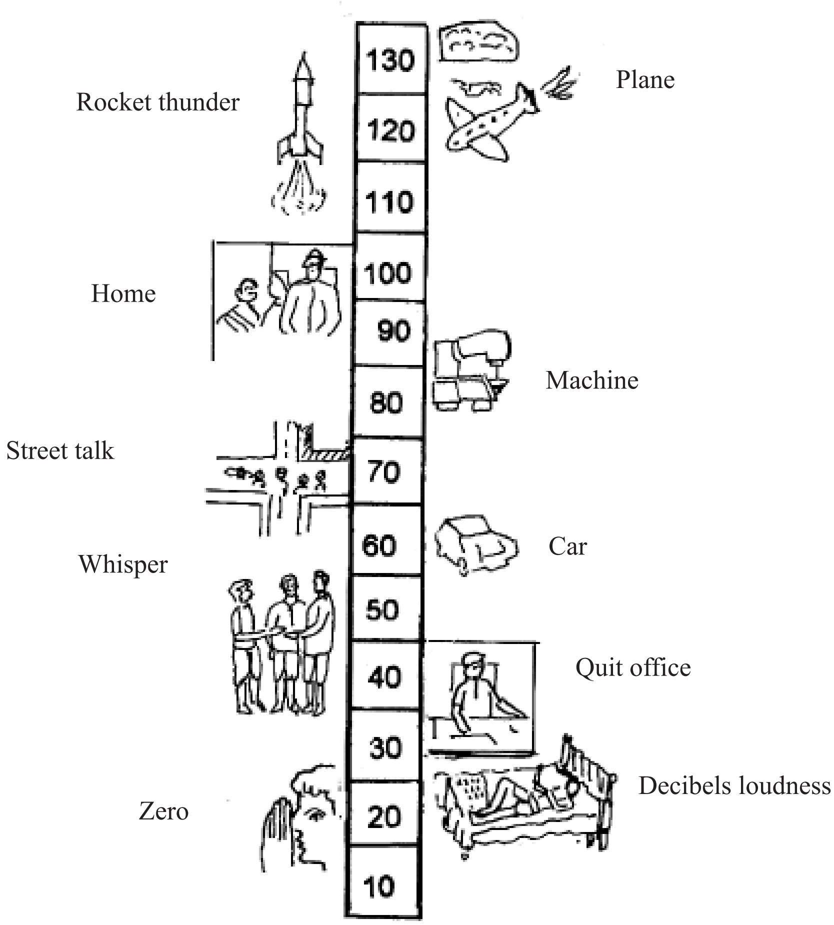


Fig. 27.6 Sources of noise pollution

27.2.4b Effects of noise pollution

- Inability to sleep, slow recovery from sickness.
- Irritability and interference in communication.
- Temporary loss of hearing, earache, sometimes even leading to permanent deafness.
- Inability to concentrate, headache.
- Ringing of ears (a feeling, sound coming from within the ear in a very quiet environment).
- Increased blood pressure, irregular heart beat.

27.2.4c Prevention and control of noise pollution

Following steps can be taken to control or minimize noise pollution :

- Control the noise emanating from your radio and television.
- Use automobile horn only in case of emergency.
- Do not burn fire crackers as they are noisy and also cause air pollution.
- Get all machinery and engines properly tuned and serviced at regular intervals and by the use of silencers.
- Use of sound proof cabins and sound-absorbing materials in the walls.
- A green belt of vegetation is an efficient absorber of noise.
- Not playing loudspeakers during odd hours. It is legally banned and should be reported to the police immediately.

27.3 GREENHOUSE EFFECT AND GLOBAL WARMING

In the earlier classes, you have studied about greenhouse effect and global warming. Greenhouse is an enclosure usually made of glass in which temperature inside is higher than outside. An increase in the percentage of greenhouse gases which prevent the escape of heat from earth, would increase the average temperature on earth worldwide known as greenhouse effect.

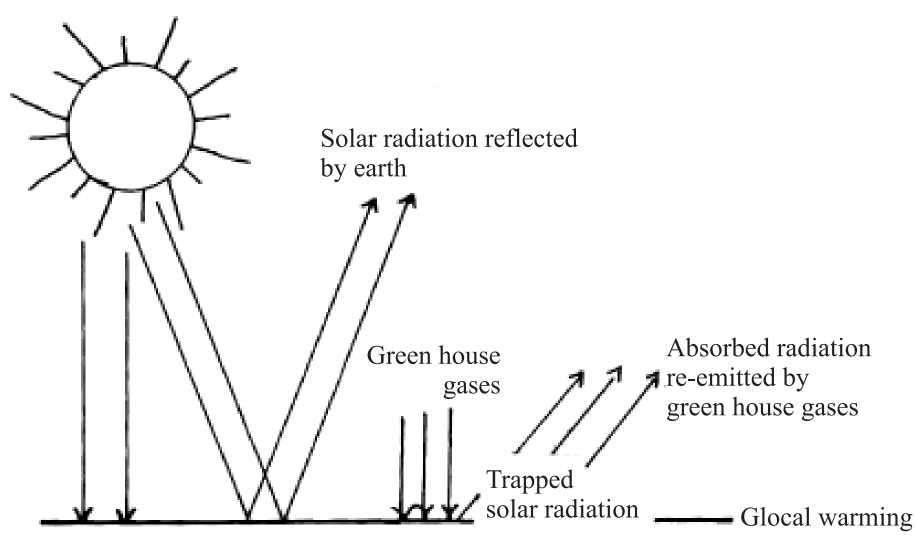


Fig. 27.7 (a) Green house effect

Greenhouse gases in the atmosphere behave much like the glass panes in a greenhouse. They allow sunlight to enter the atmosphere of earth. When the sunlight enters the surface of the earth, sun's energy is absorbed by land, water and biosphere. Some of this energy is reflected back to the atmosphere by earth. Some of this energy passes back into the space. However, most of the energy remains trapped in the atmosphere by the greenhouse gases causing global warming on earth.

27.3.1a Causes of global warming

Carbon dioxide (CO_2), Chlorofluorocarbons (CFCs), Methane (CH_4) and Nitrous oxides (N_2O) are the main greenhouse gases that cause global warming. An increase in the concentration of these greenhouse gases leads to an increased trapping of long wave radiations resulting in an increase in earth's temperature causing **global warming.**

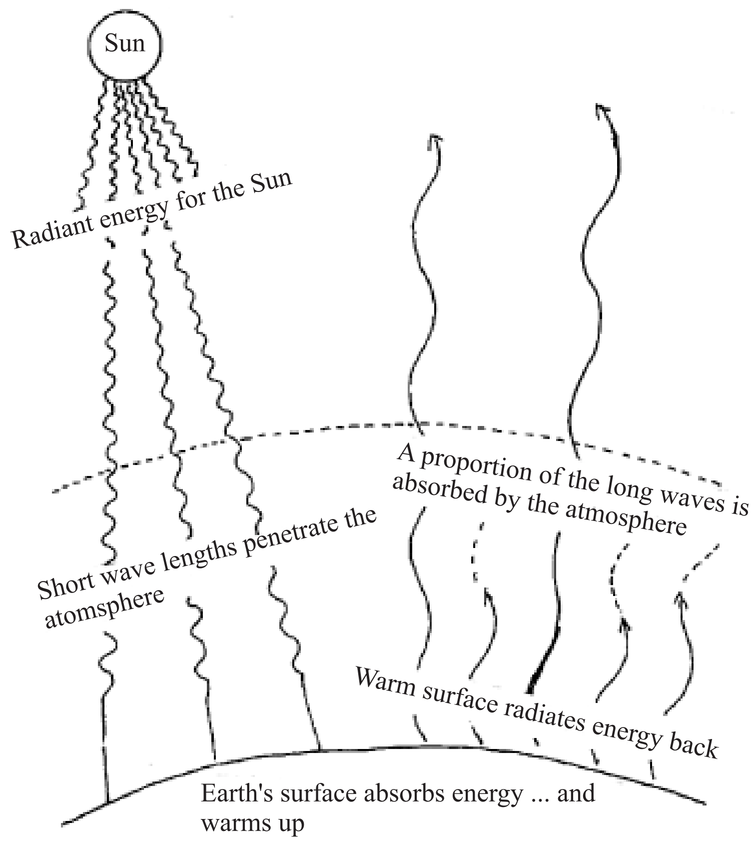


Fig. 27.7 (b) Global warming

There are various sources which add these greenhouse gases to the atmosphere.

- Human activities such as burning of fossil fuels in homes, industries and automobiles, biomass burning in agricultural practices etc. add large amount of carbon dioxide to the atmosphere.

- Marshes, paddy field, cattle sheds and biogas plants add methane to the atmosphere.

- Refrigerators, air conditioners etc emit CFCs to the atmosphere.
- Nitrogen oxides are added to the atmosphere by organic matter and fertilizers by denitrifying bacteria as well as automobiles.

27.3.1b Effects of global warming

- An increase in the atmospheric temperature will cause sea level to rise by 1 to 2 mm per year.
- Temperature near ocean surface would Increase and cause glaciers and polar ice sheets to melt faster. This would flood the low lying coastal areas and a number of islands.
- Global warming will produce severe heat waves during summers causing heat related illness and death.
- Due to increase in surface temperature, the parasites and pests will get adequate temperature to survive leading to an increase in their numbers. This will reduce the crop production and there will be more incidences of plant, animal and human diseases.
- Due to increased temperature of earth's atmosphere, the precipitation of water will increase. This will decrease the soil moisture content and lead to frequent downpours also.

27.3.1c Prevention and control of global warming

We can prevent global warming by reducing the production of greenhouse gases. This can be done by

- using energy efficient devices in automobiles and appliances other than fossil fuels.
- minimizing the use of fossil fuels such as petrol, diesel etc and opt for better alternatives like solar energy and other renewable sources of energy.
- reusing home wastes, newsprints, cardboards, glass and metals. By doing so we can reduce the CO_2 emission by 850 pounds annually.
- planting more and more trees. By planting more and more trees we can reduce the amount of CO_2 in the atmosphere. Because plants act as CO_2 sink as they take up CO_2 for photosynthesis.

27.3.2 The ozone hole : depletion of the ozone layer

The ozone layer present in the earth's atmosphere prevents the entry of sun's harmful ultraviolet (UV) radiations reaching the Earth's surface. Industrial use of chemicals called chlorofluorocarbons (CFCs) in refrigeration, air conditioning, cleaning solvents, fire extinguishers and aerosols (spray cans of perfumes, insecticides, medicines, etc.) damage the ozone layer. The ozone hole is formed as follows :

Chlorine contained in the CFCs on reaching the ozone (O_2) layer splits the ozone molecule to form oxygen (O_2) Amount of ozone, thus, gets reduced and cannot prevent the entry of UV radiations. There has been a reduction by 30-40% in the thickness of the ozone umbrella or shield over the Arctic and Antarctic regions.

Notes

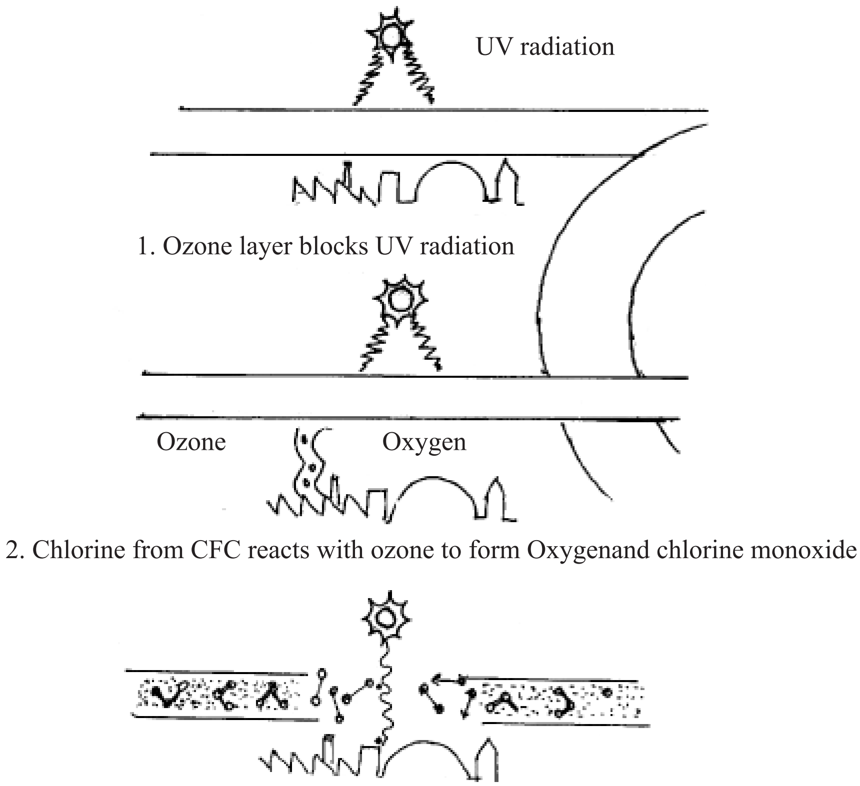


Fig. 27.8 Depletion of the ozone

27.3.2a Effects of depletion of ozone layer

- Sunburn, fast ageing of skin, cancer of skin, cataract (opaqueness of eye lens leading to loss of vision), cancer of the retina (sensitive layer of the eye on which image is formed)
- Genetic disorders
- Reduced productivity in the sea and the forests

27.3.2b Prevention of ozone layer depletion

Damage to the ozone layer can be prevented by :

- Reduced consumption of CFCs by adopting alternative technologies (substituting air conditioning gases by non-CFCs).
- Discouraging the use of spray cans containing aerosol.

27.3.3 Acid rain

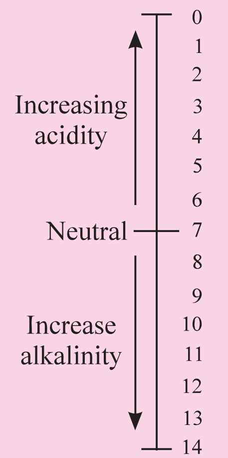
Acid rain occurs when Sulphur dioxide (SO_2) and oxides of Nitrogen (NOx) are emitted into the atmosphere, undergo chemical transformations and are absorbed by water droplets in clouds. This causes the formation of sulphuric and nitric acids in rain clouds. The droplets then fall to earth as rain, snow or mist. If rain falls through polluted air it picks up more of these gases and increases its acidity. This is called **acid rain**. This can increase the acidity of the soil, and affect the chemical balance of lakes and streams. Thus, acid rain is defined as any type of precipitation with a pH that is unusually low. A pH of less than about 5 is used as a definition of acid rain. Acid rain is a serious environmental problem that affects large parts of the world.

What is pH?

Acid rain is measured using a scale called pH. Because acids release hydrogen ions, the acid content of a solution is based on the concentration of hydrogen ions and is expressed as "pH." This scale is used to measure the acidity of rain samples.

- 0 = maximum acidity
- 7 = neutral point in the middle of the scale
- 14 = maximum alkalinity (the opposite of acidity)

The **smaller** the number on the pH scale, the more **acidic** the substance is. Rain measuring between 0 and 5 on the pH scale is acidic and therefore called acid rain. Clean rain usually has a pH of 5.6. It is slightly acidic because of carbon dioxide which is naturally present in the atmosphere. On the other hand, vinegar is very acidic and has a pH of 3.



The pH scale

27.3.3a Sources of acid rain

Sulphur dioxide (SO_2) is generally a byproduct of industrial processes and burning of fossil fuels. Ore smelting, coal-fired power generators and natural gas processing are the main contributors to sulphur dioxide in the atmosphere.

The main source of oxides of nitrogen (NOx) emissions is the combustion of fuels in motor vehicles, residential and commercial furnaces, industrial and electrical-utility boilers and engines, and other equipments.

27.3.3b Effects of acid rain

It causes acidification of lakes and streams and contributes to the damage of trees trees any many sensitive forest soils. In addition, acid rain accelerates the decay of building materials and paints, including heritage buildings, statues, and sculptures that are part of our nation's cultural heritage. Prior to falling to the earth, suphur dioxide (SO_2) and nitrogen oxide (NOx) gases and their particulate matter derivatives— sulphates and nitrates- contribute to visibility degradation and harm public health.

Some major effects of acid rain on vegetation, buildings and human health are given here.

Effect on surface waters and aquatic animals

Lower pH in surface water that occurs as a result of acid rain can cause damage to fish and other aquatic animals. Acidity releases aluminium into the water. This builds up as a layer of aluminium hydroxide in the gills of fishes. At pH lower than 5 most fish eggs do not hatch and lower pH can kill adult fish. As lakes become more acidic biodiversity is reduced.

Damage to plants

Acid rain is highly injurious to plants. Acid Rain depletes minerals from the soil and then it stunts the growth of the plant. It causes death of young shoots, leaves turn yellow and fall off. The fine root structure is damaged and the whole plant eventually dies. Acid rain can slow the growth of forests, cause leaves and needles to turn brown and fall off and die. In extreme cases trees or whole areas of the forest can die.

Effect on human health

The human beings may also be affected due to acid rain. Fine particles, formed from the same gases disolve in water and form as acid rain (sulphur dioxide and nitrogen dioxide) may cause illness in humans.

Damage to soil

Acid rain may make the soil more acidic. It may cause mineral nutrients to be washed away. It can release toxic chemicals such as aluminium and mercury into the soil. Thus, acid rain could make soil less fertile. The microbes which are unable to tolerate low pHs may be killed due to acid rain. This is because the enzymes of these microbes may be denatured by the acid.

Other adverse effects

Acid rain can also cause damage to certain building materials and historical monuments. Acid rain can cause erosion of ancient monuments. This is because the Sulphuric acid in the rain chemically reacts with the calcium in the stones (limestone, sandstone, marble and granite) to create gypsum. Which then flakes off'. Acid rain also causes an increased rate of oxidation for iron affecting iron furnitures, grills, doors, windows and other materials etc. Acid rain can also reduce visibility due to presence of sulphate and nitrate in the atmosphere due to acid rain.

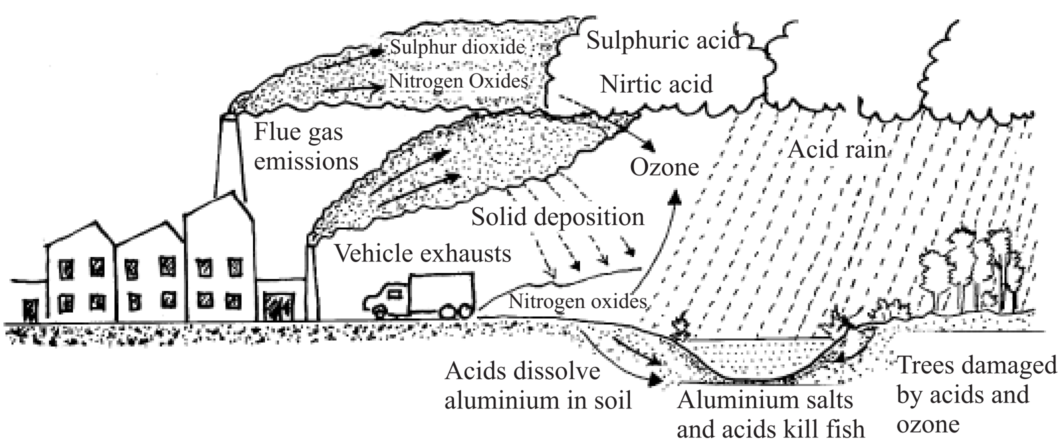


Fig. 27.9 Sources and effects of acid rain.

27.3.3c Prevention of acid rain

- There are several ways by which sulphur dioxide and nitrogen oxide emissions can be reduced.
- Coal can be crushed and washed before burning.
- Oil can be treated to remove sulphur.
- Cleaning systems can be fitted into chimneys to remove sulphur dioxide before it can be released into the atmosphere.
- Improved furnaces can be built which burn fuel more effectively and produce less pollution.
- Vehicle exhausts can be fitted in vehicles, which remove pollutants from engine emissions.

INTEXT QUESITONS 27.4

1. Name any two biodegradable pollutants.

   ....

2. Mention two source of noise pollution.

   ....

3. Name any two green house gases.

   ....

4. What is acid rain?

   ....

27.3.4 Radiation–an environmental pollutant

Radiation is one of the chief forms of energy consisting of high energy particles. Radiation could be natural (solar and cosmic) or and human (nuclear). Radiation has also become a major factor causing environmental pollution.

Radiation may have both short term or long term effects. They can further be divided functionally into :

- Ionising and
- Non Ionising (Table 27.5) radiations

Table 27.5: Ionizing and Non Ionising Radiations

Type	Ionizing	Non ionizing
Examples	Alpha, Beta, Gamma and X-Ray	Ultraviolet radiation
Properties	Short wave lengths, high energy.	Higher wave lengths, low energy
Effects	Causes ionisation in cells photo products	Damage through toxic
Harmful Effects	• Deep penetrating power effects both external & internal organs	• Only superficial tissues are damaged

	• Breakage of chromosomes • Gene mutation and genetic variations • Cancer of bone marrow (Leukaemia) • Loss hair • Male sterility	• Kills micro-organism and egg of fish & amphibians • Prevents synthesis of DNA and RNA, Cell division • Skin cancer in humans

> Inhabitants of Hiroshima (Japan) exposed to nuclear fallout had no children for a long time or had deformed infertile offsprings.

Effect of exposure to ionizing radiations on living organism

Time of exposure		**Effect of exposure**	
millisecond	⟶	energy absorption	
↓		↓	
few seconds	⟶	molecular changes	
↓		↓	
minutes	⟶	metabolic changes	genetic changes
↓		↓	↓
hours	⟶	cell damage	mutations
↓		↓	↓
hours to years	⟶	cell death	abnormal growth
		↓	
		death of the organism ⟵	

Nuclear Radiation and its harmful effect

Radiations emitted by **nuclear** substances or wastes (fallout) or from atomic power plant or an atomic explosion cause **nuclear radiation**. Nuclear wastes continue to emit radiation for a very long period.

Radioactive Iodine (^{131}I) and Strontium (^{90}Sr) are two **nuclear wastes** from an atomic explosion and may cause cancer of thyroid and cancer of bone narrow/ respectively. By entering food chain they also get accumulated in high concentration in the body of the top consumer causing harmful effect on the health of both humans and animals.

Nuclear power plants

Nuclear power plants help in generating electrical energy by utilising heat generated by nuclear reactions. India has some of its nuclear power plants at Narora in U.P., Kalpakkam in Tamil Nadu, and Kota in Rajasthan etc.

Disposal of nuclear wastes

It is essential to dispose nuclear wastes carefully as it remains radioactive (emits radiation) for a very long time. Waste is normally packed in sealed lead containers as lead absorbs all radiation. These containers are then dumped in deep pits or in high seas.

Protection against radiation

Exposure to radiation may affect both young and adults. Entry of children and pregnant females is prohibited in the nuclear installations. Nuclear radiation may have the following harmful effects

- Cancer in child
- Male sterility
- Malformation of the growing embryo

People working in the nuclear establishments can be provided protection against radiation by

- Increasing the distance between the source of radiation and the working people.
- Use of lead shields to serve as absorbing material.
- Thick concrete walls around the reactor to work as shields
- Use of protective apron and gloves for people.

Applications of Radiation

Despite all the harmful effects of radiation, their use in various fields for the benefit of mankind is gradually increasing as show in Table 27.6. Almost all our sources of energy originate from **solar radiation**. For example **photosynthetic process** for the formation of food and fossil fuel. Artificially generated radiation are also used for various purposes.

Table 27.6: Applications of Radiation

Field	Use
1. Industry process	Radiation detector for metals, moisture, quality,
2. Nuclear Energy	Power Plants
3. Communications	Radio, TV, Satellite,
4. Medicine	Radiation Tomography (CAT Scan), X ray for anatomy Diathermy to relieve pain by localised heating Artheritis Destruction of cancerous growth Sterilisation of surgical instruments
5. Scientific research	Radiocarbon dating - to determine the age of objects or fossils

INTEXT QUESTIONS 27.5

1. Give one example each of natural and man made radiations
   (i) ....
   (ii) ....
2. List two wastes of atomic explosion.
   (i) ....
   (ii) ....
3. Name the containers which should be used for the disposal of nuclear wastes.
   ....
4. List any two harmful effects of nuclear radiations.
   (i) ....
   (ii) ....

WHAT YOU HAVE LEARNT

- Pollution is the addition of undesirable material in the environment.
- A pollutant is a constituent which when added adversely affects the environment.
- Pollution may be of different types such as Air, Water, Soil, Noise, Thermal or because of radiations.
- Pollutant could be gaseous, particulate or a physical factor.
- Air Pollution turns clear, odourless, air into hazy and/or smelly.
- Air pollution causes a number; of respiratory problems such as anaemia, heart palpitation, choking and eye irritation.
- Plants may show chlorosis, necrosis, stunted growth, leaf and fruit fall due to air pollution.
- Air pollution caused by suspended particular matters may be controlled by use of filter bags, electrostatic precipitators and by planting vegetation.
- Water may be polluted by domestic, agricultural or industrial activities.
- Biodegradable matter present in water causes depletion of oxygen content and death of aquatic life.
- Uncontrolled release of pollutants by the industry has made water in water streams unfit for human consumption.
- Use of non biodegradable pesticides (DDT etc.) gives rise to the phenomenon of biomagnification.

- Soil pollution may be caused due to pesticides, radioactive wastes, domestic wastes etc.
- Noise is unwanted sound which may cause deafness, lack of concentration, high blood pressure and nervous disorders.
- Soil pollution includes addition of substances that reduce the fertility of the soil.
- Waste can he classified into biodegradable (e.g. cow dung, vegetable peels, paper, wood etc.) and non-biodegradable (e.g. aluminium cans, glass bottles, plastics, DDT etc.).
- Recycling of wastes such as cow dung, paper, sewage and rice husk, into useful products help in conservation of resources.
- Ozone provides a protective layer against harmful ultra-violet rays coming from the sun. Excessive use of chemical, such as CFCs used in spray cans, gas used in refrigerators and air conditioners, lead to thinning of the ozone layer.
- Accumulation of high concentration of carbon dioxide has led to the phenomenon of global warming (due to green house effect), and has resulted in increased earth's temperature. The climate has changed.

TERMINAL EXERCISES

1. Which of the following are biodegradable materials?

   Aluminium, wood, fruit peels, DDT, paper, glass, dung
2. Which gaseous pollutant has the ability to absorb infra-red radiations?
3. A ship carrying oil from the gulf region collides with hug rocks and get damaged. It this just news or has some serious consequences? Give your opinion in one sentence.
4. To set up a new industry, a large forest area had to be cut. List four ways in which the environment in that area may be affected.
5. List any three ways in which noise from various sources can affect the well-being of a person. Suggest few methods to control noise pollution.
6. What does 'Global warming' mean ? Name the gas responsible for this phenomenon and why should it be considered an environmental problem.
7. How would you classify the waste generated at home? What is the difference between the different groups? How would you manage this waste so that it cause least pollution?

ANSWERS TO INTEXT QUESITONS

27.1 1. Addition of unwanted substances to the environment which have adverse effects on organisms.

2. Air pollution, water pollution, land polluton, noise pollution.

3. Respiratory problems in humans, chlorosis (loss of chlorophyll in plants).

27.2 1. Soil erosion/leaking of mineral from rock/decay of organic matter (any two)

2. Accumulation in greater concentration of chemicals at higher levels of food chain.

3. eutrophication

4. See table 27.3

27.3 1. Detachment and removal of soil particle by flowing water and blowing wind.

2. Wind erosion, sheet erosiion, Gully erosion.

3. Wind, water

27.4 1. Sewage, kitchen, waste, certain agricultural waste, hay, dung etc. (any two)

2. loud speakers/sound of automobiles/sound from heavy machines/fire works (any two)

3. Nitrogren oxides, methane, carbon dioxide, chlorofluoro carbons. (an two)

4. When harmful gases like SO_2 and NO_x in the atmosphere dissolve in water to form acid during veins.

27.5 1. Solar/cosmic (any one); x-ray/gamma rays (any one)

2. Radioactive Iodine and strontium

3. Lead containers

4. (i) cancer (ii) gene mutations.

28

NUTRITION AND HEALTH

Food is the basic necessity of life. We all know that regular supply of food is essential for human beings in order to keep fit and to carry on all the life processes. We eat a large variety of food according to our taste, availability and body requirement. In this lesson we will learn about nutritional requirement of the body and the problems of health related to specific deficient nutrition.

OBJECTIVES

After completing this lesson you will be able to :

- *define the terms food, nutrition and disease;*
- *explain the biological significance of food;*
- *differentiate between micro- and macronutrients;*
- *list the sources and describe the functions of carbohydrates, fats, proteins, vitamins, minerals, water and roughage;*
- *explain the energy requirement of the body;*
- *emphasise the need of balanced diet especially for growing children, persons in different occupations and lactating mothers;*
- *list the common deficiency diseases PEM, minerals and vitamins; deficiency, obesity, hypervitaminosis, their symptoms and recommended food sources.*

28.1 WHAT IS FOOD

Food is any substance which performs the following functions in the body :

(i) yields enegy for life processes,

(ii) builds up new cells during growth,

(iii) repairs worn out (damaged) tissues,

(iv) aids in production of useful body compounds.

Biological Classification of Food

Food can be classified into three categories based on their functions (Table 28.1)

(i) Energy providing foods

(ii) Body building foods

(iii) Protective/regulatory foods

(i) **Energy providing foods** : These are rich in carbohydrates and fats and provide energy on biological oxidation in the body. Example : cereals, sugar, fats, oils, jaggery, coconut, and groundnuts.

(ii) **Body building foods :** These are rich in proteins and help in the formation of new tissues. Example : legumes, milk, egg, meat, fish, pulses, nuts and oilseeds.

(iii) **Protective/regulatory foods :** These are rich in minerals, vitamins, roughage and water. They help in regulaiton of internal metabolism in the body. Example : green leafy vegetables, fruits, amla, guava, citrus, oranges and water melon.

Table 28.1 The three food groups

Food group	Major nutrients	Food sources
Energy providing food	Carbohydrate and fats	• Cereals (rices, wheatm maize)
		• Sugar
		• Fats (oil and ghee)
		• Jaggery
Body building food	Proteins	• Milk
		• Legumes
		• Egg white
		• Meat (chicken, mutton, fish)
Protective food	Minerals and vitamins	• Green leafy vegetables
		• Roughage such as fruits, beans and other lagumes.
		• Amla, guava, citrus, orange, etc.

28.2 NUTRITION

> Nutrition is the sum of the processes by which an organism takes in, metabolises and utilises food substance for its various biochemical activities.

Nutrients are the organic or inorganic substances which help in our survival and in maintaining proper health. A nutrient supplies energy to the body, builds and repairs body tissues and regulates the body metabolism.

On the basis of quantity required by the body, nutrients are classified into two categories :

(i) Macronutrients (ii) Micronutrients

Macronutrients (Nutrients required in a large amount) : Carbohydrates, fats, proteins and water contained in food comprise macronutrients.

Micronutrients (nutrients required in small amount) : Vitamins and minerals form only a small fraction of the total weight of the food.

> One molecule of glucose yields 38 ATP molecules
> 1 ATP gives 34 kJ
> ∴ 1 mole of glucose yields $38 \times 34 = 1292$ kJ upon complete biological oxidation

Let us learn in some detail about these nutrients.

28.2.1 Carbohydrate

Carbohydrates are the chemical compounds made up of carbon, hydrogen and oxgyen. They release energy on biological oxidation with the help of cellular enzymes. They are the cheapest source of energy. Complete biological oxidation of one gram of carbohydrate yields about 18 kilo joules of energy. One kilo calorie of heat is required to raise the temperature of 1 litre of water through 1°C.

1 kilocalorie = 4.18 kJ

1 kilojoule = 1/4.18 × 1000 calories

Carbohydrates in the diet provide about 60-80% of total energy required by our body.

Types of carbohydrates

The three types of carbohydrates that we consume in our food are :

(i) sugars (ii) starch (iii) cellulose (Table 28.2)

Table 28.2 Carbohydrates required in our diet

Carbohydrates			
Sugar		**Starch**	**Cellulose**
Monosaccharides Glucose (found in molasses, honey and sweet fruits like grapes) Fructose (Found in honey and ripe fruits)	Disaccharides Sucrose (found in sugarcane and sugar beet) Maltose (found in sprouted cereals) Lactose (found in milk)	Storage form of carbohydrates (found in cereals, grains, seeds, roots, potato, rice, wheat, barley, maize, nuts etc.)	Found in cellulose of plants, seed coats, fruits, vegetables and cereals

Common sources of carbohydrates

- **Starch**

  Cereals (wheat, rice, maize), millets (bajra, jowar, barley), roots and tubers (sweet potato, tapioca, potato)

- **Sugar**

  Cane sugar, beet root, fruits (banana, mango, sapota or chiku), milk, honey, and cereals.

- **Cellulose**

  Cell walls of fruits, vegetables, and cereals

  During digestion both starch and sugars are absorbed as glucose. The surplus glucose is changed into glycogen which is stored in the liver for subsequent use. (For detail refer to lesson 13)

  Cellulose is a fibrous substance which is not digested by human body. However, it serves as roughage and facilitates bowel (stool) movement.

  A normal person needs about 400-500 grams of carbohydrates daily in the diet. A growing child, a lactating mother and a person doing hard physical work need more carbohydrates than an average person because of their greater energy requirements. The percentage of carbohydrates in different food items is given in table 28.3 below :

Table 28.3 Percentage of carbohydrates present in some common food items

Food	Percentage (per 100 g of food)
Sugar	99.4
Rice	78.2
Wheat flour	69.4
Potato	22.7
Banana	24.7
Mango (ripe)	11.8
Green gram	69.4
Red gram	57.6
Carrots	1.6
Cow's milk	4.4

Functions of carbohydrates

- Lactose sugar promotes growth of intestinal bacteria that facilitate the absorption of calcium.
- Excess carbohydrates are converted into glycogen and fat and serve as reserve sources of energy.
- Cellulose provides faecal bulk and helps in bowel movement.
- Glucose is the only source of energy for the central nervous system.

28.2.2 Fats

Fats are members of lipids. Like carbohydrates, fats are also made up of carbon, hydrogen and oxygen. However fats contain more carbon and hydrogen and less oxygen. Fats are the richest source of energy. Fats are insoluble in water but soluble in solvents like acetone, and benzene. Chemically fats are triglycerides.

One gram of fat on biological oxidation gives about 9.0 kcal (37 kilojoules) of energy.

Sources :

Animal sources : Ghee, butter, fish oil, meat, egg.

Plant sources : Vegetable oil from the seeds of coconut, mustard, sunflower, safflower, milk, nuts, soyabean, cheese.

Functions of fats

- fats are the richest sources of energy. On biological oxidation, one gram of fat provide 37 kJ of energy.
- Form structural components of cell cytoplasm and cell membrane.
- help in absorption of fat-soluble vitamins A, D, E and K
- act as precursor of various hormones.
- can be stored for subsequent use by the body.
- sub-cutaneous fats serve as insulators in the body thus protecting it from cold weather and pressure.
- stored fat provides padding to protect the vital organs of the body from shocks.
- help in the synthesis of vitamin D and steroid hormones in the body.

28.2.3 Proteins

Proteins are extremely large molecules composed of many amino acids. Proteins are complex organic compounds rich in carbon, hydrogen, oxygen, nitrogen and sometimes phosphorous and sulphur also.

Proteins are needed by the body for :

- growth and development
- repair and maintenance
- the synthesis of antibodies, enzymes, and hormones

They can also be used as a source of energy. 1 gram of protein yields about 4 kcal of energy. Building blocks of proteins are the amino acids. You have already learnt in lesson one that there are only about 22 different amino acids of which almost all proteins found in living organisms are made. Nutritionally, amino acids belong to two categories :

(a) **Essential amino acids :** These are the amino acids which can not be synthesised in the animal body and must be supplied with food e.g. leucine.

(b) **Non essential amino acids :** which can be synthesised in the body particularly from carbohydrates and need not be supplied in the diet. e.g. alanine.

Digestion of protein

Like fats, proteins can not be absorbed in the tissue until they are broken down into their amino acids. Digestion of proteins occurs in stomach and small intestine where acids and enzymes break up proteins into amino acids.

Sources :

Animal sources : Milk, egg, fish, bean, meat, and liver. contain adequate amount of essential amino acids.

Plant sources : Whole cereals (wheat and maize), pulses, nuts, grams, and legumes.

Intake of more than one plant protein in the same meal (dal-roti, sambar-idli) can produce a mixture containing all the essential amino acids.

Proteins are structural components of body. For example, protein **keratin** is present in hair and nails. Collagen present in the connective tissue is also an example of protein. Actin and myosin are examples of contractile proteins present in the muscles.

Functions of proteins

- Proteins are required for building and maintaining body tissues.
- Proteins are found in all the enzymes e.g. Trypsin, pepsin and rennin.
- Some proteins function as hormones, to regulate many body functions. For example, insulin is a hormone which regulates blood glucose level in the body.
- Proteins also act as antibodies and protect the body from antigen (foreign agent).
- Transport protein carries different substances from blood to the tissues in the body. Haemoglobin is a transport protein.

28.2.4 Vitamins

Vitamins are complex chemical substances required by the body in very small amounts. They do not yield energy but act as biocatalysts in the body. They are essential for good health and protect the body from various diseases. They are essential for the utilisation of other nutrients that we take in our diet.

Vitamins are grouped into two classes :

(a) Water soluble vitamins are vitamins B complex and C

(b) Fat soluble vitamins are vitamins A, D, E and K

Since vitamins cannot be made in our body except for vitamin D, they need to be supplied through food that contain them. Table 28.4 lists the vitamins and their sources as well as the daily requirements in the body, deficiency diseases and symptoms in 13-15 year old boys and girls.

Table 28.4 Vitamins : their functions, sources and deficiency diseases.

Vitamin	Daily requirement	Function	Best food sources	Deficiency diseases	Symptoms
1. Water Soluble Vitamins					
Vitamin B_1 (Thiamine)	1.3 mg (boys) 1.2 mg (girls)	Carbohydrate metabolism; sharpens appetite; functioning of heart, nerve and muscles	Yeast; liver; milk; cheese; leafy vegetables; meat; whole grain cereals	Beri-beri	Pain in hands and feet. Swelling of body. Paralysis of limbs. Oedema.
Vitamin B_2 (Riboflavin)	1.6 mg (boys) 1.4 mg (girls)	Carbohydrate and protein metabolism; keeps skin healthy;	Milk; liver meat; eggs peas; yeast; whole grains; green leafy vegetables.	Riboflavinosis; photophobia	Retarded growth and mental disorder. Cracking of skin at corners of mouth. Lesions of eyes.
Vitamin B_3 (Niacin)	1.8 mg (boys) 1.5 mg (girls)	Coenzyme for protein, fat and carbohydrate metabo lism. Keeps the skin healthy.	Fish; eggs; meat; legumes; whole grains; leafy vegetables; peanuts; bean; tomato; potato.	Pellagra	Dermatitis (bad skin), diarrhoea (loose motions) dementia (mental disorder).
Vitamin B_{12} (Cyanocobalamine)	0.2-100 mg	Blood formation, Nervous tissue metabolism, Nucleic acid synthesis.	Liver; fish; cheese; milk; eggs; meat.	Pernicious anaemia.	Paleness of skin; breath lessness; retarded growth.
Vitamin C (Ascorbic Acid)	40 mg	Resistance to infections; keeping teeth, gums and joints healthy; healing of cuts and wounds; maintenance of connective tissue.	Amla, cabbage; tomatoes, lemon; orange; mangoes; chillies, guava, pineapple; sprouted grams.	Scurvy	Bleeding gums; pain in joints; general weakness.
2. Fat Soluble Vitamins					
Vitamin A (Retinol)	750 mg	Maintenance of vision and skin; Essential for synthesis of visual pigment	Milk, cheese, butter, eggs codliver oil, carrots mangoes papaya, yellow pumpkin spinach, sweet potato	Night blindness. Xerophthalmia or keratinol acid. Dry skin	Cannot see in dimlight, (night blindness); Retarded keratinization of epithelia

Vitamin D (Calaciferol)	200 IU	Keeps teeth and bones healthy, absorption of calcium and phosphorus	Milk; cheese; egg yolk; cod liver oil, fish; butter; expo sure to sunlight.	Rickets in children; (Fig. 28.1)	Failure of growing bones to calcify; bow legs pigeon chest; softening of bones
				Osteomalacia in adults	Painful bones; spontaneous fracture.
Vitamin E (Tocopherol)	Trace	antioxidant; ageing vitamin	Grains vegetable oil, green leafy vegetables, nuts, liver	reproduction failure in males and females	Sterlity in males, miscar-riage, or death of embryos during pregnancy in females.
Vitamin K (Phylloqu-inone)	Trace amount	Clotting of blood	Green leafy vegetables; soyabean; tomatoes.	Faulty blood clotting; haemorrhage.	Delayed blood clotting.

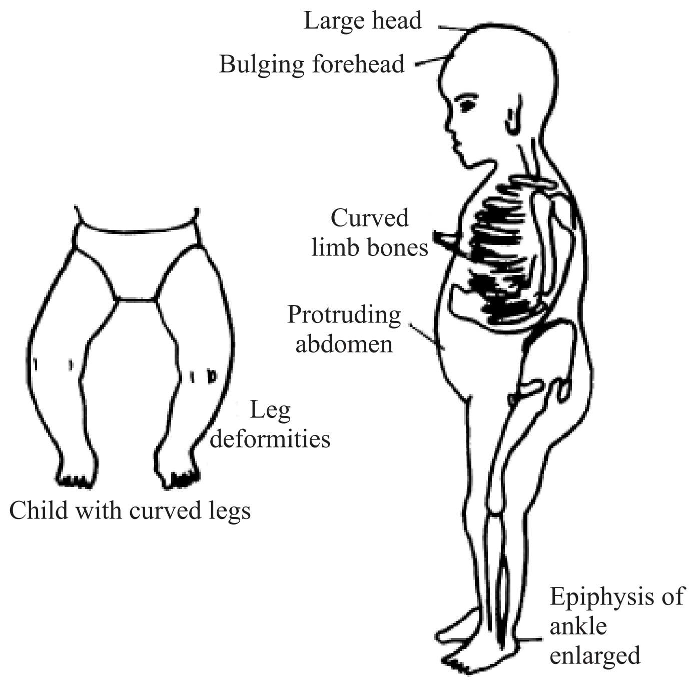


Fig. 28.1 Child with rickets

28.2.5 Minerals

Minerals are micronutrients required in varying amounts for proper functoning, normal growth and keeping good health of our body. They are inorganic elements, occuring in the form of their salts e.g. calcium, potassium, sodium, phosphorus, iron etc. They do not supply energy to our body but are essential for protection against diseases and also have role in body functions.

Minerals	
Required in larger amounts	**Required in trace amounts**
Calcium, Phosphorus Sodium Potassium, Sulphur Chloride, Magnesium.	Iron, Iodine, Zinc, Chromium Cobalt, Copper, Fluoride, Manganese, Molybdenum Selenium, and Boron

Functions

Minerals perform the following functions :

- Essential for development of bone and teeth e.g. calcium, phosphorus.
- Regulate the fluid balance and acid alkalinity of body fluids e.g. sodium, potassium, chloride.
- Iron is major component of haemoglobin, which helps in transport and release of oxygen.
- Iodine is required for the synthesis of thyroid hormone thyroxine, which regulates the rate of oxidation energy sources within cells.
- Zinc, coper and magnesium regulate a host of vital reactions in our body.

Table 28.5 Lists the minerals, their sources, function, deficiency diseases and symptoms

Table 28.5 Minerals required by and in our body, their sources and functions

Minerals	Functions	Food sources	Deficiency diseases	Symptoms
1. Calcium	Formation of bones and teeth, necessary for nerve, teeth and muscles	Milk and milk products; fish; meat; beans; green leafy vegetables; brocolli, tapioca; cereals.	Rickets; Oesteomalacia loss of teeth	Softening of bones; deformities; pain in bones; enamel.
2. Iron	Formation of haemoglobin; acts as carrier of oxygen.	Liver; green leafy vegetables; eggs, spinach; groundnuts; cereals; jaggery.	Anaemia.	Loss of weight; pale appearance; tiredness; loses of appetite.
3. Phosphorus	Formation of bones and teeth	Milk; cereals; green leafy vegetables; nuts, bajra meat.	Rickets and Oesteomalacia;	Softening of bones; bowlegs; pigeon chest.

4.	Iodine	Metabolic control of hormone thyroxine; controls growth and mental ability.	Iodized salt; sea food; fish; green leafy vegetable	Goitre (Fig. 28.2)	Enlargement of thyroid gland; retarding of physical and mental growth.
5.	Sodium and Potassium	Maintenance of normal water balance in the body; associated with conduction of nerve impulse.	Common salt; meat; poultry; fish; fruits; cereals; egg; spinach; pulses; potato; yoghurt.	High blood pressure; Oedema; Osmotic pressure disturbed.	Severe malnutrition; high blood pressure; fatigue; loss of appetite; vomiting.

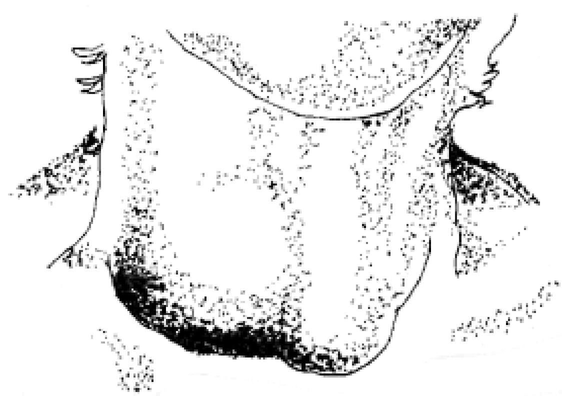


Fig. 28.2 Patient with goitre

28.2.6 Water

Water is an important constituent of our diet. 75% of an infant body and 60% of an adult body is nothing but water. Various functions of water are as follows.

- essential for the transport and digestion of food material.
- excretes wastes.
- maintains the body temperature.
- acts as solvent in various reactions in the body.

Sources of water

Water is replenished by :

- drinking of plain water or of tea, coffee, milk and fruit juices.
- eating fruits, vegetables and fish.
- some amount of water comes as a by-product of oxidation of glucose in the body.

28.2.7 Roughage

Roughage is the fibre present in some food items like fruits and vegetables. Though roughage is not a food, it forms an important part of our diet. Roughage consists mainly of cellulose.

Function

- It helps in bowel movement.
- It cleans our digetive tracts and protects the body from digestive ailments.
- It prevents constipation.
- It helps in retaining water in the body.
- It helps in maintaining optimum levels of blood sugar and cholesterol.

INTEXT QUESTIONS 28.1

1. Define nutrition and nutrients

   ....

2. Name the various nutrients of food.

   ....

3. Differentiate between macronutrients and micronutrients

   ....

4. Name the following :

   (i) two water soluble vitamins

   ....

   (ii) two sources of roughage

   ....

   (iii) two sources of proteins

   ....

5. If equal amount of sugar and butter are consumed, which one will provide more energy?

   ....

28.3 ENERGY REQUIREMENTS OF THE BODY

Our body needs energy to carry on various activities of life. We get this energy by eating food.

The energy requirement of an individual depends on various factors like age, sex, amount of work done (occupation), special needs like pregnancy and lactation. The average daily requirements of our body for different age groups are given below.

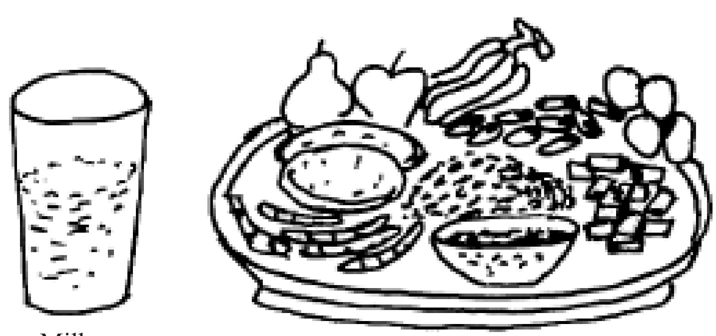
Table 28.6 Energy requirements of body

Group	Sex	Age/Profession	Required calories
Infants	-	0-12 months	100-120/kg body weight
Children	-	2-6 years	1200-1800
		7-12 years	1800-2000
Adolescent	Boys	13-15years	2500
	Girls	13-15 years	2200
Adult	Man	Sedentary work	2400
		Moderate physical work	2800
		Heavy physical work	4000
	Woman	Moderately active	2400
		Pregnancy (later half) during lactation (upto 1 year)	3300 3700

Growing children, persons engaged in hard physical work (labourers), pregnant women, lactating mothers, sportsman, persons recovering from illness and persons working in cold weather require more energy.

28.4 BALANCED DIET

You have studied that our balanced diet consists of all the nutrients in varying amounts. (Fig. 28.3)



Milk

Apple, chapati, green vegetables, eggs
paneer, dal, rice, banana

Fig. 28.3 Sample of a balanced meal.

To maintain proper health, one needs the right type of food in right quantity. The need generally varies with age, sex, type of work and state of body, (See Table 28.6).

A balanced diet is one that contains all essential nutrients in suitable proportion and amount to provide necessary energy and keeps the body in a healthy state.

A balanced diet has the following qualities :

– it meets the nutrient requirement of the body,

– it consists of different types of food items,

– it provides adequate amount of energy,

The box given below shows recommended dietary requirements according to age, sex and different physical activities.

Recommended dietary requirements (in gram) according to age, sex and different physical activities

Food items	Adult man			Adult woman			Children		Boys	Girls
	Sedentary	Moderate Work	Heavy Work	Sedentary	Moderate Work	Heavy Work	1-3 years	4-6 years	10-12 years	10-12 years
Cereals,	460	520	670	410	440	570	175	270	420	380
Pulses	40	50	60	40	45	50	35	35	45	45
Leafy vegetables	40	40	40	100	100	50	40	50	50	50
Other vegetables	60	70	80	40	40	100	20	30	50	50
Roots and tubers	50	60	80	50	50	60	10	20	30	30
Milk	150	200	250	100	150	200	300	250	250	250
Oils and fats	40	45	65	20	25	40	15	25	40	35
Sugar and jaggery	30	35	55	20	20	40	30	40	45	45
Fruits	20	30	30	30	30	30	5	10	10	10

28.4.1 Balanced diet for special needs

Balanced diet varies with age, occupation, and state of health. Under special conditions more food is required by an individual. Let us learn about it.

1. Nutritional needs for growing children

Growing children need more food in proportion to their body weight. They need –

(i) extra protein to make new tissues for growth,

(ii) more calcium and phosphorous for formation of bones and red blood cells,

(iii) vitamin A for development of healthy eyesight,

(iv) vitamin C for general health, and

(v) vitamin D for healthy bones.

2. Nutritional needs for persons in different occupations

Persons doing hard physical work like rickshaw pullers, labourers, carpenters, mill workers. require food which is rich in energy (carbohydrates and fats). Similarly, athletes also require diet of high energy value.

3. Nutritional needs during pregnancy and lactation

A pregnant women has to feed the developing embryo, therefore, she has special need for extra nutrients.

The pregnant women and lactating mothers should take,

(i) extra protein for tissue growth

(ii) more calcium and phosphorus to form bones of the baby

(iii) more iron for making sufficient blood of the baby

(iv) more carbohydrates for herself because extra energy is required to carry out all the building processes linked with embryo.

Similarly, nursing mothers (who breast feed their babies), also need a special diet to take care of their additional requirements of lactation (milk formation). So their diet should contain more proteins, calcium and vitamins.

4. Nutritional needs depending upon the state of health

The persons recovering from illness need more proteins, minerals and vitamins in their diet to repair the damage caused by the ailment. If there is loss of blood due to surgery or an accident the patient needs more of proteins and iron to make up for the loss of blood.

28.5 WHAT IS HEALTH AND DISEASE?

According to the World Health Organisation (WHO), health is defined as:

Health is a state of complete physical, mental, and social well being and not merely absence of disease or infirmity.

Disease :

Disease is a malfunctioning process related to a certain part of the whole body in which normal functions are disturbed or damaged. Disease literally means not at ease (dis = not)

Deficiency diseases :

The diseases which occur due to deficiency of one or more nutrients (proteins,carbohydrates, vitamins and minerals) in our diet are called **deficiency diseases**.

Malnutrition : The condition resulting from lack of nutrients in the diet is called malnutrition.

A large number of people in our country suffer from malnutrition. Malnutrition affects the health of the children adversely as it results in physical and mental retardation.

The deficiency diseases are of three types :

- Protein Energy Malnutrition (PEM)
- Mineral deficiency diseases.
- Vitamin deficiency diseases.

Let us learn in some detail about some of these diseases:

28.5.1 Protein energy malnutrition (PEM)

Generally the growing children suffer from protein energy malnutrition as the required amount of proteins needed for their growth and development is not available. A number of children in the age group of 1-5 years suffer from this disease. PEM is due to two reasons :

(a) Lack of proteins or carbohydrates or both in the diet.

(b) More intake of carbohydrates than proteins.

Protein energy malnutrition results in two diseases :

(i) Marasmus, and

(ii) Kwashiorkor

Marasmus

It is caused due to the deficiency of carbohydrates, fats and proteins. It usually affects infants below the age of one year (Fig. 28.4a)

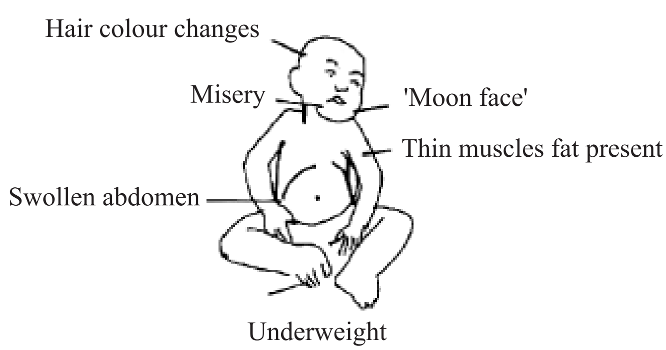


Fig. 28.4(a) A child suffering from marasmus

Symptoms

– wasting of muscles reduces the child to skin and bones.

– folded skin.

– sunken eyes, thin face, thinning of limbs and abdominal walls.

- retarded physical and mental growth.
- ribs become prominent (Pigeon chest).
- Oedema and skin pigmentation are absent.

Kwashiorkor

This disease develops when mothers stop feeding their babies with breast milk and the child is given traditional family food having low protein in it. (Fig. 28.4b)

Fig. 28.4(b) A child suffering from kwashiorkor

Symptoms :

A child suffering from Kwashiorkor disease shows the following symptoms

- under weight
- has protruding bellly
- the skin is dark and scaly
- has enlarged liver
- has anaemia
- suffers from repeated diarrhoea
- stunted growth
- loss of appetite
- hair becomes reddish
- swelling of legs and feet due to retention of water by the cell (oedema)

Cure : The child suffering from kwashiorkor and marasmus can recover if adequate protein and carbohydrate rich food is given.

28.6 MINERAL DEFICIENCY DISEASES

Common deficiency diseases of iron, calcium and iodine are given below:

Anaemia (Iron deficiency) : Iron is important for the formaiton of the respiratory pigment **haemoglobin** present in blood. Deficiency of iron results in reduction of red blood cells. This reduces the oxygen carrying capacity of blood.

A person suffering from Anaemia becomes pale, tires easily, loses appetite and loses weight.

Cure : This disease can be cured by eating food stuff rich in iron and vitamin B12, e.g. eggs, meat, liver, milk, green leafy vegetables, such as spinach and fruits like apple, banana, guava (Iron tablets and tonics can also supplement the food).

Deficiency of calcium, phosphorus and vitamin D

Calcium : Chief constituent of bones and teeth, regulates heart beat and muscle contraction, helps in the clotting of blood. Calcium metabolism is closely related to that of phosphorus and vitamin D.

Deficiency of calcium causes : Rickets in children and Osteomalacia in adults.

Rickets (See Figure 28.2)

(i) The bones become soft, get deformed or bend easily,

(ii) bow legs (bent legs),

(iii) pigeon chest,

(iv) loss of teeth enamel (outer shiny layer in teeth), and

(v) tender (soft) bones that tend to fracture easily.

Osteomalacia :

The persons suffering from osteomalacia show

(i) softening of bones

(ii) pain in bones which tend to fracture easily.

Cure : Rickets and osteomalacia can be prevented by giving diet rich in calcium like milk, cod liver oil, egg yolk, and green leafy vegetables.

Goitre

Iodine is essential for the synthesis of thyroxine (hormone produced by thyroid gland). Iodine deficiency causes thyroid gland to enlarge and swell, this is called goitre. (Fig. 28.3).

Symptoms

The person suffering from goitre has

(i) protruding eyes,

(ii) stunted growth,

(iii) puffy appearance

(iv) irregular heart beat

(v) low intelligence

(vi) deficiency of iodine results in another disease called cretinism

Cure : Use of iodised table salt and eating sea food, and fish.

Cretinism

The person suffering from cretinism shows stunted growth, retarded mental growth, delayed puberty and low metabolic rate.

28.7 VITAMIN DEFICIENCY

If the diet is deficient in one or more vitamins like A, B complex, C, D, E and K, it leads to a variety of diseases as given in table 28.3

INTEXT QUESTIONS 28.2

1. Define malnutrition.

   ....

2. What is PEM ? Name two diseases caused due to PEM.

   ....

3. A person has low haemoglobin content, tires easily and looks pale. Name the disease he is suffering from.

   ....

4. Give two food items which can prevent vitamin D deficiency.

   ....

28.8 OBESITY AND EXCESSIVE INTAKE OF FOOD

If a person continues to eat more food than required by his body, he soon becomes overweight and bulky. Excess of carbohydrates and fats instead of providing energy get accumulated in the body.

The overweight and bulkiness of a person's body due to accumulation of carbohydrate and fat is called obesity.

Causes of Obesity

(i) Overeating

(ii) Insufficient exercise

(iii) Hormonal imbalance (deficiency of thyroxine) or other metabolic disturbances.

Harmful effects

An obese person tends to have high cholesterol (fatty substance) deposited in blood arteries. This leads to **hypertension** (high blood pressure) **atherosclerosis** (hardening of arteries), **coronary attack** (heart attack), diabetes and respiratory problems.

Methods to prevent obesity

The obese person should be very careful about diet. Some suggestions are :

(i) avoid fried food

(ii) not to take carbohydrate rich foods

(iii) not to take saturated fats like ghee and vansaspati hydrogenated vegetable oils. Instead, take unsaturated fats like oils, and that too in as little quantity as possible.

(iv) take regular physical exercise.

(v) eat green leafy vegetables (to add roughage).

(vi) if suffering from hormonal imbalance, take the advise of a physician

Effects of excessive intake of Iron

It leads to a condition called hemosiderosis (large deposits of iron in the liver). This may cause

(i) Constipation and diarrhoea
(ii) Nausea and vomitting
(iii) Heart burn
(iv) Epigastric pain

Effect of excessive intake of vitamins (Hyper vitaminosis)

Some persons tend to take vitamins in excess amounts. An excessive intake of water solouble vitamins (vitamins B complex and C) may not cause any harm to the body because they are excreted out through urine. Intake of fat soluble vitamins (vitamin A and D) can be toxic (poisonous) to the body which may lead to certain diseases.

The disease caused by presence of vitamins in excessive quantities in the body is called **hypervitaminosis.**

Hypervitaminosis A

Excess vitamin A accumulation in liver is toxic. This results in

(i) loss of hair
(ii) drowsiness
(iii) painful swelling of long bones
(iv) loss of appetite,
(v) nausea and vomitting.

Hypervitaminosis D

Excess of vitamin D leads to high calcium absorption in the intestine. This results in :

(i) deposition of calcium in soft tissues of body like kidney,
(ii) drowsiness,
(iii) nausea,
(iv) loss of weight.

So we find that both, deficiency and excess of nutrients is harmful to the body.

INTEXT QUESTIONS 28.3

1. List any two causes of obesity.

   (i) ....

   (ii) ....

2. Suggest two methods to prevent obesity

   (i) ....

   (ii) ....

3. Mention two symptoms of excessive intake of Iron.

   (i) ....

   (ii) ....

4. Define hypervitaminosis. Name two vitamins which when taken regularly in diet cause hypervitaminosis.

   (i) ....

   (ii) ....

WHAT YOU HAVE LEARNT

- Food is required for the proper growth and development of the body.
- Food provides nutrients required for a healthy body.
- Carbohydrates, fats, proteins and water are macronutrients whereas vitamins and minerals are micronutrients. In addition, roughage is also as important component of our diet.
- Food has six major components
- Food can be classified into three types : Energy giver-carbohydrates and fats, body building-proteins, protective/regulatory-minerals and vitamins.
- The requirement of energy and different nutrients for the body are needed according to age, sex and profession as well as state of the body.
- A balanced diet provides proper amount of carbohydrates, fats, proteins, minerals, water and vitamins in food.
- A balanced diet is essential for proper growth and health of an individual.
- Malnutrition is the lack of essential nutrients or food elements in the diet. It results in deficiency diseases.
- an excessive intake of fat solutble vitamins A and D results in hypervitaminosis.
- An excessive intake of food for prolonged periods results in obesity. An obese person suffers from cardiovascular diseases, respiratory problems and diabetes.

TERMINAL EXERCISES

1. Differentiate between
   (i) Marasmus and Kwashiorkor.
   (ii) Rickets and Osteomalacia
   (iii) Essential and non-essential amino acids
   (iv) Body-building and protective foods.
   (v) Water soluble vitamins and fat soluble vitamins.
2. Give reasons why do children of 1-5 years develop **PEM**.
3. Why one should include more than one type of proteins in the meals?
4. What is the importance of water in the diet ?
5. What is a balanced diet ? Why does a pregnant women or a nursing mother needs special diet ?
6. Why should food contain roughage ? Name two sources of roughage in our diet.
7. Why is polishing of rice not advisable ? If a person always consumes polished rice, what is he likely to suffer from ? Give two sysmptoms.
8. State **four** important functions of food.
9. If a child is not able to see in dim light, which two food stuffs will you advise him to eat. Give reasons.
10. Name **two** sources rich in

(i) Vitamin A	(ii) Calcium	(iii) iron
(iv) Vitamin B12	(v) starch	(vi) Glucose

11. What are minerals ? Name any two minerals and their sources.
12. What are deficiency diseases ? Name two diseases caused by the deficiency of protein and carbohydrates. Also write the symptoms of these deficiency diseases.

ANSWERS TO INTEXT QUESTIONS

28.1 1. Nutrition : Sum of the processes by which an organism takes in, metabolises and utilises food substances.

Nutrients : Substances which help in maintaining proper health and are required for the survival of an individual.

2. (a) Carbohydrates, fats, proteins, minerals, vitamins and water.

3. Nutrients required in large quantities are called macronutrients such as carbohydrates fats, proteins and water.

   Nutrients required in small amounts are micronutrients e.g. minerals and vitamins

4. (i) Water soluble-vitamin B and C (ii) leafy vegetables, fruits, (iii) milk, fish.

5. Butter

28.2

1. The condition resulting from lack of essential nutrients in diet is malnutrition

2. Protein Energy Malnutrition; Marasmus, Kwashiorkor

3. Anaemia

5. milk, cod liver oil, egg yolk, exposure to light (Any two)

28.3

1. Over eating, lack of exercises, hormonal imbalance.

2. Avoid fried food, carbohydrates, take regular exercise, eat green leafy vegetable (Any two).

3. Constipation, Diarrhoea, epigastric pain (any two).

4. Excess presence of vitamins in the body. vitamin A and D.

29

SOME COMMON HUMAN DISEASES

In the previous lesson you have read about the diseases due to nutritional deficiencies. In this lesson, you will learn about diseases caused due to other reasons.

OBJECTIVES

After completing this lesson, you will be able to :

- *define a disease and learn its types;*
- *differentiate between parasite and pathogen;*
- *differentiate between infection and infestation;*
- *list the symptoms, causative agents, prevention and control of influenza, measles, polio, hepatitis, tuberculosis, diphtheria, leprosy, malaria, filariasis and dengue.*
- *identify certain diseases that are caused due to improper functioning of some organs of the body system;*
- *describe the causes, symptoms and prevention and cure for hypertension;*
- *list the symptoms of and methods for diagnosing coronary heart disease and suggest preventive measures;*
- *describe the cause, the symptoms, preventive and curative methods of diabetes mellitus and osteoporosis;*
- *recognize cancer as a cell-regulation disorder;*
- *define and differentiate between benign and malignant tumors;*
- *interpret the category of allergies as immune system related disorders;*
- *define the special category of sexually transmitted diseases;*

- *list the causative agents, symptoms, prevention and control of syphilis, gonorrhea and AIDS;*
- *define drug abuse and its prevention.*

29.1 DISEASES

29.1 What is a disease?

Any malfunctioning process which interferes with the normal functioning of the body is called a disease. In other words, disease may be defined as a disorder in the physical, physiological, psychological or social state of a person caused due to nutritional deficiency, physiological disorder, genetic disorder, pathogen or any other reason.

29.1.1 Types of Diseases

The diseases may be classified into two broad categories (Table 29.1).

Table 29.1 Classification of human diseases

- Diseases
  - Congenital diseases (Present since birth)
  - Acquired diseases (Develop after birth)
    - Communicable diseases (Spread from infected person to healthy person
    - Non-communicable diseases (do not spread from a diseased person to a healthy person)
      - Degenerative diseases (caused due to malfunctioning of vital body organ)
      - Deficiency diseases (caused due to lack of nutrients in diet)
      - Allergies (caused due to hypersensitivity of the body to certain foreign substances)
      - Cancer (caused due to uncontrolled growth of cells/ tissues)
      - Other diseases (caused due to various physical agents or any other reason)

A. Congenital disease : The disease which is present from birth (e.g. hole in the heart in infants). They are caused by some genetic abnormality or metabolic disorder or malfunctioning of an organ.

B. Acquired disease : The disease which may occur after birth during one's lifetime.

Acquired diseases may generally be classified into :

(i) **Infectious diseases :** The diseases which can be transmitted from diseased healthy person person to e.g. measles.

(ii) **Degenerative diseases :** The diseases caused by the malfunction of some vital organs of the body e.g. heart failure.

(iii) **Deficiency diseases :** These are caused due to nutritional deficiency such as that of minerals or vitamins in the diet e.g. anaemia (Fe), Beri- beri (vitamin B). You have read about such diseases in an earlier lesson 27.

(iv) **Cancer :** This is an abnormal, uncontrolled and unwanted growth of cells. e.g. breast cancer.

Acquired diseases are studied under two categories (Table 29.2).

(i) **Communicable diseases :** The diseases which can be transmitted from an infected person to a healthy person.

(ii) **Non-communicable diseases :** These diseases do not spread from an affected person to a healthy person.

Table 29.2 Differences between communicable and non-communicable diseases

Communicable diseases	Non-communicable diseases
1. Caused by some biological agents or pathogens, such as viruses, bacteria, protozoans and helminths (worms).	Caused due to some specific factor, such as malfunctioning of some vital organ, and deficiency of nutrients.
2. Spread from one person to another through contact, water, air, and food, etc.	Do not spread from one person to another by contact.
3. The concern of the diseases involves the society as these are related to community health.	The concern of the disease is restricted to the individual only.

29.1.2 Modes of Spread of Communicable Diseases

Communicable diseases spread from the infected person to a healthy person in the following ways.

Direct transmission

The pathogens of diseases infect a healthy person directly without an intermediate agent. It can take place by various means such as,

(i) **Direct contact between the infected person and the healthy person :** Diseases like small pox, chicken pox, syphilis, gonorrhoea spread through direct contact.

(ii) **Droplet infection :** The infected person throws out tiny droplets of mucus by coughing, sneezing or spitting. These droplets may contain the pathogen. By inhaling the air containing the droplets, a healthy person may get the infection. Diseases like common cold, pneumonia, influenza, measles, tuberculosis and whooping cough spread through droplet infection.

(iii) **Contact with soil** contaminated with disease-causing viruses and bacteria.

(iv) **Animal bite :** Viruses of rabies are introduced through the wound caused by the bite of rabid animals, especially dogs. The virus is present in the saliva of the rabid animals.

Indirect transmission

The pathogens of certain diseases reach the human body through some intermediate agents. It can take place by various means, which are as follows :

(i) **By vectors such as houseflies, mosquitoes, and cockroaches.** Examples: Houseflies carry the causative organisms of cholera on their legs and mouth parts from the faeces and sputum of infected persons to food and drinks and contaminate them. When this contaminated food is taken by a healthy person, he gets the infection. Similarly, mosquitoes carry virus of dengue and malarial parasite which causes malaria.

(ii) **Air-borne :** The pathogens may reach humans with air and dust. The epidemic typhus spreads by inhalation of dried faeces of infected fly.

(iii) **Object borne (Fonite borne) :** Many diseases are transmitted through the use of contaminated articles, such as clothes, utensils, toys, door handles, taps, syringes and surgical instruments.

(iv) **Water borne :** If potable water (drinking water) is contaminated with pathogens of diseases such as cholera, diarhhoea, hepatitis or jaundice, it reaches a healthy person upon consuming such water.

29.2 SOME IMPORTANT TERMS TO REMEMBER

Pathogen : A living organism which causes a disease.

Parasite : An organism which gets food and shelter from host.

Host : The living body on or inside which the disease-producing organism takes shelter.

Infestation : Presence of a large number of parasitic organisms on the surface of body of the host or on the clothings.

Vector : It is an organism which harbours a pathogen and may pass it on to another person to cause a disease (Mosquitoes harbour malarial parasite and transmits it to humans).

Carrier : It is an organism which itself does not harbour the pathogen but physically transmits it to another person (Housefly is the carrier of cholera germs).

Reservoir : An organism which harbours pathogens in large numbers that do not cause any suffering to it.

Epidemic : Spreading of a disease among a large number of people causing a huge loss of life in the same place for some time e.g. plague.

Endemic : A disease which is regularly found among a particular group of people e.g. goitre, restricted to a certain locality or a country.

Pandemic : A disease which is found all over the world e.g. AIDS.

Interferon : Type of proteins produced by infected cells of the body when attacked by a virus, which act to prevent the further development of the same virus.

Inoculation : Introduction of antigenic material inside the body to prevent suffering from a disease.

Vaccination : Injection of a weak strain of a specific bacterium (Vaccine) in order to secure immunity against the corresponding disease. It is also called immunisation.

Incubation period : The period between entry of pathogen inside a healthy body and appearance of the symptoms of the disease.

Symptoms : Specific morphological or physiological expressions which appear on the deseased organism and help in the identification of the disease.

INTEXT QUESTIONS 29.1

1. Define the term disease. ....
2. Give appropriate terms for
   (i) the kind of disease which is present from birth.. ....
   (ii) disease caused by malfunctioning of vital organs. ....
3. Name any two communicable and any two non-communicable diseases in humans
   ....
4. What does infestation mean?
   ....

29.3 COMMUNICABLE DISEASES (INFECTIOUS DISEASES)

The diseases which spread from one diseased person to another through contaminated food, water or contact or through insecticides, and animals are called the communicable diseases. These are caused by different causative agents (pathogens).

29.3.1 Diseases caused by viruses

1. Chicken pox

Pathogen : Chicken pox virus (voricella)

Mode of transmission : By contact or through scabs

Incubation period : 12-20 days

Symptoms

(i) Fever, headache and loss of appetite

(ii) Dark red-coloured rash on the back and chest which spreads on the whole body. Later, rashes change into vesicles.

(iii) After few days these vesicles start drying up and scabs (crusts) are formed.

(v) These scabs start falling (infective stage)

Prevention and cure

There is no vaccine against chicken pox as yet. But precautions must be taken as follows:

(i) The patient should be kept in isolation.

(ii) Clothings and utensils, used by the patient should be sterilised.

(iii) Fallen scabs should be collected and burnt.

One attack of chicken pox gives life long immunity to the person recovered from this disease.

2. Measles

Pathogen : Virus (*Rubeola*)

Mode of transmission : By air

Incubation period : 3-5 days

Symptoms

(i) Common cold

(ii) Appearance of small white patches in mouth and throat.

(iii) Appearance of rashes on the body.

Prevention and cure

(i) The patient should be kept in isolation.

(ii) Cleanliness should be maintained.

(iii) Antibiotics check only the secondary infections which can easily recur.

3. Poliomyelitis

Pathogen : Polio Virus

Mode of transmissions : Virus enters inside the body through food or water.

Incubation period : 7-14 days

Symptoms

(i) The virus multiplies in intestinal cells and then reaches the brain through blood.

(ii) It damages brain and nerves and causes infantile paralysis.

(iii) Stiffness of neck, fever, loss of head support.

Prevention and Cure

Polio vaccine drop (oral polio vaccine, OPV) are given to children at certain intervals.

Pulse polio programme is organised in our country to give polio vaccine to children.

4. Rabies (also called hydrophobia)

Pathogen : Rabies virus

Mode of Transmission : Bite by a rabid dog.

Incubation period : 10 days to 1-3 months depending upon the distance of bite from Central Nervous System (CNS), that is the brain or spinal cord.

Symptoms

(i) Severe headache and high fever.

(ii) Painful contraction of muscles of throat and chest.

(iii) Choking and fear of water leading to death.

Prevention and Cure

(i) Compulsory immunisation of dogs.

(ii) Killing of rabid animals.

(iii) Anti-rabies injections or oral doses are given to the person bitten by a rabid animal.

5. Hepatitis

Pathogen : Hepatitis B virus.

Mode of Transmission : Mainly through contaminated water.

Incubation Period : Generally 15-160 days.

Symptoms

(i) Bodyache.

(ii) Loss of appetite and nausea.

(iii) Eyes and skin become yellowish, urine deep yellow in colour (due to bile pigments).

(iv) Enlarged liver.

Prevention and Cure

(i) Hepatitis B vaccine is now available in India.

(ii) Proper hygeine is to be observed.

(iii) Avoid taking fat rich substances.

6. Influenza

Influenza, commonly known as ‘flu’ is an illness caused by viruses that infect the respiratory tract. Compared to common cold, influenza is a more severe illness.

Causes

Influenza is caused by a virus which attacks our body’s cells, resulting in various effects depending on the strain of the virus.

There are many strains of influenza virus. The virus mutates all the time and new variations (strains) arise. This constant changing enables the virus to evade the immune system of its host. Unfortunately immunity against one strain (which is conferred by exposure or immunisation) does not protect against other strains. A person infected with influenza virus develops antibodies against that virus; as the virus changes, the antibodies against the virus do not recognize the changed virus, and influenza can recur, caused by the changed or mutated virus.

Symptoms

Typical symptoms of influenza include:

(i) fever (Usually 100° F to 103° F in adults and often even higher in children).

(ii) respiratory tract infection symptoms such as, cough, sore throat, running nose, headache, pain in the muscles, and extreme fatigue.

Although nausea and vomiting and diarrhoea can sometimes accompany Influenza infection, especially in children, gastrointestinal symptoms are rarely prominent.

Most people who get flu, recover completely in 1 to 2 weeks, but some people develop serious and potentially life-threatening complications, such as pneumonia.

Treatment and Control

(i) Much of the illness and death caused by influenza can be prevented by annual influenza vaccination. Influenza vaccine is specifically recommended for those who are at high risk for complications with chronic diseases of the heart, lungs or kidneys, diabetes, or severe forms of anaemia.

(ii) The persons suffering from influenza should

- drink plenty of fluids
- take symptom relief with paracetamol, aspirin (not in children under the age of 16) or ibuprofen as recommended by the doctor.
- Consult doctor immediately for treatment.

7. Dengue

Dengue is an acute fever caused by virus. It is of two types: (i) Dengue fever, (ii) Dengue hemorrhagic fever.

Dengue fever is characterized by an onset of sudden high fever, severe headache, pain behind the eyes and in the muscles and joints.

Dengue hemorrhagic fever is an acute infectious viral disease. It is an advanced stage of dengue fever. It is characterized by fever during the initial phase and other symptoms like headache, pain in the eye, joint pain and muscle pain, followed by signs of bleeding, red tiny spots on the skin, and bleeding from nose and gums.

How does Dengue spread?

Dengue spreads through the bite of an infected *Aedes aegypti* mosquito. The transmission of the disease occurs when a mosquito bites an infected person and subsequently bites a healthy person. In doing so, it transmits blood containing the virus to the healthy person and the person becomes infected with dengue. The first symptoms of the disease occur about 5 to 7 days after the infected bite.

Aedes mosquito rests indoors, in closets and other dark places, and is active during day time. Outside, it rests where it is cool and shaded. The female mosquito lays her eggs in stagnant water containers such as coolers, tyres, empty buckets, in and around homes, and other areas in towns or villages. These eggs become adults in about 10 days.

Incubation period

The time between the bite of a mosquito carrying dengue virus and the start of symptoms averages 4 to 6 days, with a range of 3 to 14 days.

Diagnosis

Diagnosis is made through blood tests by scanning for antibodies against dengue viruses. In addition the blood platelet counts also get drastically reduced in the infected person.

Symptoms

Symptoms of Dengue fever

(i) Sudden onset of high fever, generally 104-105 °F (40 °C), which may last 4-5 days.

(ii) Severe headache mostly in the forehead.

(iii) pain in the joints and muscles, body aches.

(iv) Pain behind the eyes which worsens with eye movement.

(v) Nausea or vomiting.

Symptoms of Dengue hemorrhagic fever

These include symptoms similar to dengue fever, plus other symptoms such as:

(i) Severe and continuous pain in the abdomen.

(ii) Rashes on the skin.

(iii) Bleeding from the nose, mouth, or in the internal organs.

(iv) Frequent vomiting with or without blood.

(v) Black stools due to internal bleeding.

(vi) Excessive thirst (dry mouth).

(vii) Pale, cold skin, weakness.

Prevention

Following steps can be taken to prevent spread of dengue fever:

(i) Avoid water stagnation for more than 72 hours so that the mosquitoes do not breed there.

(ii) Prevent mosquito breeding in stored water bodies, like ponds, and wells.

(iii) Destroy discarded objects like old tyres and bottles, as they collect and store rain water.

(iv) Use mosquito repellents and wear long sleeved clothes to curtail exposure.

(v) Use mosquito nets, also during daytime.

(vi) Avoid outdoor activities during dawn or dusk when these mosquitoes are most active.

(vii) Patients suffering from dengue fever must be isolated for at least 5 days.

(viii) Report to the nearest health centre for any suspected case of Dengue fever.

Treatment for dengue and dengue hemorrhagic fever

There is no specific treatment for dengue fever. Persons with dengue fever should rest and drink plenty of fluids. Dengue hemorrhagic fever is treated by replacing lost fluids. Some patients need blood transfusions to control bleeding.

INTEXT QUESTIONS 29.2

1. How does chicken pox spread?

   ....

2. Mention the most obvious symptom of measles.

   ....

3. Which organ system of the body is affected by the polio virus?

   ....

4. Name the causative organism of hydrophobia.

   ....

5. Which mosquito spreads dengue?

   ....

29.3.2 Diseases caused.by Bacteria

1. Tuberculosis

Pathogen : A bacterium (*Mycobacterium tuberculosis*).

Mode of Transmission : airborne-discharged through sputum, cough and sneeze, of the infected person.

Incubation period : 2-10 weeks during which the bacteria produce a toxin, tuberculin.

Symptoms

(i) Persistent fever and coughing.

(ii) Chest pain and blood comes out with the sputum.

(iii) General weakness.

Prevention and Cure

(i) Isolation of patient to avoid spread of infection.

(ii) BCG vaccination is given to children as a preventive measure.

(iii) Living rooms should be airy, neat and with clean sorroundings.

(iv) Antibiotics be administered as treatment.

2. Typhoid

Pathogen : A Bacillus rod-shaped bacterium (*Salmonella typhi*)

Mode of transmission : Through contaminated food and water

Incubation period : About 1-3 weeks

Symptoms

(i) Continuous fever, headache, slow pulse rate.

(ii) Reddish rashes appear on the belly.

(iii) In extreme cases, ulcers may rupture resulting in death of the patient.

Prevention and Cure

(i) Anti-typhoid inoculation should be given.

(ii) Avoid taking exposed food and drinks.

(iii) Proper sanitation and cleanliness should be maintained.

(iv) Proper disposal of excreta of the patient.

(v) Antibiotics should be administered.

3. Cholera

It often breaks out among people in crowded areas and the areas with poor sanitary conditions.

Pathogen : Comma shaped bacterium (*Vibrio cholerae*)

Mode of transmission : Contaminated food and water. Housefly is the carrier.

Incubation period : 6 hours to 2-3 days.

Symptoms

(i) Acute diarrohoea and watery stool.

(ii) Muscular cramps.

(iii) Loss of minerals through urine.

(iv) Dehydration leads to death.

Prevention and cure

(i) Cholera vaccination should be given.

(ii) Electrolytes (Na, K, sugar) dissolved in water should be given to the patient to check dehydration (In market it is available as ORS–oral rehydration solution).

(iii) Proper washing and cooking of food.

(iv) Proper disposal of vomit and human excreta.

(v) Flies should not be allowed to sit on eatables and utensils.

4. Diphtheria

This disease generally occurs in children of 1-5 years of age.

Pathogen : Rod-shaped bacterium (*Cornybacterium diphthereae*)

Mode of Transmission : Through air (droplet infection)

Incubation period : 2-4 days

Symptoms

(i) Slight fever, Sore throat and general indisposition.

(ii) Oozing semisolid material in the throat which develops into a tough membrane. The membrane may cause clogging (blocking) of air passage, resulting into death.

Prevention and cure

(i) Immediate medical attention should be given.

(ii) Babies should be given DPT vaccine.

(iii) Sputum, oral and nasal discharges of the infected child should be disposed off.

(iv) Antibiotics may be given under doctor's supervision.

(v) Isolation of the infected child.

5. Leprosy

Pathogen : A bacterium (*Mycobacterium leprae*)

Mode of transmission : Prolonged contact with the infected person. Nasal secretions are the most likely infectious material for family contacts.

Incubation period : 1-5 years

Symptoms

(i) Affects skin.

(ii) Formation of nodules and ulcer.

(iii) Scabs and deformities of fingers and toes.

(iv) Infected areas lose sensation.

Prevention and Cure

(i) The children should be kept away from parents suffering from leprosy.

(ii) Some medicine may arrest the disease and prevent from spreading.

INTEXT QUESTIONS 29.3

1. Name the causative bacterium of (i) TB (ii) Typhoid (iii) Cholera.

   ....

2. State the most obvious symptom of diphtheria.

   ....

3. What is the mode of transmission of leprosy.

   ....

29.3.3 Diseases caused by protozoans

1. Malaria

Pathogen : Malarial parasite (different species of *Plasmodium*)

Mode of transmission : By bite of female *Anopheles* mosquitoes

Incubation period : Approximately 12 days

Symptoms

(i) Headache, nausea and muscular pain.

(ii) Feeling of chilliness and shivering followed by fever which becomes normal along with sweating after some time.

(iii) The patient becomes weak and anaemic.

(iv) If not treated properly secondary complications may lead to death.

Prevention and cure

(i) Fitting of double door and windows (with "Jali" i.e. wire mesh) in the house to prevent entry of mosquitoes.

(ii) Use of mosquito net and mosquito repellents.

(iii) No water should be allowed to collect in ditches or other open spaces to prevent mosquito breeding.

(iv) Sprinkling of kerosene oil in ditches or other open spaces where water gets collected.

(v) Antimalarial drugs to be taken.

2. Amoebiasis (Amoebic dysentery)

Pathogen : *Entamoeba histolytica*

Mode of transmission : Contaminated food and water

Symptoms

(i) Formation of ulcers in intestine.

(ii) Feeling of abdominal pain and nausea.

(iii) Acute diarrhoea and mucus in stool.

Prevention and cure

(i) Proper sanitation should be maintained.

(ii) Vegetables and fruits must be properly washed before eating.

(iii) Antibiotics may be given to the patients.

29.3.4 Diseases caused by worms (helminths)

1. Filariasis

Pathogen : Filarial worm (*Wucheraria bancrofti*)

Mode of transmission : Bites of mosquitoes - *Aedes* and *Culex*.

Symptoms

(i) Fever

(ii) Collection of endothellial cells and metabolites in the wall of lymph vessels.

(iii) Swelling takes place in certain parts of the body like legs, breasts, and scrotum.

(iv) Swelling of legs which appear as legs of elephant, so this disease is also called elephantiasis (Fig. 29.1)

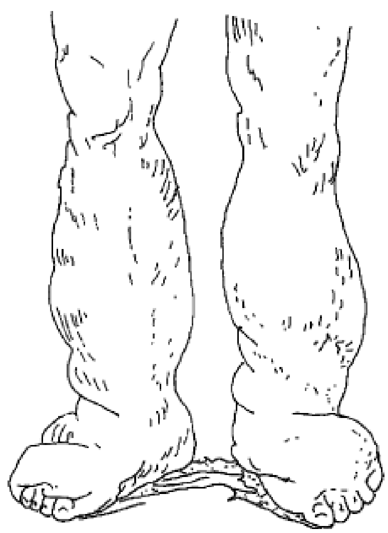


Fig. 29.1 Patient suffering from Elephantiasis.

Prevention and cure

(i) Mesh doors and windows in the house to check the entry of mosquitoes.

(ii) The water collected in tanks or other articles should be properly covered.

(iii) Sprinkling of kerosene in ditches.

(iv) Drugs may be administered.

INTEXT QUESTIONS 29.4

1. Which mosquito carries stages of life history of the malarial parasite?

   ....

2. Which protozoan causes amoebic dysentery?

   ....

3. Name the disease cause by *Wuchrareria bancrofti*.

   ....

29.4 NON-COMMUNICABLE DISEASES

1. Diabetes mellitus

The disease can be diagnosed by blood test or urine test.

Causes

(i) Less secretion of insulin hormone from the pancreas.

(ii) Mental stress

(iii) Through heredity from parents to children.

Symptoms

(i) More glucose in blood.

(ii) Excessive and frequent passing of urine.

(iii) Feeling thirsty and hungry frequently.

(iv) Reduced healing capacity of injury.

(v) General weakness of the body.

(vi) In extreme cases diabetic coma can take place making the patient unconscious.

Prevention and cure

(i) Control the excessive weight of the body.

(ii) A regulated and controlled diet is to be taken.

(iii) The food should not contain sugar and much carbohydrates.

(iv) Injection of insulin before meals, if required (only on doctor's prescription).

2. Cardio vascular diseases

Common Causes

(i) Deposition of cholesterol (a kind of fat) in the walls of coronary arteries which restrict the flow of blood to the heart muscles. This leads to heart attack.

(ii) Due to reduced blood supply, and reduced oxygen available to the muscles, heart's efficiency is affected.

(iii) Due to stress and strain.

(iv) Obesity (over weight).

(a) Hypertension : (high blood pressure)

Symptoms

(i) Persistent high blood pressure (BP)

(ii) It may damage the arteries of kidney.

(iii) In extreme cases the arteries may burst or blindness may be caused.

(iv) It may also cause paralysis.

Prevention and Cure

(i) Do not build up mental tension.

(ii) Low fat diet should be taken.

(iii) Weight of the body must be kept under control.

(iv) Good eating habits should be cultivated

(v) Medicines may be taken as per doctor's advice.

(b) Coronary heart disease

Symptoms

(i) Severe pain in the chest gasping for breathe.

(ii) Intense nausea and vomiting.

(iii) Lot of sweating takes place.

(iv) Blood clot may be formed within the blood vessels.

Prevention and Cure

(i) A diet low in saturated fats may control the formation of cholesterol.

(ii) Sound eating habits should be developed.

(iii) Over weight should be checked.

(iv) Avoid smoking, alcoholic drinks and drugs.

(v) Take treatment under a qualified doctor.

(vi) Electrocardiogram (ECG) can diagnose the disease.

(vii) By-pass surgery is performed in extreme cases.

3. Osteoporosis

Osteoporosis is an age dependent disorder with loss of the normal density of bone. The bones become fragile and are easily fractured. Bones that are affected by osteoporosis can fracture with only a minor fall or injury. Elderly men and women are most susceptible because of hormonal changes which occur with advancing age.

Symptoms

(i) The persons suffering from osteoporosis may not know about their condition for a long time, because osteoporosis doesn't cause clear cut symptoms and one may not realise till a bone fracture.

(ii) The symptoms of osteoporosis are related to the location of the fracture.

(iii) Fractures of the spine can cause severe 'band like' pain that radiates around from the back to the side of the body. Repeated spine fractures can cause chronic lower back pain, as well as curving of the spine, which gives the individual a hunched-back appearance.

(iv) Some patients with osteoporosis develop stress fractures of the feet while walking or stepping off. Hip fractures typically occur as a result of a fall. With osteoporosis, hip fractures can occur upon even minor accidents. Hip fractures may take a very long time to heal because of poor bone quality.

Treatment

(i) Patients suffering from osteoporosis are generally treated with vitamin D and calcium supplements. In addition they are advised bed rest so that the condition does not worsen.

(ii) Changes to lifestyle and diet are also recommended. The patients are advised to take calcium either via dietary means or via supplements in the form of tablets. Since body absorbs about 500 mg calcium at a given time, the calcium intake should be spread throughout the day.

(iii) Exercise also helps to protect persons from the risk of getting osteoporosis. However, it is important to do exercises for osteoporosis under the guidance of a professional physiotherapist.

4. Cancer

1t is the uncontrolled and unwanted growth of cells.

Cause

(i) No definite cause has been arrived at so far. However, it is found that body has proto-oncogenes. These are activated by some substances or stimulus, which convert these into active cancer-causing oncogenes.

(ii) Heavy smoking and alcoholism.

(iii) Chewing of tobacco.

(iv) Consistent irritation of skin or repeated injury at the same point.

Cancer is a kind of tumorous growth. Tumours can be classified into two categories :

(a) Benign tumour

It remains confined to the place of origin and does not spread to other body parts. It is relatively harmless.

(b) Malignant tumour

It spreads to other parts of the body and growth is rapid. This is serious and may cause death of the patient.

Symptoms

(i) Persistent lump or thickening in tissues, specially in tongue, breast and uterus.

(ii) Any irregular bleeding or blood-tinged discharge from any body opening.

(iii) Any sore that does not heal quickly.

(iv) Change in the form of mole or wart.

(v) Persistent hoarseness in voice, cough or difficulty in swallowing.

Prevention and cure

(i) Cancer check up should be done once a year.

(ii) Treatment should be taken under medical advice.

(iii) Avoid smoking, taking alcohol and chewing of tobacco.

(iv) Observe regularity in life style to keep body healthy.

5. Allergy

(i) Includes a group of non-infectious diseases.

(ii) No definite cause is known

(iii) It is believed that they occur due to hypersensitiviness of certain individuals to foreign matter (allergens) which may enter inside the body.

(iv) Symptoms may be sneezing, gasping, running of eyes, irritation of throat or trachea.

(v) Allergens may be pollen grains, feathers, some animals or insects, drugs, medicines and odour.

INTEXT QUESTIONS 29.5

1. Why is diabetes called a hereditary disease?

   ....

2. What happens to the blood pressure in persons with hypertension?

   ....

3. State one point of difference between malignant and benign tumour.

   ....

29.5 SEXUALLY TRANSMITTED DISEASES

The diseases that are transmitted through sexual contact are known as sexually transmitted diseases. Sexually transmitted diseases are those diseases that are transmitted via the mucous membrane and secretions of the sexual organ, throat and the rectum. Syphilis, gonorrhoea, and AIDS are some sexually transmitted diseases.

29.5.1 AIDS (Acquired Immuno Deficiency Syndrome)

It is a pandemic disease. The word "immuno deficiency" signifies that the immune system becomes very weak. It is a disease of cell-mediated immune system of the body.

Lymphocytes are the main cells of the immune system i.e. T-lymphocytes and B-lymphocytes. 'Helper T' lymphocytes play a great role in regulating the immune system. Damages to or destruction of 'Helper' lymphocytes leads to the development of a cellular immune deficiency which makes the patient susceptible to wide variety of infections.

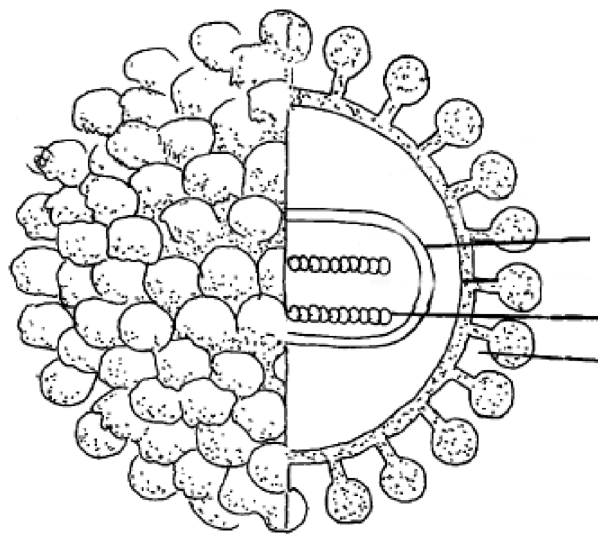


Fig. 29.2 Human Immunodeficiency Virus (HIV)

Mode of transmission : AIDS may be transmitted through any of the following means :

(i) Sexual contact with the affected person. In India, the most common route of HIV transmission is through unprotected heterosexual sex.

(ii) Using the same syringe that was used for affected person.

(iii) Blood transfusion which contains human immuno deficiency virus.

(iv) Organ transplantation of the affected person.

(v) Artificial insemination.

(vi) From mother to new born baby during the process of giving birth.

Incubation period : The average period is 28 months though it may range between 15 to 57 months

Symptoms : The sufferer may show one or more of the following symptoms :

(i) A type of lung disease develops (tuberculosis).

(ii) A skin cancer may be observed.

(iii) Nerves are affected.

(iv) Brain is badly damaged with the loss of memory, ability to speak and to think.

(v) The number of platelets (thrombocytes) becomes less which may cause haemorrhage.

(vi) In severe cases the patient shows swollen lymph nodes, fever and loss of weight. A full blown (disease at its peak) AIDS patient, may die within three years.

Prevention and cure

No medicine or vaccine is known to be available against HIV infection. Therefore, care has to be taken through following measures:

(i) There should not be any sexual contact with the person who has HIV infection or STI. Since STI causes some damage to the genital area and mucous layer, and thus facilitates the entry of HIV into the body.

(ii) Use disposable syringe and needle.

(iii) The blood to be transfused to the needy person, should be free from HIV germ.

(iv) Prostitution and homosexuality should be avoided.

(v) Condom should always be used during intercourse.

Control

AIDS can be detected by ELISA test.

There are three points which may be important to control STD.

(i) **Partner notification :** Identification of potential infected contact, examination and treatment.

(ii) **Education of STD :** This should be a part of general education.

(iii) **Screening for STD :** Serological screening of groups, such as, blood donors, women before giving birth.

Facts about HIV transmission

- HIV is a weak virus and hard to get infected with. It cannot be transmitted through air or water outside the human body.
- A person cannot get AIDS by hugging or sneezing of an infected person, insect bites (including mosquito), sharing the same comb, plates, glass, handkerchiefs, knives or cutlery.
- A person cannot get AIDS by using public toilets, swimming pools, showers and telephones.
- HIV cannot be transmitted by being near to someone, touching someone or working with someone who is suffering from AIDS.

INTEXT QUESTIONS 29.6

1. How is HIV transmitted? Mention any three ways of infection.

....

2. Mention any two methods to prevent AIDS.

   ....

3. Write full form of HIV.

   ....

4. Give any two symptoms of AIDS.

   ....

5. Mention three general points the knowledge of which may control STD.

   ....

29.5.2 Syphilis

Causative organism

Treponema pallidum (a long corkscrew bacteria)

Mode of spread

Sexual contact with the infected person

Incubation period

Symptoms of the disease occur in about 10-90 days after contraction, but generally noticed in 3-4 weeks after getting infected with the bacteria.

Symptoms

Symptoms of syphilis occur in stages. The common symptoms of syphilis include.

(i) Fever, and sores on the skin, in the throat and urinogenital areas especially vagina or penis, anus, rectum and mouth. Sores are firm, round and often painless.

(ii) Rashes on hands, feet and palms.

(iii) White patches in the mouth.

(iv) Acne-like warts in the groin area.

(v) Hair fall in patches from infected areas.

(vi) The last three symptoms can be very serious. They often become internal and affect organs like brain, nerves, liver, eyes, blood vessels, bones and joints, which show up after about 10 years of getting the infection. It can lead to paralysis, blindness, dementia and sterility.

Prevention and cure

(i) Having sexual intimacy with only one person.

(ii) Avoiding prostitution and homosexuality.

(iii) Practising abstinence, and use condoms.

(iv) Taking appropriate medical treatment, and maintaing personal hygience.

29.5.3 Gonorrhoea

Gonorrhoea is a sexually transmitted disease that often involves urethra, vagina or penis, cervix, anus, and throat, as its target sites.

Causative organism

A gonococcus bacterium, *Neisseria gonorrhoeae*. It grows and multiplies quickly in warm moist areas of the body, such as the cervix, rectum and mouth.

Modes of spread

Having multiple sex partners increases the risk of contracting it. Any kind of unprotected sex is always a risk. Any kind of contact of sores with an infected person is also risky.

Incubation period

About 2-5 days after getting infection.

Symptoms

(i) Inflammation of mucous membrane in the urinogenital tract.
(ii) Burning sensation while passing out urine and urethral discharge.
(iii) Rectal discomfort.
(iv) Pain in the joints.
(v) Rashes on palms, Mild sore throat
(vi) In females, it may cause sterility

Prevention and cure

(i) Having sexual contact with only one person.
(ii) Avoiding prostitution and homosexuality.
(iii) Taking antibiotics, such as penicillin injection or appropriate medicines at the appropriate time as per Doctor's advice.

In males, gonorrhoea primarily affects the urethra, anus, throat, joints and eyes. Most victims of this disease are teenagers and young adults. One of the advanced complications of gonorrhoea is gonococcal septicemia (blood poisoning).

29.6 DRUG ABUSE AND ITS PREVENTION

What is a drug

A drug is a chemical substance that changes the way our body and mind work. A pharmaceutical preparation or a naturally occurring substance used primarily to alter the physical or mental functioning of an individual, is called a drug.

What is drug abuse

When drugs are taken for medical reasons to treat or cure disease both physical and mental, they are called *medications or therapeutic drugs.*

Drug abuse occurs when drugs are taken without medical reasons and without medical supervision, especially when they are taken in an amount, strength, frequency, or manner that damages the physical and mental functioning of the individual. Cough syrups, pain killers, and tranquillizers are some common medicines that are often abused.

Drug abuse also occurs when certain chemicals that have no medical use or benefits are taken, such as sniffing glue and solvents. The extent of drug abuse depends on the quantity of the drug being taken, and the method and frequency of its consumption. Drug abuse leads to many serious physical, emotional, and social problems.

What are the effects of drug abuse?

Drug abuse leads to a number of short-term and long-term effects that are detrimental to health:

- *Short-term effects :* These are the effects that appear instantly or a few minutes after the intake of drugs. The effects include a sense of well-being and a pleasant drowsiness.
- *Long-term effects :* Constant and excessive use of drugs over a long period can cause both physical and mental damage and illness. This includes failure in academic studies, employment, and interpersonal relationship; financial ruin; increased risk of contracting STIs; and increased risk of being involved in vehicular accidents. Addicts stop thinking of everything in life except when and how they will get their next drug dose. They will do anything for the dose, including committing crimes such as theft and in certain case even murder.

Some Basic Facts

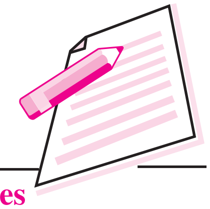
Teenagers sometimes try a smoke or drink just to see how it feels, but they do not start using drugs on a regular basis. What is the harm in trying drugs just to see how it feels?

Ideally, there is no need to try out a smoke or drink.

But there is a great difference between " trying out" smoking or drinking as compared to drugs.

Smoking and drinking once only or very occasionally does not always lead to addiction. But drugs are very powerful chemicals that can cause profound alterations in the metabolism of the body and in the chemistry of the brain. Even a single dose of a powerful drug can start the addiction process. When one's mind and body becomes addicted to drugs, stopping drugs produces very unpleasant and distressing mental and physical symptoms. This makes the addict persist with the usage of the drug. Addicts cannot give up their habit unless they get medical treatment and counselling.

You should not boast about your strong will power and assume that you can experiment with drugs without becoming addicted. ALWAYS KEEP AWAY from drugs. Do not allow yourself to succumb to pressure by friends and acquaintances. If you remain firm in your resolve, you can prevent your life from being ruined.

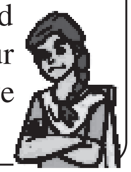


Notes

Some Basic Facts

What are Reproductive Tract Infections (RTIs)?

RTIs are infections of the upper and lower reproductive tracts of both sexes. Agents of infection include bacteria, viruses, and protozoa. Not all RTIs are sexually transmitted; some may occur due to an imbalance of the bacteria normally found in the reproductive tract and poor personal hygiene.

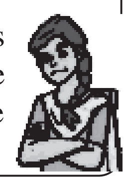


Some Basic Facts

Is it possible for a person to have an RTI (Reproductive Tract Infection) without knowing about it?

Symptoms of RTIs in men are visible, and hence they become aware that their sexual organs have been infected.

However, RTIs in women sometimes can be *asymptomatic*. This means that signs or symptoms are not experienced even though the infection is active. Hence women often do not know that they have RTI.



INTEXT QUESTIONS 29.7

1. Name the pathogen that causes syphilis.

   ....

2. Mention any two symptoms of the disease gonorrhoea.

   ....

3. Give the main method of checking syphilis.

   ....

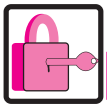
WHAT YOU HAVE LEARNT

- Diseases are broadly classified into two categories–Acquired (Occur after birth) and congenital (present from birth).
- Infectious diseases are transmitted from a diseased person to a healthy person and degenerative diseases are due to malfunctioning of some organs.
- Cancer is uncontrolled growth of cells.

- Acquired diseases are studied in two categories of communicable and non-communicable diseases.
- Communicable diseases are transmitted and may be caused by virus, bacteria, protozoa or helminths (worms).
- Non-communicable diseases are not transmitted from a diseased person to a healthy person.
- diseases which spread by sexual contact are called sexually transmitted diseases (STD).
- AIDS is caused by HIV.
- Gonorrhoea is caused by a bacterium (*Neisseria gonorrhoeae*). Syphilis is caused by a long, corkscrew bacterium (*Treponema pallidum*).

TERMINAL EXERCISES

1. What is a disease? How does it differ from disorder?
2. Name the two categories of acquired diseases.
3. Explain the term (i) parasitism (ii) reservoir.
4. Give two symptoms of coronary diseases and of typhoid.
5. What precautions should be taken to prevent malaria?
6. Name the pathogen that causes diphtheria and the one, that causes cholera.
7. Mention the four types of acquired diseases.
8. Differentiate between :
   (i) Communicable and non-communicable diseases
   (ii) Pathogen and vector
   (iii) Syphilis and gonorrhoea
   (iv) HIV and AIDS
   (v) Benign and malignant tumours
9. How does polio virus enter human body? How does it paralyse limbs?
10. A nursing mother is given an immunization for BCG and DPT to the baby. What are the diseases against which she would be protected?
11. Give the cause, symptoms and treatment of haemorrhagic dengue fever.
12. Give full form of STD.
13. Mention any two sympotms of syphilis.
14. State the means by which we may prevent and cure gonorrhoea.
15. What does the term AIDS stand for?
16. Write four possible symptoms of AIDS.
17. Mention three general points which may control sexually transmitted diseases.



ANSWERS TO INTEXT QUESTIONS

29.1 1. Any condition which interfers with the normal functioning of the body.

2. (i) congenital (ii) degenerative
3. Refer text.
4. Presence of large number of organisms on the surface of body.

29.2 1. Contact or scabs

2. Appearance of rashes on the body
3. Nervous system
4. Rabies virus
5. *Aedes aegypti*

29.3 1. (i) *Mycobacterium tuberculosis*

(ii) *Salmonella typhi*

(iii) *Vibrio cholerae*

2. Oozing semisolid material in the throat, form a membrane which blocks the air passage.
3. Prolonged contact with patient.

29.4 1. Female *Anopheles*

2. *Entamoeba histolytica*
3. Elephantiasis or Filariasis

29.5 1. It is passed down from parents to offspring.

2. The blood pressure remains persistently high.
3. Benign tumor does not spread to other parts of the body, whereas malignant tumor cells spread to other parts of the body.

29.6 1. Any three points mentioned under "mode of transmission"

2. Give any two points written under "prevention and cure".
3. Human immunodeficiency virus.
4. Mention any two points given under "symptoms."
5. (i) Partner-notification.

(ii) Education of STD.

(iii) Screening for STD.

29.7 1. *Treponema pallidum*

2. (i) Swelling of mucous membrane of urinogenital tract.

(ii) Burning sensation during passing of urine.

3. (i) Prostitution and homosexuality should be avoided.

(ii) Certain medicines may check the diseases.

Mukta Vidya Vani

Mukta Vidya Vani is a pioneering initiative of the National Institute of Open Schooling (NIOS) for using Streaming Audio for educational purposes. This application of ICT will enhance accessibility as well as quality of programme delivery of NIOS Programmes. This is a rare accomplishment of NIOS as the first Open and Distance Learning Institute to start a two way interaction with its learners, using streaming audio and the internet.

Keeping in mind the fact that the transmission is done through the web, the NIOS website (www.nios.ac.in) has a link that will take any user to the Mukta Vidya Vani. Mukta Vidya Vani thus enables a two way communication with any audience that has access to an internet connection, from the studio at its Headquarters in NOIDA, where NIOS has set up a state-of-art studio, which will be used for this purpose as well as for recording educational audio programmes meant for NIOS learners, though others can also take advantage of this facility.

Mukta Vidya Vani is a modern interactive, participatory and cost effective programme, involving an academic perspective along with the technical responsibilities of production of audio and video programmes, which are one of the most important components of the multi channel package offered by the NIOS. These programmes will attempt to present the topic/ theme in a simple, interesting and engaging manner, so that the learners get a clear understanding and insight into the subject matter.

NIOS has launched a scheme to motivate the learners to participate in the Mukta Vidya Vani by sending their Audio CD's to the respective regional centre on various subjects such as-

1. Poetry / Shloka recitation
2. Story telling
3. Radio Drama
4. Music
5. Talks on various topic related to the NIOS curriculum including Painting, Vocational Subjects etc.
6. Quiz
7. Mathematics puzzles etc.

The selected CD can be webcast on Mukta Vidya Vani and the winner participant be rewarded suitably.

Learners may visit the NIOS website and participate in live programmes from 2pm to 5pm on all week days and from 10.30am to 12.30pm on Saturdays, Sundays and all Public Holidays. The Subject Experts in the Studio will respond to their telephonic queries during this time. A weekly schedule of the programmes for webcast is available on the NIOS website. The Studio telephone number are 0120-4626949 and Toll Free No. 1800-180-2543.

MODULE - V
EMERGING AREAS IN BIOLOGY

Awards Won by NIOS

Several projects have been implemented by the NIOS to tap the potential of Information and Communication Technology (ICT) for promoting of Open and Distance Learning (ODL) system. The Ni-On project of NIOS won the National Award for e-governance and Department of Information and Technology, Govt. of India. In further recognition of its On-line initiatives and best ICT practices, the NIOS received the following awards:

NIOS WINS National Award for e-Governance 2008-09

Silver icon for Excellence in Government Process Re-engineering, Instituted by Government of India Department of Administrative Reforms and Public Grievances & Department of Information Technology.

NIOS receives NCPEDP MPHASIS Universal Design Awards 2012

National Institute of Open Schooling (NIOS) has been awarded THE NCPEDP - MPHASIS UNIVERSAL DESIGN AWARDS 2012 instituted by National Centre for Promotion of Employment for Disabled People. The award was given by **Sh. Mukul Wasnik, Hon'ble Minister for Social Justice and Empowerment, Govt. of India** on 14th August, 2012. NIOS has been selected for its remarkable work done for the learners with disabilities through ICT by making its web portal www.nios.ac.in completely accessible for such learners.

The Manthan Award South Asia & Asia Pacific 2012

The Manthan Award South Asia & Asia Pacific 2012 to recognize the best ICT practices in e-Content and Creativity instituted by Digital Empowerment Foundation in partnership with World Summit Award, Department of Information Technology, Govt. of India, and various other stakeholders like civil society members, media and other similar organisations engaged in promoting digital content inclusiveness in the whole of South Asian & Asia Pacific nation states for development. The award was conferred during **9th Manthan Award Gala South Asia & Asia Pacific 2012 at India Habitat Centre on 1st Dec. 2012.**

30

BIOTECHNOLOGY

At home we prepare food items such as yoghurt (curd), cake, bread, idli and dosa by the action of microorganisms, such as the bacteria and fungi. Brewers use yeast (fungus) to make beer. Antibiotics such as penicillin are obtained from certain fungi. Nowadays, biological processes such as fermentation by microorganisms is being used in industry on a commercial scale for making food, drinks, drugs (medicines) and industrial chemicals. Modern techniques in biotechnology are programming microorganisms for this task. In this lesson, you will learn about use of microorganisms in industries.

OBJECTIVES

After completing this lesson, you will be able to:

- *appreciate the importance of biotechnology in human welfare;*
- *explain the use of biotechnology in industry;*
- *list the microbes used in the industry and the products manufactured through their use;*
- *explain fermentation and outline the process of making alcohol by using microorganisms;*
- *describe the process of making yoghurt and cheese on a large scale;*
- *explain the contribution of microorganisms in making antibiotics and vaccines;*
- *define genetic engineering and mention its utility;*
- *define transgenic organisms, mention the steps in their production and cite a few examples of transgenic plants and animals;*
- *explain the process and importance of gene therapy;*
- *explain bioremediation and biopesticides.*

30.1 BIOTECHNOLOGY

The word **biotechnology** has come from two words, **bios** (meaning biology) and **technology** (meaning technological application). Thus **biotechnology is defined as the industrial application of living organisms and their biological processes such as biochemistry, microbiology, and genetic engineering, in order to make best use of the microorganisms for the benefit of mankind.**

Biotechnology is applied in many areas to produce foods and medicines, in the development of new diagnostic tools, gene therapy, and DNA finger-printing for forensic purposes.

30.1.1 Applications of Biotechnology

1. Health and medicine

Fighting infectious diseases : Biotechnology is used extensively in the study of infectious diseases such as SARS (Severe Acute Respiratory Syndrome), and influenza. As a result more effective pharmaceuticals have been developed.

Development of vaccines and antibiotics : Using technology, microorganisms are used to develop antibiotics and vaccines to cure diseases. For example, bacteria *Bacillus polymysea* is used to produce polymyxin B (antibiotic used to cure urinary tract infections), fungus *Penicillium notatum* is used to produce penicillin (used to cure pneumonia, and many other bacterial infections.)

Treating genetic disorders : Disease can occur when genes become defective due to mutations. With advancements in biotechnology, in the near future it will be possible to use gene therapy to replace an abnormal or faulty gene with a normal copy of the same gene. It may be used to treat ailments such as heart disease, inherited diseases such as SCID, and Thalassaemia.

In forensic science : A lot of New techniques have been developed such as **DNA fingerprinting**, besides having a number of other applications which have facilitated the speedy identification of the criminals.

2. Environment

Cleaning up and managing the environment : Cleaning up the environment using living organisms is called **bioremediation**. Naturally occurring, as well as genetically modified microorganisms, such as bacteria, fungi and enzymes are used to break down toxic and hazardous substances present in the environment.

3. Agriculture

Biotechnology has also made possible the production of crops improved disease resistan; herbicide-toleran and insecticide-resistan. Plants with improved nutritional value for livestock have also been obtained through biotechnology.

Control of pests : One application of biotechnology is in the control of insect pests. The genetic make-up of the pest is changed by causing some mutations. These pests become sterile and do not reproduce further.

Manufacturing and bio-processing : With the help of new biological techniques it has become possible to grow, the plants that produce compounds for use in detergents, paints, lubricants and plastics on large scale.

Food and drinks : Biotechnology, has also made the processing of foods and their products easier. Preservation and storing of food for consumption later has become easy and cheap with the help of biotechnology. Seedless grapes and seedless citrus fruits have been developed using biotechnology.

4. Industry

Biotechnology has been used in the industry to produce new products for human consumption. Food additives have been developed which help in the preservation of food. Microorganisms are used in the mass production of items such as cheese, yoghurt, and alcohol.

30.1.2 Industrial Microorganisms and Their Industrial Products

Important microorganisms used in industries include

- yeasts (fungi)
- moulds (fungi)
- bacteria
- filamentous bacteria (*actinomycetes*)

Microbes are used in the manufacture of several products. Some of these are

- alcohol-containing beverages
- proteins
- vitamins, steroids and enzymes
- yoghurt (curd)
- antibiotics and monoclonal antibodies
- biogas

> The progress in gene manipulation and genetic engineering has introduced the use of cultured mammalian cells and 'hybridomas' in the industries. Hybridomas are created by fusion of cells belonging to organisms of different species.

30.1.3 Production of Alcohol – Containing Beverages

> **Fermentation**
>
> Fermentation is a process by which carbohydrates such as sugar are converted into alcohol.
>
> $$\text{Glucose} \xrightarrow[\text{enzyme}]{\text{yeast}} \text{Ethyl alcohol} + \text{Carbon-dioxide} + \text{ATP}$$
>
> Yeast is capable of fermenting sugar to alcohol. Fermentation is an energy yielding process.

In the mid nineteenth century, Louis Pasteur showed that fermentation by the yeast *Saccharomyces cerevisiae* yields beer and buttermilk. Presently yeast is being used on a large scale for brewery and bakery.

Bakers use yeast to leaven (raise) dough to make bread. Yeast is also grown on molasses and is packed and sold. Yeast is used to raise cakes and bread while baking.

Alcoholic beverages are manufactured by fermentation of sugars by the yeast, *Saccharomyces cerevisiae*. It is called **Brewer's yeast**. The source of carbohydrate fermented by yeast gives the beverage its specific flavour. For example :

– Wine is obtained by fermentation of grapes. Grapes are fermented by *S. cerevisiae* and its soluble sugars (glucose and fructose) are converted into CO_2 and ethyl alcohol.
– Fermentation is carried out in large tanks called bioreactors.
– Barley malt is fermented to yield beer.

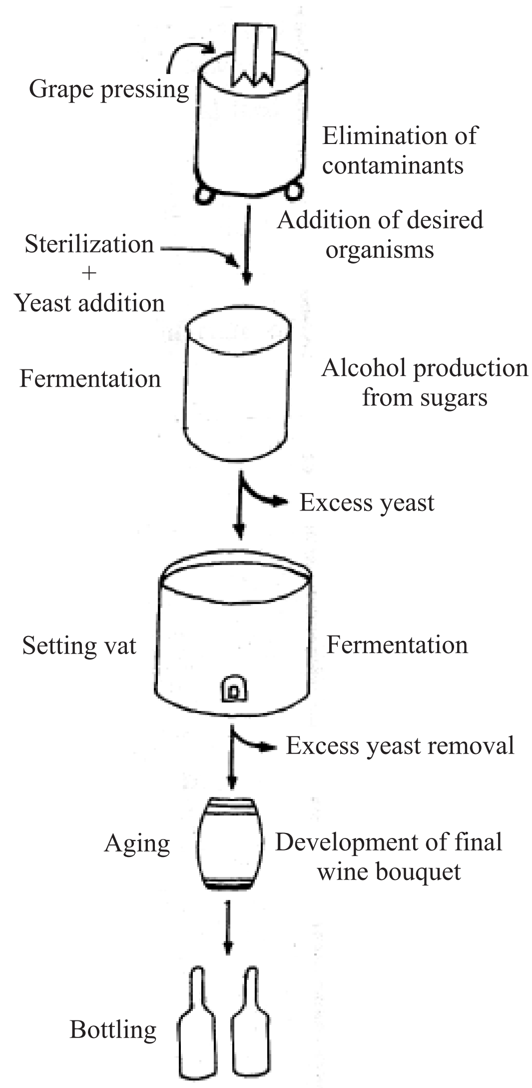


Fig 30.1 Obtaining wine from *grapes by fermentation by* Yeast

Steps taken for fermentation

(i) Fermenter or tank and the nutrient medium are sterilised by steam under pressure (autoclave).

(ii) The correct strain of yeast is selected.

(iii) The yeast is inoculated into the medium. Inoculation can be done in two ways:

  (a) Yeast can be grown as a layer on the surface of nutrient medium. This is called **support growth system**.

  (b) Cells or mycelia are suspended in a liquid medium. This is called **suspended growth system**.

(iv) Care is taken to maintain the right temperature, pH, oxygen and carbon-dioxide concentration.

(v) The medium is stirred and left to ferment.

(vi) The sugar in the medium gets fermented by enzymes released by yeast.

(vii) The fermented product is taken out (Fig. 30.1).

Some alcohols manufactured by yeast fermentation are : Ethyl alcohol, butanol and glycerol. The same method also yields **lactic acid** and **acetic acid** (vinegar) by using specific bacteria.

The yeast extract left after removal of the beverage can be used as animal feed. It is also a rich source of vitamins.

INTEXT QUESTIONS 30.1

1. Name three different kinds of microorganisms used in the manufacture of industrial products.

   ....

2. Name three products obtained in industries by using microorganisms.

   ....

3. Name two alcohols produced through fermentation by yeast.

   ....

4. Name the two methods of inoculation of yeast in the medium.

   ....

5. Match the items given in columns A with those given in column B.

Column A	**Column B**
1. Bioreactor	(a) Butanol
2. Steaming under pressure	(b) Fermentation tank
3. Alcohol	(c) Autoclave

30.2 YOGHURT AND CHEESE MAKING

At home we add a bit of yoghurt (starter) to milk and it sets. The milk becomes yoghurt or curd due to the milk curdling enzymes released by the increasing population of bacteria, *Lactobacillus* present in the starter. (Table 30.1) On a commercial scale, making of yoghurt as well as cheese utilises **Rennet** tablets for this purpose. Rennin is the milk curdling enzyme obtained from the calf stomach. However, this method is popular any more.

Whether by bacteria or by "rennin", when milk is 'curdled', milk protein casein, separates from the liquid which is called whey. *Lactobacillus* convert lactose in the milk into lactic acid which lowers the pH. Lowered pH causes souring which is essential for preservation.

Butter can be made by violently shaking (churning) sour milk. The fat globules separate and form butter. A starter culture of *Streptococcus cremosis,* and *Leuconostoc is* added to the milk when butter, yoghurt or cheese are made.

Table 30.1 **Fermenting microbes used for dairy products**

Fermented product	Fermenting microorganism	Description
Yoghurt	*Streptococcus thermophilus* and *Lactobacillus bulgarians*	Product made from low or non-fat milk and stabilisers like gelatin added.
Butter	*Lactococcus lactis*	Cream is incubated till the desired acidity is achieved followed by churning, washing and salting

30.2.1 Microorganisms and antibiotics

In 1928, Alexander Fleming accidentally discovered that one microorganism can inhibit the growth of another organism. Selman Waksman 1942 coined the term antibiotic (anti: opposed to, biotic: living organism)

> Antibiotic is a substance produced by a microorganism such as bacteria or fungi which inhibits the growth of another microorganism. Antibiotics are generally small molecules with a molecular weight less than 2000 Da. They are not enzymes. The antibiotic interferes with the vital metabolic processes of the pathogenic bacterium and prevents its growth and reproduction.

Wide-spectrum and narrow-spectrum antibiotics

Modern medicines have found a specific antibiotic for almost every different pathogen. *Streptomyces* bacterium yields some of the most widely used antibiotics like Chloramphenicol, Erythromycin, Tetracycline etc. These are called '**broad spectrum antibiotics**' and can be used against more than one kind of pathogenic bacterium. Streptomycin and Penicillin are **narrow spectrum antibiotics** used against few pathogenic bacteria.

Drawbacks of antibiotics

Use of antibiotics was a big step in curing infectious diseases which offered a safe, sure and relatively inexpensive cure. But even now we find many people suffering from bacterial diseases. The reasons for this are:

1. Some people are allergic to a particular antibiotic.
2. Some disease causing bacteria undergo mutation and become resistant to a particular antibiotic to which they were sensitive earlier.

Sources of antibiotics

Some of the common antibiotics and their source organisms are given in table 30.2.

Table 30.2 Major antibiotics and their sources

Antibiotic group	Source
Tetracyclin	*Streptomyces sp*
Chlorotetracycline	*Streptomyces auriefaciens*
Chloramphenicol	*S. venezuelae*
Cycloheximide	*S. griseus*
Streptomycin	*S. griseus*
Cephalosporin	*Cephalosporium acremonium*
Penicillin	*Penicillium chrysogenum*

30.3 VACCINATION

In 1790, Edward Jenner observed that milkmaids did not get smallpox as they were exposed to a milder disease cowpox. Jenner infected a boy with cowpox germs and after two months with small pox germs. The boy did not get small pox. Jenner proposed that if mild or attenuated (weakened) germs were introduced into the body, they would not cause the disease. He gave the term **vaccine** (latin *vacca* : cow) or vaccination, for the weakened germ and its protective inoculation.

Today, the principle of vaccination has been extended to prevent attack of many diseases. When vaccines are made from attenuated disease causing bacteria, they are termed as "first generation vaccines". The "second generation vaccines" have been produced by genetic engineering or recombinant DNA technology about which you shall study in the next section. Second generation vaccines for Hepatitis B virus and *Herpes* virus are already in use. Vaccines synthesised from chemicals are called "third generation vaccines".

30.4 PRODUCTION OF VITAMINS

Vitamins are nutrients required in very small amounts for essential metabolic reactions in the body. They are produced using biotechnology. Vitamin C was the first vitamin to be produced during a fermentation process by using bacteria. B_{12} or cyanocobalamin and B_2 or Riboflavin were obtained from liver extract. The production of B_{12} involved fermentation by propionic bacteria. In nature B_2 is found in cereals, vegetables and yeast but the yield of B_2 can be enhanced hundred to three hundred fold by using microbes.

30.5 PRODUCTION OF BIOGAS

Biogas is a new conventional source of fuel. Its use can save fossil fuel (coal, kerosene, and petrol) which are fast getting depleted.

Biogas is made from organic waste including faecal matter. Cowdung or faeces have lignocellulose. The energy used as fuel comes from methane (CH_4). Cowdung forms the primary source of biogas. In India cowdung is available in plenty in villages and small scale methane generating plants have been designed.

Any biodegradable substance (which can be decomposed by bacteria) can be fermented anaerobically (in the absence of oxygen) by methane-producing (methanogenic) bacteria. Cowdung or faeces are collected and put in a biogas digester or fermenter (a large vessel in which fermentation can take place). A series of chemical reactions occur in the presence of methanogenic bacteria (CH_4 generating bacteria) leading to the production of CH_4 and CO_2.

While generating biogas, few parameters have to be taken into account. These are as follows:

1. Fermentation should be in an anaerobic environment and no free oxygen should be present.
2. pH in the fermenter should be close to neutral, around 6.8 to 7.6
3. Methanogenic bacteria are to be used for fermentation.

Several kinds of reactors have been designed. One side of the reactor is for input, that is, for introducing cowdung or faecal matter into the reactor. Whiel other side of the reactor has an outlet for removal of biogas: The material is left behind is called **slurry**. The gas gets stored above the slurry level. Slurry forms excellent manure.

Advantages of biogas

1. Biogas is a fuel used to cook food, and light lamps.
2. Slurry left after biogas production forms a soil conditioner (manure).
3. Biogas is much cheaper than LPG (Liquefied Petroleum Gas) which we commonly use these days in our houses.

INTEXT QUESTIONS 30.2

1. Name the bacterium responsible for curdling of milk.

   ....

2. Who discovered antibiotic?

   ....

3. What do you mean by second generation vaccines?

   ....

4. Which was the first vitamin to be produced by fermentation?

   ....

5. Which bacteria cause the production of biogas?

   ....

30.6 GENETIC ENGINEERING

An engineer fixes a machine to make it work efficiently. Body is like a machine and genes, the nucleotide sequences in DNA have the information for products to run this machine. With progress in molecular biology, techniques have been developed by which a scientist can now manipulate genetic material, replace genes or replace gene products in the body, make identical copies of these genes and store them in a gene library. This is called **genetic engineering**.

30.6.1 Importance of genetic engineering

You know that **diabetes mellitus** is a genetic disorder. A diabetic patient lacks a gene which has the information for synthesis of insulin, therefore such a person cannot secrete insulin. Take another example. A person suffering from **Thalassemia** lacks the gene for haemoglobin and can survive only through frequent blood transfusions. A person suffering from sickle cell anemia has an altered gene whose product makes the red blood corpuscles abnormal on exposure to oxygen because they contain faulty haemoglobin.

Humans suffering from genetic disorders such as those cited above have now hope in genetic engineering. Genetically engineered copies of DNA can be produced and stored in gene libraries to be used when required.

In the previous sections of this lesson you have studied about the use of microbes to produce various products on a commercial scale. Currently bacteria are being genetically manipulated to act as biological factories to produce various kinds of proteins such as enzymes, hormones, and antibodies through genetic engineering. Researchers have isolated genes which can be used to produce effective vaccines.

Workers have also developed bacterial strains, through genetic manipulation, which can degrade harmful environmental pollutants.

30.6.2 Recombinant DNA technology

Genetic engineering may be defined as construction and utilisation of new DNA molecules that have been engineered by recombinant DNA techniques. **The technique of genetic engineering is in the production of recombinant DNA.** Recombinant DNA, as the name suggests, involves cutting a piece of original DNA and inserting in its place a different segment of DNA having desred characters. The recombined or recomposed DNA is then copied multifold inside bacterial cells and stored in a gene library for use when required. The multiple copies of the gene are termed **cloned DNA or cloned genes.**

Causing genetic change by artificially manipulating DNA is genetic engineering.

Clone is a group of genetically identical cells. Such cells are descendents of a single cell. When a bacterium with recombinant DNA divides several times, it provides a clone containing a specific segment of DNA from another species.

The production of genetically identical individuals or genetic material from a single cell is called cloning.

Recombinant DNA technology resulted from the two discoveries made while experimenting with bacteria :

(i) presence of plasmids or extra chromosomal DNA fragments in the bacterial cell which replicate along with bacterial DNA and can be used as a vector for carrying foreign DNA.

(ii) presence of specific restriction enzymes which attack and cut DNA at specific sites.

30.6.3 Tools and steps in recombinant DNA technology

Recombinant DNA technology is a "cut and paste" technology. Specific nucleotide sequences are cut from the DNA of humans, other animals or plants and "pasted" into plasmids. DNA of the plasmid carrying nucleotide sequence of another organism is the recombinant DNA. It is then inserted into bacteria. Bacteria divide repeatedly and a clone of bacteria with the recombinant DNA is obtained.

Five requirements for recombinant DNA technology are:

(i) Cell culture (ii) Restriction endonuclease enzyme

(iii) Plasmids (iv) Ligases

(v) Host bacteria

(i) Cell culture : Cultured cells of an animal or plant (or even a bacterium) carrying the required gene (nucleotide sequence of DNA) in its nucleus.

(ii) The enzyme Restriction endonuclease : Restriction endonucleases cut short specific DNA sequences. There are many different restriction endonucleases found in bacteria. Each of these enzymes very specifically recognises a particular DNA sequence (usually 4 to 6 bases) and cuts it. These enzymes are the "molecular scissors". They either cut both the strands at the same place or at different places so that the two DNA strands hang out at the two ends. Two cuts at the two ends of a DNA segment releases the cut part as the restriction fragment. The ends are single stranded and called sticky ends.

Thus a piece of DNA containing a particular gene can be obtained by selecting a particular restriction endonuclease.

(iii) Plasmids : Plasmids are extra chromosomal DNA molecules in a bacterial cell which have sequences matching those of the required gene and can be similarly cut by the same restriction enzymes. Plasmids can readily enter bacteria, yeast or other speedily reproducing cells.

(iv) DNA ligase : It is an enzyme called 'joining enzyme' since it joins two DNA fragments, both of which have having sticky ends. Ligase is the "molecular glue".

(v) Host Bacteria : Host bacteria are the bacteria whose plasmid is used for carrying foreign DNA.

Sequences of steps in recombinant DNA technology:

1. Specific restriction enzyme is selected.
2. Cell culture with required gene in the cells is obtained.
3. Restriction enzyme cuts the DNA at two ends of the specific gene and a restriction fragment is obtained (Fig. 30.2 a, c)
4. Same restriction enzyme cuts a matching DNA sequence from a plasmid (Fig. 30.2 b, d)

5. Ligase joins the restriction fragment in the place vacated by the cut DNA segment of the plasmid. The plasmid becomes a *recombinant plasmid* containing a foreign DNA fragment (Fig. 30.2 e, f). Its DNA is the *recombinant DNA*. Since plasmids can carry foreign DNA, they are called **clonal vectors**. Bacteriophages (viruses) can also function as clonal vectors.
6. The recombinant plasmids are then placed with the comptent cells to enter the bacteria.
7. Bacteria divide. Recombinant plasmids replicate along with bacterial DNA.
8. A large population of bacteria (more than a million) containing recombinant DNA can be obtained in less than ten hours.
9. Multiple identical copies of DNA fragments inserted into plasmids or bacteriophage (bacterial virus) are then obtained and preserved in a DNA library.
10. These DNA fragments are the cloned DNA.

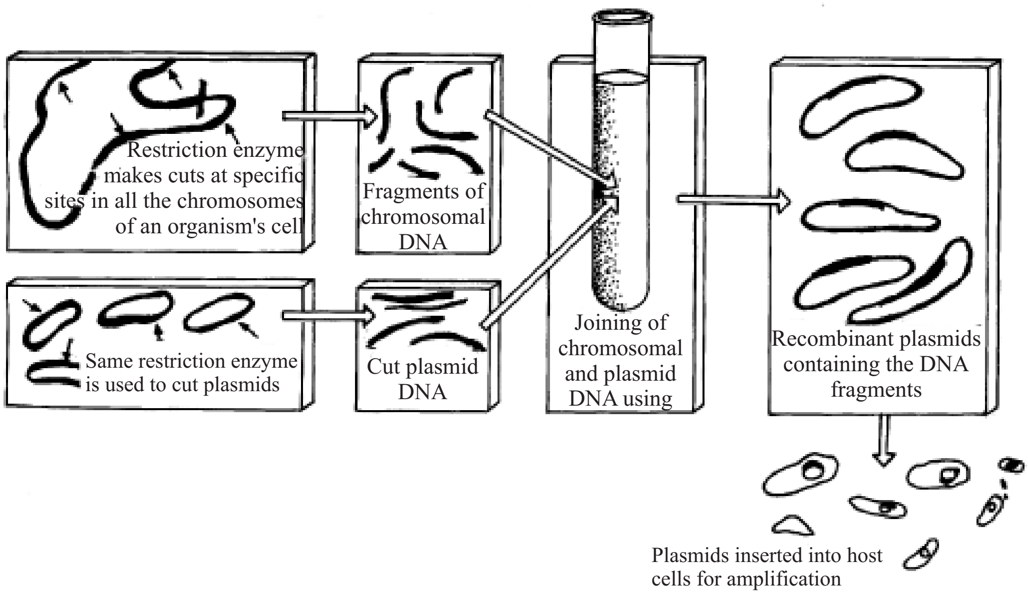


Fig. 30.2 Steps in formation of multiple copies of recombinant DNA for DNA library

INTEXT QUESTIONS 30.3

1. Define genetic engineering.

   ....

2. What is a clone?

   ....

3. What do you mean by the term recombinant DNA?

   ....

4. Where are plasmids found?

....

5. Why are restriction enzymes called "molecular scissors"?

....

6. Name the enzyme which joins DNA fragments.

....

7. What is a clonal vector?

....

8. What do you mean by transgenic organism?

....

30.6.4 Applications of genetic engineering

1. Protein manufacture

You would recall from earlier section of this lesson that bacteria and yeasts have been used for centuries to produce cheese, and alcohol, and more recently antibiotics. Currently, plasmids in bioengineered bacteria carry some human genes and these genes are expressed to give large quantities of human proteins which are clinically useful. The development of recombinant DNA technology and gene cloning has generated a new industry for manufacturing proteins. Earlier valuable proteins could be obtained from eukaryotes in small amounts and at heavy expense, but now these can be produced in large quantities. For example, until sometime back, growth hormone was available only in tiny amounts and was extremely expensive as it had to be extracted from endocrine glands of certain animals. Today, it can be made available in large quantities through recombinant DNA technology. In 1982 production of human insulin became the first commercial success of recombinant DNA technology.

There are several proteins of therapeutic (medical) value which are available now through recombinant DNA technology. These are cloned human gene products approved for use or being developed. Following table 30.3 gives the names and uses of some of these:

Table 30.3 The names of proteins and their uses

Protein	Used in
1. Insulin	Diabetes mellitus
2. Growth hormone	Pituitary dwarfism
3. Erythropoietin	Anaemia
4. Interferons	viral infections
5. Interleukin 2	Cancer
6. Clotting factor VIII	Haemophilia A
7. Clotting factor IX	Haemophilia B
8. Monoclonal antibodies	Infectious diseases
9. Tissue Plasminogen factor	Heart attack

2. **Enzymes** have also been produced from cloned genes. The following table 30.4 gives the names of such enzymes and their uses:

Table 30.4 The names of enzymes and their uses

Enzymes	Used in
Proteases	manufacture of detergents, meat tenderisers.
Amylases	manufacture of beer, bread and textiles
Glucoisomerases	to make corn syrup, which is sweeter than sucrose and used to flavour soft drinks

Enzymes are fragile and have to be entrapped in gel and encapsulated in small artificial cells.

3. Antibiotics

Since the discovery of Penicillin in 1920s, more than 6000 antibiotics have been isolated from various microorganisms and have resulted in an enormous improvement in human health. Research is in progress to genetically engineer biosynthetic pathways for the synthesis of antibiotics. Novel antibiotics have also been obtained through genetic manipulation.

4. Vaccines

Bioengineered vaccines have been developed for rabies and hepatitis B. A gene for the antigen protein is inserted into a plasmid and the bacteria containing recombinant DNA then generate large quantities of the protein. The protein is added to the vaccine. Antibodies immediately form against the antigen when vaccinated.

INTEXT QUESTIONS 30.4

1. Name any two proteins and two enzymes obtained by recombinant DNA technology.

   (i) .... (ii) ....

2. How is recombinant DNA technology useful for pharmaceutical companies?

   ....

3. Name any two diseases for which bioengineered vaccines have already been developed.

   (i) .... (ii) ....

30.8 TRANSGENE AND TRANSGENIC

Genetic engineering has made possible production of organisms of one species carrying genes of another species. The foreign gene is called a **transgene.** The plant or animal carrying it is termed as **transgenic.**

> **Genetically engineered organisms carrying foreign genes are termed transgenics.**

1. Usefulness of transgenic organisms

1. For a better yield desirable traits can be introduced or increased in agricultural plants and domestic animals, especially the cattle.
2. Valuable products can be produced by transgenic plants and animals.
3. Transgenic plants and animals can be used for investigating biological processes such as gene expression.

2. Methodology for production of transgenics

There are two methods which are mostly used for generating transgenics:

(i) Microinjection of foreign DNA into pronuclei of fertilised eggs.

(ii) Retroviral vector method. Infection of pre-implantation embryos with retroviruses carrying foreign DNA.

The first method has the following steps:

(i) Collection of oocytes from the animal killed in slaughter house or surgically removed from female parent.

(ii) In-vitro maturation of oocytes.

(iii) In-vitro fertilisation with male semen.

(iv) Eggs (oocytes) to be centrifuged to concentrate yolk which in normal cells prevents male pronuclei from being seen under the dissecting microscope.

(v) Microinjection of "input DNA" into male pronuclei (Fig. 30.3). Usually hundred to thousand copies of the gene of interest are injected.

(vi) In-vitro development of embryos.

(vii) Non-surgical implantation of one embryo into a recepient foster mother.

(viii) Screening of DNA of the offspring of foster mother for presence of transgenes.

(ix) Offspring with the transgenes are the transgenic organisms.

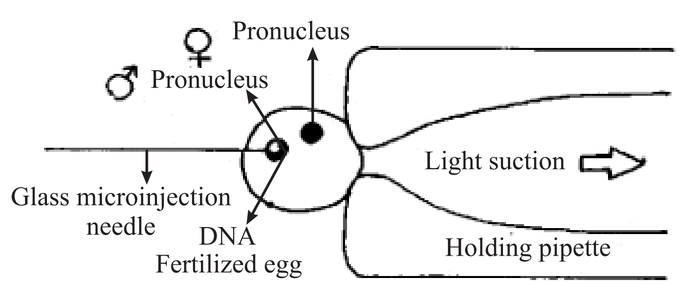


Fig. 30.3 Microinjection of input DNA into male pronucleus

In the **second method** called the **retroviral vector method,** DNA required to be transferred into the female is introduced through the retrovirus which infects the cells of an early stage embryo before implantation into a receptive female.

Transgenic plants

By recombinant DNA techniques, plant breeders can now directly modify the DNA of plants. They can add genes from other species to the plant. The most popular method for doing this is to produce a transgenic plant by the use of *Agrobacterium tumefaciens.* It is a soil bacterium which has a natural "genetic engineering" system. It has a plasmid which can be inserted into plant cells. *Agrobacterium tumefaciens* causes galls (tumours) (Fig. 30.4) in several plants. The information for production of galls is present on a plasmid, (T_i) in the bacterium. A segment of DNA from the plasmid can be transferred into plant cell. In the T_i plasmid, gall forming genes can be removed and substituted by desired genes. The plasmid can then be used to transform plant cells. Such foreign genes in the chromosomes of transformed plant cells can be expressed normally (Fig. 30.4).

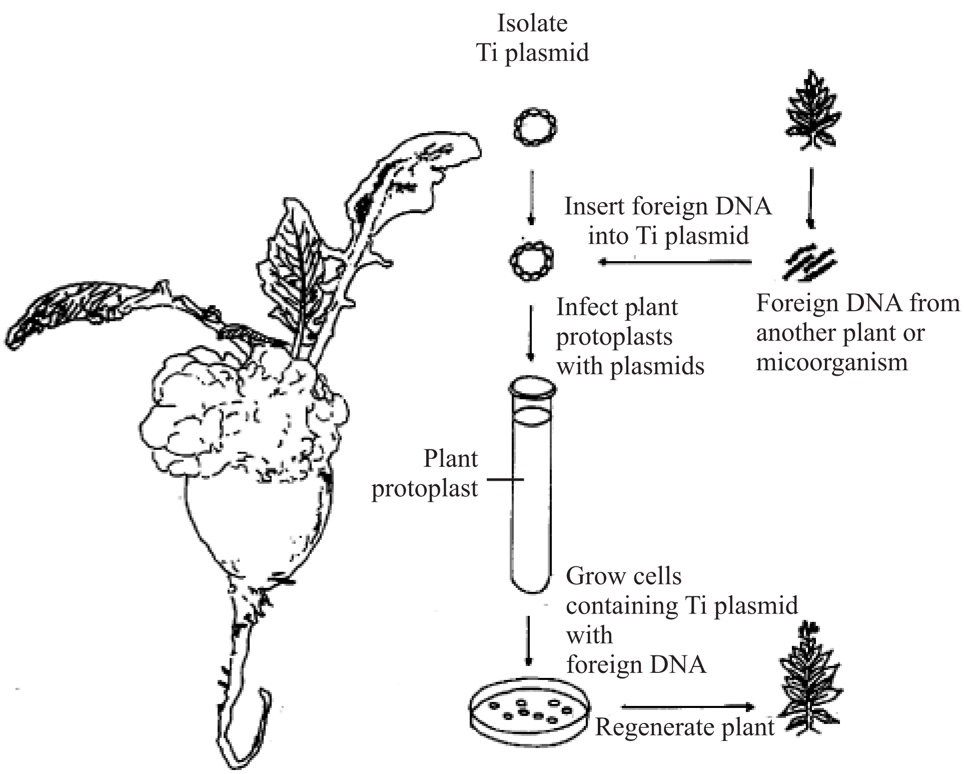


Fig. 30.4 Gall caused on turnips by bacteria carrying T1 plasmid

Examples of transgenic plants

(i) Cotton which can resist attack by worms.

(ii) Corn and soyabean which are more tolerant to drought and pesticides.

Transgenic plants can also serve as factories to produce medically and commercially useful proteins. Serum albumin is used in preparations given to patients with burn injuries and others for replacement of body fluid. Genetically altered potato and tobacco plants can yield serum albumin.

Transgenic animals

Mice : It is difficult to generate transgenic animals as animal cells do not accept plasmids. Transgenic mice are, however, routinely produced in the laboratories throughout the world by microinjecting foreign DNA. Gene for growth hormone from rats was microinjected into mouse eggs. These mice grew larger than their litter mates. This was because rat gene got integrated into mouse DNA and was being expressed. (Fig. 30.5).

Fig. 30.5 Transgenic mouse compared to normal mouse

Goats : Transgenic goats have been developed from a fertilised egg injected with recombinant DNA consisting of goat gene sequences spliced with human genes for tPA (tissue plasminogen activator). Goat milk contains this factor which dissolves blood clots. This has proved very useful for heart attack (coronary thrombosis) and stroke patients.

Cattle : Transgenic livestock have the potential to produce large quantities of drugs faster and at much cheaper rates than from bacteria which have to be cultured in huge industrial vessels.

Chinese hamster : Blood clotting factor VIII genes have been inserted in chinese hamster ovary cells. This factor saves the patients suffering from haemophilia A. Blood clotting factor has also been generated through recombinant DNA technology in Chinese hamster. This eliminates the need to get it from human blood alongwith remov of the the risk of transmitting AIDS.

30.8.1 Bioremediation (remedy through organisms)

Genetically engineered bacteria can clean up pollutants from the environment. This is called **Bioremediation**. The transformed bacteria metabolically breakdown toxic pollutants into harmless compounds.

Mercury resistant bacteria process metallic mercury (which damages the nervous system) into a nontoxic compound.

INTEXT QUESTIONS 30.5

1. Define the term transgenic.

   ....

2. Name the gall producing bacterium and the plasmid which can be conveniently used to produce transgenics.

   ....

3. What is bioremediation?

   ....

30.9 HUMAN GENE THERAPY

Many people are born with and suffer from diseases such as sickle cell anaemia, haemophilia, severe combined immuno deficiency (SCID), and colour blindness. Such diseases are caused due to genetic defects. These genetic defects are hereditary. It has been estimated that around 2000 children in India alone are born every day with genetic disorders. Let us learn about the methods of removal and correction of genetic defects.

30.9.1 Gene function

Genes play a number of different roles in the proper functioning of an organism by (a) controlling synthesis of enzymes involved in biochemical reactions, (b) regulating their synthesis such that the right enzyme appears at the right time. Sometimes genes may not function properly due to some irregularity or defect in their structure. This may lead to genetic disorders. A defective gene may appear in an individual in the following two ways:

(i) Certain defective genes are inherited and the defect runs in the family. For example : Colour blindness, haemophilia, sickle cell anaemia.

(ii) A gene becomes defective all of a sudden due to mutation during early development. For example : Albinism (non-heritable).

A gene mutation may alter the synthesis or activity of an enzyme needed for the normal completion of chemical reactions or for the normal functioning of an organism.

The consequences are :

(i) accumulation of the metabolic substances that are toxic, or

(ii) deficiency of a compound that is important for normal cell functioning.

There are mutations that can lead to disorders in any part of the body, including muscles, eyes, liver, bones, kidneys, nerves, and blood system. Under normal conditions, genes work in total harmony completing their specific job of converting a raw material into a finished product, by synthesising the specific enzyme.

Normal gene functioning

Gene A → Enzyme A
Gene B → Enzyme B
Gene C → Enzyme C

Substrate —(Enzyme A)→ Product A —(Enzyme B)→ Product B —(Enzyme C)→ End Product

↓

(Intermediate Products)

Defective Gene Functioning

Sometimes, absence of a gene or defect in a single gene may result in defective metabolism and a desired product may never be formed, rather a harmful product may be obtained.

Gene A → Enzyme A
Gene B (defective or absent) → No Enzyme

Substrate —(Enzyme A)→ Product A —(No Enzyme)→ No Product B — No End Product

The absence of enzyme B results in accumulation of unuitilised product A and end product is not produced.

You will be alaimed to know that a number of human disorders are caused due to single gene defects. Following table 30.5 gives an idea of some such diseases, caused due to the missing or defective gene products, and the symptoms, of the diseases.

Table 30.5 Some Common Single Gene Defects

Disease	Gene Product	Symptoms
(i) Severe Combined Immuno Deficiency syndrome (SCID)	Absence of adenosine deaminase	Loss of immunity, T lymphocytes and B lymphocytes in low count.
(ii) Haemophilia	Absence of blood clotting factor VIII	Defective blood clotting, chronic bleeding in joints.
(iii) Sickle Cell anaemia	defective β chain of haemoglobin	damage to heart, spleen, kidney, liver and brain
(iv) Phenylketonuria (PKU)	Accumulation of aminoacid phenyl alanine in blood	Severe mental .retardation, albinism (lack of pigmentation)

30.9.2 Gene therapy

Most of the genetic disorders may result in serious complications, health problems and untimely death. Techniques are being developed to replace defective genes or manipulate them to remove the genetic disorder. Such treatment is called **Gene Therapy**.

Gene Therapy thus may be defined as a technique in which a patient (sufferer) is given healthy genes to replace the defective ones inherited from the parents, or to enhance the action/reaction of the genes they already have.

Replacement and alteration of defective gene is called Gene therapy.

Human gene therapy in a broad sense is the addition of functional normal gene or genes to the genetic material contained in the human cell. This is with the aim of correcting an inherited defect.

The ultimate goal is to let 'protein assembling unit' of the cell make desired proteins needed for the normal functioning of an individual. It is like supplying a patient with the necessary gene product formed within the cells by the patient's own body.

INTEXT QUESTIONS 30.6

1. What causes the alteration of normal functioning of a gene ?

   ....

2. Name two single gene disorders in human beings.

   ....

3. State which cells have a low count in Severe Combined Immuno Deficiency (SCID).

   ....

4. Define gene therapy.

   ....

30.9.3 Approach to human gene therapy

There are two basic approaches to human gene therapy:

(i) Somatic gene therapy, and

(ii) Germ-line gene therapy.

(i) Somatic (body cell) gene therapy

Once a normal gene has been cloned, it can be used to correct a genetic defect. Body cells are targeted for genetic transformation (defective gene transformed to normal). This approach helps in the correction of a genetic defect confined to a specific organ or tissue.

(ii) Germ line (sex cell) gene therapy

In this approach, cells of germinal epithelium or gametes or zygote are genetically modified to create an individual that will carry remedial gene(s) in the following generation. Presently all research on human gene therapy is directed towards correcting gene defects in somatic cells (non-sex cells). Somatic gene therapy can be grouped under the broad categories of :

(a) Ex-vivo gene therapy,

(b) In-vivo gene therapy, and

(c) Antisense gene therapy.

(a) Ex-vivo (outside the body) gene therapy:

This type of therapy usually involves the use of cells (with defective gene) taken from the patient. After the gene alteration when the same cells are transfused (transferred back), no immunological response takes place. The steps involved in the procedure are :

1. Isolating the cells with gene defects from a patient.
2. Growing the isolated cells in culture.
3. Altering the genome of the isolated cells with remedial gene.
4. Selecting, growing and testing the altered cells.
5. Transplanting or transfusing the altered cells back into the patient (Fig. 30.6).

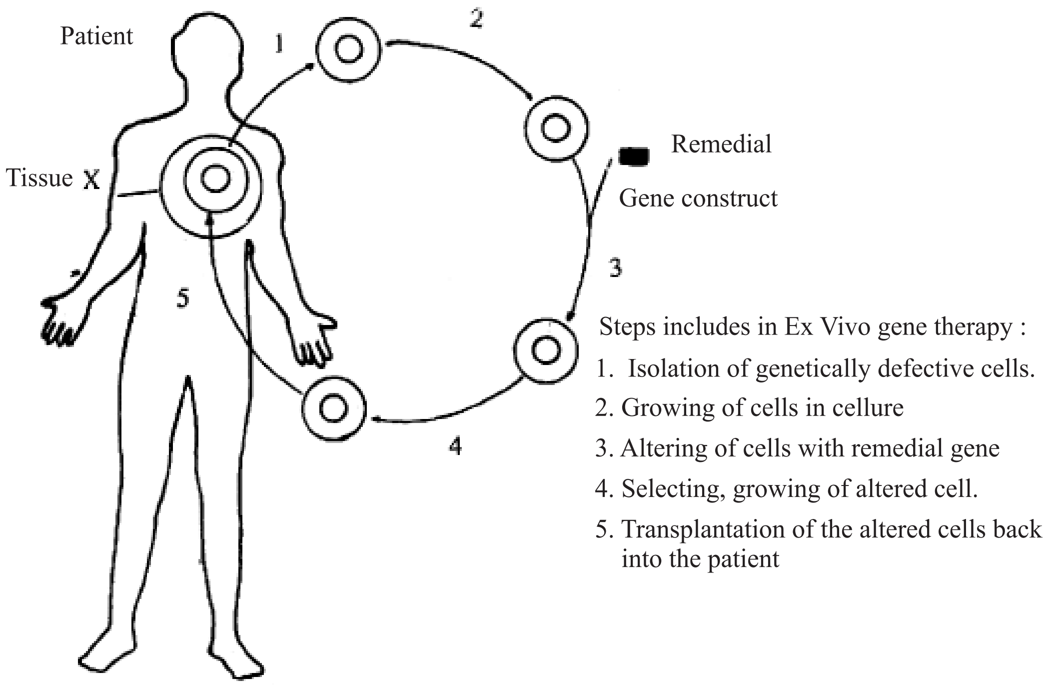


Fig. 30.6 Steps in the Ex-vivo gene therapy

Vectors such as retrovirus is used for the integration of normal gene in the host genome. Stem cells of the bone marrow are continuously producing new cells. If such cells are taken and put back after alteration, to remove genetic defects, these cells can divide and differentiate into various important cells such as B cells and T cells, macrophages, red blood cells, platelets and bone cells.

Genetically engineered stem cells on transplanting back into the patient's body result in a continuous supply of the required gene product. The technique can be used in the treatment of the following genetic disorders:

(i) Severe Combined Immuno Deficiency (SCID).

(ii) Sickle cell anaemia.

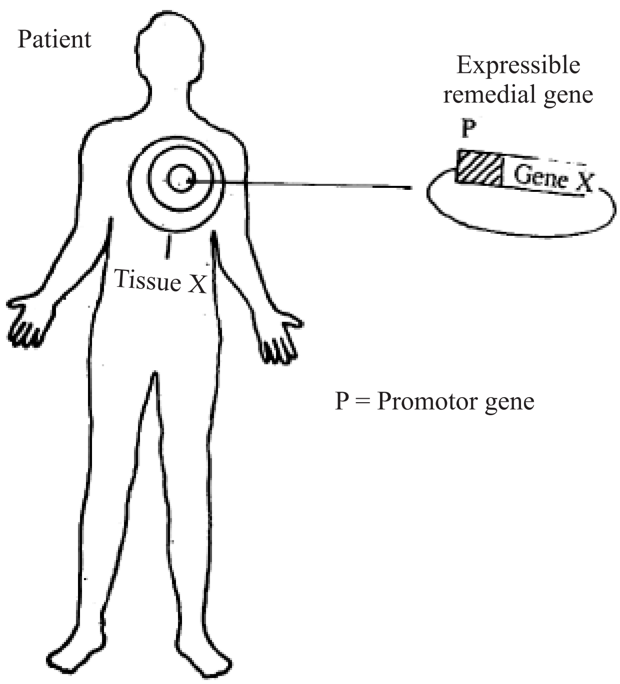
(iii) Thalassaemia

(iv) Certain tumours.

(b) In-vivo (within the body) gene therapy

This type of gene therapy includes direct delivery of a remedial gene into the cells of a particular tissue of the patient. Adenovirus, a double stranded DNA virus, is being used as a vehicle for transferring the remedial gene, (Fig. 30.7). The viruses used are weak enough to cause any disease. The tissue specific virus integrates with the host genome and can only infect dividing cells and not the other healthy cells.

This therapy may become useful in the treatment of cancer, Alzheimer's disease and Parkinsons's disease.



In-vivo gene therapy

A cloned expressible is delivered to cells of tissue with genetic defect.

(P) Promoter gene in tissue specific Gene X (remedial gene) encodes a protein that corrects the genetic defect of the patient.

Fig. 30.7 Steps in In-vivo gene therapy

(c) Antisense Therapy

You have learnt the steps involved in protein synthesis, transcription and translation.

This therapy is designed to prevent or lower the expression of specific gene thus limiting the amount of translation of protein from the over producing gene.

This therapy involves the introduction of nucleic acid sequence that is complementary to all or part of m-RNA (messenger RNA formed in the target cell) into the cells overproducing the gene product (Fig. 30.8). This therapy will prove useful in certain human genetic diseases and cancers where too much of a gene product or its continuous presence changes the normal functioning of the cell. It has been tried for treatment of malignant glioma or brain tumour. Tlaur-save tomato with a long shelp life has been produced by this technique.

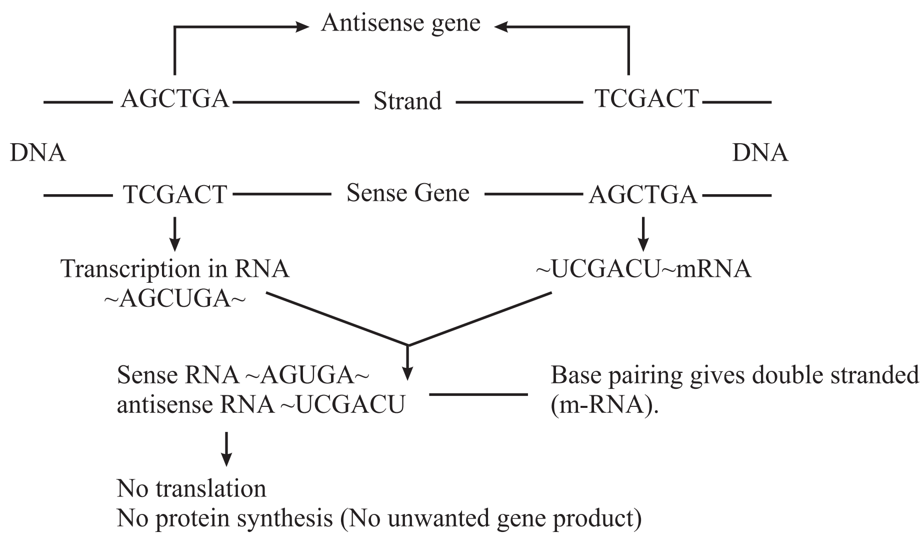


Fig. 30.8 Antisense gene therapy

Antisense gene therapy

An expressible gene is cloned in its reverse (order) orientation and is introduced into a cell. The RNA thus transcribed forms the antisense sequence of normal mRNA. When the antisense RNA base pairs with the mRNA, translation of the mRNA is prevented. The antisense RNA does not contain signals for the initiation of translation.

30.9.4 Gene Therapy—How Far?

The possibility of being able to genetically engineer humans has always been the aim of certain researchers. Somatic cell gene therapy is in its early stages of becoming a mode of treatment for a number of genetic and other diseases such as

(i) AIDS

(ii) Haemophilia

(iii) Atherosclerosis

(iv) Leukaemia

(v) Lung cancer

(vi) Severe Combined Immuno Deficiency-SCID

Germ line gene therapy is not being currently practised. Any manipulation in the genetic material of sex cells may introduce unforeseen characters with alarming consequences in the offspring. Gene therapy is thus not only risky but an expensive and time consuming technique available only in few advanced countries.

Gene therapy has the following limitations

(i) Research is limited to only somatic cells. Treated individuals can not pass the genetic improvement to offspring.

(ii) There could be a possibility of random integration of DNA into a human chromosome leading to inactivation or activation of a normal gene. This may result in either deficiency of an important enzyme or uncontrolled cell division leading to cancerous growth.

(iii) The Procedure Planned has to meet strict safety standards in animal trials.

(iv) Target diseases have to be limited to those that involve known defects in a single gene, and the normal gene must be cloned and be available for transplant.

INTEXT QUESTIONS 30.7

1. State the two approaches to human gene therapy.

   ....

2. Name the three categories of somatic cell gene therapy.

   (a) .... (b) .... (c) ....

3. Name any two genetic diseases that can be treated by somatic gene therapy.

   (i) .... (ii) ....

4. What is the direct delivery of the corrected gene into the tissue of the patient by the use of Adenovirus called?

   ....

WHAT YOU HAVE LEARNT

- Biotechnology is the application of scientific knowledge by industries that produce biological products like food supplements, enzymes, and drugs.
- Yeasts (Fungi), moulds (Fungi) and bacteria are important microorganisms used in industries.
- Yoghurt, alcoholic beverages, antibiotics, vaccines and biogas can be obtained on a commercial scale by the use of microorganisms.
- Fermentation is a process by which sugar is converted into alcohol and CO_2 by yeast.
- Fermentation by the yeast *Saccharomyces* yields beer and that by **Lactobacillus,** yields butter milk.

- In fermentation on large scale, bioreactor and nutrient medium are sterilised by autoclaving. Yeast is inoculated into the medium by support growth system or suspended growth system.
- Yoghurt is made from milk set by a bacterium *Lactobacillus*. Rennet tablets made from calf stomach or ficin from sap of fig trees are used for setting milk into curd.
- Bacteria also yield antibiotics as was discovered by Alexander Fleming. Waksman gave the term antibiotic.
- An antibiotic attacks and terminates a vital step in the metabolic pathway of the pathogenic bacterium which then stops growing.
- Vaccines are prepared (a) from weakened or attenuated germs (first generation vaccines), (b) by recombinant DNA technology (second generation vaccines), or (c) synthetically (third generation vaccines).
- Vitamins may also be generated through fermentation.
- Biogas is made by the action of methanogenic bacteria on waste matter such as the faeces of humans or of cattle.
- Genetic engineering is defined as construction and use of DNA molecules engineered by recombinant DNA technology.
- Recombinant DNA (r-DNA) technology resulted from the discovery of (i) plasmids, and (ii) restriction enzymes.
- Tools of r-DNA technology are cell culture, restriction enzymes, plasmids, ligase and host bacteria.
- Recombinant DNA technology may be used to obtain proteins commercially such as insulin, clotting factors, monoclonal antibodies, enzymes, antibodies and vaccines.
- Genetically engineered organisms carrying foreign genes are called transgenics.
- Transgenic plants may be obtained by using the T_1 plasmid of the bacterium *Agrobacterium tumefaciens*.
- Transgenic animals are produced by microinjection of foreign DNA into fertilised eggs or by using retrovirus for introducing foreign DNA into early embryonic stages.
- Genetically engineered bacteria can clean up pollutants from environment. This is called bioremediation.
- A mutated gene in a cell may result in some form of genetic disorder/disease. Sickle cell anaemia, Haemophilia, SCID are some single gene human disorders.
- Addition of a normal functioning gene to the defective cells to correct the genetic disease is called gene therapy.
- Treatment which is applied to body cells excluding germ line cells is called somatic gene therapy.

- There are three main therapeutic approaches to gene therapy : (a) ex-vivo gene therapy, (b) in-vivo gene therapy, and (c) antisense gene therapy.
- Ex-vivo gene therapy includes addition of corrected genes through retroviral cloning vectors.
- In-vivo gene therapy includes direct delivery of corrected genes into the tissues by use of adenovirus.
- Antisense therapy is designed to prevent or lower the expression of gene in order to have less accumulation of a gene product.
- Gene therapy has certain limitations such as (i) somatic cell gene therapy can not rectify the defect in subsequent generation, (ii) random integration of DNA from outside may interfere with normal gene, (iii) strict safety standards are to be maintained, (iv) proper clones of requisite genes have to be available.

TERMINAL EXERCISES

1. Define biotechnology.
2. How are alcoholic beverages produced by fermentation? Mention the steps in the process.
3. How can you make cheese and curd on a large scale?
4. What are antibiotics? Name five antibiotics and their sources.
5. How are different generations of vaccines produced?
6. Describe the steps in the production of biogas and mention the precautions to be taken.
7. Enumerate in a sequence the steps in recombinant DNA technology.
8. Describe the uses of genetic engineering.
9. How can a transgenic animal be obtained?
10. Write a note on bioremediation.
11. Define the term gene therapy. Under what condition does it become necessary to opt for such a therapy ?
12. What is meant by human somatic gene therapy? How does it differ from the germ line gene therapy? Which of the two have been successful so far and why?
13. Discuss in brief the different types of somatic gene therapy.

ANSWERS TO INTEXT QUESTIONS

30.1 1. Fungi, yeast, bacteria

2. Alcohol/antibiotics/curd/cheese/vitamins/vaccines/biogas (any three)

3. Ethanol/Butanol/Glycerol (any two)

4. Support growth system and suspended growth system
5. 1-b, 2-c, 3-a

30.2 1. *Lactobacillus*
2. Alexander Fleming
3. Vaccines produced by the use of recombinant DNA technology
4. Vitamin C
5. Methanogenic bacteria

30.3 1. Construction and use of novel DNA molecules obtained by recombinant DNA technology.
2. Clone is a collection of genetically identical cells obtained by asexual division of a cell.
3. When a fragment of foreign DNA is inserted in DNA of a phage or plasmid, DNA of the latter is called r-DNA.
4. In bacteria
5. Because they can cut specific sequences of DNA. (6) Ligase.
7. A phage or plamid which can carry foreign DNA and divide along with the bacterium whose part it is.

30.4 1. (i) Insulin, Growth hormone (ii) Proteases, Amylases
2. Antibiotics, vaccines and proteins of clinical value can be manufactured abundantly.
3. Rabies and hepatitis B

30.5 1. An organism containing foreign DNA in its genome
2. *Agrobacterium tumefaciens* and T_1 plasmid.
3. Bioremediation is removal of pollutants in the environment by the use of genetically engineered bacteria.

30.6 1. Mutation
2. Haemophilia, Sickle cell anaemia, SCID (Any two)
3. B-cells and T-cells
4. Replacement and alteration of defective gene is called gene therapy.

30.7 1. Somatic and Germ line cells
2. In-vivo gene therapy, Ex-vivo gene therapy and Anti-sense gene therapy
3. Thalassamia, certain types of cancer
4. In-vivo gene therapy

31

IMMUNOBIOLOGY : AN INTRODUCTION

We all get infections, but some of us fall sick more frequently than others. This is related to the immune system. Proper functioning of immune system protects us from the infections. On the other hand its malfunctioning provides opportunity to infectious agents for causing diseases. Besides protection from infection, immune system also performs a number of other functions. It is about all this that you will learn in this lesson.

OBJECTIVES

After completing this lesson, you will be able to :

- *define the term immunity;*
- *explain the concept of "self" and "non-self";*
- *describe the types of defence mechanisms in the body;*
- *describe the types of immunity;*
- *list and describe various cells of the immune system;*
- *differentiate between cellular and humoral immunity; innate and acquired immunity;*
- *describe various components of the immune system;*
- *explain the concept of immunization (vaccination) and list various types of vaccines.*

31.1 IMMUNITY

Immunity is broadly defined as "the capacity of the body to recognize materials as foreign to itself and to neutralize, eliminate or metabolize them with or without injury to its own tissues".

Immunobiology is the study of organization and functioning of immune system. Immune system provides 'immunity' (protection against diseases).

Jenner, the father of immunology

Edward Jenner (1749-1823) is considered to be the father of modern immunobiology. He demonstrated that inoculation of cowpox crusts afforded protection to humans against smallpox. He observed that milkmaids who recovered from cowpox never contracted the disease smallpox. Hence the name vaccination from the Latin word "Vacca" for cow came into beng. The milkmaids and the vaccinated individuals were protected from smallpox virus. Such protection gave them what is called `immunity' to smallpox, although Jenner neither knew the actual causative agent of this disease nor the actual mechanism of protection.

Concept of "Self" and "Non-Self"

The basis of the above mentioned protection was the ability of the immune system of the milkmaid and vaccinated individuals to distinguish between **'self** (their own tissues) and **'non-self'** components of the outsiders i.e. the smallpox virus) in this context.

An individual induces a physiological response (immune response) to substances that are different from self components. For example, an immune response is induced against pathogens (bacteria, virus, fungi and parasites) attacking the body of the host.

Let us now learn about the different ways by which the body defends itself from pathogens and other harmful substances.

31.2 DEFENCE MECHANISMS IN THE BODY

There are four defence mechanisms in our body :

1. Immunity to defend the body from infections.
2. Metabolic defence to metabolize and detoxify foreign chemicals.
3. Stoppage of bleeding (Haeostasis) to prevent to blood loss.
4. Resistance to stress mainly through release of hormone.

Immunological defence is the most important defence mechanism. It provides protection against various infective agents e.g. virus, bacteria, fungi and parasites and also against the development of a tumour.

Thus immunological defence serves three main functions :

1. Defence against microorganisms.
2. Recognition and destruction of mutant cells (Surveillance).
3. Removal of damaged or non functional cells to maintain normal state (Homeostasis).

INTEXT QUESTIONS 31.1

1. Who is considered as the father of immunobiology?

   ....

2. What are the three main functions of immunological defence?

   (i) ....

   (ii) ....

   (iii) ....

3. Define immunology.

   ....

31.3 IMMUNE SYSTEM

By now, you are aware that immunity to infection is one of the most important factors facilitating survival of an individual. Immunity is mainly provided by a complex network of cells, tissues and soluble factors. This network is collectively referred to as the **'immune system'.** Cells participating in the immune response are organized into discrete **'lymphoid tissues and organs'.**

1. Tissues and Organs involved in the Immune System

Lymphoid organs are divided into two groups :

(i) Central lymphoid organs or primary lymphoid tissue. Example : Thymus and bone marrow.

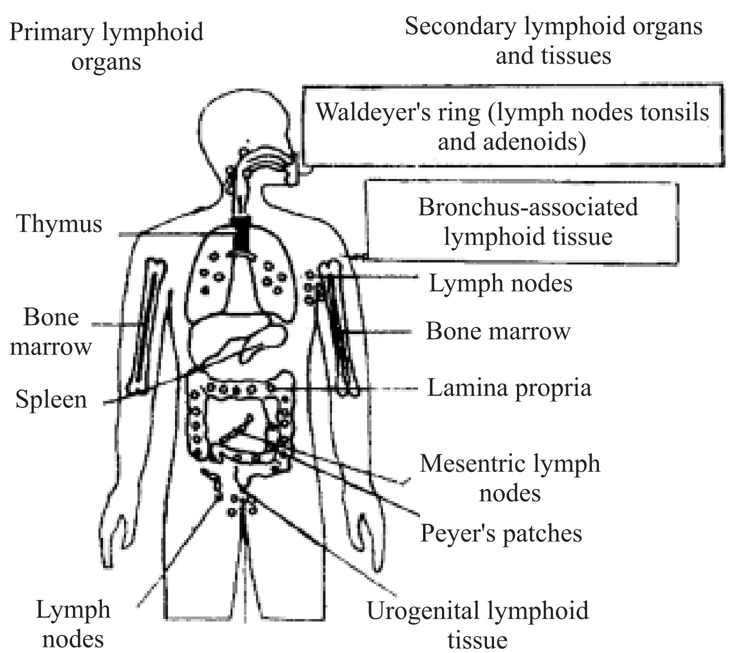


Fig. 31.1 Major lymphoid organs and tissues.

(ii) Peripheral lymphoid organs or secondary lymphoid tissue. Examples spleen, Peyer's patches, tonsils, lymph nodes and mucosa-associated lymphoid tissue (MALT), which is associated with the respiratory system, urogenital and alimentary canal (Fig. 31.1).

2. Cells of Immune System

(i) Lymphocytes (Lymphoid cells)

All these are initially derived from the hemopoietic (blood cell producing) stem cells of bone narrow. Stem cells mean undifferentiated cells which can undergo unlimited division and can give rise to one or several different cell types. Apart from producing lymphocytes bone marrow stem cells also differentiate to produce **erythrocytes (red blood cells), thrombocytes (blood platelets), granulocytes** and **monocytes (white blood cells).**

(ii) The macrophage

These are derived from monocytes.

Lymphocytes are the major cell types responsible for performing immune functions. About 10^{12} lymphocytes constitute the mature lymphoid system in humans. Functionally, lymphocytes are divied into two sub-classes:

(i) B-cells or B-lymphocytes

(ii) T-cells or T-lymphocytes

Morphologically, these cells cannot be differentiated, but functionally these are distinct. Cells of immune system are differentiated on the basis of presence or absence of specific cell surface markers.

(a) B-Cells (B-lymphocytes)

Main functions of B-cells

1. Initiate antibody-mediated immune response.
2. Transform into plasma cells which secrete antibodies.

Origin of B-Cells

"B" stands for Bursa. Studies in birds showed that the bursa of Fabricius, a hind-gut lymphoid organ was the site of antibody-producing cells. These cells are therefore termed as 'B-cells' ('B' derived from bursa of Fabricius). B-cells mature in the bone marrow and then are carried by the blood to the peripheral lymphoid organs. In mammals, B-cells lineage begins in foetal (embryonic) liver. This process begins during the 8th week of human gestation (pregnancy). The foetal liver continues to be the major site for production of the B-cells, until well into second trimester (4-6 months of pregnancy). Stem cells then populate the bone marrow and thereafter the B-cells are continuously produced in the bone marrow throughout life (Fig. 31.2).

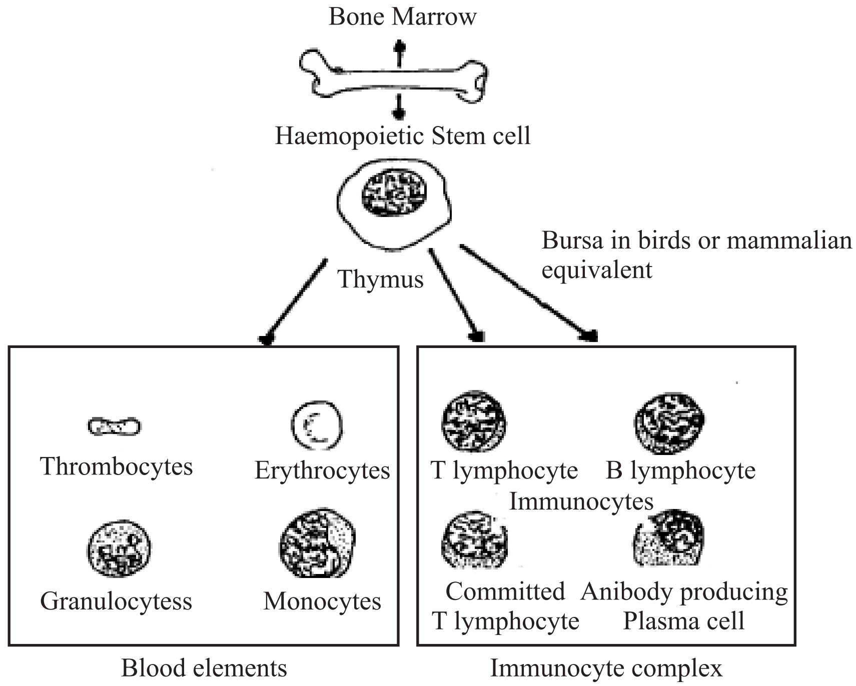


Fig. 31.2 Origin of B and T Cells

Characteristics of B-cells

(i) B-cells display **immunoglobulin** as an integral protein *of* their cell membranes.

(ii) This surface immunoglobulin (antibody) acts as the receptor for antigen specific to it.

(iii) B-cells are responsible for the production of antibodies. Activated B-cells transform into plasma cells (Fig. 31.3). You will learn about 'antigen' and 'antibody' in the next section of this lesson.

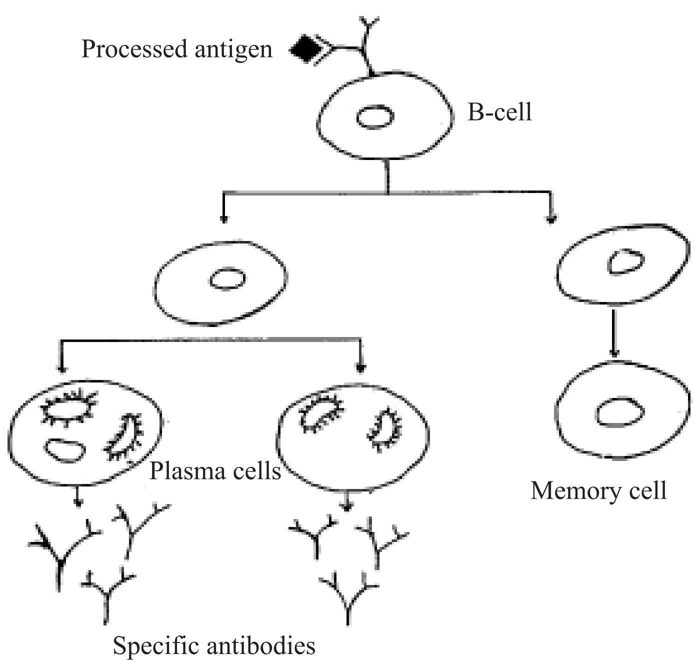


Fig. 31.3 B-cell differentiation and antibody production.

Plasma cells produce thousands of antibody molecules per second before they die in a day or so.

Some of the B-cells progeny do not differentiate into plasma cells but rather become 'memory cells' which produce antibodies in the event of the antigen re-appearing again in future.

(b) T-Cells (T-lymphocytes)

In contrast to B-cells, other lymphocytes leave bone marrow in an immature state during foetal and early stages of life. These are carried to the 'thymus', mature in thymus, and then they migrate to the peripheral lymphoid organ. These cells constitute the second major class of lymphocytes, the T-lymphocyte or T-cells. 'T' derived from thymus. Production of T-cells is completed early in life, but like B-cells, they also undergo mitosis in peripheral lymphoid organs, the daughter cells being identical to the original T-cells.

Main functions of T-cells

(i) Regulate immune response.

(ii) Mediate cell-mediated immune (CMI) response.

(iii) Induce B-cells to produce antibody.

T-cells are functionally classified into three categories (T_H, T_C, T_S)

1. Helper T-cells (T_H)

Promote response of B-cells resulting in antibody production (activate other T-cells).

2. Cytotoxic T-cells (T_C)

Kill virus-infected cells and tumour cells.

3. Suppressor T-cells (T_S)

Suppress helper T-cells and may also B-cells to limit/regulate activity of the latter.

Thus we see that T-cells mediate two general type of immunological functions : **effector** and **regulatory**.

Structurally, T-cells are differentiated on the basis of presence or absence of some specific surface molecules (T-cell receptors). But both B-cells and T-cells work in cooperation.

INTEXT QUESTIONS 31.2

1. Name the **two** categories of immune cells.

   (i) ....

   (ii) ....

2. Name the organ found in birds where B-cells are produced.

   ....

3. Write the **two** main functions of B-cells.

   (i) ....

   (ii) ....

4. Name the cells responsible for synthesis of antibodies.

   ....

5. What is the function of T-helper cells?

   ....

31.4 ANTIGEN AND ANTIBODY

While discussing about 'self' and 'non-self, we got a broad idea of **antigen**. Let us learn more about it.

31.4.1. Definition and Properties of an antigen

An antigen is any foreign molecule that can trigger a specific immune response.

Most antigens are either **proteins** or very large **polysaccharides**. Another term 'immunogen' is also used for antigen. However, there is a slight difference between the two. Immunogen describes a molecule that provokes an immune response while antigen describes a molecule which reacts with the antibody produced.

Paratopes and Epitopes : The part of antibody molecule which makes contact with the antigen is termed the **paratope**. The part of antigen molecule that makes contact with paratope is called the **epitope**. There may be a series of epitopes on an antigen. Such epitope clusters are called 'antigenic determinant'.

Requirements for becoming an antigen :

1. Substance should be foreign to the host.
2. Molecular weight of molecule should be 10,000 Dalton or more.
3. It should possess chemical complexity.

31.4.2 Antibody : Definition and properties

Antibody is a protein molecule produced in animals in response to an antigen.

Antibodies belong to the category of proteins called immunoglobulin. Each antibody molecule is composed of four interlinked polypeptide chains. The two long chains are called **heavy chains**, and the two short chains are called **light chains**. An antibody has a "stem" called "Fc" portion which comprises the lower half of the two heavy chains, and two "prongs' (the amino acid sequences that bind antigen).

The amino acid sequences of Fc portion are identical (constant) for all antibodies of same class. In contrast, amino acid sequences for antigen binding sites vary from antibody to antibody in a given class (Fig. 31.4)

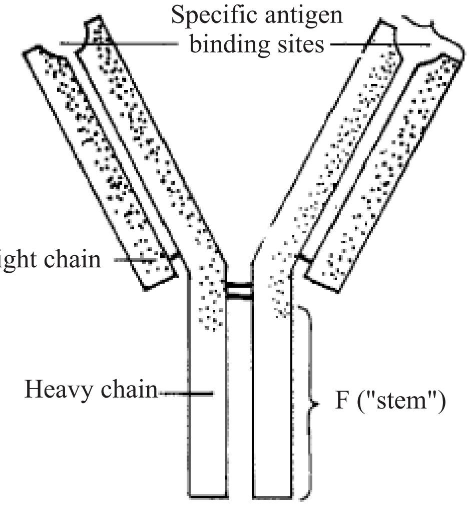


Fig. 31.4 Antibody structure

31.4.3 Type of immunoglobulins

- There are five major classes of antibodies (or immunoglobulins) distinguished by the amino acid sequences in the heavy chains. These classes are designated as Ig, IgD, IgA, IgE, IgG and IgM (1g = Immunoglobulin)
- They also differ in their molecular weights and functions.
- IgG is found in highest concentration (almost 75% of the total immunogloblulins in humans).
- Antibodies are produced by plasma cells which are differentiated B-cells. Each B-cell type produces antibodies which react with a particular epitope of antigen.
- Secreted antibodies travel all over the body through blood and reach antigens of the kind that stimulate the immune response, combine with antigens (Fig. 31.5) and then direct an attack (by phagocytic cells which eat up foreign material) and eliminate the antigen or the cells bearing them.

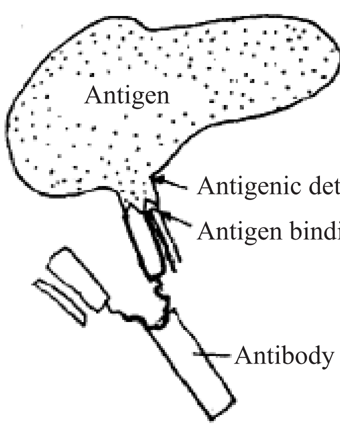


Fig. 31.5 Antigen-antibody binding

31.5 TYPES OF IMMUNE RESPONSES

Broadly, immune responses can be classified into two categories : **Non-specific immune responses** and **specific immune responses**.

1. **Non-specific immune responses** are those which non-selectively protect against foreign substances or cells without having to recognize their specific identities. Phagocytosis (engulfing, of particulate matter) by macrophages and extracellular killing by proteins known as 'complement'. There are two non-specific types of immune responses.
2. **Specific immune responses** (adaptive immune response) depend upon the immunological recognition of the substances or cells to be attacked. Specific immune responses are again of two types :
   (a) **Cell mediated immune responses :** Mediated by cytotoxic T-cells and natural killer cells. These constitute major defence against intracellular viruses and cancer cells.
   (b) **Antibody-mediated or humoral immune responses :** These responses are mediated by antibodies secreted by plasma cells, which arise from activated B-cells. They constitute major form of protection against bacteria and viruses.

The above two differ from each other as shown in Table 31.1

Both cell mediated and antibody mediated immune responses are facilitated by helper T-cells and inhibited by suppressor T-cells (Fig. 31.6)

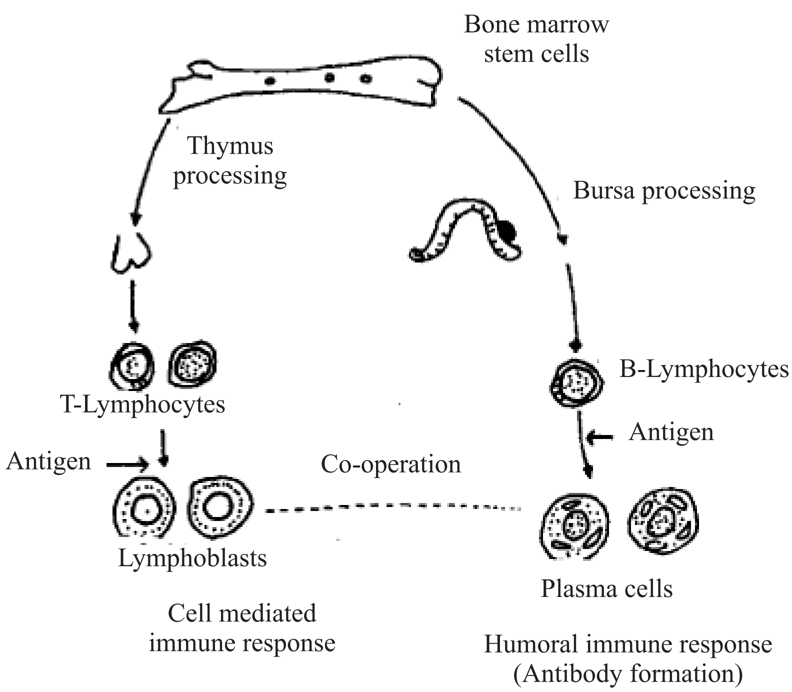


Fig. 31.6 Cell-mediated and humoral immune responses

Table 31.1: Differences between cell-mediated and humoral (antibody mediated) immune responses

Cell-mediated immune response	Humoral immune response
1. Killing of intracellular organisms.	1. Antibodies specifically combine with antigen which stimulate their production.
2. Destruction of tumour cells	2. The combination of antibody with antigen may result in clumping of molecules or particles, their toxicity may be neutralized, their uptake and digestion by phagocytes may be facilitated.
3. Rejection of graft tissue.	3. Combination of antigen with antibody may also cause lysis of cellular antigens present on the red blood cells or bacteria.
4. Delayed type of hypersensitivity reaction after contact with certain antigen.	

INTEXT QUESTIONS 31.3

1. Name the part of antigen which makes contact with antibody.

   ....

2. How many types of immunoglobulins are known? (Give only the number).

   ....

3. Name the immunoglobulin found in highest concentration.

   ....

4. Which type of immune response is responsible for the killing of cancer cells?

   ....

31.6 TYPES OF IMMUNITY

There are two main types of immunity : (i) Natural or innate (i.e. genetic, from birth), and (ii) Acquired (i.e. developed during life time).

A. Natural or Innate Immunity

A healthy individual is generally immune to potentially harmful microorganisms by a number of very effective mechanisms. These mechanisms are termed **innate** or **natural immunity.** Innate defence consists of three main components :

(i) Physical barriers (preventing entry of germs)

(ii) Phagocytic cells and (Dealing with germs which enter)

(iii) Soluble components (complement)

(i) Physical Barriers

It is the first line of defence. It means preventing the entry of pathogens into the body. (Fig. 31.7).

Skin : The outer tough layer of skin is formed of keratin and is almost impermeable to germs. Sebaceous glands in the skin generate an acidic environment by producing lactic acid which kills many pathogens.

Epithelial lining of various organs : The respiratory tract, the alimentary tract (the gut) and the urino-genital tract have an exterior epithelial cell layer covered by a protective mucous lining. In the respiratory tract, cilia covering to the external surface of the epithelial cells continually beat upwards towards the nasopharynx and this helps to expel particles and pathogens. Epithelial cells are constantly renewed and their removal expels pathogens lodged on their surface.

Body secretions : Body secretions such as sweat and secretion from eyes also ward off pathogens. Other body fluids contain molecules which are bactericidal that is capable of killing bacteria (e.g., spermine in seminal fluid, hydrochloric acid in gastric juice).

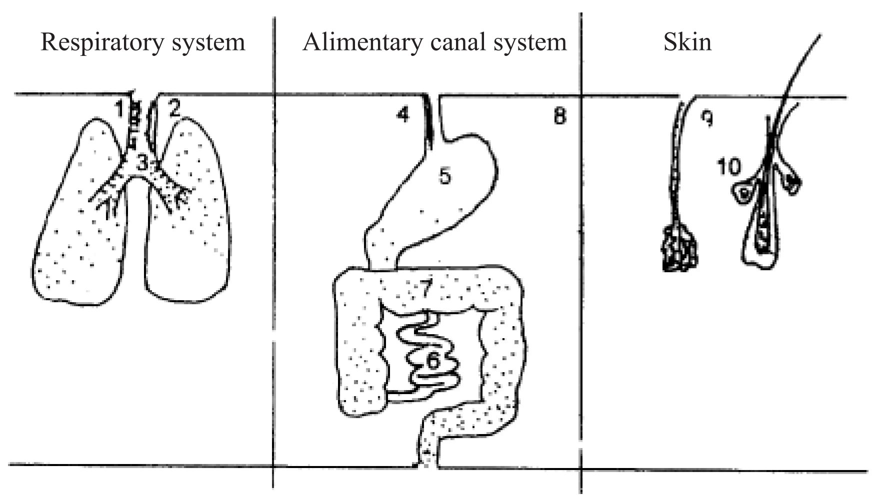


Fig. 31.7 Natural physical barriers to infections

If the germs somehow enter the body by evading physical barriers of the body, the other two main defence mechanisms come into play – **phagocytosis** and the **bactericidal effect** of soluble chemical factors collectively known as **complement system** which are described below.

(ii) Phagocytic Cells

When the micro-organisms or inert particles such as colloidal carbon enter the tissue fluid or blood stream, these are very rapidly engulfed and destroyed by phagocytic cells. Such cells may either be circulating in body fluids or may be fixed in some tissues. This phenomenon is called phagocytosis (literally meaning 'eating' by the cell). The engulfment and destruction/digestion of microorganisms is assigned to two major types of cells named as **microphages** (certain WBC) and **macrophages** (in Liver and Spleen).

Important features of phagocytic cells

1. They rapidly engulf the foreign molecular foreign agent oncoming in contact or which they come in contact with.
2. They contain digestive enzymes to breakdown engulfed material.
3. They are an important link between innate and acquired immunity (described below).

(iii) Complement System

The group of proteins known as 'complement' provides another innate immunity mechanism for killing microbes without prior phagocytosis.

> Complement system is an extremely complex system consisting of at least 20 proteins.

Some of the complement components are designated by the letter 'C' followed by a number. The most pivotal and most abundant component is C_3. Complement component may also act as **opson** in (e.g. C_36). Opson is that type of antibody whose binding to antigens on virus or bacterium facilitates their subsequent ingestion by the phagocytic cells. Such antibodies can also cause direct destruction of microbes by making their membrane leaky.

B. Acquired Immunity

It is the immunity mediated by lymphocytes and characterized by antigen specificity and memory.

An acquired immunity may be brought about in an individual in two main ways:

1. By infection, so that antibodies are produced against the infective agent and by deliberate artificial immunization. This is termed as **actively acquired immunity.**
2. By transfer from an actively immunized individual through blood, serum component etc. This is called **passively acquired immunity.**

(i) Actively acquired immunity

Actively acquired immunity due to infection falls into two general categories.

(i) Some infections, such as diphtheria, whooping cough, smallpox and mumps usually induce a lifetime immunity i.e. a patient once recovered does not get the disease subsequently.

(ii) Other diseases such as common cold, influenza, bacillary dysentery and pneumococcal pneumonia confer immunity for a shorter period, sometimes only for a few weeks.

(ii) Passively acquired immunity

It may be developed in the following ways :

1. Transfer of antibodies (e.g. IgG) from mother into foetus across the placenta.
2. Breast fed children also receive antibodies from the mother's milk.
3. Pooled human immunoglobulin is also used as source of antibody in a number of cases including measles infection and infectious hepatitis.
4. Human immunoglobulin is also given to patients with a congenital inability to make antibody globulin.

31.7 ACTIVE IMMUNIZATION (VACCINATION)

People had observed in the past that individuals who recovered from certain diseases are protected for lifetime from recurrences. This gave rise to the concept of **immunization**. Edward Jenner introduced **vaccination** in 1796 using cowpox to protect against smallpox.

The objective of vaccination is to introduce the attenuated germs into the body. The body then generates specific population of memory cells. These memory cells can rapidly increase in number on the renewed contact with the same antigen and more antibodies can be produced to provide protection against infection.

31.7.1 Type of Vaccine

Three main types of vaccines are available :

1. Killed organisms as vaccines : Examples : typhoid, cholera, pertussis (whooping cough), rabies and poliomyelitis.
2. Live attenuated (weakened) organisms as vaccines; Examples: BCG, *Rubella*, measles and polio.

   Attenuation mimics the natural behaviour of the organism without causing disease. The actively multiplying organism provides a sustained antigen supply.
3. Toxoid vaccines : Examples: diptheria and tetanus.

   Toxoid is a chemically or physically modified toxin that is no longer harmful but retains immunogenicity.

31.7.2 Important Vaccines – BCG, DPT and MMR

- BCG = Bacillo Calmette Guerin (Calmette and Guerin were the scientists who contributed in the development of tuberculosis vaccine).
- DPT is a triple vaccine (or antigen) for diptheria and tetanus toxoids and for pertussis *Bordetella pertussis,* the whooping cough organism.
- MMR vaccine = Attenuated strain of measles, mumps and *Rubella*).

Another class of vaccines termed as **polysaccharide vaccines** are available comprising vaccines for influenza, meningitis and pneumonia. In these vaccines, the relevant immunogenic portions of the organism are used.

Vaccines of future : against Malaria, Leprosy, Anthrax, AIDS

INTEXT QUESTIONS 31.4

1. Mention two physical barriers of the body.

   ....

2. Macrophages are found in large numbers in the following organs :

   (i) ....

   (ii) ....

   (iii) ....

3. Give two examples of each of the following:

   (i) Killed organism vaccine ....

   (ii) Live attenuated organism vaccine ....

   (iii) Toxoid vaccine ....

WHAT YOU HAVE LEARNT

- There are various types of defence mechanisms in our body. Immunity defends us against infections.
- Immune system is a complex network of cells, tissues and soluble factors working in close co-ordination.
- Thymus and bone marrow are the central or primary lymphoid organs.
- Lymphocytes which are the major cells performing immune functions are of two main types - B-lymphocytes and T-lymphocytes.
- B-cells are transformed into plasma cells which produce antibodies.
- Foreign molecule which triggers an immune response is called antigen.
- Antibodies (immunoglobulins) are of five types, of which 1gG is found in the highest concentration.
- There are two main types of immune responses — specific and non-specific.
- Specific immune responses can be either cell-mediated or antibody (humoral)-mediated.
- There are two types of immunity — natural or innate and acquired.
- Vaccination is a type of actively acquired immunity.
- There are three types of vaccines – (i) killed organisms as vaccines, (ii) live attenuated organisms as vaccines, and (iii) toxoid vaccines.

TERMINAL EXERCISES

1. Define the term immunity.
2. What are the main defence mechanisms operating in our body?
3. 'Immune system is a complex network of cells, tissues and soluble factors'. Justify this statement.
4. Describe the process of antibody production.
5. List main functions of T-cells.
6. Draw a schematic diagram of the structure of antibody.
7. What are the main physical barriers of the body?
8. Describe important features of phagocytic cells.
9. Give one main difference between passively acquired immunity and actively acquired immunity.
10. Define the process of attenuation.
11. Name two toxoid vaccines.
12. What do the following abbreviations mean?

    (i) BCG   (ii) DPT   (iii) MMR

ANSWERS TO INTEXT QUESTIONS

31.1

1. Edward Jenner
2. Broadly immunological defence serves three functions :
   - (i) Defence against microorganisms.
   - (ii) Homeostasis i.e. removal of damaged (non functional) cells to maintain normal state.
   - (iii) Surveillance i.e. recognition and destruction of mutant cells.
3. Study of organisation and function of the immune system.

31.2

1. (i) Central or primary lymphoid organs.

   (ii) Peripheral or secondary lymphoid organs.
2. Bursa of Fabricius.

3. Main functions of B-cells:

   (i) Initiate antibody mediated-immune response.

   (ii) Transform into plasma cells which secrete antibodies.

4. Plasma cells/B-cells

5. Promote response by B-cells resulting in antibody production and also activate other T-cells.

31.3 1. Epitope

2. Five

3. Immunoglobulin G

4. Cell-mediated immune response

31.4 1. (i) Skin

   (ii) Epithelial cell layer of respiratory system.

2. (i) Lung

   (ii) Liver

   (iii) Spleen

3. (i) Typhoid vaccine, Pertussis vaccine.

   (ii) BCG, *Rubella* vaccine.

   (iii) Diphtheria vaccine, Tetanus vaccine.

QUESTIONS PAPER DESIGN

Subject: **Biology (314)** Class: **Senior Secondary**
Paper Marks: **80** Duration: **03 Hrs.**

1. Weightage by Objectives

Objective	Marks	% of the Total Marks
Knowledge	20	25
Understanding	36	45
Application and Skill	24	30
Total	**80**	**100**

2. Weightage by Types of Question

Type of Questions	Marks × No. of Questions	Marks Allotted
Essay (E)	6 × 4	24
Short Answers I (SA1)	4 × 6	24
Short Answers II (SA2)	2 × 12	24
Multiple Choice Questions (MCQ)	1 × 8	8
Total	**30 Questions**	**80 Marks**

3. Weightage by Content

Module Number	Module Name	Marks
1	Diversity and Evolution of Life	12
2	Form and function of plants and animals	26
3	Reproduction and Heredity	22
4	Environment & Health	13
5	Emerging Areas in Biology	07
	Total	**80**

4. Difficulty Level

	Essay	Average	Difficult	Total
Percent Weight	25%	45%	30%	100%
Marks Allotted	20	36	24	80
No. of Questions	6	14	10	30

5. Time Management

Type of Questions	Total Time 180 minutes
Essay (E)	60
Short Answers I (SA1)	60
Short Answers II (SA2)	25
Multiple Choice Questions (MCQ)	15
Reading and Revision	20

SAMPLE QUESTIONS PAPER

BIOLOGY (Sr. Secondary)

TEE

1. The only kingdom which includes one-celled organisms without a well defined nucleus is
   a) Bacteria b) Monera
   c) Protoctista d) Prokaryote 1

2. The fresh water fish are ammonotelic so removal of urine requires.
   a) lot of water b) very little water
   c) moderate amount of water d) no water at all 1

3. The phylum which humans share with Kangaroos, bats and tigers is
   a) Vertebrata b) Animalia
   c) Chordata d) Carnivora 1

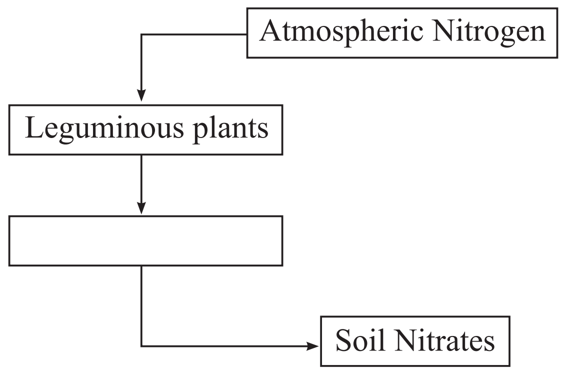
4. The antheridia and archegonia are the
   a) male and female sex organs of bryophytes with gametophyte as the main body.
   b) female and male sex organs of bryophytes with saprophyte as main body.
   c) Spores of Pteridophytes in their gametophytes
   d) Two phases of the main plant body of both bryophytes and pteridophytes 1

5. What is a gemmule?
   a) Reproductive body of sponges for sexual reproduction.
   b) Plant spores that withstand adverse weather conditions.
   c) A kind of spicules of sponges.
   d) Reproductive body of sponges for asexual reproduction 1

6. Bt crops are
   a) Transgenic crops
   b) Crops on which *Bacillus thuringiensis* forms galls
   c) Hybrid crops
   d) Crops which resist pesticides 1

7. A male infant was born with an extra X chromosome. The infant was pronounced to be
   (a) Turner (b) Klinefelter
   (c) transgender (d) Mongol 1

8. Fill in the blank in the part of Nitrogen cycle drawn below;



a) Nitrifying bacteria sticking to roots of leguminous plants

b) Nitrifying bacteria in soil.

c) Nitrogen fixing bacteria in root nodules of leguminous plants

d) Nitrogen fixing bacteria in soil. 1

9. List four processes associated with Carbon cycle. State one effect of deforestation and one of afforestation on Carbon cycle. 2

10. State any two points of difference between transpiration and guttation. 2

11. Compare nervous system of cockroach with that of humans, with respect to its

(a) location in the body (dorsal/ventral)

(b) parts present in the head, thorax and abdomen. 2

12. What happens to the Graafian follicle when ovulation takes place? Name the hormones released by it before and after ovulation. 2

13. Polyembryony is the formation of more than two embryos in a single ovule. It is classified into cleavage polyembryony and adventive polyembryony depending on which cells form the second embryo. State the difference. 2

14. State two points of difference between innate and acquired immunity. 2

15. What is meant by 'Cell mediated response' to an antigen? How is it different from 'humoral response'? 2

16. Thallasemia is a genetic disorder. What kind of disorders are:

a) drug dependence b) goitre

c) HIV-AIDS d) colour blindness 2

17. A son and a daughter were born colour blind. The father was colour blind but mother had normal colour vision. Draw a self explanatory cross to show this. 2 Marks

18. After a major surgery, a man was advised to include more of protein and Iron in the diet. Give reasons and mention one source of each. 2 Marks

19. Why is 'biogas' considered to be a better fuel option than fossil fuels? State any two advantages. 2 Marks

20. A scientist discovered the presence of a chemical substance in a herb which had medicinal properties. His friend said, 'Beware of biopiracy, apply for a bio patent'. What did the friend mean by biopiracy and biopatent? 2 Marks

21. a) State the law of independent assortment.

    b) With the help of Punnett square, explain how Mendel arrived at the law of independent assortment.

    c) State any one condition under which this law is not applicable. 4 Marks

22. The diagram shows various pathways of water movement. What kind of pathway is shown by the (i) thin arrow and (ii) curved arrow Distinguish between the two pathways. 4 Marks

23. Explain how muscle contract and relax to cause locomotion. 4 Marks

24. The blood pressure of a person was falling. Explain to your friend the role of Renin – Angiotensin which elevated the blood pressure to the normal state. 4 Marks

25. Parturition, Ovulation, implantation are technical terms used to describe reproductive events in a human female.

    (i) Place them in the correct sequence of occurrence.

    (ii) In a sentence each, state their meanings. 4 Marks

26. Your friends insist that round worm and earthworm are too similar to be placed in separate phyla. Convince your friends by comparing two very different characteristics in them. Mention their phyla and give one major feature of each phylum. 4 Marks

27. State two contrasting features each of sex determination, in humans, birds and honey bees.

    6 Marks

28. Green house gases cause Acid rain, Global warming. What is the difference between these two phenomenon? Add a note of the change in ozone layer due to particular greenhouse gases.

    6 Marks

29. State the salient points of Darwin's theory of Natural selection. What is Neo Darwinism?

    6 Marks

30. (i) Define Photosynthesis and give a generalized balanced equation for photosynthesis.

    (ii) Describe Calvin cycle in four steps. Or express Calvin cycle by a diagram. 6 Marks

MARKING SCHEME

1. (b) 1

2. (a) 1

3. (c) 1

4. (a) 1

5. (d) 1

6. (a) 1

7. (b) 1

8. Nitrogen fixing bacteria 1

9. Respiration, photosynthesis, burning fossil fuels (Combustion), Decomposition (of living organisms) 1/2 × 4 = 2

10.

Transpiration	Guttation
Water lost as vapour	As water drops
Through stomata	Through hydathodes
During day/High temperature	At night/low temperature
No minerals in lost water	Minerals in lost water
(any two)	

1+1=2

11.

Cockroach	Humans
Ventral	Dorsal
Cerebral ganglia, Thoracic ganglia, abdominal ganglia	Brain spinal cord Spinal cord

1+1=2

12. Ovum drops off; Corpus luteum forms Estrogen (before); Progesterone (after) ½ × 4=2

13. **Cleavage**: Zygote divides & each cell forms a separate embryo.

Adventive: Other cells of embryo sac/synergids/antipodal cells divide and forms embryos

1+1=2

14.

Innate	Acquired
Natural defense mechanisms which prevent entry of germs	Mediated through lymphocytes reacting to antigen.
Mediated through general body surface, phagocytes, secretions etc. General prevention no specificity	Antigenic specificity
No memory	Memory
(any two differences)	

½ × 4=2

15.

Cell mediated Response	Humoral response
Mediated by (cytotoxic) T cells and natural killer cells	Mediated through antibodies secreted by B cells.
Defence against intracellular viruses and cancer cells	Major protection against bacteria and viruses in intercellular fluid.

½ × 4=2

16. a) Addictive disorder

b) Deficiency/Hormonal disorder

c) Viral/Communicable

d) Genetic/Hereditary ½ × 4=2

17. Father (X^CY) (Colour blind) × Mother (X^CX) (Carrier)

F1	X^CX^C	X^CX	X^CY	XY
	Colour blind daughter	Daughter with Normal vision (Carrier)	Colour blind son	Normal son

Parents genotype = 1+1
Offspring genotype = ½ × 4

Marking Scheme

18. **Protein** – body building food required during healing after surgery.

    Source: Dal, pea, beans, soybean, gram (any one)

    Iron: Builds blood as it is part of Hb molecule

    Source: Liver, Leafy vegetables like spinach, egg, molasses, grains, peanuts (any one)

    ½ × 4

19. Cost effective (cheap)/environment friendly as organic waste recycled does not give out gases like SO_2 (any two) 1+1=2

20. Biopiracy is when another country takes away without permission a beneficial invention. Bio patent is kind of a copyright for a particular invention and registered by the government for not being used by others without permission. 1×4

21. In the inheritance of two features, genes for the two different features are passed down to the offspring independently.

Genes for Tall plant and Red flowers in gametes	**TR**	**Tr**	**tR**	**tr**
TR	TTRRTall Red	TT RrTall red	Tt RRTall Red	TtRr Tall Red
Tr	TT RrTall Red	TTrrTall white	TtRr Tall red	Ttrr Tall white
tR	Tt RRTall Red	TtRrTall Red	tt RR Dwarf Red	ttRr Dwarf Red
tr	Tt RrTall Red	TtrrTall White	ttRrDwarf Red	ttrr Dwarf White

    1 mark for stating law

    1 mark for correctly writing the gametes

    1 mark for correctly writing the phenotype

    1 mark for arriving at 9:3:3:1 ratio (9 tall red, 3 dwarf red, 3tall white, 1dwarf white)

22. Thick arrow – Symplast pathway, Thin arrow – Apoplast pathway. Symplast pathway = movement across cytoplasm.Apoplast pathway = across cell wall & intercellular spaces

    1 × 4=4

23. Stimulus arrives; calcium enters sarcoplasmic reticulum of each sarcomere. Sarcomere shortens due to contraction of myofibrils of A band; go close to I band; H band remains unchanged; all sarcomere contract at the same time; muscle contracts. The opposite happens for relaxation. ½ × 8=4

24. Juxtaglomerular cells secrete Renin; acts on Angiotensin I; Converts it to angiotensin II; acts upon adrenal cortex; Aldosterone secreted; makes blood vessels permeable to salt; water follows salt due to osmosis; blood volume increases; blood pressure increases and becomes normal. ½ × 8=4

25. Sequence: Ovulation, Implantation, Parturition.

Parturition: Uterine contraction under influence of oxytocin; to deliver fully formed foetus.

Implantation: Egg is fertilized in fallopian tube and Zygote begins dividing upto blastocyst formation;

Blastocyst sticks to thickened endometrium (uterine inner wall) to develop further.

Ovulation: Egg released from graafian follicle; under influence of LH or Luteinising hormone.

Mark for correct sequence	1	
Mark for Parturition	½ × 2	
Mark for Implantation	½ × 2	
Mark for Ovulation	½ × 2	4 Marks

26. Earthworm: Phylum Annelida

Round worm: Phylum Aschelmenthes 1+1=2

Characteristics distinguishing the two 2

Earthworm: Segmented

clitellum present

Setae present (any two)

Roundworm : Smooth cylindrical body, sexual dimorphism ½ × 4=2

Total 6

Distinguishing feature

Phylum Annelida - Segmented body or any other

Phylum Aschelminthes – Endoparasites or any other 1+1=2

Total=6

27. **Humans**

Chromosomal basis; homogametic female (XX) and hetrogametic male (XY); gametes fuse to give XX daughter & XY male.

Birds

Chromosomal basis; heterogametic female (ZW) and homogametic male (WW); females fuse to give ZW female offspring & WW male offspring.

Marking Scheme

Honey Bees

Chromosomal basis; male haploid & female diploid; unfertilized eggs give to males by parthenogenesis; fertilized eggs give female. $2 \times 3 = 6$

28. Acid Rain

Green house gases like CO_2, SO_2 and NO_x dissolve in water present in air to form, carbonic acid, sulphuric acid & nitric acid which falls as rain.

Global warming: Greenhouse gases especially CO_2 trap long wave length sun rays radiated back from earth. This increases temperature of earth & causes global warming

Ozone hole; Ozone layer formed in the upper reaches of atmosphere is damaged by chlorine from CFC & the hole due to damage causes solar radiations to penetrate. $2 \times 3 = 6$

29. **Darwin's theory**

Over- population due to enormous potential for reproduction of all species.

Struggle for existence

Variation among individuals of population

Natural selection causes Survival of fittest.

Fittest best adapted to environment 1×4

Neo-Darwinism

Based on progress in genetics, Darwin's theory modified to state that Population evolves through interaction of variation and Natural Selection and differential reproduction takes place. 2

$4 + 2 = 6$

30. Process by which green plants, in presence of light & chlorophyll, combine water and carbon-dioxide to form carbohydrates and O_2 is released. 1

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6H_2O + 6O_2 \quad 1$$

RuBP accepts CO_2; forms 2 mols of PGA using ATP and NADPH PGA reduced to Triose Phosphate; 1.mol of sugar produced & RUBP regenerated. 4

$2 + 4 = 6$

Or

Expressed as a diagram

Success Stories

Jaspal Singh
Enrolment No.: Secondary - 27020212195
Senior Secondary – 92279300066

Forced to discontinue his tenth class in 1993 in order to earn a livelihood to support his family, when his parents met with an accident, Jaspal Singh resumed his studies in 2003 by enrolling for the Secondary level course in NIOS. The flexibility of the NIOS system enabled him to pursue his studies along with his vocation. He acquired skills in fashion designing while working as a freelancer in garment export houses.

Having completed his Senior Secondary course from the NIOS and moved by the desire to continue studies, Jaspal Singh has managed to obtain admission to a three year course in Fashion Management at the University of Thames Valley, London.

Ms. Sudha
Enrolment No. : 27029182593

Ms. Sudha was a only housewife until such time that her husband passed away and she was offered the job of a constable in the Delhi Police. She then took up the job to support the family consisting of her two children.

Sudha who had not completed her schooling was motivated by her children to join the NIOS. She then passed the Secondary examination from NIOS in April 2009. A resident of Sant Nagar, Burari, Delhi and posted at the Rohini Court, Delhi, Sudha today feels more confident and empowered by the qualification acquired by her through the NIOS.

Complete and Post the feedback form today

Final fold and seal

Feed back on Lessons

Lesson No.	Lesson Name	Content			Language		Illustrations		What You Have Learnt	
		Difficult	Interesting	Confusing	Simple	Complex	Useful	Not useful	Very helpful	Not helpful
19.										
20.										
21.										
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25.										
26.										
27.										
28.										
29.										
30.										
31.										

---Fourth fold----

---Third fold----

Feed back on Questions

Lesson No.	Lesson Name	Intext Questions		Terminal Questions		
		Useful	Not useful	Easy	Diff.	V. diff.
19.						
20.						
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Second Fold

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