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**Intermediate (TOSS) Course
Senior Secondary Course**

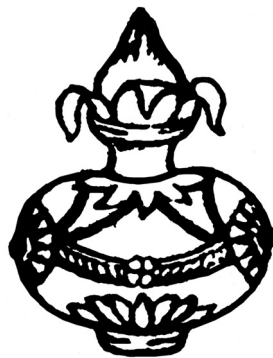
BIOLOGY

2

(CORE MODULES)

Designed and Developed by

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FOREWORD

Dear Learner,

We are very happy that you have joined NIOS and decided to become an Open and Distant Learner.

NIOS has brought out its revised Senior Secondary Course material. This course has been designed in a **modular format** in the sense that the content is divided into different modules. These modules are made up of a number of lessons. The modules are self contained and you can pick up any of the modules first that interests you. However, we would like you to proceed as the modules have been arranged because there are references and cross references to other lessons.

One of the main features of this course is the division of the modules into **core** and **optional** modules. The core modules are compulsory for all learners, but you can choose any **one** of the two optional modules. For example, in Geography, you can pick up either Local Area Planning **or** Tourism Geography; in Business Studies, you can study either Wage Employment in Business **or** Self Employment in Business. Each subject offers two optional modules. The idea is to allow you to study what interests you more even in one particular subject. This is something unique to the NIOS courses of study. You will not find such **choice** elsewhere.

This course is revised on the lines of the guidelines contained in the National Curriculum Framework 2005. We have tried to make the material as **activity based** as possible. We believe that you learn more when you do something with your own hands rather than just passive reading. We have made efforts to keep the **language of the study material simple** to facilitate you to understand the content easily.

The examples that we have chosen and used in the course material are from daily life to enable you to relate easily what is new to what you already know. Through the Self Learning Materials, we are trying to help you to construct your own knowledge so that you learn by understanding and not just by memorizing everything.

Another important feature of this learning material is integration of Adolescence Education issues with the learning content. Realising that development of life skills like self awareness, critical thinking, negotiation and communication skills is important, we have used different opportunities to build desirable skills in the lessons.

The study materials developed by NIOS are **self-learning materials**. You are supposed to read and work on your own. Unlike a textbook, you do not need a teacher to tell you what to do.

With our good wishes, start studying, do what you are told to do, attempt all activities, answer the intext questions, check your answers from the answers given, learn each topic well and be a **successful self learner**.

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 Physics.

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.

(K. R. Chandrasekaran)

April 2007

A Word With You

Dear Learner,

Welcome!

Keen observation, careful experimentation and single minded devotion have helped successive generations of researchers to accumulate vast treasure of knowledge. As you go to higher classes, you will appreciate that the method of sciences is characterised by objectivity, openness to change, innovation, self-correction and dynamism. It is therefore important in these formative years for you to learn science by doing: develop problem solving and experimenting skills to unfold unknown situations. To encourage this, we have included a number of exercises and activities. These can be performed by using readily available materials to get a feel of the physical principles in operation. This will also provide you an opportunity to reflect on how a scientist works.

Physics has always been an exciting subject. But fundamental discoveries in rapid succession in the early half of the 20th century brought in profound changes in our concepts of space, time, matter and energy. Another phenomenon characteristic of the previous century is the reduction in the time gap between a new discovery and its applications from a decade or so to a few years due to close linking of science and technology. Therefore, future development in knowledge society will heavily depend on the availability of well trained scientific human capital endowed with entrepreneurship capabilities. This should provide you enough motivation to study science, do well and participate in the process of sustainable growth and national development.

The organisation of the course is generic. It is divided into eight core modules spread over 29 lessons. Out of two optional modules, which intend to develop professional competencies, you will be required to opt for any one. You will get an opportunity to work in a physics laboratory and make precise measurements using sensitive instruments. This will also give you an opportunity to understand basic physical principles.

As a self-learner, you would be required to demonstrate the ability, capacity and eagerness of Ekalavya. Your confidence in yourself and genuine interest in learning science should help you develop being an independent learner with drive and initiative. Experience shows that interactive learning is more rewarding. So to ensure your active participation in teaching-learning as also to facilitate self-regulation and pacing, we have given questions in the body of each lesson. You must answer these.

In curriculum design an effort has been made to put thematically coherent topics together for brevity and completeness. Although we have strived hard to lucidly explain various concepts, it is possible that you may still find some concepts/topics difficult to comprehend. You are therefore advised to make a note of your difficulties and discuss them in the counselling sessions as well as amongst peers.

You will find some useful information on the life and works of leading physicists/scientists who have contributed to our vast pool of knowledge. It is sincerely hoped that their lives will inspire you as role models to contribute your best!

Our best wishes are with you.

*Curriculum Design and
Course Development Team*

HOW TO USE STUDY MATERIAL

Congratulation! You have accepted the challenge to be a self-learner. NIOS is with you at every step and has developed the material in Biology with the help of a team of experts, keeping you in mind. A format supporting independent learning has been followed. You can take the best out of this material if you follow the instructions given. The relevant icons used in the material will guide you.

Title: will give a clear indication of the contents within. Do read it.

Introduction: This will introduce you to the lesson and also link it to the previous one.



Objectives: These are statements of outcomes of learning expected from you after studying the lesson. You are expected to achieve them, do read them and check if you have achieved.

Content: Total content has been divided into sections. Section leads you from one content element to another. The text in bold, Italics or **boxes** is important and must be given attention.

Notes: Each page carries empty space in the side margins, for you to write important points or make notes.



Activities: Certain activities have been suggested for better understanding of the concept.



Intext Questions: Very short answer, self check questions are asked after every section, the answers to which are given at the end of the lesson. These will help you to check your progress. Do solve them. Successful completion will allow you to decide whether to proceed further or go back and learn again.



What you have learnt : This is the summary of the main points of the lesson. It will help in recapitulation and revision. You are welcome to add your own points to it also.



Terminal Exercises: These are long and short questions that provide an opportunity to practice for a clear understanding of the whole topic.



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 content 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.

Glosary : For ready reference

Question for practices : There are questions for practives given at the end of each book. Kindly complete it within the time stated.



These are few selected web sites that you can access for extended learning.

1. Biology : wikipedia the free encyclopedia www.en.wikipedia.org
2. Biology in the yahoo directory dir.yahoo.com/science/biology
3. www.biolgy online.org
4. Google directory : science > biology
5. www.scitoys.com>biology

FORE WORD

Education plays an important role in the modern society. Many innovations can be achieved through Education. Hence the Department of Education is giving equal importance to non-formal education through Open Distance Learning (ODL) mode on the lines of formal education. This is the first State Open School established in the country in the year 1991 offering courses up to Upper primary Level till 2008. From the academic year 2008-2009 SSC Course was introduced and Intermediate Course from the year 2010-2011. The qualified learners from the Open School are eligible for both higher studies and employment. So far 7,67,190 learners were enrolled in the Open Schools and 4,50,024 learners have successfully completed their courses.

With the aim of improving the administration at the grass-root level the Telangana Government re-organized the existing Districts and formed 31 new Districts. The formation of new Districts provide wide range of employment and Business opportunities besides self employment. Given the freedom and flexibilities available, the Open School system provides a second chance of learning for those who could not fulfill their dreams of formal education.

Government of Telangana is keen in providing quality education by supplying study materials along with the text books to enable the learners to take the exam with ease. Highly experienced professionals and subject experts are involved in preparing curriculum and study material based on subject wise blue prints. The study material for the academic year 2018-19 is being printed and supplied to all the learners throughout the state.

I wish the learners of Open School make best use of the study material to brighten their future opportunities and rise up to the occasion in building Bangaru Telangana.

With best wishes



S. Venkateshwara Sharma
DIRECTOR,
Telangana Open School Society,
Hyderabad

Overview of the Learning Material

1

CORE MODULES

Module-1 Diversity and Evolution of Life

1. Origin and Evolution of Life and Introduction to Classification
2. The Kingdom Monera, Protocista and Fungi
3. Kingdoms Plantae and Animalia
4. Cell Structure and Function
5. Tissues and other Level of Organization

Module-2 Forms and Functions of Plants and Animals

6. Root System
7. Shoot System
8. Absorption, Transport and Water Loss in Plants

9. Nutrition in plants - Mineral Nutrition
10. Nitrogen Metabolism
11. Photosynthesis
12. Respiration in Plants
13. Nutrition and Digestion
14. Respiration and Elimination of Nitrogenous Wastes
15. Circulation of Body Fluids
16. Coordination and Control - The Nervous and Endocrine Systems
17. Homeostasis : The Steady State

2

CORE MODULES

Module-3 Reproduction and Heredity

18. Reproduction in Plants
19. Growth and Development in Plants
20. Reproduction and Population Control
21. Principles of Genetics
22. Molecular Inheritance and Gene Expression
23. Genetics and Society

Module-4 Environment and Health

24. Principles of Ecology

25. Conservation and Use of Natural Resources
26. Pollution
27. Nutrition and Health
28. Some Common Human Diseases

Module-5 Emerging Areas in Biology

29. Biotechnology
30. Immunobiology : An Introduction

3

CORE MODULES

Module-6A Tools and Techniques in Biology

31. Some Common Tools and Techniques used in Biology
32. General Laboratory Equipments
33. Some Common Preservatives, Stains and Reagents
34. Providing Organisms for Laboratory Work
35. Some Aids in Biology

Module-6B Economic Biology

31. Agriculture, Forestry and Medicinal Plants
32. Floriculture, Mushroom Culture and Hydroponics
33. Animal Husbandry
34. Fisheries and Aquaculture
35. Apiculture, Lac Culture and Sericulture

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MODULE-III
REPRODUCTION AND HEREDITY

- Lesson 18. Reproduction in Plants
- Lesson 19. Growth and Development in Plants
- Lesson 20. Reproduction and Population Control
- Lesson 21. Principles of Genetics
- Lesson 22. Molecular Inheritance and Gene Expression
- Lesson 23. Genetics and Society



REPRODUCTION IN PLANTS

Reproduction is one of the most important characteristic 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 offspring 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 lower plants (Chlamydomonas) and filamentous green algae (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;*

MODULE - 3

Reproduction and
Heredity



Notes

Reproduction in Plants

- describe the stages of development of gametes 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.

18.1 MODES OF REPRODUCTION

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

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

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

- A single parent is involved
- Offspring are genetically identical to the parent.

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

- Fission** : As in unicellular organisms like bacteria and yeast 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.
- Budding** : 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.
- Fragmentation** : In filamentous algae, an accidental breaking of the filament into many fragments, each fragment may give rise to a new filament of the algae by cell division e.g. *Spirogyra*.
- 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 protective wall. When they reach the suitable environment they develop into a new plant body e.g. in bread moulds, moss, fern.



Notes

- (b) **Vegetative reproduction** : 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 daughter plant. It is similar to a sexual reproduction in that it also requires only mitotic division, no gametic fusion and daughter plants are genetic clones of the parent plant.

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

- (c) **Sexual reproduction** involves fusion of male and female reproductive cells (gametes) which are haploid 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.

**INTEXT QUESTIONS 18.1**

1. Define reproduction.

.....

2. How is asexual reproduction different from sexual reproduction?

.....

3. What is a gamete?

.....

4. Name two types of asexual reproduction.

.....

18.2 REPRODUCTION IN LOWER PLANTS

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

18.2.1 Chlamydomonas (A Unicellular Alga)

- It is a haploid unicellular alga found in fresh water ponds:
- The plant body is pear-shaped with two flagella attached at the narrow end.
- On one side of the cell an eye spot is present.
- A large cup-shaped chloroplast is present.
- Towards the centre, a definite nucleus is present.
- Chloroplast contains a single pyrenoid. (Fig. 18.1a).

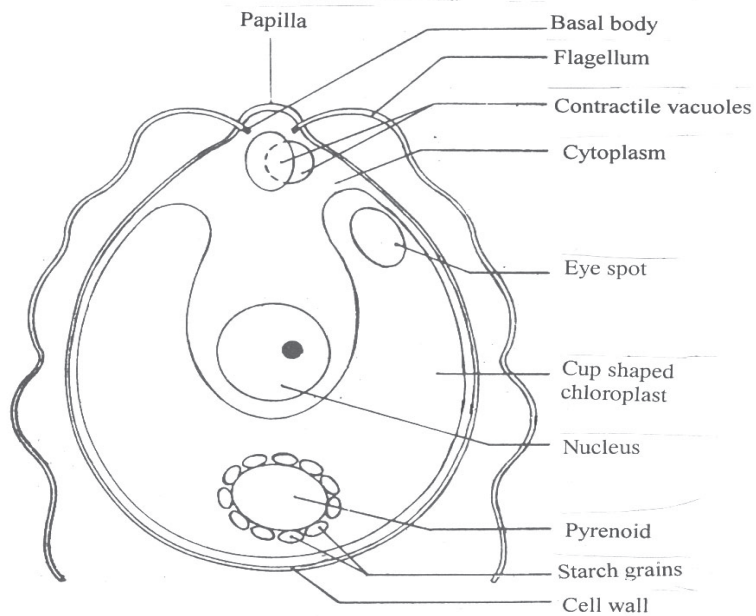


Fig. 18.1a A Chlamydomonas cell

Reproduction

A. Asexual-with the help of zoospores

- *Chlamydomonas* loses flagella and becomes non-motile.
- Its protoplasm (cytoplasm and nucleus) divides mitotically and forms 4-8 zoospores.
- The parent cell wall is ruptured and zoospores are released.
- Each zoospore develops a cell wall and grows into an adult cell. (Fig. 18.2-b, c)
- The parent cell does not exist, any more.

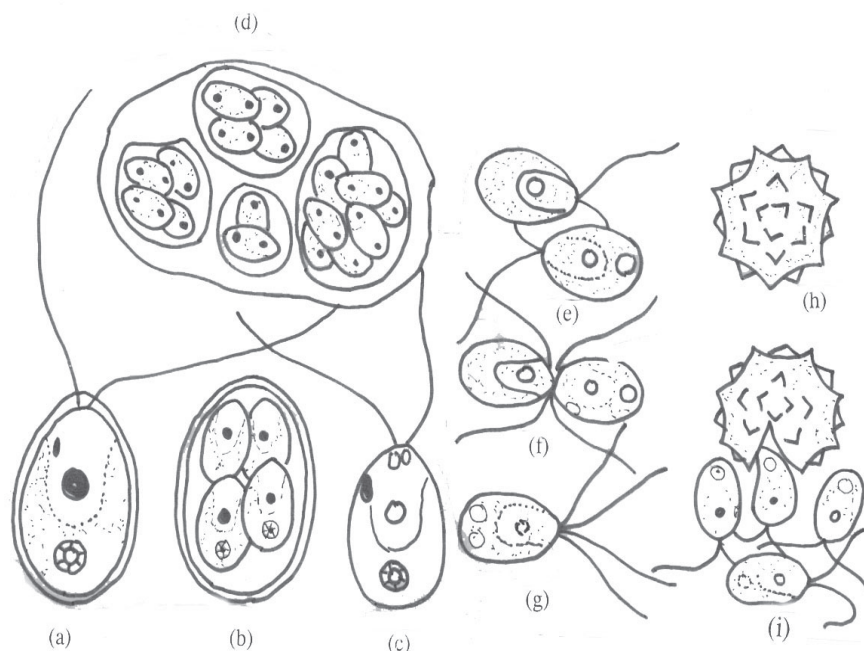
B. Sexual Reproduction

- The cell becomes non-motile by losing its flagella.
- The protoplasm divides mitotically into 2, 4, 8, 16, 32 daughter cells.
- Each daughter cell develops flagella and is released in water by the rupture of mother cell wall. It acts as a gamete.
- The gamete is morphologically identical in structure but all identical (Isogamous).
- Gametes released from two different mother cells fuse together.
- The contents of the gametes fuse and form a zygote (diploid). This is the only diploid stage in the life cycle of *Chlamydomonas*.



Notes

- The zygote develops a thick wall around itself to tide over unfavourable conditions (zygospores)
- On the return of favourable conditions (temperature, food and water) the diploid nucleus divides by meiosis and forms four haploid zoospores. (Fig. 18.2 d-i)
- Each zoospore grows into a new adult *Chlamydomonas*.



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

Fig. 18.2 Asexual and Sexual reproduction in *Chlamydomonas*



INTEXT QUESTIONS 18.2

1. Define the term isogamy.
.....
2. Where does meiosis occur in *Chlamydomonas* ?
.....
3. Give the method of asexual reproduction takes place in *Chlamydomonas*. What is the function of zoospores in *Chlamydomonas*.
.....



Notes

18.2.2 Spirogyra (A Multicellular Alga)

Structure

- (i) It is a free floating alga found in fresh water ponds.
- (ii) The body has a row of rectangular cells joined end to end (filamentous alga).
- (iii) Each cell has a spiral ribbon shaped chloroplast with many pyrenoids.
- (iv) Central region has a large vacuole.
- (v) The nucleus is present in the centre of vacuole supported by cytoplasmic strands. (Fig. 18.3)

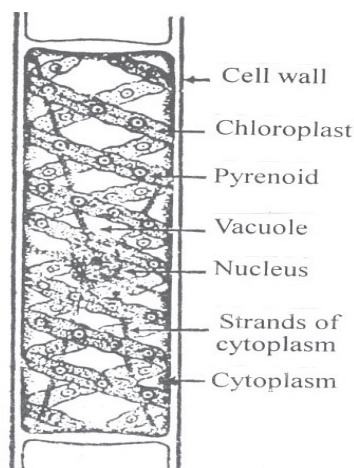


Fig. 18.3 Spirogyra : part of the filament.

Reproduction

A. Vegetative Reproduction by fragmentation :

- (i) The filament breaks into small fragments.
- (ii) Each fragment grows into a new filament by cell division.

B. Sexual Reproduction

Scalariform Conjugation (conjugating filaments give a ladder-like appearance). (Fig. 18.4)

- Two filaments come to lie very close to each other.
- 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.
- Each filament acts either as male or female.
- The contents of two gametes fuse in the female cell and form a diploid zygote.

- The zygote develops a thick wall around itself and tides 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 zygote ruptures and a small tube like structure, containing one haploid nucleus comes out.
- The small tube develops into 1 filament by repeated mitotic divisions.



Notes

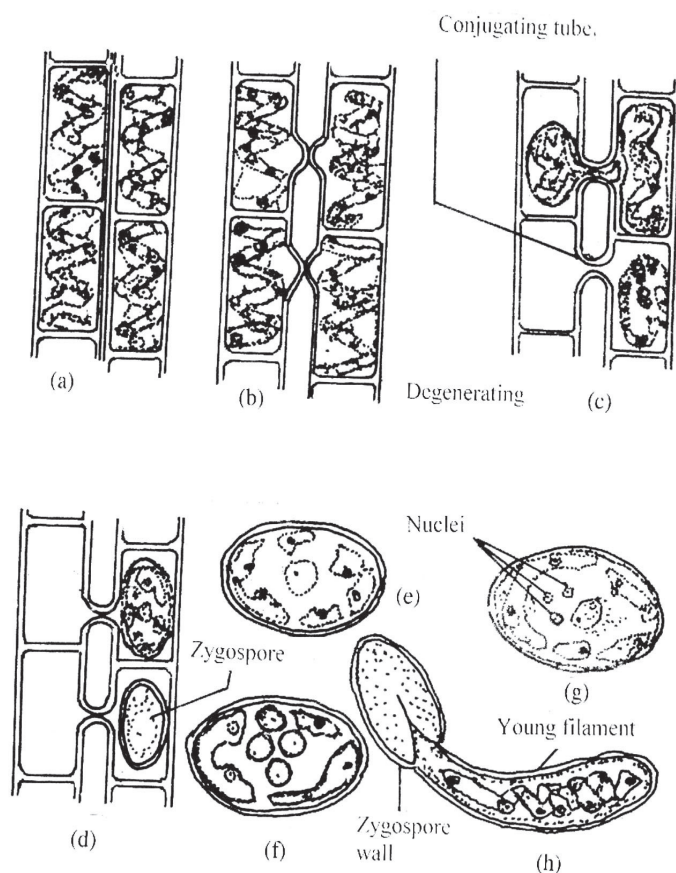


Fig. 18.4 Life cycle of Spirogyra : Sexual reproduction-Scalariform conjugation. (a) Filaments lie close, (b) Formation of conjugation tube, (c) Transfer of gamete from the donor to the recipient cell, (d) Zygospore within the recipient cell, (e) Zygospore breaks from filaments, (f) Meiotic division in zygospore produces haploid nuclei, (g) 3-4 haploid nuclei degeneration, (h) formation of young filament

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

MODULE - 3

Reproduction and Heredity



Notes

Reproduction in Plants



INTEXT QUESTIONS 18.3

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* ?
.....
.....

18.3 REPRODUCTION IN ANGIOSPERMS (FLOWERING PLANTS)

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

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

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

- (a) **Annuals** : Plants live for **one year**. The plants which produce flowers and seeds 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 year, the plants remain in the vegetative state. In the second year, 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, neem etc.
- (d) **Monocarpic** : However, some perennial plants reproduce only once in their lifetime and then die. Such plants are called Monocarpic e.g. bamboo.

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. As listed above this transition from vegetative, the flowering stage may take several years in trees but only a few weeks or days in annuals.



Notes

Table 18.1 Difference between Juvenile and Adult Shoot

Juvenile Shoot	Adult Shoot
1. Small, soft stem bearing a few young leaves.	1. Well developed stem and 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 flower.

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 is called **vernalisation**.

Photoperiodism : It is the response in growth and flowering of a plant to the duration of light and dark period per day. (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).

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 consist of four whorls borne on a thalamus or stalk. These whorls are from outside

- Calyx - consisting of sepals.
- Corolla - consisting of petals
- Androecium - consisting of stamens
- 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

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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 reproduction.

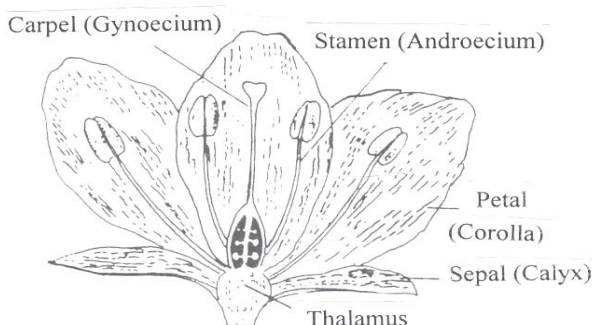


Fig. 18.5 T.S. of a typical flower



INTEXT QUESTIONS 18.4

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.
.....

18.4 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 cell or the microspore mother cells (Fig. 18.6). 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.



Notes

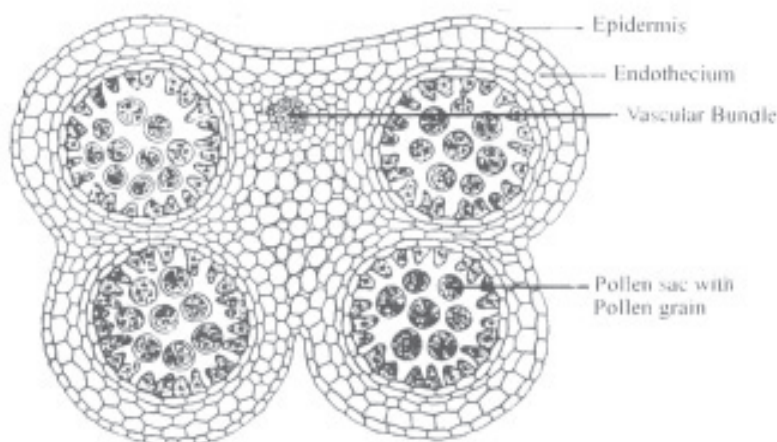
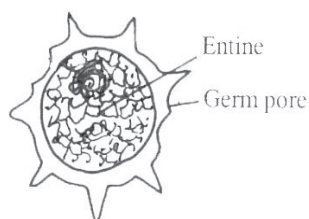


Fig. 18.6 T.S. of anther to show the various tissues.

Microspore mother cells undergo meiosis and each of them forms four *haploid* microspores (Pollen grains which are diploid) arranged in a tetrad (Fig. 18.7a)

Development of male gametophyte (pollen grains)

- (i) The wall of the microspore (pollen grain) consists of two principal layers. (Fig. 18.7b)
 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 external view



(b) Pollen grain showing internal view

Fig. 18.7 Structure of pollen grain

At this stage pollen grains are released by the rupture of the stomium 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 the male gametophyte.



Notes

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). Chalaza is the basal part (Fig. 18.8a)

Female gamete

The gynoecium or pistil represents the female reproductive part in the flower. Each pistil consists of a stigma, style and ovary. The ovary contain one or more ovules (megasporangia) which are the future seeds. An ovule develops as a projection on the placenta in the ovary. It consists of a parenchymatous tissue called the nucellus and 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 on the other end (Fig. 18.8b).

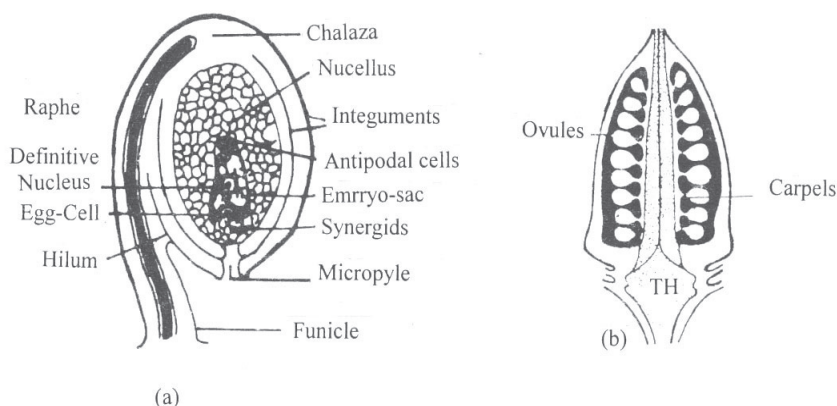


Fig. 18.8 (a) Various parts of ovule (b) Pistil

Development of female gametophyte

Within the nucellus, a single hypodermal cell (below the epidermis) enlarges and becomes the megaspore mother cell, the mother cell undergoes meiotic division and gives rise to four haploid megaspore cells, usually three of them degenerate and the remaining one becomes the functional megaspore. It enlarges and its 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 **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 is the centre. 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.



Notes

The Nucellus contains embryo sac (female gametophyte).

Thus, in a mature ovule the embryo sac contains eight haploid nuclei but only seven cell. 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 use 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 : No function.



INTEXT QUESTIONS 18.5

1. What is the innermost 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.
.....

18.4.1 Pollination

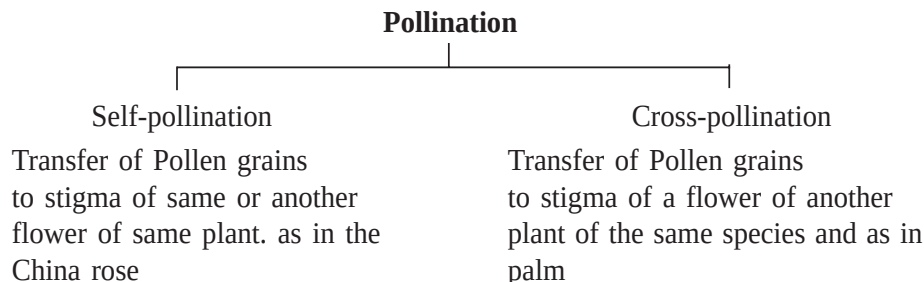
When mature pollen grains released from anther are carried to stigma of a flower of the same or different species, it is called pollination.

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



Notes

Pollination is of two types.



Importance of Pollination :

1. It results in fertilization and ovule is 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 convert ovary 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 carried with 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 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. 18.9).

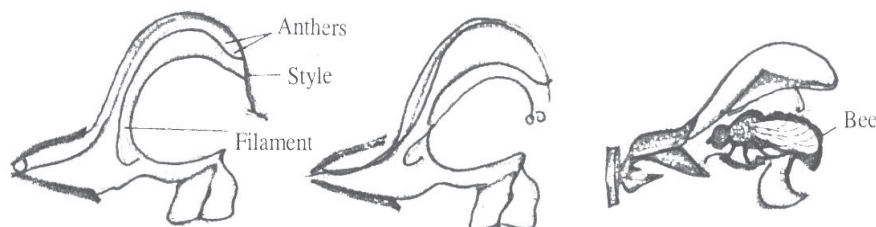


Fig. 18.9 Pollination in *Salvia* by bees

**Notes****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*, *Vallisneria*.

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

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

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

Some Adaptations to Promote Cross Pollination :

1. **Unisexuality** : Flowers may be only male or female, borne on different plants e.g. papaya, palm.
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 do not open completely on maturity.
- (ii) Male and female sex organs mature at the same time e.g. ground-nut.

**INTEXT QUESTIONS 18.6**

1. What is pollination?

.....

2. Mention suitable terms for the following :

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

.....

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

.....

3. Give two features of insect pollinated flowers :

- (i)

- (ii)



Notes

18.4.2 Fertilization

- Pollen grains reach the right stigma and begin to germinate.
- Pollen grain form a small tube like structure called pollen tube which emerges through the germ pore. The contents of the pollen grain move into the tube.
- Pollen tube grows through the tissues of the stigma and style and finally the ovule through the *micropyle*.
- Vegetative cell degenerates and the generative cell divides to form two sperms (or male gametes).
- Tip of pollen tube bursts and the two sperms enter 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, primary endosperm nucleus develops into an endosperm.
- Endosperm provides food to the developing embryo.
- Later the synergids and antipodal cells degenerate.

Significance of Fertilisation

- Gives stimulus for the growth of ovary, leading to fruit formation.
- Helps in recombination of characters as genes from two different individuals combine and form the zygote.

Post fertilisation change

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. Can you tell why this is to establish 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 nucleus undergoes repeated division to give rise to free nuclei which arrange themselves at the periphery leaving a large central space. Cell wall formation starts subsequently and endosperm becomes cellular at maturity. This is the most common type of endosperm development and is seen in maize, wheat, rice etc.



(b) **In Cellular**, each nuclear division is followed by cytokinesis, making it cellular from the beginning

(c) **In Helobial type**, the first mitosis gives rise to two unequal cells, subsequently division are free nuclear but becomes cellular after cytokinesis.

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

Development of embryo

- (i) The zygote divides into two cells, the upper cell (embryonal cell) and; lower cell (Suspensor cell). (Fig 18.10)

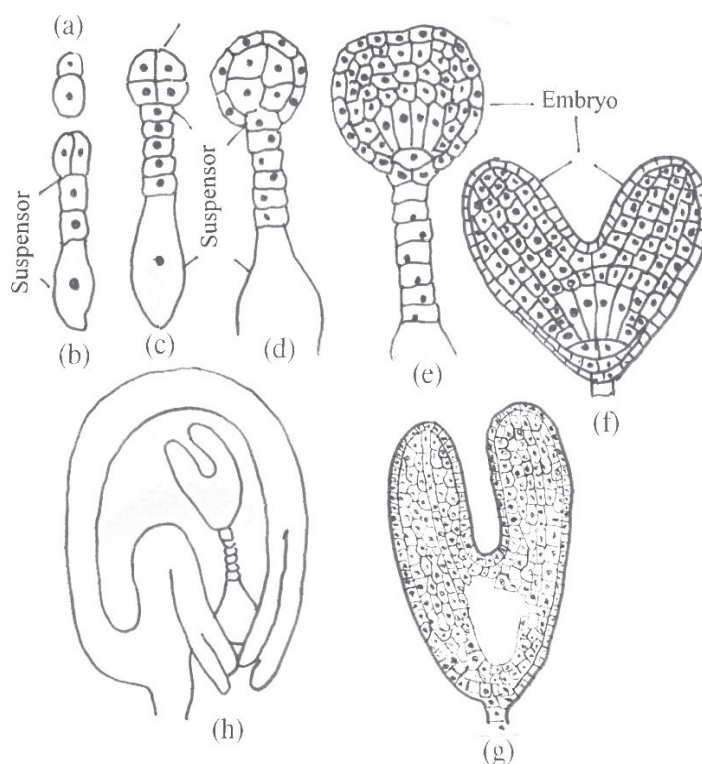


Fig. 18.10 Development of embryo, A-H

- (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.

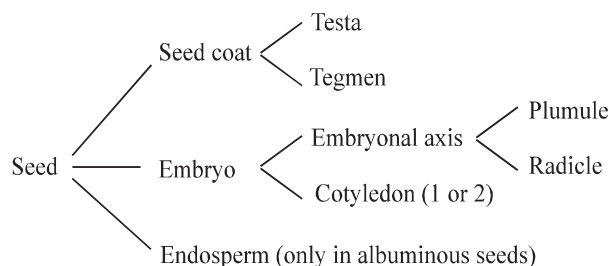


Notes

- (v) The integuments become hardened and thus form the seed coat, seed coat protects the seed.
- (vi) Thus a seed may be dicotyledonous with two cotyledons. (pea, gram) or monocotyledonous with one cotyledon (wheat, rice).

18.4.3 Seed

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



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 thus help in dispersal.

A. Structure of Gram (dicot) Seed :

- (i) The seed is enclosed in the pod. (Fig. 18.11a)
- (ii) It is somewhat conical in shape. (Fig. 18.11b)
- (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 embryo is enclosed by the two fleshy cotyledons. (Fig. 18.11c)

B. Structure of Maize grain : (Monocot)

- (i) The maize grain is broader in shape. (Fig. 18.11d)
- (ii) Testa and tegmen are fused together.
- (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 embryo is found inside scutellum. (Fig. 18.11e)



Notes

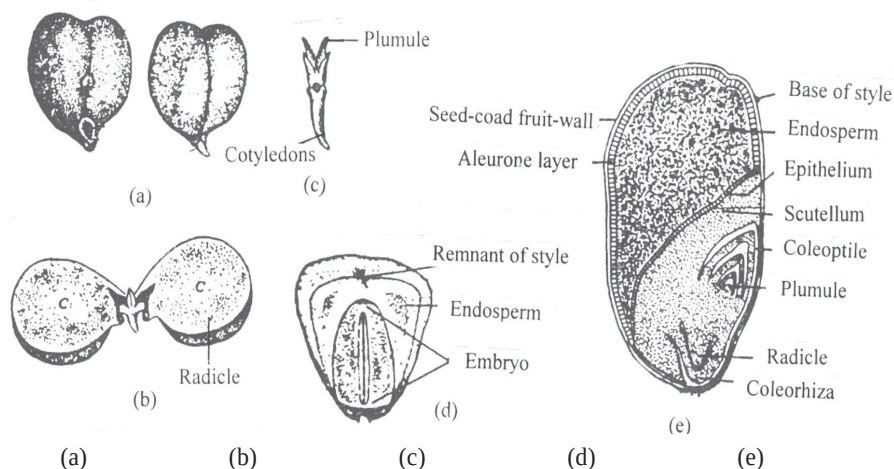


Fig. 18.11 Structure of dicot and monocot seeds : (a) External view of gram seed; (b) Internal structure of gram seed (c) embryo (gram) (d) Maize grain entire; (e) L.S. of maize grain

18.4.4 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.

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

The phenomenon of development of fruit from unfertilised ovary is called **parthenocarp** and such fruits are called parthenocarpic fruits.

Commercial value of parthenocarpic fruits :

- (i) The fruits are seedless and are hence valued more, for eating purposes and contain seeds which can not develop into a new plant.
- (ii) The fruits contain sufficient growth hormones.

MODULE - 3

Reproduction and
Heredity



Notes

Reproduction in Plants



INTEXT QUESTIONS 18.7

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.

.....

18.4.5 Seed

Seed is the final product of sexual reproduction and seed becomes relatively dry. The metabolic activity of the embryo slows down and in majority of cases the embryo enter into a phase of inactivity called dormancy or in some case if favourable conditions are available they germinate. Dormancy help 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) they germinate. Germination is the process by which the embryo grow and establishes itself as a seedling.

Step of germination

- Imbibition of water (through the micropyle) and by the seed coat.
- Seed swells up as it gets hydrated.
- Enzyme activity converts the reserved 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.



Notes

Germination can be of two types

- (a) **Epigeal** where cotyledons come above the ground and form the first leaves of the new plant e.g. in castor, neem, bean, plumule emerges from the cotyledon
- (b) **Hypogeal** where cotyledons remain underground and plumule emerges from the soil and develops into the shoot system. e.g. maize, rice etc.

18.5 VEGETATIVE REPRODUCTION IN ANGIOSPERMS

Vegetative reproduction in Angiosperm : Reproduction 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 reproduction.

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. 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 near the flower. These are called bulbils which when fall on the ground grow into new plant.

MODULE - 3

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Notes

Reproduction in Plants

Table 18.2 Modes of Vegetative reproduction with examples

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



INTEXT QUESTIONS 18.8

- Define vegetative reproduction.
.....
- Give an example of each of the following :
 (a) rhizome
 (b) tuber
 (c) bulb
 (d) runner
 (e) sucker
- Give an example of vegetative reproduction which is carried out by leaves.
.....
- Name two ways by which vegetative reproduction occurs in plants.
.....



Notes

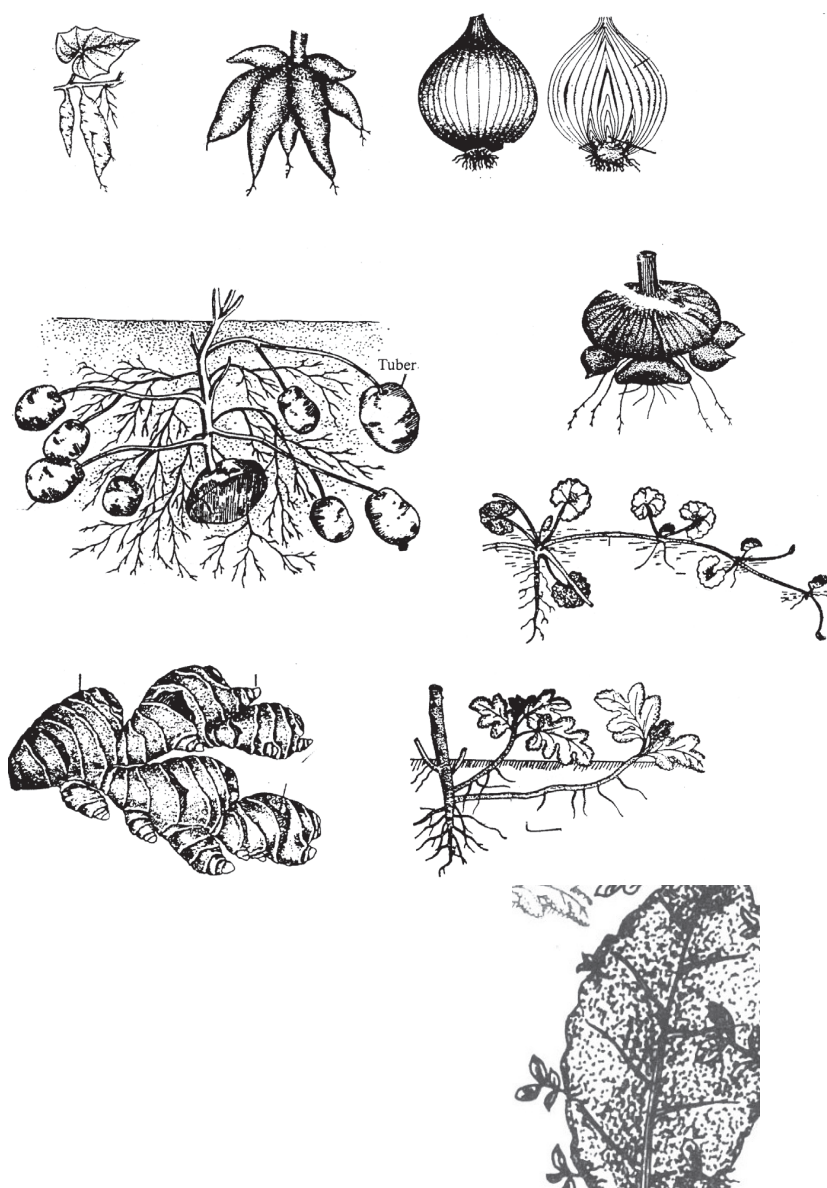


Fig. 18.12a Sweet potato

Fig. 18.12c (a) Bulb of onion (b) L.S. of bulb

Fig. 18.12e Rhizome of Ginger

Fig. 18.12g Runner of grass

Fig. 18.12b Dahlia

Fig. 18.12d Tuber of potato

Fig. 18.12f Corm of colocasia

Fig. 18.12h Sucker of Chrysanthemum

Fig. 18.12 Vegetative propagation of adventitious buds in the margins of leaves in Bryophyllum



Notes

18.6 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 plants, sugarcane etc. are grown through their stem cuttings. (Fig. 18.13). Cuttings of these plants can be grown even in water where they strike roots and develop adventitious buds.



Fig. 18.13 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. 18.14). 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, straw berry, grapevine, *Bougainvillea* etc.

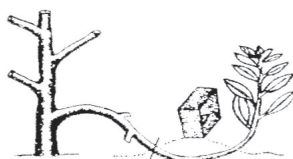


Fig. 18.14 Vegetative reproduction by layering

- (c) **Aerial layering or Goatee** is a similar practice where bending of branches isn't 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. 18.15).



Notes



Fig. 18.15 Vegetative reproduction by goatee

- (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 disease 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. 18.16)

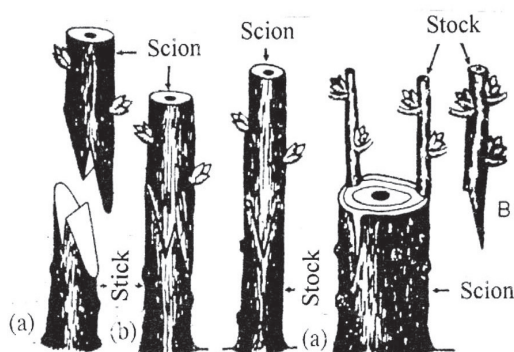


Fig. 18.16 (a) The lower part of the stem of scion is cut in a wedge. (b) The shoot of the plant to be used as a stock is cut off. The stem is slit vertically the scion is inserted into the stock and is tied with a tape (c) the graft union occurs within a short time

18.7 ADVANTAGES AND DISADVANTAGES OF VEGETATIVE REPRODUCTION

Advantages

- Rapid means of reproduction and spread.
- Offsprings identical to parent. The desired varieties can thus be preserved genetically for use.
- Food storage organs allow perennation or survival in adverse conditions.



Notes

- (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 decimatr a crop.



INTEXT QUESTIONS 18.9

- What are the various methods which man uses for propagating plants artificially?
.....
- Name at least four specialised plant parts which help in vegetative propagation.
.....
- Write one advantage of vegetative reproduction.
.....

18.8 THE MICROPROPAGATION

The technique of plant tissues culture is utilised for propagation of plants. The process as 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.

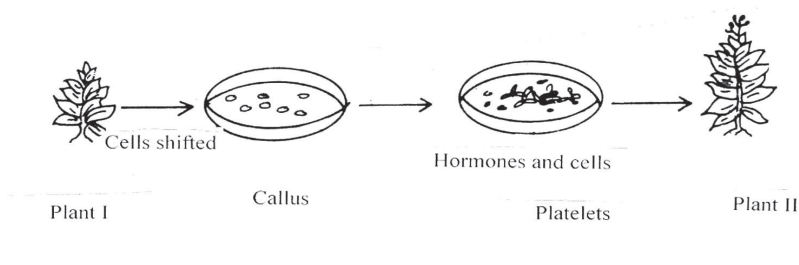


Fig. 18.17 Steps of micropropagation.

**Notes****18.8.1 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**

- Give two examples each of plants which are propagated by the following methods:
 - Cutting
 -
 -
 - Layering
 -
 -
 - Grafting
 -
 -
- Name the artificial means of vegetative propagation commonly used in the laboratory.
.....
- Give two examples of plants which are propagated by micropropagation technique.
.....

**WHAT YOU HAVE LEARNT**

- *Chlamydomonas* reproduce asexually by zoospores and sexually by isogamy.
- *Spirogyra* reproduce by fragmentation and scalariform conjugation.
- In angiosperms flowers are the organs of reproduction.
- Temperature and light are two main factors which influence flowering.
- Stamens and carpels are the male and female organs of reproduction respectively.
- Male gametes are produced in pollen grains, formed inside the anther.
- Female gamete is produced in the embryo sac in the nucellus of the ovule.
- The embryo sac contains egg apparatus, antipodals and secondary nucleus.

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Reproduction and
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Notes

Reproduction in Plants

- 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 **double fertilisation**.
- Pollination is the transference of the pollen grains from anther to stigma. It may be in the same plant (self pollination) or in different plants (cross-pollination). Wind, water, insects and animal are agencies of cross pollination.
- Wind pollinated flowers have light pollen grains or bring pollen and the stigma is usually large feather and protruding feathery.
- 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 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 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 exactly like the parent plant.



TERMINAL EXERCISE

1. Explain the term isogamy taking *Chlamydomonas* as an example.
2. Describe scalariform conjugation in *Spirogyra*.
3. Differentiate between annuals, biennials and perennial plants.

**Notes**

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.
18. 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?

**ANSWER TO INTEXT QUESTIONS**

- 18.1**
1. The process by which living organisms produced their offsprings for the continuity of the species.
 2. Offsprings reproduce from a vegetative unit produces by a parent without fusion of gamete. In case of sexual reproduction fusion of male and female reproductive cells from male and female reproductive organs.
 3. Male and female reproductive cells are known as gametes.
 4. Fission, budding, fragmentation and spore formation.

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Notes

Reproduction in Plants

- 18.2**
1. Male and female gametes are identical in structure.
 2. Zygote
 3. Asexual reproduction
- 18.3**
1. Fragmentation
 2. Scalariform Conjugation.
 3. Diploid nucleus in zygote on return of favourable conditions.
- 18.4**
1. Annual - Plants which produce flowers and seeds within one season.
Biennial - Plants which complete their life cycle in two seasons. In First year they are in vegetative state and in second year reproductive state.
Perennial - Plants which live for several years. For first few years they are in vegetative state and later in reproductive state.
 2. Temperature, light - day length
 3. *Cannabis* or *Cucumis*
 4. Stamens and carpels
- 18.5**
- (i) Tapetum
 - (ii) Pollen sac
 - (iii) Exine and intine
 - (iv) Nucellus and integuments
- 18.6**
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.
- 18.7**
1. Integuments.
 2. Ripened ovule.
 3. Pea or Gram, Maize grain.
 4. Ripened ovary.
Seed coat
 5. Embryo
Endosperm
Cotyledons

**Notes**

- 18.8** 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
- 18.9** 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.
- 18.10** 1. (a) (i) Croton (ii) Money plant
(b) (i) Jasmine (ii) Grapevine
(c) (i) Rose (ii) Mango
2. Micropropagation
3. Orchids, Chrysanthemum, Asparagus etc.



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.*

19.1 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.



Notes

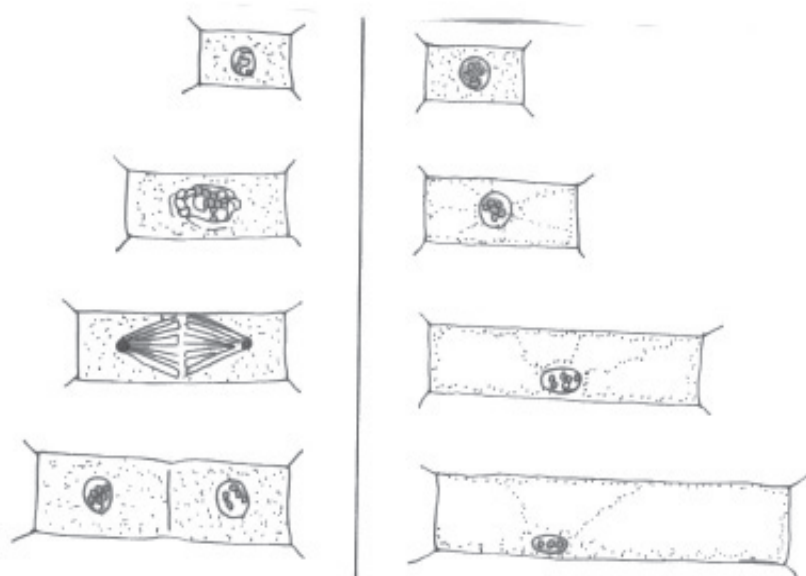
Growth in living organisms is not uniform throughout the life span. Growth takes place at a faster rate till the plants or animals attain maturity. Then it slows down and at a particular time it stops. Later in life death occurs. All these changes that occur in an organism starting from its beginning 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 changes such as growth, differentiation and maturation, which an organism undergoes throughout its life cycle.

19.2 STAGES OF CELLULAR GROWTH

You have already learnt that growth of an organism is always associated with growth of cells. This growth of cells occurs in three successive stages. They are

- (i) **Cell division** : The number of cells increases due to mitosis (Fig. 19.1a).
- (ii) **Cell enlargement**: The size of individual cell increases after cell division due to increase in the volume of its protoplasm (Fig. 19.1b).
- (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. 19.1 Comparison of cell division and cell enlargement



Notes

In lower organisms such as bacteria and algae the entire body grows. But in higher organism 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.

19.3 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-shape curve is obtained. This is called growth curve or **sigmoid curve**. (Fig 19.2)

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 for the entire life span.
- (iii) **Stationary Phase** – Here the rate of growth starts decreasing and finally it stops.

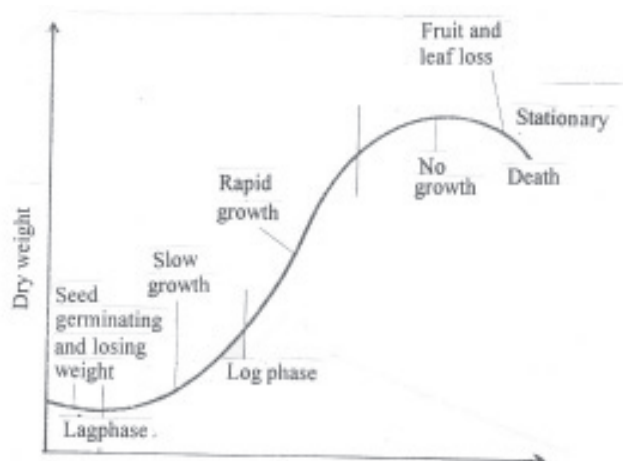


Fig. 19.2 Sigmoid curve

The total time period during which all the phases occurs is called **grand period of growth**.

19.4 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.



Notes

19.4.1 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	

19.4.2 Auxanometer

For more accurate measurement of length, we can use the specially designed equipment called **auxanometer**. (Fig 19.3). 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.

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Notes

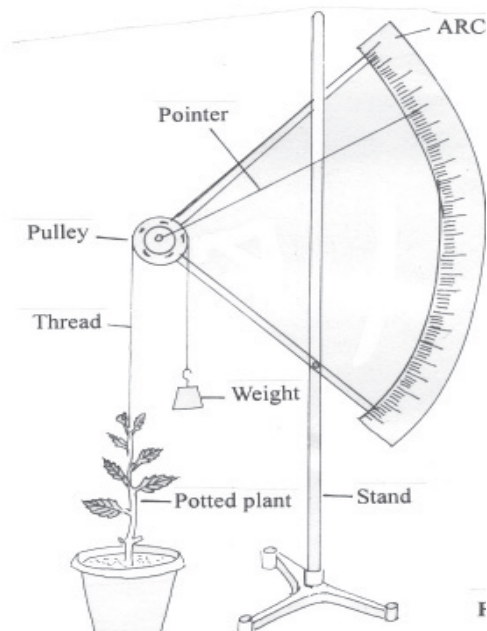


Fig. 19.3 Auxanometer



INTEXT QUESTIONS 19.1

1. Distinguish between growth and development.

.....

2. What is differentiation?

.....

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

.....

19.5 FACTORS AFFECTING PLANT GROWTH

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

19.5.1 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.



Notes

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, use 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, “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.

19.5.2 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 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 auxin is Indole-3-Acetic Acid (IAA). They are

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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), Naphthalene acetic acid (NAA).

The Greek word **auxin** 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 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 some specific 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).

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

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

Functions of Cytokinins

- (a) They stimulate cell division, cell enlargement and differentiation.
- (b) They prevent aging of plant parts.
- (c) They inhibit apical dominance and help in growth of lateral buds.

**Notes****(iv) Ethylene**

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

Functions of Ethylene

- (a) It induces ripening of fruits.
- (b) It promotes senescence and abscission of leaf, flowers, etc.
- (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 plant. 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.

19.6 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 during storage by application of growth inhibitors.

**INTEXT QUESTIONS 19.2**

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)



19.7 DORMANCY AND GERMINATION IN SEEDS

In the previous lesson-7 you have already learnt about formation of seed 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 remain 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, presence of inhibitors like abscissic acid, etc.

19.7.1 Types of Seed Germination

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

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

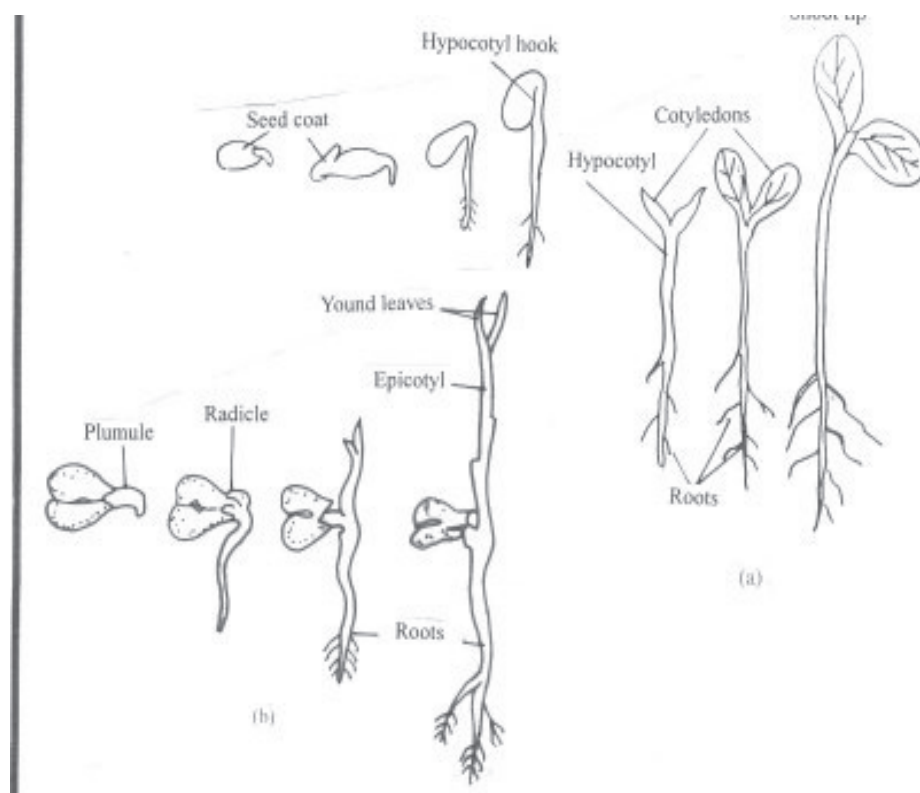


Fig.19.4 Epigeal Germination and Hypogeal Germination



Notes

(a) Epigeal Germination

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

(b) Hypogeal Germination

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

Some plants, which grow in marshy places show a special type of germination called **Vivipary Germination** (Fig. 19.5). 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*.

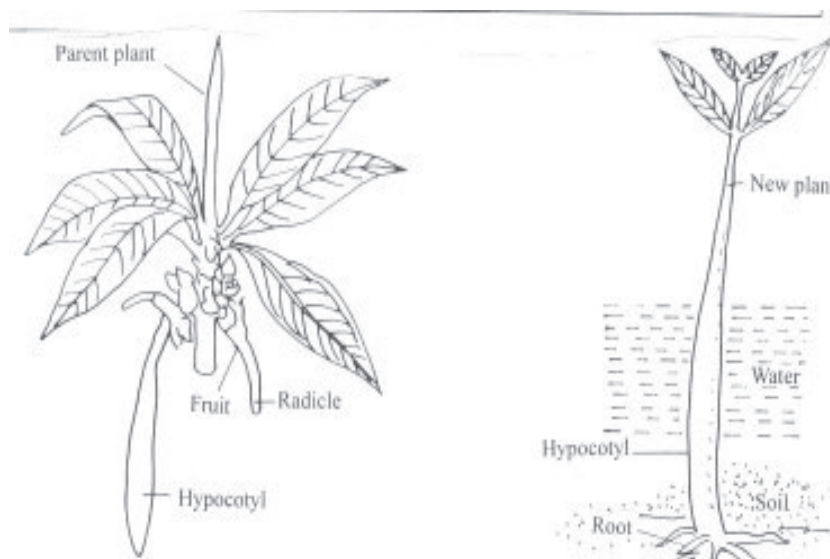


Fig 19.5 Vivipary Germination

19.7.2 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.

19.7.3 Factors Affecting Seed Germination

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Growth and Development in Plants

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 releasing energy for metabolism and 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 the germination process.

19.8 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 produce flowers in summer require longer duration of light per day than those 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, reproduction (flowering) of a plant to the 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.



Notes

(iii) **Day-neutral Plants (DNP)** : In these plant flowering is not affected by length of light period i.e. they produce flower in almost all photoperiods. Cucumber, Tomato, 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, tuber formation in potato etc. are affected by period of light.

19.9 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 flower in plants. Florigen is a 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 P_r and the other, P_{fr} . While P_r 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 converts into P_{fr} form and the P_{fr} form absorb far-red light and converts into P_r form.

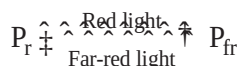


Fig: 19.6 Inter-conversion of the phytochrome P_r and P_{fr}

19.10 VERNALISATION—APPLICATION OF LOW TEMPERATURES

You have already learnt that temperature affects growth and development of plants. For flowering 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 inducing flowering by subjecting or exposing the plant to low temperature.

Practical Utility of Vernalisation

Vernalisation has some practical applications like:

- Plants whose life cycle is completed in two years or two seasons (biennials) can produce flower in one season if their seeds are treated to a low temperature.
- Crops can be grown and harvested earlier i.e. biennials can be turned into annuals.



Notes

19.11 SENESCENCE AGING ON PLANTS

Like animals, plants also have fixed life span and after completing it they die. Before death we can observe several degradation processes in their body. You might have noticed yellowing of leaves, fading of flower colour, etc. 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, tomato, etc. In many other plants, parts above soil die each year and root system stays alive. This is called **organ 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.

19.12 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 parts from the main 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.

19.13 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, pollutants, etc.

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



Notes

19.13.1 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, etc.

(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 and growth and development of plants are retarded.

19.14. 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, bending towards sun light, etc. 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 Movements (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 tendrils and the drooping of leaves of sensitive plant by touch.
- (iv) **Hydrotropism** : Induced by water i.e., growth of roots towards source of water.



Notes

(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 19.3

1. Distinguish between Phototropism and Geotropism
2. Give two examples of turgor movement
 - (i)
 - (ii)



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 changes (growth, differentiation, maturation), which an organism undergoes throughout its life cycle.

**Notes**

- Growth of cells occurs in three successive stages i.e., cell division, cell enlargement, cell elongation.
- 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 those affect the growth of the plant are light, temperature, Water and mineral nutrients.
- The internal factors those responsible for plant growth are auxin, gibberellins, cytokinins, ethylene, abscissic acid. These are 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.
- 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 response in growth, reproduction (flowering) of a plant to the duration of light, which falls on it per day.
- Florigen is a plant hormone, which is responsible for initiation of flowering in plants.
- The method of inducing early flowering in plants by keeping their at low temperature is called vernalisation
- Senescence is a process during which any part or the whole plant completely loss as 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 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?

MODULE - 3

Reproduction and
Heredity



Notes

Growth and Development in Plants

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.



ANSWER TO INTEXT QUESTIONS

- 19.1** 1. Growth : Increase in number and size of a cell, organ
Development : Series of 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
- 19.2** 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)
- 19.3** 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)



20

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. A process by which a living organism produces its own kind is known as **reproduction**.

Organisms reproduce in two ways : gametes not produced and hence no fusion (asexual reproduction), and by formation and the fusion of gametes (sexual reproduction).



OBJECTIVES

After completing this lesson, you will be able to:

- *define reproduction and differentiate between asexual and sexual reproduction;*
- *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 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.*



Notes

Reproduction: Reproduction is the ability of living organism by which they produce off spring of their own kind. Organisms reproduce by this way:

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, protocista, lower plants and lower animals.

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.

20.1 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.

(a) Reproductive System

The puberty is 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 year, 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. this leads ultimately 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 adolescence, the secondary sexual charaters that develop are as follows:

In males, they 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.

The reproductive organs are described and illustrated below.

20.1.1 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. 20.1) (Table 20.1).

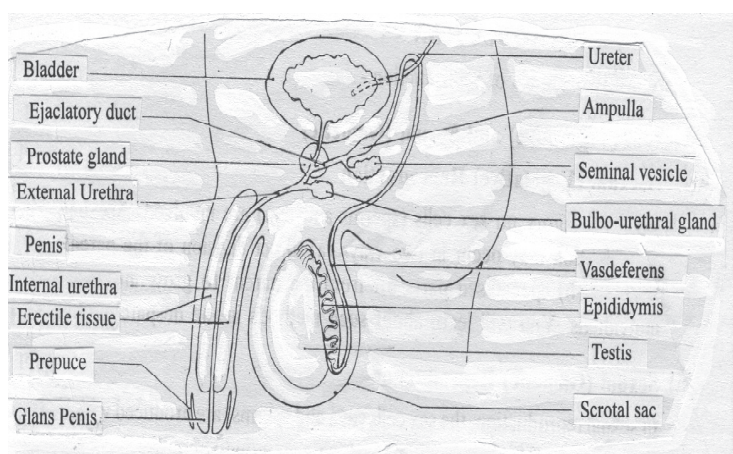


Fig. 20.1 Male Reproductive system

(i) Testes

Testes (singular: testis) (Fig. 20.2) are the male gonads. In an adult male, each testis is approximately 4-5 cm long and about 12 g in weight. These 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.

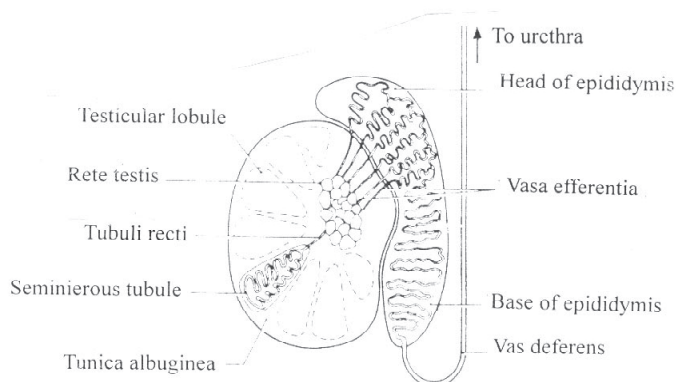


Fig. 20.2 Microscopic Structure of Testis



Notes



Notes

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. 20.2) 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 function 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 20.1.

Table. 20.1 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

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. Prostate 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 prostate 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.

Spermatozoa and semen

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. 20.3.

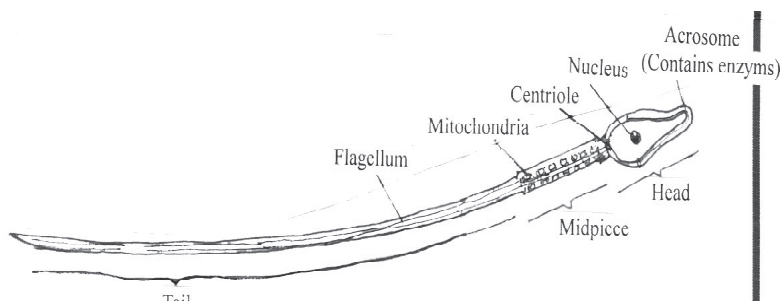


Fig. 20.3 Structure of human sperm.

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 the female.

Fig. 20.4 shows the course of sperms from their production in the testes to reach the urethra in penis.



Notes



Notes

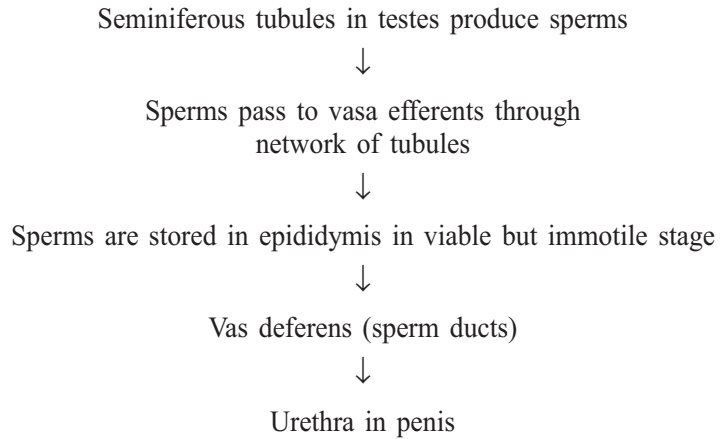


Fig. 20.4 The course of sperms in male.

20.1.2 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. 20.5). The functions of the main reproductive organs in the human female are listed in Table 20.2.

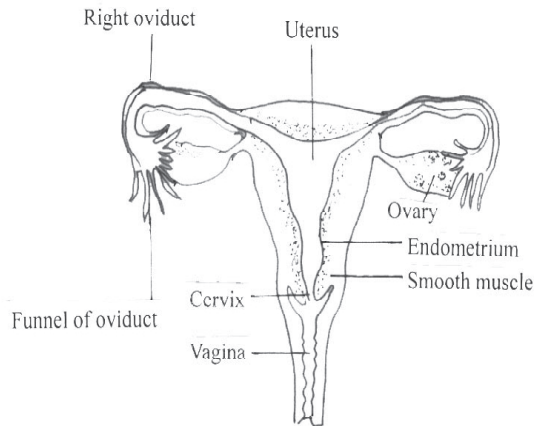


Fig. 20.5 Female reproductive system

(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. 20.6).

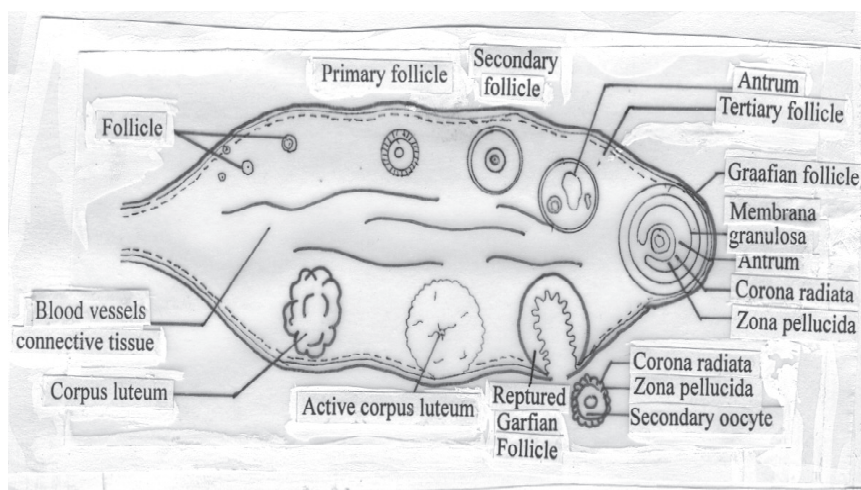


Fig. 20.6 Ovary showing microscopic structure



Notes

(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 20.2.



Notes

Table 20.2. 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;



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 and one is worried about it, 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.





20.1.3 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.

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. 20.7), 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

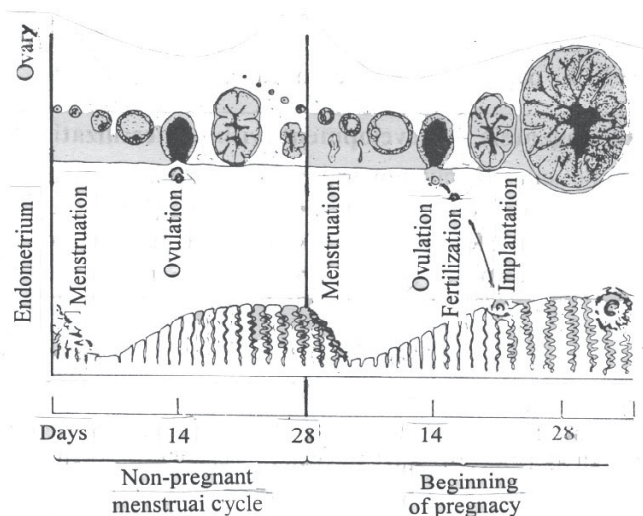


Fig. 20.7 Graphical representation of menstrual cycle

MODULE-3

Reproduction and
Heredity



Notes

Reproduction and Population Control

start of a slow disintegration of the thickened lining of the uterus and the next 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 20.1

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

20.2 FERTILIZATION, PREGNANCY AND DEVELOPMENT OF THE EMBRYO

20.2.1 Fertilization and implantation

Spermatozoa 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.



Notes

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.

Placenta

Placenta is an association between maternal and foetal tissue meant for some extremely important physiological exchange. The developing embryo is attached to the uterus by a tissue called **placenta** (Fig. 20.8). **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.

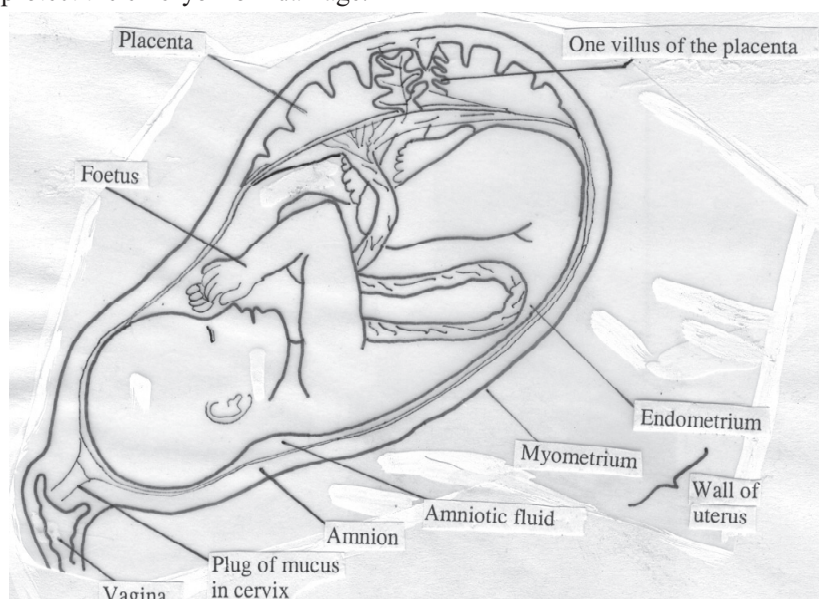


Fig. 20.8 Foetus and placenta

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. 20.9 Summarises the steps in fertilisation of human egg, its implantation and development in the uterus up to birth.

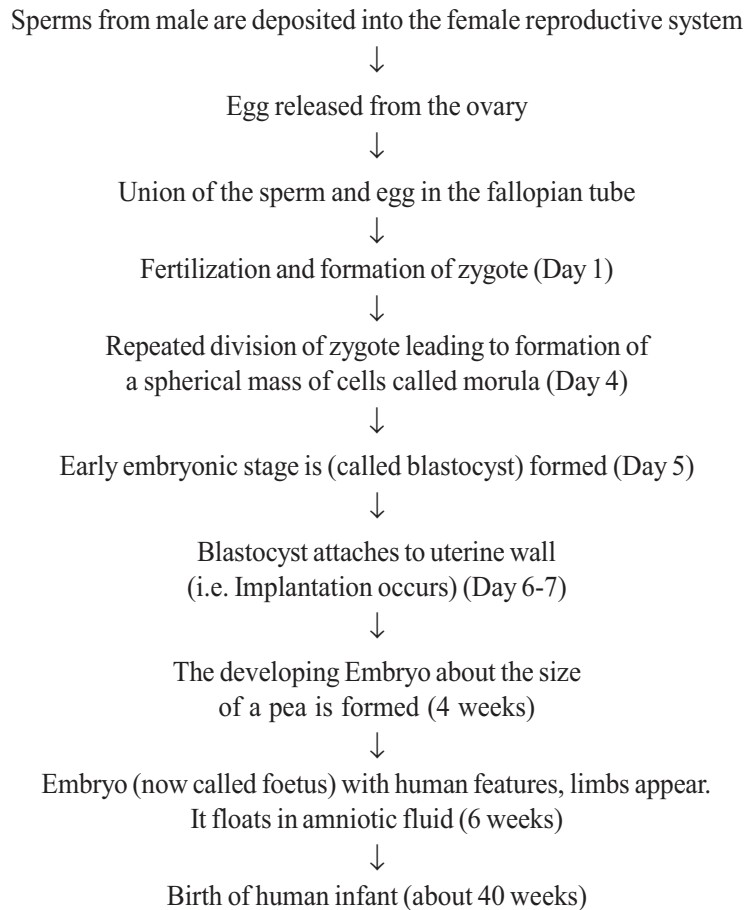


Fig. 20.9 Development of human embryo

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.

20.2.2 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.



Notes

20.2.3 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 this different sperum. 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.

20.3 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

Some women their oviducts (Fallopian tubes) get 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.



Notes



INTEXT QUESTIONS 20.2

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.

.....

20.4 POPULATION-PROBLEMS AND CONTROL

20.4.1 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 (km²) 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.

20.4.2 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. Every population has an inherent tendency to grow. Similarly, the human population is growing. 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.



Notes

Table 20.3 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

20.4.3 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. Thus 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 equity, 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.



Notes

20.4.4 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 causes 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 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 overcrowding, 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 the 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).



Notes

- (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.
- (e) **Increasing population and food requirements** : Increasing population will need more food. For this purpose new agricultural land has to be created. So, forests will be 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 20.3

- List any **four** reasons for population explosion in India.
.....
- What is the inter-relationship between population, environment and development?
.....
- What is the effect of uncontrolled population growth on us and our nation?
.....
- How does population growth influence urbanization and environmental degradation?
.....
- Relate the indiscriminate increase in population with the standard of living in our country.
.....



Notes

20.4.5 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 to prevent 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 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 advise 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.
- 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 males and 11-12 years in 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.
- 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.



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.



Notes

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Notes

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- (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 the 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.



Notes

12. Differentiate between the following.

- (i) Implantation and pregnancy
- (ii) Graafian 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.



ANSWER TO INTEXT QUESTIONS

20.1 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.

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- 20.2**
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 cells called morula.
 - (iv) Amnion : From the first few stages of development, the embryo is enclosed in a sac called amnion.
 3. Amniotic fluid
- 20.3**
1.
 - (i) Advancement in agriculture
 - (ii) Religious and social custom
 - (iii) Illiteracy
 - (iv) Desire for a male child
 2. See text sub-section 20.4.4
 3. See text sub-section 20.4.4
 4. See text sub-section 20.4.4
 5. See text sub-section 20.4.4



PRINCIPLES OF GENETICS

It is common observation that seeds of mango trees grow into mango plants, dogs give birth to puppies and not into the young ones of any other animal. Humans give birth to human beings. The tendency of offspring to inherit parental characteristics is termed '**heredity**' and the science of heredity in '**Genetics**'. Genetics also seeks to answer questions like why two offspring of same parents look different, why are some people dark and others light skinned etc. In other words, why is there **variation** among individuals of the same kind. This lesson deals with heredity and variation. It also includes a section on hereditary disorders and gives an idea of the human genome too.



OBJECTIVES

After completing this lesson, you will be able to :

- *explain the terms heredity and variation;*
- *describe Mendel's experiments on garden pea and the principles derived;*
- *define the term hybridization, alleles, trait, dominance, recessive, homozygous, heterozygous, genotype, phenotype;*
- *explain the term incomplete dominance with the example of flower colour in 4 o'clock plant (*Mirabilis jalapa*);*
- *define the terms lethal genes and pleiotropic genes;*
- *explain quantitative (polygenic) inheritance supported by the examples of kernel colour of wheat and skin colour of humans;*
- *differentiate between monogenic and polygenic inheritance;*
- *explain the chromosome theory of heredity;*
- *define and give examples of linkage, crossing over and criss-cross inheritance;*
- *justify mitochondrial inheritance as a case of maternal inheritance;*
- *describe the human karyotype;*
- *differentiate between sex chromosomes and autosomes;*



- *list and describe the causes and symptoms of some common genetic disorders. Colour blindness, haemophilia, Down syndrome, Turner syndrome, Klinefelter syndrome;*
- *describe the inheritance of Rh factor and explain its significance during pregnancy;*
- *explain ABO blood group;*
- *explain the diagnostic technique of amniocentesis and give its significance;*
- *give a brief idea of human genome.*

21.1 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 from parents to children and so on generation after generation. This inheritance of genes is termed '**heredity**' the study of heredity is '**Genetics**'. New individual develop according to the genes inherited from their parents.

The transmission of characters from one generation to the next, that is from parents to offspring 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 offspring or between offspring 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 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 parental chromosomes with different gene combinations. Such a source of variation which is most common is called **recombination**.

Variation arises because of mutation and recombination.

21.2 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 and published his results in 1865. His work, however, was rediscovered in 1900, long after Mendel's death, by Tschermak,



Notes

Correns and DeVries. But since Mendel was the first to suggest principles underlying inheritance he is regarded as the founder or **father of genetics**.

21.2.1 Mendel's Experiments

Mendel designed his experiments such 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.

In the following spring, seeds from the new plants were collected and sown. He 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. 21.1).

In this way he tried to cross pea plants with seven such contrasting characters. These were

1. red flowered and white flowered plants;
2. axillary flowered (flower arising in the axil 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 such contrasting characters exist in varieties that are 'self pollinating' so that generation after generation they express only one type of feature (Fig. 21.2).

Crosses considering the inheritance of **one feature only** are called **monohybrid crosses**. Mendel also tried crosses involving two contrasting features, such as tall and red flowered with dwarf and white flowered plant such a cross is termed **dihybrid cross**.

21.2.2 Mendel's Principles (laws) of inheritance

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

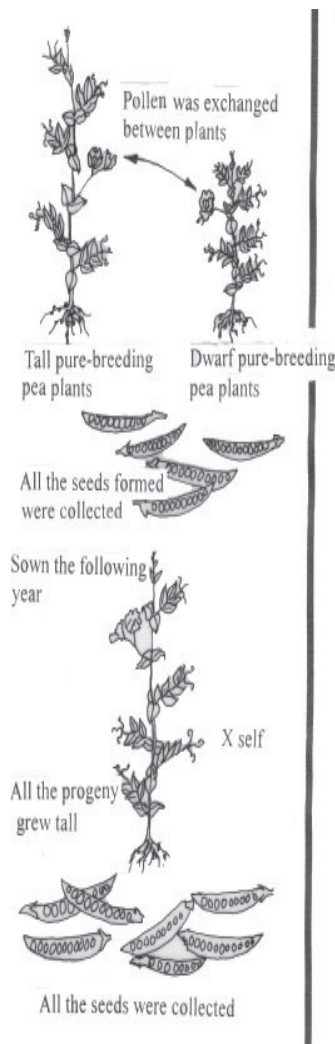


Fig. 21.1 Mendel's experiment with tall and dwarf peas.



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.

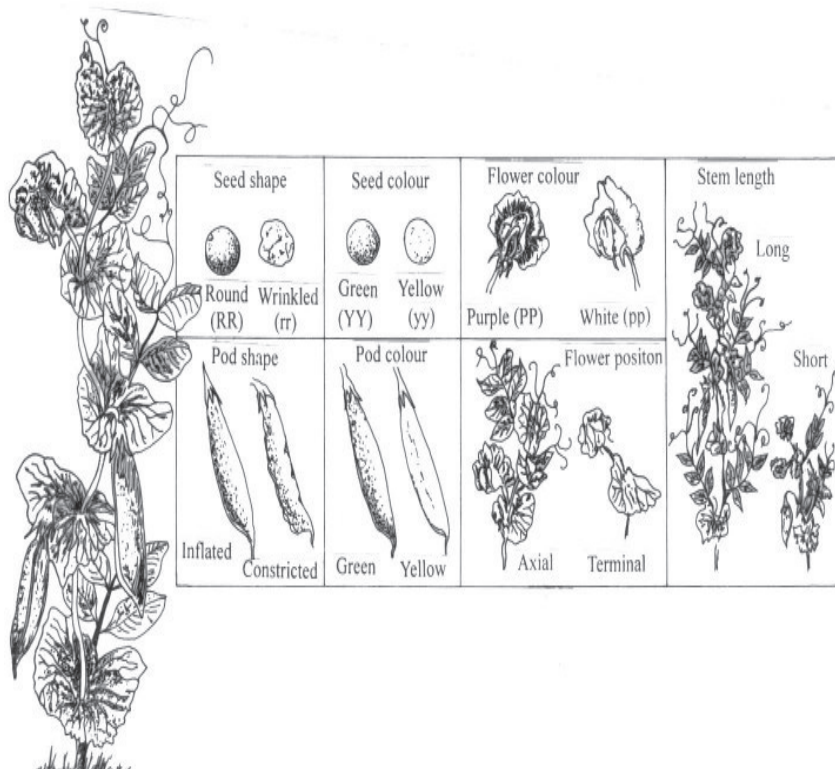


Fig. 21.2 Seven traits studies by Mendel

2. **Law of dominance.** Inheritance of many features (e.g. eye colour, flower colour, seed shape etc.) is controlled by **one pair of genes**. When the two genes are of the same kind (e.g. brown colour of eyes, red colour of flower) the condition is termed **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 its pair (termed its **homologue**), the condition is termed **heterozygous**.

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



Notes

The law of dominance was found to be true in both monohybrid and dihybrid crosses in cases of the 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. 21.3) i.e. the segregation of one pair of factors is independent of the segregation of the other.

	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 White red	ttRr White red
tr	TtRr Tall red	TtRr Tall red	ttRr Dwarf red	ttrr Dwarf white

Fig. 21.3 Dihybrid phenotypic ratio

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

Fig. 21.3 Results showing independent assortment in two pairs of genes. R stands for red flower colour, r for white flower colour, T for tall gene and t for gene for dwarfness.

You would have noticed that the composition of genes or **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 etc.

21.2.3 Reasons for Mendel's success

1. **His choice of material** was good. He selected garden pea which has a short life cycle, has self pollinated bisexual flowers with closed corolla so pollination



Notes

can be easily controlled. Also it is easy to cultivate pea plants and a large number of pure line plants with several pairs of contrasting characters were available.

2. **His selection of traits :** The seven pairs of contrasting characters of pea plant considered by Mendel in his experiments were responsible for the desired results that helped Mendel postulate the laws of inheritance.
3. **Mendel's Technique :** His technique of experimentation was excellent and was as follows :
 - (i) Homozygous pure line plants with contrasting characters were crossed.
 - (ii) Self pollination was prevented by removing stamens.
 - (iii) Female plants were dusted with pollen grains from another plant with the opposite feature and were tied in a bag to prevent any further pollination.
 - (iv) Seeds were collected and shown in time.
 - (v) He considered the inheritance of one character at a time.
 - (vi) The results were analysed statistically.
 - (vii) He performed reciprocal crosses and test crosses to confirm the results. (see section 21.3 for definition of these crosses)

21.3 IMPORTANT TERMS IN GENETICS

- **Factor :** The unit responsible for the inheritance and expression of a particular character. Now replaced by the term gene.
- **Gene :** It is a particular segment of a DNA molecule which determines the inheritance and expression of a particular character.
- **Alleles or Allelomorphs :** Two or more alternative forms of a factor or a gene are called alleles. For example in pea plant, the gene for producing seed shape may occur in two alternative forms: round (R) and wrinkled (r). Genes for round and wrinkled seeds are alleles of each other. Similarly, there are three alleles for gene controlling blood group in man I^A , I^B , i (I = immunoglobulin gene). Alleles occupy same locus on homologous chromosomes.
- **Trait :** is the expressed character, e.g. colour of flower, shape of seed etc.
- **Dominant trait :** Out of the two alternating forms (allelomorphs) of a trait, the one which expresses itself in a heterozygous organism in the F_1 hybrid is called the dominant trait (dominant allele) and the phenomenon is called dominance. For example in an organism with Tt, T (tallness) expresses itself and t (dwarfness) cannot, so T is the dominant allele.
- **Recessive trait :** Out of the two alternating alleles for a trait, the one which is suppressed (does not express) in the F_1 hybrid is called the recessive trait



Notes

(recessive allele). Recessive allele expresses only in the homozygous state (e.g. tt).

- **Genotype** : The genetic constitution of an individual (which he/she inherits from the parents) is called the genotype, e.g., the genotype of pure round seeded parent pea plant is RR .
- **Phenotype** : The outward (morphological) appearance of an individual for any trait or traits is called the phenotype, e.g. for seeds, round shape or wrinkled shape is the phenotype.
- **Homozygous** : an individual possessing identical alleles for a trait is called homozygous or pure for that trait, e.g. plant with RR alleles is homozygous for the seed shape.
- **Heterozygous** : An individual receiving dissimilar alleles for a trait is called (heterozygous or impure for that trait, e.g. a plant with Rr alleles is heterozygous for the seed shape.
- **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 hybridization 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 as the **hybrid**. The phenotypic ratio of 3 dominants : 1 recessive obtained in the F_2 generation from the monohybrid cross is called **monohybrid phenotype ratio** (eg. 3 : 1 in Mendelian Inheritance).
- **Dihybrid cross** : The cross between two parents in which two pairs of contrasting characters are studied simultaneously for the inheritance pattern is called dihybrid cross. The phenotypic ratio obtained in the F_2 generation from a dihybrid cross is called dihybrid ratio phenotypic (e.g. 9 : 3 : 3 : 1 in Mendelian crosses).
- **Hybridisation** : Crossing organisms belonging to different species for getting favourable qualities in the offspring.
- **Test cross** : 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.
- **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.

MODULE - 3

Reproduction and
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Notes



INTEXT QUESTIONS 21.1

1. Who is called the founder of genetics and why?
.....
2. State one difference between
 - (i) homozygous and heterozygous
.....
 - (ii) dominant and recessive
.....
 - (iii) genotype and phenotype
.....
 - (iv) monohybrid and dihybrid crosses.
.....
3. Define heredity and variation.
.....
4. Give the monohybrid and dihybrid phenotypic ratios.
.....
5. Mention two sources of variation.
.....

21.4 DEVIATION FROM MENDEL'S LAWS INCOMPLETE DOMINANCE

In the four O'clock plant *Mirabilis jalapa* and Snapdragon or *Antirrhinum* law of dominance is not followed. Thus when a homozygous red flowered plant (RR) is crossed to a homozygous white flowered plant, all flowers in the F_1 are pink when F_1 plants are self pollinated, the phenotypic ratio 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

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 both (1 : 2 : 1) same.

Multiple alleles and codominance

Tall or dwarf, red or white, brown eyes or blue eyes, these are just two varieties or **alleles** of genes for plant height and flower colour and eye colour. Most genes, however, have more than two alleles or **multiple alleles**. An example of multiple alleles is the gene for blood group.



Notes

The four blood groups of humans are determined by a single gene. 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 has the blood group AB as both the genes I^A and I^B are **co-dominant**. The gene i when homozygous (ii) gives the blood group O. Genotype and phenotype of blood groups in humans are given in Table 21.1.

Table 21.1 Genotypes and Phenotypes of human blood groups

Genotype	Blood group
$I^A I^A$ and $I^A i$	A
$I^B I^B$ and $I^B i$	B
$I^A I^B$	AB
ii	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 which is also responsible for killing the mouse born with that gene. Such genes are termed **lethal genes**. Some lethal genes kill only in the homozygous condition and are **recessive lethals**. **Dominant lethals** cause death even when present in the heterozygous condition.

Pleiotropy

While a gene may have multiple alleles and thus give multiple genotypes, one gene may control several genotypes. 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 vestigial wings and curled abdomen.

Polygenic or quantitative inheritance

When a trait (feature or character) is controlled by a single gene it is termed **monogenic inheritance**. Many traits or features are controlled by a number of different genes. For example the 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 many chromosomes. Each of these genes has equal contribution and cumulative the total 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 inheritance controlled by many genes is termed **quantitative inheritance** or **polygenic** (poly meaning due many genes) **inheritance**.

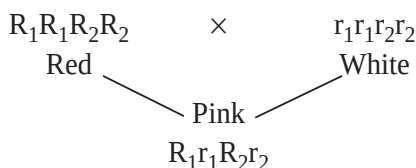
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Notes

Principles of Genetics



	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 : 1 White

In polygenic inheritance:

- Each dominant gene controls equally the intensity of the character.
- The effect of the dominant genes is cumulative.
- The intensity of character or trait depends upon the number of dominant genes.



INTEXT QUESTIONS 21.2

1. Define :

- An allele
- Codominance
- Polygenes
- Lethal gene

2. Which kind of inheritance is found for

- blood groups of humans
- flower colour of snapdragons



(iii) wheat kernel colour

.....

(iv) human skin colour?

.....

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

.....

21.4 CHROMOSOMAL THEORY OF INHERITANCE

It was observed by **Sutton and Boveri** in **1902** that

1. Maternal (from mother) and paternal (from father) characters come together in the progeny which is diploid or $2n$ and has chromosomes in pairs and later on segregate during the formation of gametes. The gametes have a single chromosome from each pair and is haploid or n .
2. Chromosomes from two parents come together in the same zygote as a result of the fusion of two gametes and again separate out during the formation of gametes. You have already learnt that chromosomes are filamentous bodies present in the nucleus and seen only during cell division.

The above two observations proved that there is a remarkable similarity between the behaviour of characters 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 (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 same genes) 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 segments of DNA are the genes.

21.5 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 they got the ratio $7 : 1 : 1 : 7$. So the parental forms were more than the new combinations of characters (recombinants). It means the two genes chosen for the experiment do not follow the principle of independent assortment. Instead they tend to be inherited together or are **linked** together. Thus genes present on same chromosome tend to be inherited together and are said to be **linked**. This phenomenon is called **linkage**.



Notes

A group of genes present on the same chromosome and tend to be inherited together forms a **linkage group**.

In the above experiment some recombinant types 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 chromosomes of homologous pair (Fig. 21.4).

Crossing over occurs during meiosis I prophase I at the time of gamete formation. The point where crossing over occurs is called **chiasma**. (plural : chiasmata) See Fig. 21.3. 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. 21.4. The figure 21.4 shows linked genes of the parents and **recombinants** due to crossing over.

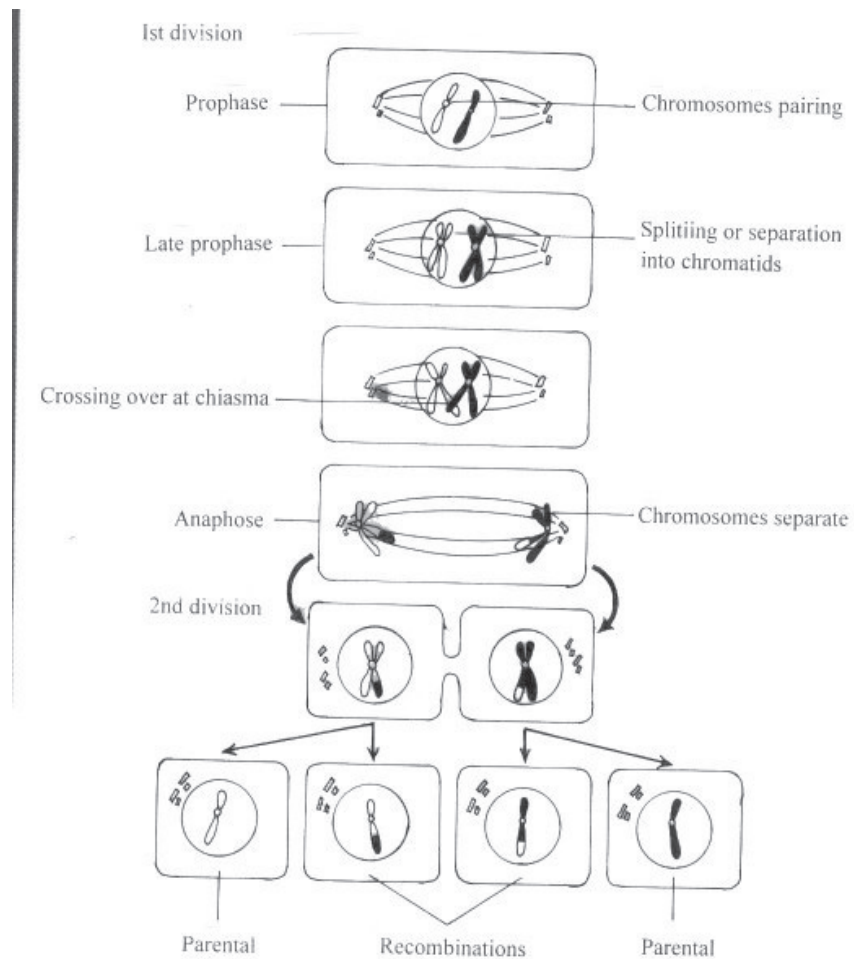


Fig. 21.4 Schematic diagram showing recombination by crossing over

Fig. 21.4 Schematic diagram showing recombination by crossing over



Notes

21.6 CHROMOSOMES AND SEX DETERMINATION

In some diploid organisms, specific chromosomes have a role in sex determination. Such chromosomes some 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 gamete (containing X). For example : all eggs of the human female contain an X chromosome. So human female is termed homogametic.

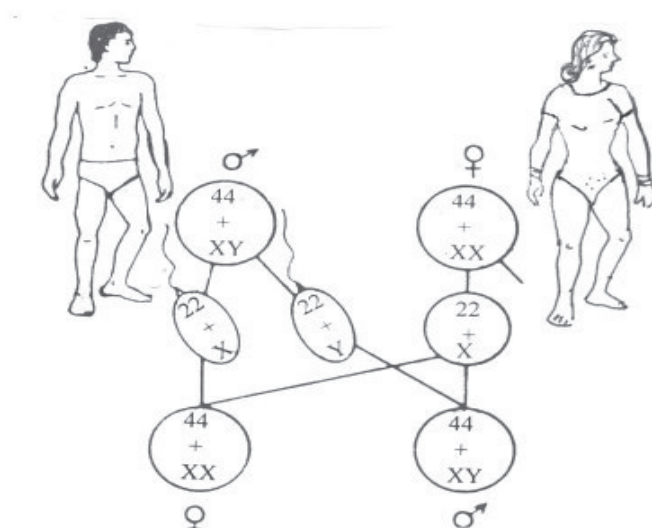


Fig. 21.5 Chromosomal basis of sex determination in humans.

- If sex chromosomes are morphologically dissimilar (i.e. XY) in an individual, is termed **heterogametic**. Such individuals produce two types of gametes. (one containing X and the other containing Y). 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 boy is born (Fig. 21.6). 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.

21.7 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 criss-cross inheritance as shown in Fig. 21.6.

When a male has a defective sex linked gene located on X chromosome during reproduction, he transmits the defective X chromosome to his **daughter only**. The female who has this gene transmits it to her sons 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 genetic defect



Notes

while females are only **carriers** of these defective genes. Females express the trait if they are homozygous for the recessive gene.

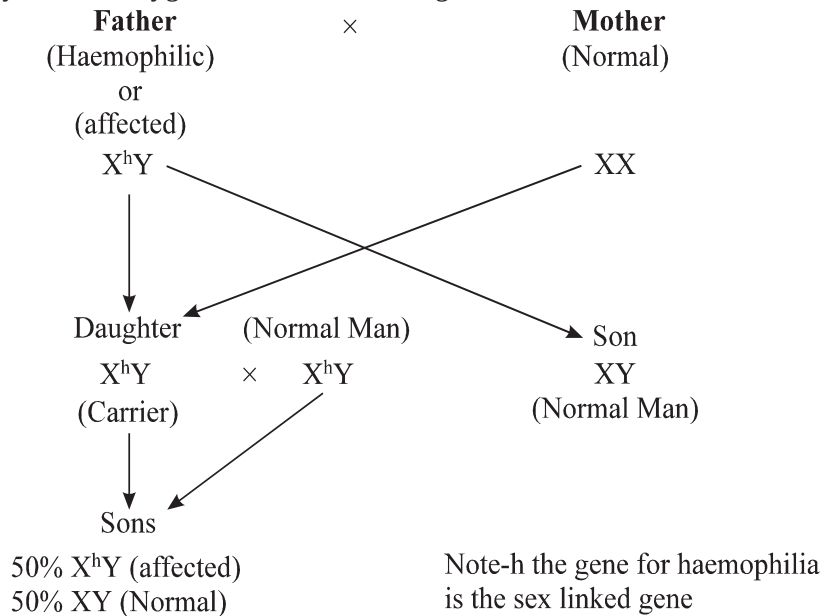


Fig. 21.6 Cris cross inheritance or X-linked inheritance

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

Cris 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. See Fig. 21.7 (a), (b) and (c).

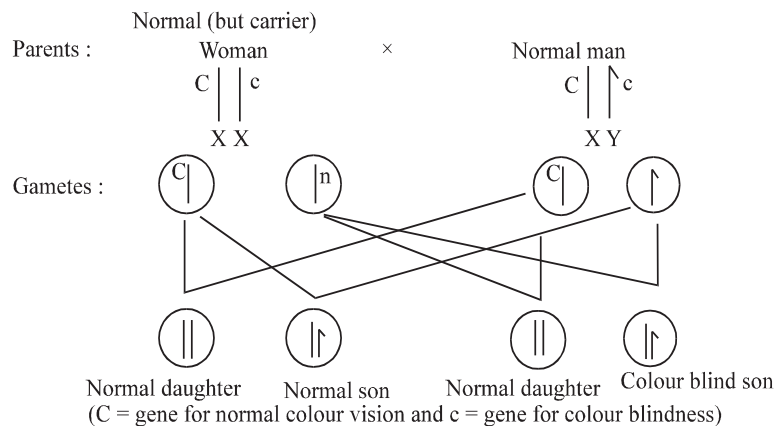


Fig. 21.7 (a) Progeny of carrier female for colour blindness and a man with normal colour vision.



Notes

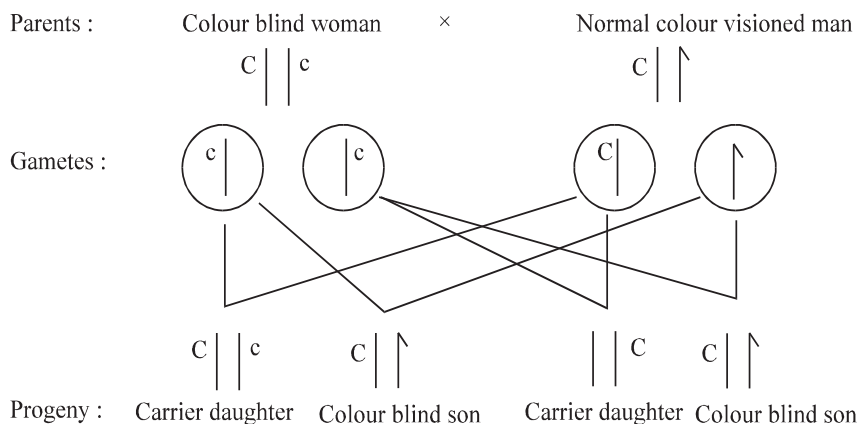


Fig. 21.7 (b) Progeny of colour blind female and a man with normal vision.

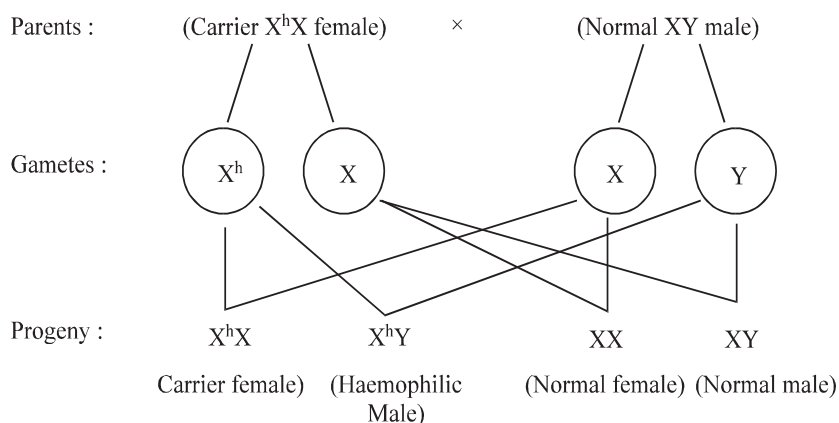


Fig. 21.7 (c) Progeny of an haemophilic carrier female and normal male

**INTEXT QUESTIONS 21.3**

- What are genes and where are they located?
.....
- State the names of the scientists who proposed the chromosomal theory of inheritance.
.....
- Define (i) linkage and (ii) crossing over.
.....

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Notes

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

.....

21.8 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 about genes on the chromosomes present in the nucleus. Since mitochondria come into the zygote from the egg, inheritance of mitochondrial DNA or 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.

21.9 HUMAN KARYOTYPE

Human karyotype is the arrangement of chromosomes in seven groups according to the types of chromosomes and their size. It is prepared by arranging chromosomes seen at mitotic metaphase.

- (i) Total no. of chromosomes or $2n = 46$ (23 pairs).
- (ii) Number of autosomes = 44 (22 pairs).
- (iii) Sex chromosomes = X and Y = 2
- (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. 21.8.

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

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

Normal female 22 pairs of autosomes + two X chromosome

Presence of Y is necessary for maleness.

Absence of Y chromosomes makes the individual a female



Notes

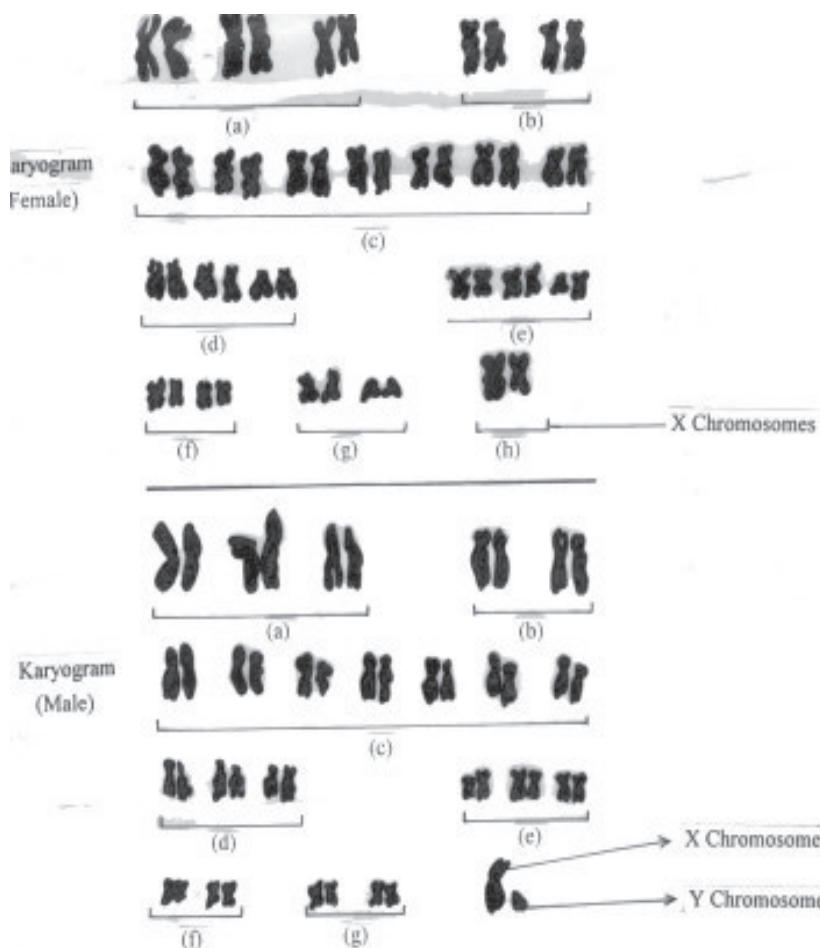


Fig. 21.8 Karyotype showing chromosomes of normal male. Female has the same autosomes but two X-chromosomes instead of XY

21.10 CHROMOSOMAL ABNORMALITIES AND GENETIC DISORDERS IN HUMANS

Any change from the normal number or structure of chromosomes causes abnormalities. Following are some of them.

1. Mongolism or Down's syndrome

The individual has 47 chromosome because of one extra chromosome in the 21st pair (Trisomy of chromosome 21). The outcome is that they are

- mentally retarded
- have a thick tongue
- and a drooping (false expression of pleasure) face. Fig. 21.9.

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Notes

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

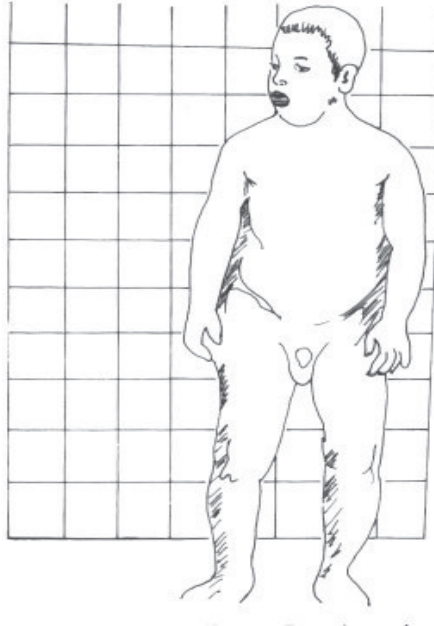


Fig. 21.9 Mongolism or Down's syndrome

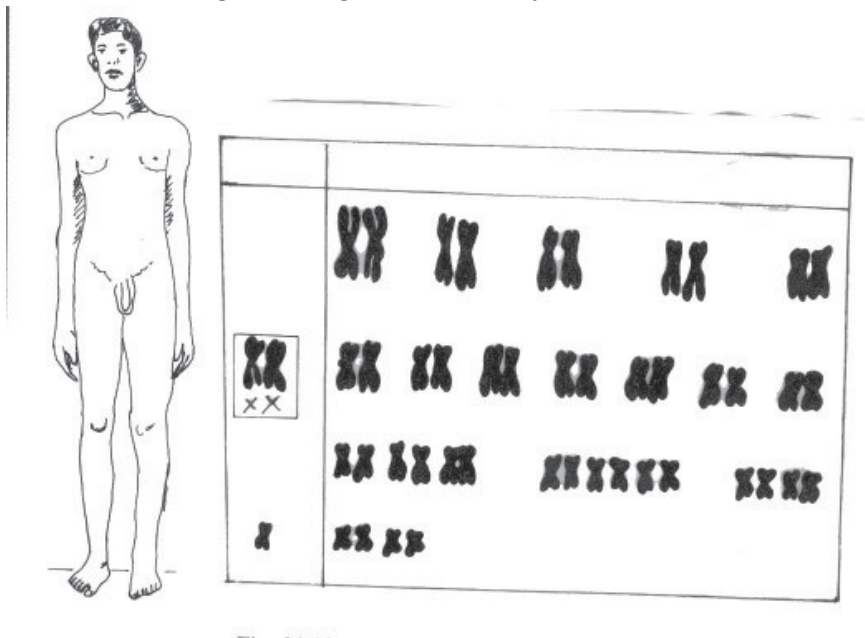


Fig. 21.10 Man showing Klinefelter's syndrome



Notes

2. Klinefelter's syndrome

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

- Tall, mentally retarded male;
- Sterile and shows breast development or **gynaecomastia** (gynae : female; massere : mammary glands). Fig. 21.10.

3. Turner's syndrome

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

- Mentally retarded
- web like skin on neck.
- incompletely developed breasts. Fig. 21.11.

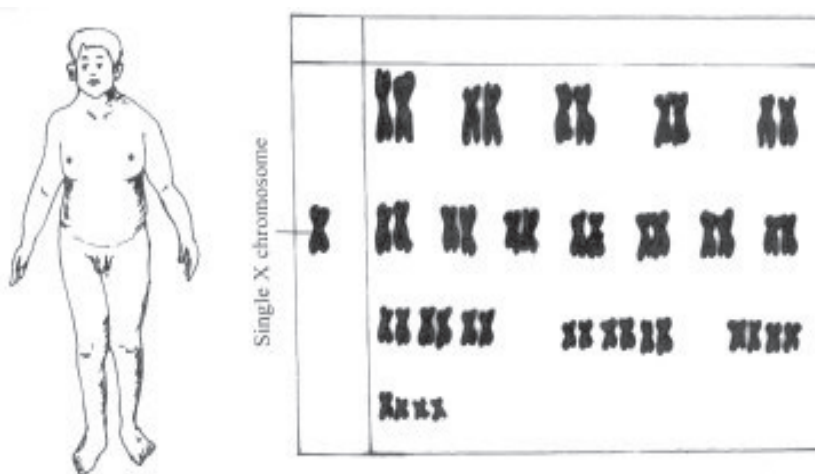
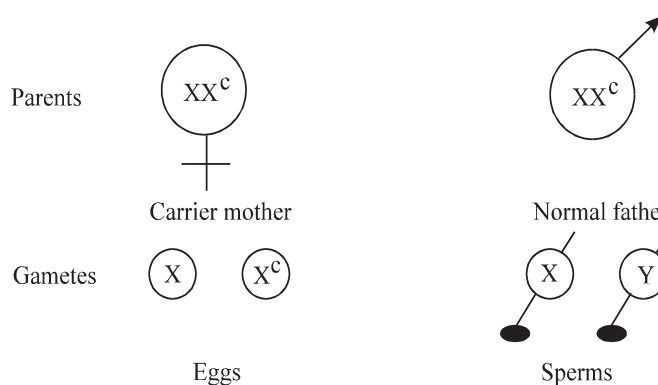


Fig. 21.11 A woman suffering from Turner's syndrome.

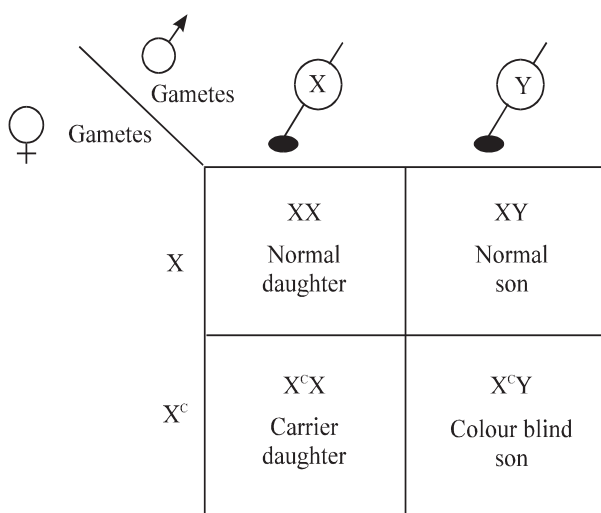
4. Colour blindness and Haemophilia (Bleeder's diseases)

Both these are sex linked disorders. (See figures 21.6 and 21.7)





The inheritance is as follows :



Note : X = normal allele; X^c = recessive mutant

Fig. 21.12 Inheritance of colour blindness

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. The defective gene received from the mother may be masked by normal allele on the other X. The daughter is then called a carrier. (Fig. 21.12).

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 a disorder in which haemoglobin is not synthesised properly. So, frequent blood transfusions are required for survival.

The defective gene is recessive and therefore 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 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. A boon in disguise against malaria for children with one defective Haemoglobin gene can survive as they are less affected by malaria because the malaria parasite cannot thrive inside the defective RBC's.



Notes

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 child who may have inherited the Rh + gene from the father. If the foetal blood enters mother's body stream, her immune system produces antibodies against Rh antigen of the embryo. Rh antigens cause no problems in first pregnancy. But in a subsequent early pregnancy, the mother's antibodies against Rh antigen may enter the foetal blood stream and destroy its red blood corpuscles causing severe anemia which may even be fatal. (erythroblastosis foetalis)

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. 21.13)



Fig. 21.13 The mechanism of Rh inheritance

- (a) shows the first pregnancy where the mother is Rh (-) and foetus Rh (+). Protein (empty circles) of the foetus stimulates the production of anti factors (black blocks) in the mother.
- (b) shows the retention of anti factors 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 same mother during the second pregnancy. The anti factors from the mother's body will destroy the infant's red blood cells.

21.11 AMNIOCENTESIS

Amniocentesis is a technique by which hereditary disorders due to defects in genes can be detected. In this technique (Fig. 21.14)



- (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.

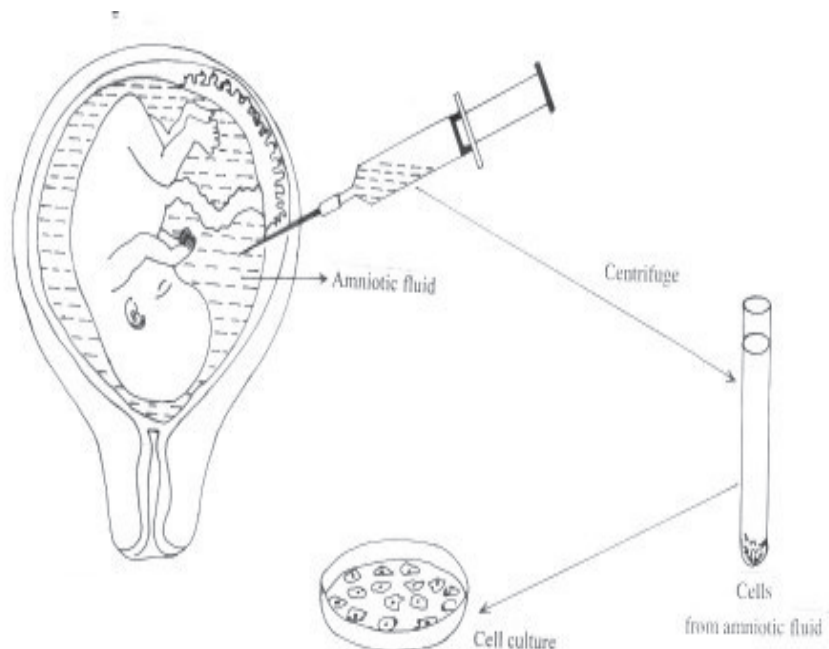


Fig. 21.14 Techniques of Aminocentesis

21.12 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 their 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, genes that control various enzymes that catalyse the various biochemical reactions in the body, genes responsible for genetic disorders have been located. Genome means genes of a particular organism. 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 on 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

**Notes**

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 and 20,000 to 25,000 genes.

**INTEXT QUESTIONS 21.4**

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 and in Mongolism.
.....

**WHAT YOU HAVE LEARNT**

- Heredity means the transmission of characters from parents to offspring.
- Variation pertains to difference between siblings or members of same species.
- Mendel was the first to explain that heredity involves transmission of units from reproductive cells of parents to offspring.
- Hugo de Vries, Correns and Tschermak rediscovered the Mendel's Laws of inheritance.
- Mendel selected seven varieties of garden pea differing in seven pairs of characters.
- According to his 'law of segregation' the factors segregate at the time of gamete formation.
- Mendel's 'law of dominance' states that one factor dominates the other contrasting factor in phenotypic expression.
- Law of independent assortment states that the inheritance of one character does not depend on inheritance of any other character.
- There are deviations from Mendelian inheritance and these patterns of inheritance are incomplete dominance, codominance, multiple alleles, polygenic inheritance and pleiotropy.

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Notes

Principles of Genetics

- Sutton and Boveri (1902) proposed the chromosomal theory of heredity. It states that Mendelian factors or genes are located on chromosomes.
- Gene 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 for female and XY for male.
- Males inherit an X chromosome from female parent and Y from the male parents. Y chromosome bears genes for maleness.
- Female receive two chromosomes one each from either of the two parents.
- Any change from normal number & structure of chromosomes causes abnormalities.
- A normal karyotype shows the 23 pairs of humans chromosomes and thousands genes.
- Down's syndrome patients have 47 chromosomes (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 disorders.
- Thalassemia and Sickle cell anaemia are due to a single 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 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 F₂ 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



Notes

5. Why do we find so many different complexions among humans?
6. State the chromosomal theory of inheritance.
7. Work out the following crosses and mention the phenotype 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 criss-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?

**ANSWER TO INTEXT QUESTIONS**

- 21.1**
1. Gregor Johann Mendel, first to suggest principles underlying heredity
 2.
 - (i) homozygous = bearing identical alleles of a trait; heterozygous = bearing dissimilar alleles of 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
Phenotype = outward expression of a gene
 - (iv) monohybrid = cross between two parents differing in a single pair of contrasting character; dihybrid cross = cross of two parents differing in two pairs of contrasting characters.
 3. Heredity : 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.
- 21.2**
1.
 - (i) Alleles are different forms of a gene.
 - (ii) Both alleles express as dominant phenotype.
 - (iii) Many genes controlling same trait.
 - (iv) whose presence in an individual proves to be fatal.

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Notes

2. (i) Codominance and multiple alleles
(ii) Incomplete dominance
(iii) Polygenic inheritance
(iv) Polygenic inheritance
3. 1 : 2 : 1

21.3 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 chromosomes is a recessive gene so gets masked by normal gene from mother.

21.4 1. Because mitochondria are inherited from the mother through the ovum.

2. Seven
3. Klinefelter : $2n = 47$; XXY
Turner : $2n = 45$; XO
Mongolism : $2n = 47$; Trisomy of chromosome 21



MOLECULAR INHERITANCE AND GENE EXPRESSION

A cell contains the nucleus, nucleus contains chromosomes which bear genes. Genes carry the hereditary information. A zygote has the information for development and differentiation in its genes. Cells of an individual has the genes for maintaining its structure and function. But what are these genes and how do they function? Genes are made of segments of the chemical 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 genetic material;*
- *describe the general structure of DNA by referring to the terms nucleotides, nucleocides, purines 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 during replication of DNA;*
- *explain the concept of central dogma;*
- *describe the sequence of steps during transcription and translation Airing protein synthesis;*
- *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.*



Notes

22.1 THE CONCEPT OF THE ONE GENE ONE ENZYME HYPOTHESIS

The British biochemist and physician Archibald Garrod had mentioned in his book “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 the mutant leads to absence of the enzyme in the mutant stopping 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 may be made of more than one polypeptide and one gene controlled production of one polypeptide.

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

22.2 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 bacteria *Streptococcus pneumoniae* when grown in the lab form smooth colonies (S Strain) and when injected into mice kill them. A mutant of this bacterium forms rough colonies (R Strain) and is harmless to mice. In 1928, Frederick Griffith found that if the smooth walled 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. 22.1).

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

Later Hershey and Chase in 1952 used T₂ bacteriophage (bacteria infecting virus) for their experiments. They labelled the protein coat of the virus with radioactive isotope of sulphur S³⁵. When the virus was introduced into the bacteria, no label (radioactivity) was found inside the bacteria as the viral coat was left outside. When they labelled viral DNA with P³² (radioactive) phosphorus, radioactivity was found



Notes

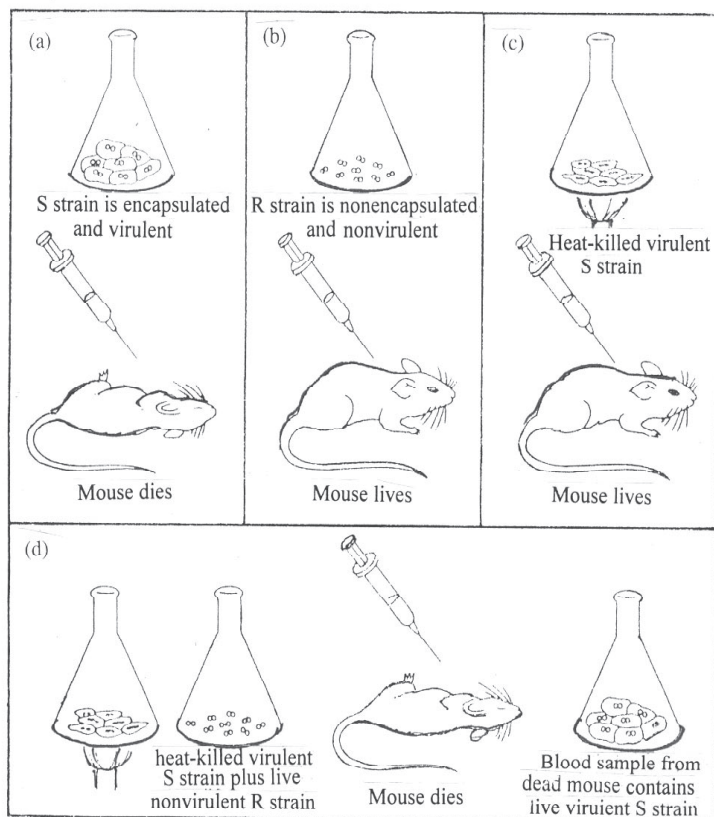


Fig. 22.1 Griffith's bacterial transformation experiment.

inside the bacteria. It became clear that new generations of the virus were reproduced inside bacteria because of viral DNA (Fig. 22.2).

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

22.3 STRUCTURE OF DNA, THE GENETIC (HEREDITARY) MATERIAL

22.3.1 Chemical nature of DNA

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

Each nucleotide consists of three subunits.

- a pentose (5 carbon) sugar called **deoxyribose**
- 4 nitrogenous bases Adenine (A), Guanine (G) (purine bases) and Thymine (T) and Cytosine (C) (pyrimidine bases)



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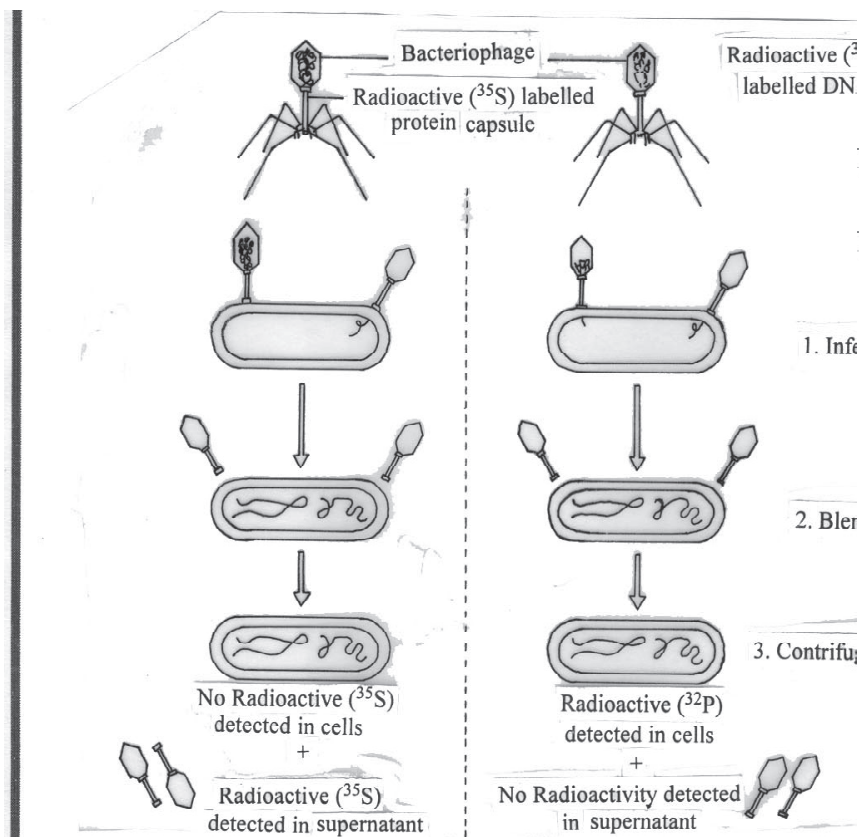


Fig. 22.2 The Hershey Chase experiment

(iii) a phosphate group (PO_4) positioned on the sugar (Fig. 22.3)

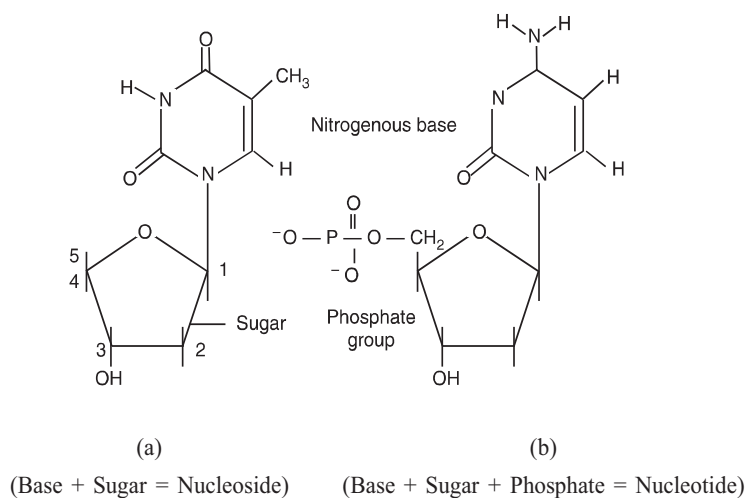


Fig. 22.3 Component of nucleoside and nucleotide

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

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.

22.3.2 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 Watson and Cricks 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. 22.4.

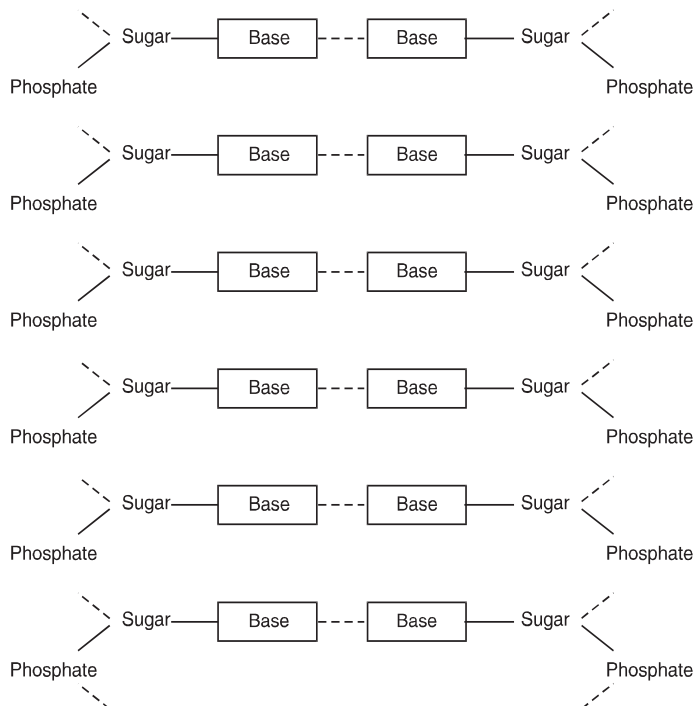


Fig. 22.4a Components of a DNA double helix

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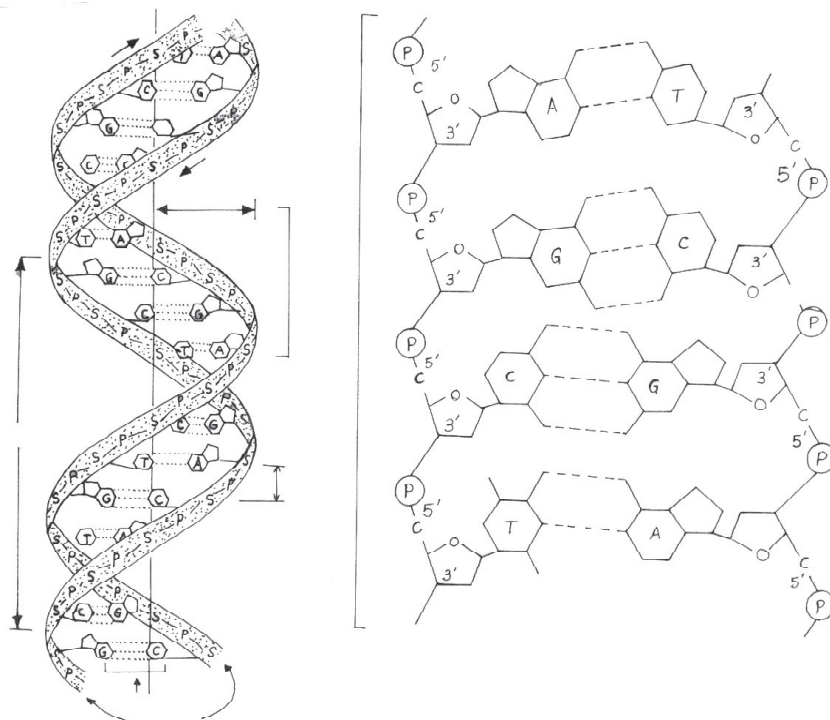


Fig. 22.4b-c DNA double helix

- The **backbone** of the helix is made of **sugar phosphate** and nitrogenous bases are linked to the **sugar**. (Fig. 22.4a and 22.4b)
- The bases of the two strands are linked by hydrogen bonds.
- Base pairing is very specific as per Chargoff's rule. A Adenine, a purine base always pairs with thymine, a pyrimidine 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.

In the DNA helix, a complete helical turn occurs after 3.4 nm (or 34 Å). 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. 22.4c).

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 capsule of (i) Replication (ii) storage of information (iii) transmission of information (iv) expression of information (v) regulation of gene expression.

Eukaryotic chromosome

In the bacteria (prokaryotes), one double stranded DNA molecule constitutes the only 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 microscopic entities during cell division? Fig. 22.5 shows packaging of the DNA molecule.

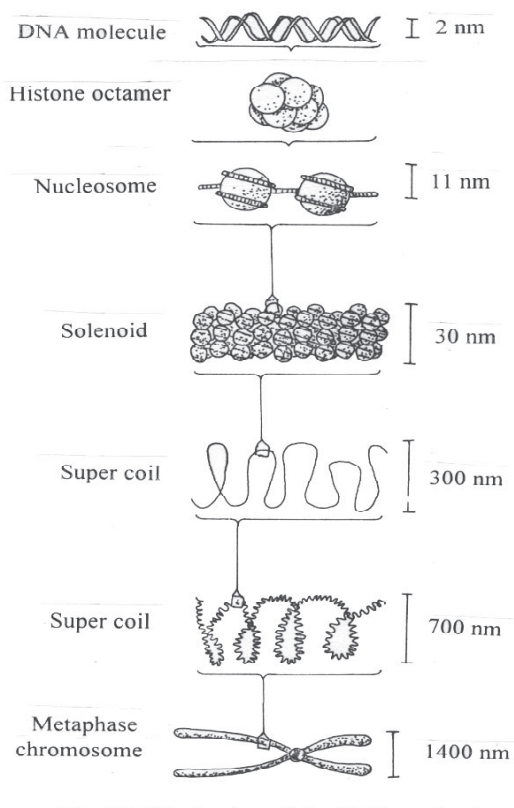


Fig. 22.5 Packaging of the DNA molecule.

- At interval DNA molecule is coiled around a “core particle” which is an octomer, 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 eucaryotic 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 as shown in the figure.



Notes



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22.4 RNA OR RIBONUCLEIC ACID

Apart from DNA, RNA is the other important nucleic acid present inside the cell. Table 22.1 gives the differences between DNA and RNA.

Table 21.1 Difference between DNA and RNA

DNA	RNA
1. Double stranded molecule	1. Single stranded molecule
2. Contains deoxyribose sugar	2. contains ribose sugar. Thymine is replaced by uracil
3. Pyrimidine base complementary to Adenine is Thymine	3. Pyridine base complementary to adenine is uracil No thymine is RNA
4. DNA has only one function, that is to bear hereditary information	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

Function of various type of RNA

mRNA or messenger RNA

mRNA or messenger RNA is transcribed in the nucleus to carry the information for 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. 22.6) 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 "transfer" the amino acids at 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 (Cytosine-Cytosine-Adenine) and the 5' end of the tRNA end in G. (Guanine) Amino acid is carried at 5' end.

tRNA contains unusual bases like inosine, dihyouridine 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 present at "nucleolar organiser" region in a chromosome.

rRNA have a role in protein synthesis

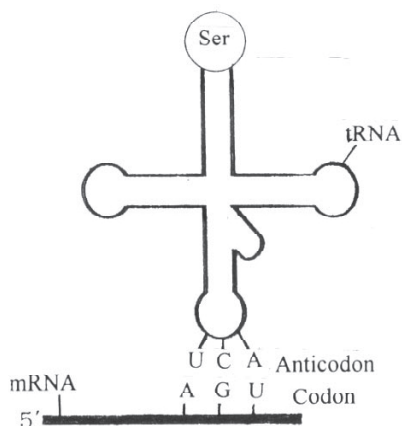


Fig. 22.6 RNA showing anti codon and codon pairing.

Mechanisms of DNA transfer

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 bacterial by any one of the three processes, 1. conjugation, 2. transformation and 3. Transduction

Conjugation

Two bacteria may come together and undergo **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 cell** through **F⁻pilus**. The single strand left behind in the donor as well as the single strand donated to the recipient cell then become double stranded. The transferred DNA gets integrated into recipient chromosome. This is recombination. Conjugation also occurs between two strains F⁺ and F⁻ strains. 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 becomes Hfr.

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



Notes



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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 carrying host bacterial genes may enter a new host bacterium and recombine into its genome. This gene process of transfer is called **transduction**.



INTEXT QUESTIONS 22.1

1. Expand 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
.....

22.6 DNA REPLICATION

DNA duplicates itself **exactly** 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 replication

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 replication fork as shown in Fig. 22.7a.

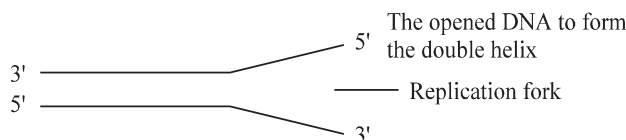


Fig. 22.7a Replication fork

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 which begins to form.

3. Synthesis of new DNA strand

The opened strands of DNA form the template. New strands complementary to template are synthesised. 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 contains synthesis complementary to one of the unwound parental DNA strand. The new strand of DNA **continues to be synthesized to uninterrupted** and is termed **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**. 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

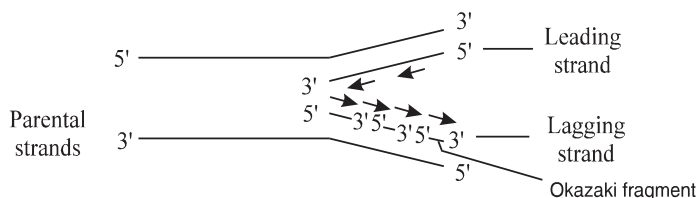


Fig. 22.7b Formation of new DNA strands

- DNA replication is remarkably accurate so that the parental DNA molecule gets an exact duplicate copy made any mistake gets chipped and repaired. This is term proof reading. At the end of results.
- 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 experimentally proven by Messelson and Stahl.



INTEXT QUESTIONS 22.2

1. In which direction does DNA polymerase proceed to catalyse DNA replication 5' to 3' or 3' to 5'.
2. What is a primer a DNA molecule or an RNA molecule?



Notes



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3. Name the four enzyme needed for DNA replication.

.....

4. Which enzyme joins okazaki pieces?

.....

22.7 GENES AND PROTEIN SYNTHESIS

The genes of an individual is its **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 DNA molecule present in the chromosome.

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

1. Central dogma
2. Genetic code

22.7.1 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.

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

For protein synthesis, first the information coded in DNA is copied as a complementary messenger RNA molecule this is termed 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 the figure.

In retroviruses, the genetic material is RNA. Therefore, during protein synthesis it is first transferred to a DNA molecule in the presence of the enzyme reverse transcriptase and then the path of central dogma is followed as shown below.

RNA $\xrightarrow[\text{transcription}]{\text{Reverse}}$ DNA $\longrightarrow$ mRNA $\longrightarrow$ Protein
(genetic material
of retrovirus)

22.7.2 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, Mathair and Ochoa.

The genetic code refers to the information for the structure of a particular protein to be synthesised coded in a DNA molecule. That 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 in the gene has the information of a particular amino acid. The codons determine for the sequence of amino acids in a protein.
2. Genetic code is **unambiguous**, that is a particular codon can code for only one certain amino acid.
3. Genetic code is **commaless** and **nonoverlapping**. 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. In fact as you can see from the figure (Fig.), the 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 from 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 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 22.1).

22.7.3 Transcription

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.



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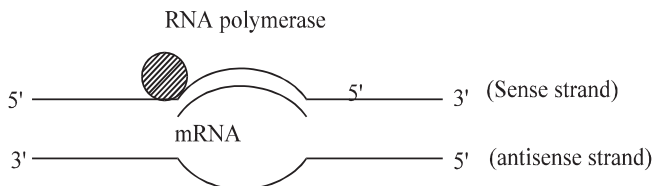


Fig. 22.8 Transcription in prokaryotes

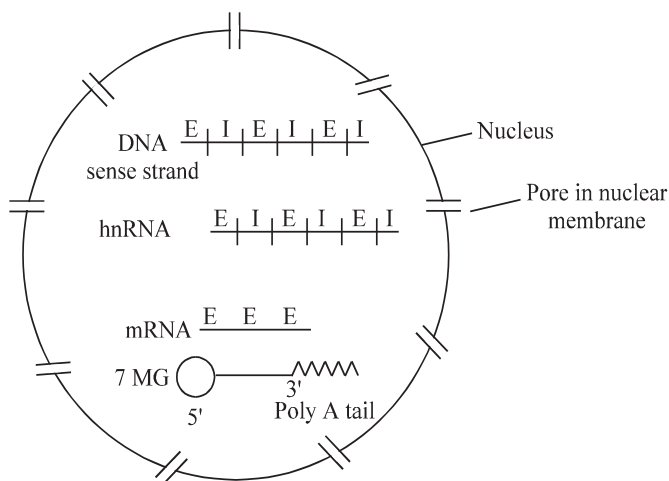
In Eukaryotes, the mRNA is synthesised within the nucleus after cistronic DNA unwinds to expose the sense strand for transcription of a large molecule of RNA called hnRNA heterogenous nuclear which is synthesised in the presence of RNA polymerase.

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 hnRNA. During processing of hnRNA introns are cut off and exons join to form mRNA.

- A nucleoside (recall from section 22.3) 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. 22.9a and 22.9b)



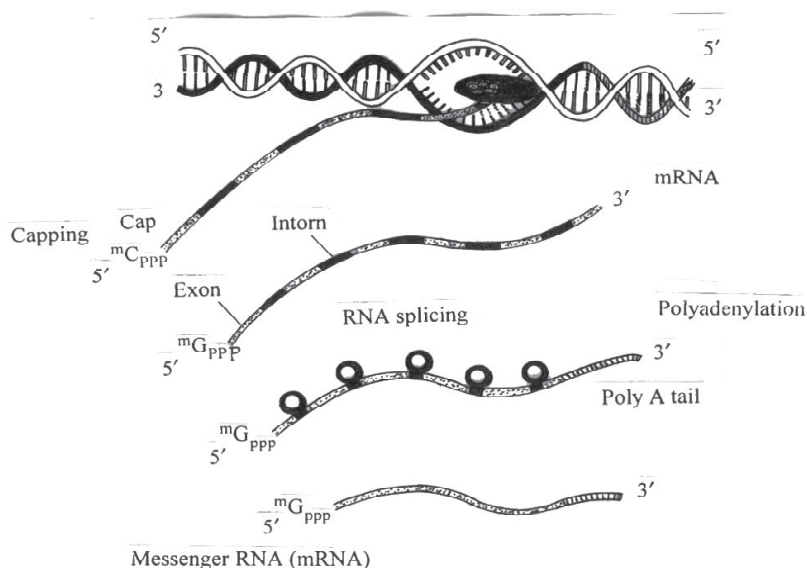


Fig. 22.9a Schematic drawing showing transcription and processing of hnRNA in eukaryotes

Fig. 22.9b Process of transcription and processing of hnRNA

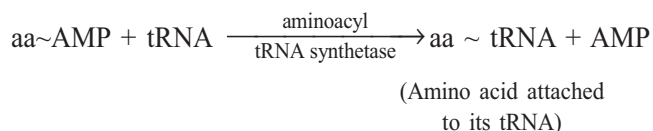
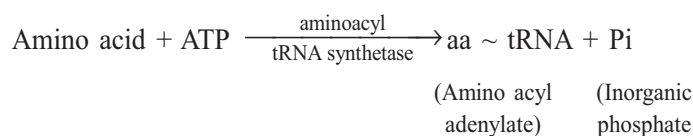
22.7.4 Translation

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 tRNA attaches to specific amino acid in the presence of the enzyme **amino acyl-tRNA synthetase** in two steps given below. This requires energy



Formation of mRNA ribosome complex and chain initiation

- mRNA binds to small ribosomal subunit



Notes



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- 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 at the A and P sites tRNA.
- 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. 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 mRNA 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 of the Ribosome then moves over 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 and methionine is bonded 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. 22.10).

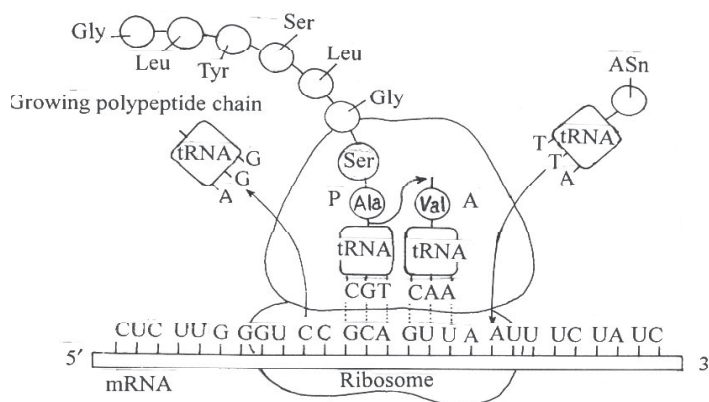


Fig. 22.10 Translation of mRNA

• 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.

• 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 22.3

1. What is central dogma of molecular Biology?

.....

2. Which molecule is synthesised at transcription.

.....

3. What is a codon.

.....

4. Where in the cell does translation occur.

.....

5. Name the three types of RNA that participate in protein synthesis.

.....

22.8 HOUSE KEEPING GENES

In multicellular organisms, all cells contain all genes but only those 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 which need to be synthesised 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 ones 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.

22.9 REGULATION OF GENE EXPRESSION

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** which has to be metabolised. 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 gene coding for enzymes needed to breakdown lactose. The operon includes 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* for the 3 above mentioned enzymes.





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The working of the operon system is given in Fig. 22.11a-b.

In absence of the substrate lactose

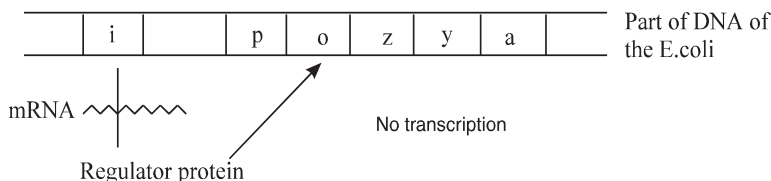


Fig. 22.11a Lac operon

Regulator protein blocks o, RNA polymerase cannot find p and z, y, a remain switched off.

In the presence of lactose

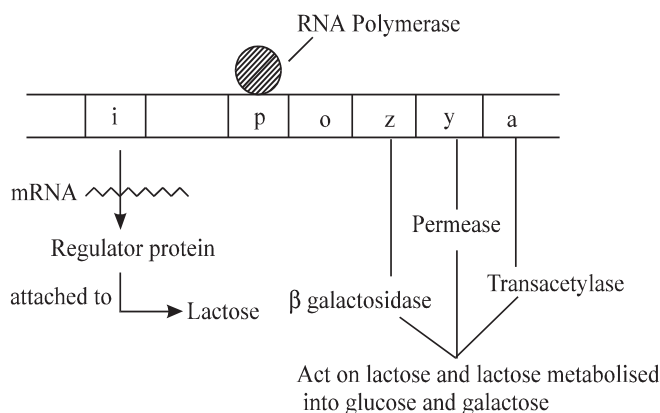


Fig. 22.11b Lac operon

Regulator attracted to lactose, o site open, 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, in several ways, and genes expression can be regulated at level of transcription or processing of hnRNA into mRNA or at translation or post translation. Fig. 22.12).



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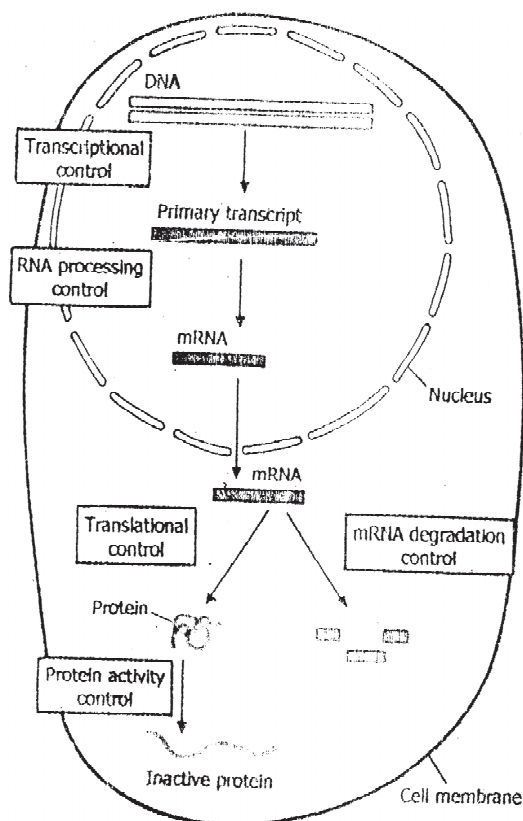


Fig. 22.12 Levels of gene control in eukaryotes

22.10 MUTATION

A heritable change in the structure, content and organization of the genetic material that can be passed down to the next generation) is termed a 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, due to 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 **Aneupoidy**. Sometimes the whole set of chromosomes may be duplicated so that instead of $2n$, an individual may possess $3n$ or $4n$ chromosomes. This is **euploidy**.

Chromosomal change in structure is also termed **chromosomal aberrations**. 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. A piece from another chromosome may get attached translocation.



Notes

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 a sequence of nucleotides. When ever 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 $\longrightarrow$ AGGC AGGC
2. Transversion : When a purine base is replaced by the another pyrimidine base and similarly a pyrimidine base by another purine
ATGC ATGC $\longrightarrow$ ATGT ATGC
3. Frameshift : Sometimes due to loss or gain of one nucleotide the reading frame of the genetic code for an entire gene changes
CAT CAT CAT CAT $\longrightarrow$ CAT ATC ATC ATC
lost
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 $\longrightarrow$ GAAUAAAA
synthesis stops
6. Silent : When the change in a nucleotide does not bring about any phenotypic change.

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 22.4

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 mutagenes?

.....

5. Name a chemical which causes mutation in the heredity material.

.....



Notes



WHAT YOU HAVE LEARNT

- One gene was responsible for the production of one enzyme, 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 three subunits (i) sugar deoxyribose (ii) 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 thymine. Many species of RNA such as mRNA, tRNA, rRNA with 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 genetic coded information 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 character.



Notes



TERMINAL QUESTIONS

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 okazaki fragments.
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.



ANSWER TO INTEXT QUESTIONS

- 22.1
 1. Deoxyribonucleic acids
 2. Avery, McClelland and McCarty
 3. Deoxyribose, Adenine, Guanine, Thymine, Cytosine
- 22.2
 1. In 5'-3' direction
 2. RNA molecule
 3. Helicase, DNA polymerase, DNA ligase, Topoisomerase
 4. DNA ligase
- 22.3
 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
- 22.4
 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 does not bring about a change in the sequence of nucleotides.

11. SEX DETERMINATION

Sex determination is an interesting aspect for scientists. Only in recent years, with the knowledge of Genetics, the problem has been solved. Most of the plants and few lower animals are bisexual. But higher animals are unisexual. In animals, sex determination is genetic, chromosomal or environmental variables.

OBJECTIVES :

After studying this lesson :

- 1 You can understand the autosomes and allosomes
- 1 You can understand heterogametes
- 1 You know about Calvin Bridges view
- 1 You can understand haplodiploidy in honey bees
- 1 Hormonal control on sex determination

I. Sex Chromosomes :

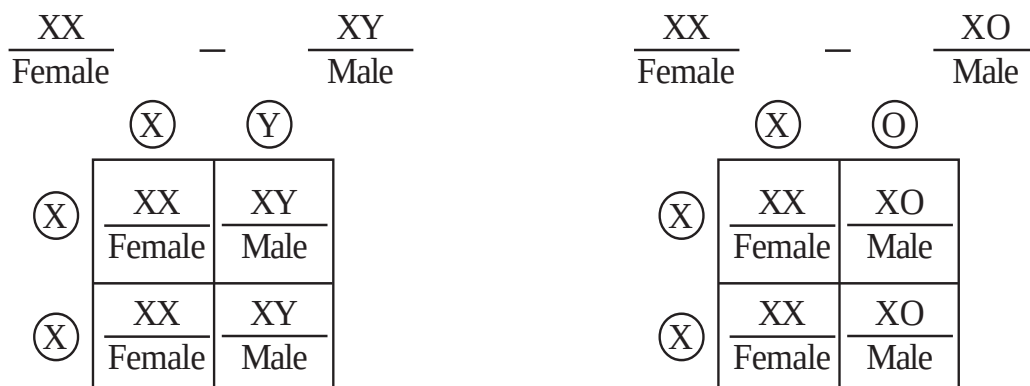
In many animals, sex is determined by a pair of chromosomes. They are called **allosomes** or **sex chromosomes**. They are X and Y. The chromosomes in a cell other than sex chromosomes are called **autosomes** or **somatic chromosomes**. Steven and Wilson discovered X - chromosome in *Protener* and Y - chromosome in *Lygaeus*. In case of males, the chromosome homologous to X - is very small and is called Y - chromosome.

II. Heterogametes :

If the two sex chromosomes in an organism are similar (XX), it is called **homogametic** (it produces similar gametes). If the two sex chromosomes are different (XY), it is called **heterogametic** (it produces two different types of gametes). Sex determination based on sex chromosomes was proposed by Correns.

1. XX - XY method (e.g., *Drosophila*)

In this method, Y chromosome determines the sex. Male is heterogametic.

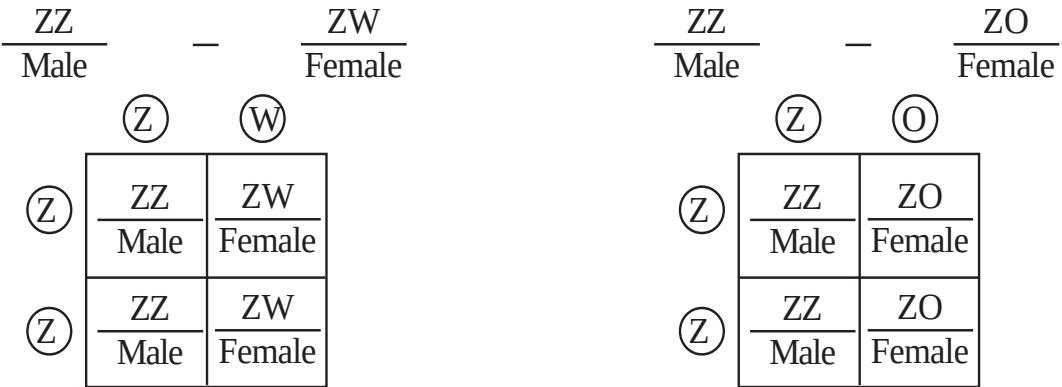


2. XX - XO method (e.g., Bugs, Grasshoppers, Cockroaches)

In this method, number of X - chromosomes determines the sex. Male is heterogametic.

3. ZX - ZW method (e.g., Butterflies, some fishes, reptiles, birds)

In this type X is replaced by Z - Chromosome and Y is replaced by W. Moreover, female is heterogametic. W chromosome determines the sex.



Sperms 3/3=1.0 Ova 2/2=1.0	(AA + XX)	(A + XX)	(A + XX)	(A + X)
(A + X)	$\frac{AAA + XXX}{\text{Intersex}}$	$\frac{AA + XXX}{\text{Metafemale}}$	$\frac{AAA + XXX}{\text{Tri.female}}$	$\frac{AA + XX}{\text{Female}}$
(A + Y)	$\frac{AAA + XY}{\text{Metamale}}$	$\frac{AA + XXY}{\text{Female with extra Y}}$	$\frac{AAA + XXY}{\text{Intersex}}$	$\frac{AA + XY}{\text{Male}}$

S.No.	Genotype	No. of X - Chromo - somes (X)	No. of sets of Autosomes	Sex Index Ratio X/A	Sex of the individual
1	AAA + XX	2	3	$\frac{2}{3} = 0.67$	Intersex
2	AA + XXX	3	2	$\frac{3}{2} = 1.5$	Metafemale
3	AAA + XXX	2	2	$\frac{3}{3} = 1.0$	Female (Triploid)
4	AAA + XX	2	2	$\frac{2}{2} = 1.0$	Female (Normal)
5	AAA + XY	1	3	$\frac{1}{3} = 0.33$	Metamale
6	AA + XXY	2	2	$\frac{2}{2} = 1.0$	Female with extra Y
7	AAA + XXY	2	3	$\frac{2}{3} = 0.67$	Intersex
8	AA + XY	1	2	$\frac{1}{2} = 0.5$	Male (Normal)

IV. Haplodiploidy : (e.g., Honey bees - *Apis mellifera*)

In *Apis mellifera* (honey bee), female (Queen) is diploid (with 32 chromosomes) and male (Drone) is haploid (with 16 chromosomes). Female produces ova each with 16 chromosomes. Males produce viable sperms with all 16 chromosomes. Fertilised ova develop into females and unfertilised ova develop into males by **Parthenogenesis**. Parthenogenetic development of male honey bees is called **arrhenotoky**.

V. Hormonal control on sex determination :

1. Crew discovered complete **sex reversal** in fowls. A fertile hen change to fertile cock due to damage to ovary or after natural cessation of ovary. It means, ovary of reproductive female secretes a male suppressing hormone.



Fig. Free Martin

2. In cattle (e.g., Cow), if twin calves of opposite sex are born, the female generally becomes abnormal and sterile. It is called **free martin**. This is beacuse, male hormones are produced earlier. They are circulated into female also through placenta. They suppress the development of ovary in female calf, resulting in its sterility.

Intext Questions :

1. What are the two types of chromosomes in a cell ?
.....
2. Name the two types of sex chromosomes
.....

3. Name the methods of sex determination in :
 - a. *Drosophila* :
 - b. Cockroach :
 - c. Butterfly, bird :
 - d. *Fumaea* :
4. What is meant by sex index ratio ?
.....
5. Determine the sex of the following genotypes as per sex index ratios :
 - a. AAA + XX :
 - b. AAA + XXY :
 - c. AA + XXX :
 - d. AAA + XY :
6. What is meant by arrhenotoky ?
.....
7. In which organisms complete sex reversal was recorded ?
.....

What you have learned ?

- 1 Chromosomes are of two types, namely, allosomes and autosomes.
- 1 Sex determination is by sex chromosomes and sexual differentiation by sex hormones.
- 1 Stevens and Wilson discovered X and Y chromosomes.
- 1 Calvin Bridges discovered that Y - Chromosome does not influence sex determination in *Drosophila*.
- 1 In honey bees, fertilized ova (i.e., Zygotes) develop into females and unfertilized ova develop into males by Parthenogenesis.
- 1 Crew discovered sex reversal in fowls.
- 1 In cattle, when twins of opposite sex are born, the female is generally abnormal and sterile and is called free martin.

Terminal Questions :

1. Explain heterogametes with examples.
2. How sex is determined in *Drosophila*
3. Describe haplodiploidy in honey bees.
4. Write notes on hormonal control on sex determination.

Answers for intext Questions :

1. Allosomes and Autosomes
2. X and Y
3. a. XX - XY method
b. XX - XO method
c. ZZ - ZW method
d. ZZ - ZO method
4. The ratio of number of X - Chromosomes and number of sets of autosomes is known as sex index ratio.
5. a. Intersex
b. Intersex
c. Metafemale
d. Metamale
6. Parthenogenetic development of unfertilized ova into males in honey bees is called arrhenotoky.
7. Fowls.



GENETICS AND SOCIETY

You have learnt from earlier lessons of this unit 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.



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;*
- *describe steps of polymerase chain reaction and mention its use;*
- *list the steps of DNA fingerprinting and mention its usefulness;*
- *explain the term genomics;*
- *justify the importance of genetic counselling.*

23.1 GENETICS THROUGH AGES

The history of genetics can be traced to prehistoric times and 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**.

23.2 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.



Notes

In the Roslin Institute in Scotland, Ian Wilmut cloned “Dolly” the sheep from her 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 as 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 in large quantities, certain enzymes, hormones and vaccines.



INTEXT QUESTIONS 23.1

1. Name any two recent techniques in genetics.

.....

2. Define gene cloning

.....

3. What is a gene bank ?

.....

23.3 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).



Notes

The steps in the production of rDNA is as follows (Fig. 23.1) :

- 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 to replace their lost parts. These become the recombinant plasmids and the DNA is rDNA.
- 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.

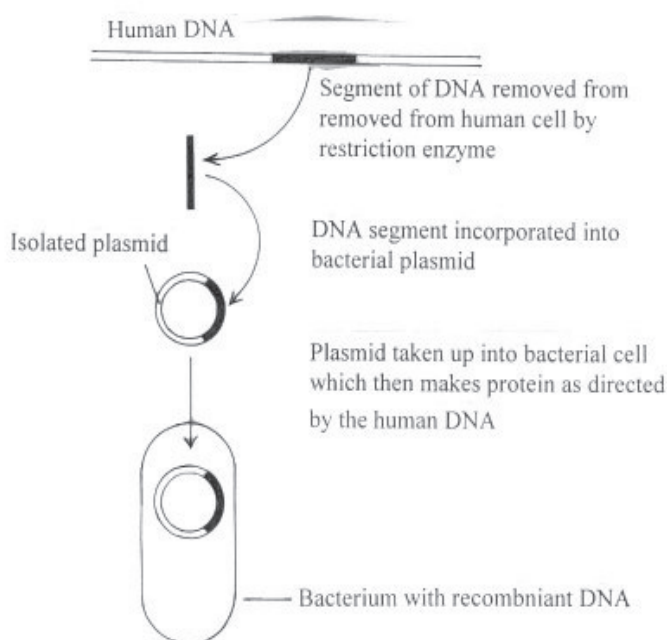


Fig. 23.1 Major steps in genetic engineering.

**Notes****23.4 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 by inserting genes responsible for them in the bacteria and then getting clones of these bacteria used 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 23.2**

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?
.....

23.5 TRANSGENIC MICROBES, PLANTS AND ANIMALS

Also called genetically modified organism (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.

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.

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.



Notes

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.

23.6 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.

DNA polymerase enzyme is used repeatedly for making many copies of a small fragment of DNA in the technique called **polymerase chain reaction (PCR)**. 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. 23.2).

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 analysis, cloning.

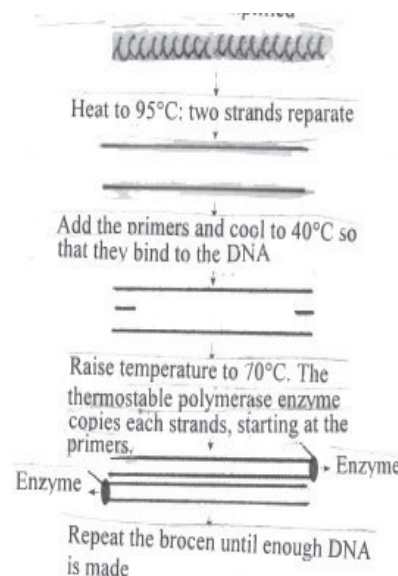


Fig. 23.2 Polymerase chain reaction

23.7 DNA FINGERPRINTING

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 Jaffreys, a geneticist invented a technique which could distinguish the DNA of a person from that of another and called this technique **genetic**



Notes

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.

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. 23.3).

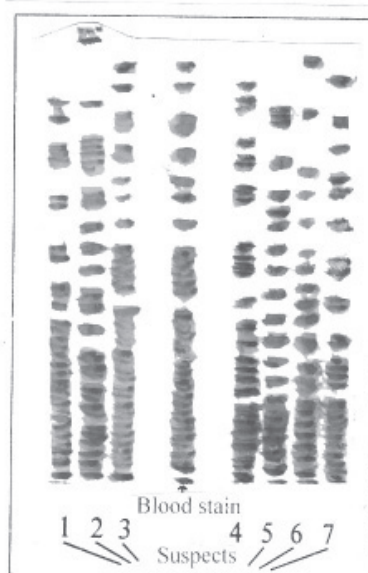


Fig. 23.3 DNA fingerprinting (Match and see that culprit is suspect No : 3)

23.8 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.

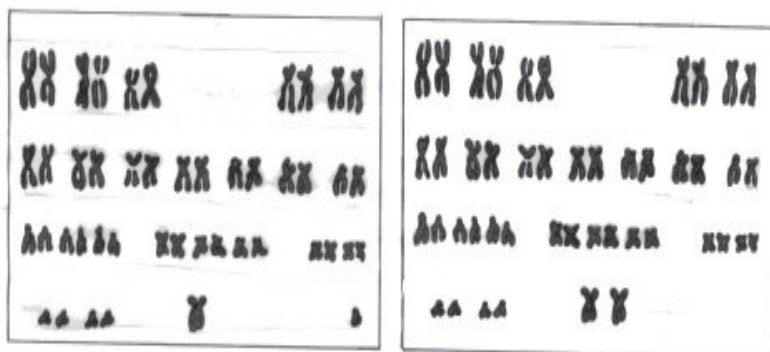


Fig. 23.4 Chromosomes of (a) male, and (b) female humans

MODULE - 3

Reproduction and
Heredity



Notes

Genetics and Society

The genome of *E. coli* bacterium, the yeast **Saccharomyces** and some other kinds of organisms such as *Drosophila* and *Anabidopsis* is already known.

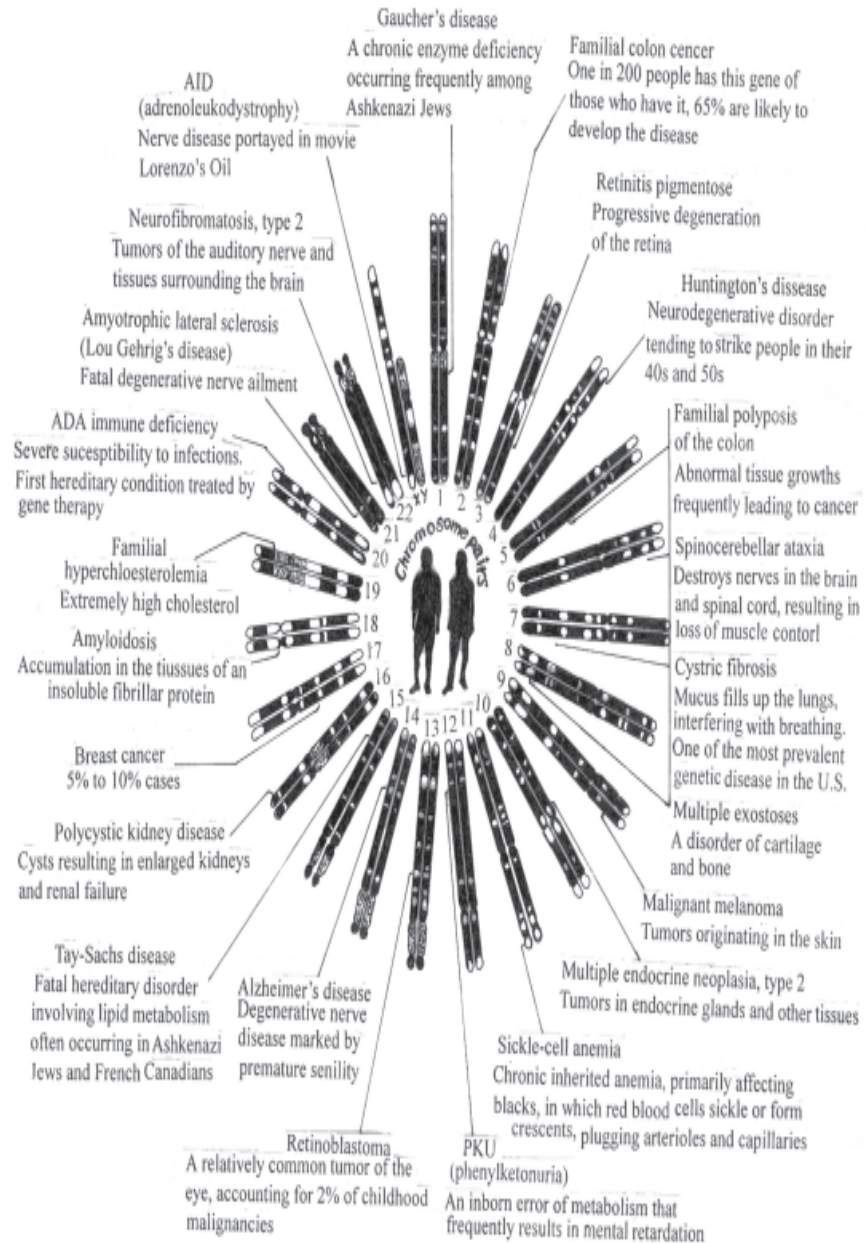


Fig. 23.5 Human genome showing location of defective genes.

The human genome has also been mapped in 2003. Humans have 23 pairs of chromosomes ($2n = 46$) and the human genome has 3×10^9 nucleotide base pairs



Notes

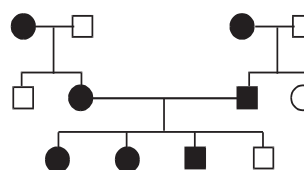
and if the sequence of nucleotides (genes) is known, it will be possible to pinpoint (i) defective genes (as shown in the figure in the box) and (ii) identify genes for correction of genetic disorders (gene therapy) and genetic counselling.

23.9 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 following pedigree chart 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. 23.6 Pedigree chart



INTEXT QUESTIONS 23.3

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?
.....

MODULE - 3

Reproduction and
Heredity



Notes

Genetics and Society



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 than 5000 BC.
- Modern genetics began after Mendel's laws of inheritance were accepted. Soon after it became 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 synthesis 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 advice 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 animals.
6. Define genomics
7. Draw and explain a pedigree chart.
8. What is genetic counselling and why is it important?

**ANSWER TO INTEXT QUESTIONS**

- 23.1**
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.
- 23.2**
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.
- 23.3**
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 - 3

Reproduction and Heredity

**Notes**

MODULE-IV
ENVIRONMENT AND HEALTH

- Lesson 24. Principals of Ecology
- Lesson 25. Conservation and Use of Natural Resources
- Lesson 26. Pollution
- Lesson 27. Nutrition and Health
- Lesson 28. Some Common Human Diseases

24



Notes

PRINCIPLES OF ECOLOGY

Earth is the only planet in the solar system that supports life. This is because of the balance between the three physical systems on it, that is, soil, water and air. Each one of these provide material essential for life. All the living beings differ from each other but they are all interdependent and interact with each other directly or indirectly as well as with their environment. Considering the significance of life on earth and to sustain it we should understand the earth's life support system and help to maintain a balance between the living things and their nonliving environment. In this lesson we will study the relationships between the organizations and their environment, the different level of organization, the characteristics of ecosystems and the major biomes.



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;*
- *discuss inter-relationship between plants and animals in an ecosystem;*
- *describe the 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 food chain;*
- *define biome;*
- *list the various biomes and their characteristics (flora and fauna);*
- *describe the biogeochemical cycles such as carbon and water cycles.*



Notes

24.1 ENVIRONMENT ECOLOGY AND BIOSPHERE

24.1.1 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

1. **Abiotic** : All the physical (climatic), edaphic (nature of soil) and chemical factors. They are also called nonliving factors. The important abiotic factors are 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** : All living organisms found in the environment and that includes plants, animals and microorganisms.

24.1.2 Ecology

Ecology is the scientific study of the relationship between organisms and their environment. The term ecology is derived from a Greek word *Oecologie* where “*oikos*” meaning “household” and “*logos*” meaning “the study of”. Literally ecology is the study of organisms at home. This term was introduced for the first time by a German Biologist Ernst Haeckel in 1869. Charles Elton a modern Ecologist defined Ecology as the study of animals and plants in relation to their habit and habitat. Thus ***Ecology deals with various forms of interactions between the organisms and their environment.***

These *interactions* can be studied at the various levels of organizations in the living systems starting from the molecules such as DNA (genes) to a biological community and the whole **biosphere**. Each step of independent interaction is called a **level of organization**. These are as follows :

Genes → Cell → organ → organism → Population → Community

At each level of organization there is a direct interaction of the physical system that is matter and energy.

The study of ecology has presently contributed a lot to the socio-economic and political issues of the world as it plays an important role in agriculture, fishery biology pest control, conservation of soil, forests and water resources. All the international issues of environment such as pollution and resource management need a sound knowledge of ecology.

Levels of biotic organizations showing a 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 has a specific place of its living which is known as its *habitat*. The habitat of sunfish

is pond and lion is a forest. The group of lions living in one forest or the group of sunfish living in one pond belong to one population.

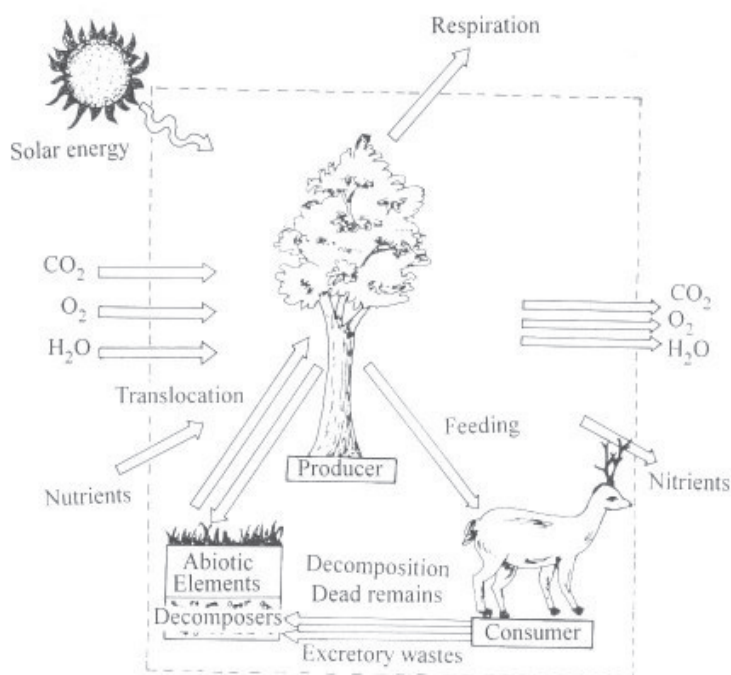


Fig. 24.1 Components of an ecosystem.

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 produce a successful offspring. These organisms may be separated in space and time into smaller groups called **populations**.

- **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** (as shown in the figure). 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**.

24.1.3 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.



Notes



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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

*In fact **ecosphere** is the largest worldwide ecosystem. Ecosphere is very huge and can not be studied as a single entity. It is divided into many distinct functional units called ecosystem.*



INTEXT QUESTIONS 24.1

1. Who coined the term ecology?
.....
2. Name the various levels of organizations.
.....
3. Define the term ecology.
.....
4. What the three physical systems that support life on earth?
.....

24.2 COMPONENTS OF THE ENVIRONMENT

The environment has two basic components

(A) Abiotic (B) Biotic

(A) Abiotic Components (Nonliving) : They can be classified into following two categories

1. **Physical components** : They are the various climatic characteristics such as light, temperature, humidity precipitation, pressure and soil profile. These factors sustain and control the growth of organisms in an ecosystem. Deficiency or excess of any one of these is harmful for their growth.
2. **Chemical components**
 - (a) **Inorganic components** : Substances such as carbon, carbon dioxide, nitrogen, oxygen, phosphorus sulphur, zinc, water and many other minerals are the inorganic nutrients required by all living beings. They may be classified into the micronutrients and macronutrients.. The essential inorganic elements such as carbon, hydrogen, nitrogen, phosphorus, calcium, potassium which are required in large quantities are called macronutrients. The essential elements required in small amounts are the micronutrients e.g. zinc, boron and magnesium. Sources of all nutrients for plants are air, water and soil. All these nutrients are converted into the living biomass by the plants.

- (b) **Organic components** : The complex molecules such as carbohydrates, proteins and lipids are the organic substances in an ecosystem. These substances when out side the organism make the abiotic component but in the living organism they make an important component of the biomass. They make a link between the biotic and abiotic components.

(B) Biotic Components (living)

The living organisms form the biotic component of the environment. All the living things require energy for their life processes and material for formation and maintenance of their body structure. Food meets both these requirements.

The biotic components can be classified as producers, consumers and decomposers.

1. **Producers** : Only plants are capable of capturing solar energy and transforming it into food energy for all the other living organisms. Therefore, they are called as producers. These plants are also named as autotrophs since they make their own food.
2. **Consumers** : Animals depend upon the plants directly or indirectly for their food and are called consumers. Their mode of nutrition is called heterotrophic. Consumers can be herbivores, carnivorous, omnivorous, parasitic or scavengers as described later in this lesson.
3. **Decomposers** : They feed on dead and decaying animals and plants. They are small microscopic organisms and help in recycling of nutrients in the environment.



INTEXT QUESTIONS 24.2

1. Name the major components of the environment.
.....
2. Enumerate the various physical factors of the environment
.....
3. What is the role of decomposer in nature?
.....
4. Why are plants called autotroph and animals called heterotrophs?
.....

24.3 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 ecosystem exist : **terrestrial** and **aquatic**.

Forests, deserts and grasslands are examples of terrestrial ecosystem.



Notes



Notes

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.

In the Fig. 24.2 (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.

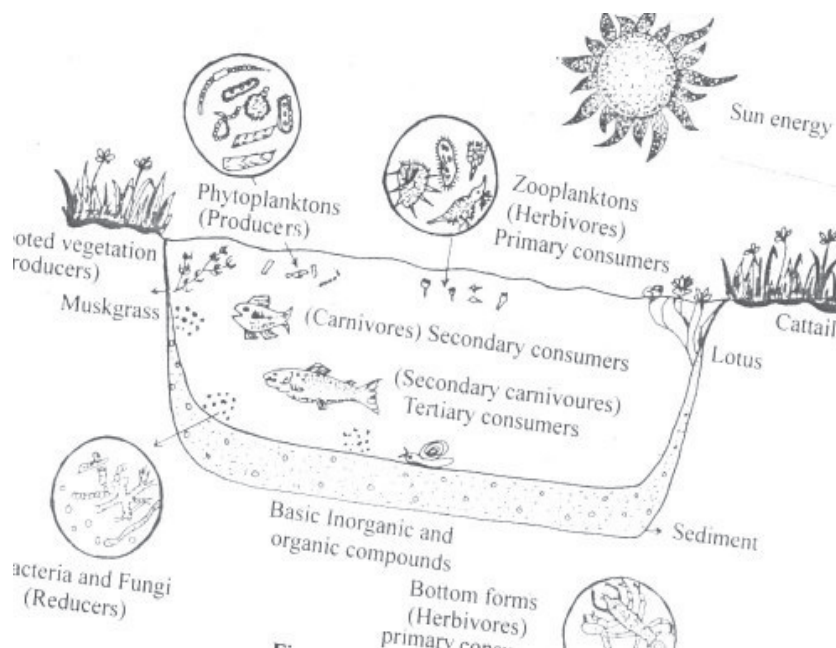


Fig. 24.2 Pond ecosystem

24.3.1 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.



Notes

- (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.



INTEXT QUESTIONS 24.3

1. Define an ecosystem.
.....
2. What are the main components of an ecosystem?
.....
3. Give reason, why are decomposers necessary in an ecosystem?
.....

24.4 ECOSYSTEM : STRUCTURE AND FUNCTION

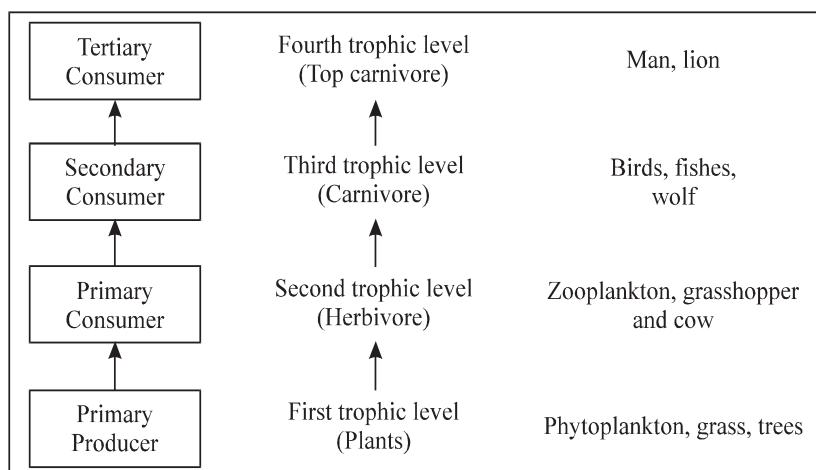
You have already learnt that ecosystem are capable of persisting as independent units of nature. In the following part of the lesson you will learn about the structure



Notes

and functions of ecosystem. Interaction biotic and abiotic components result 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 these aspects are :

- Productivity, energy flow, nutrient cycle



Diagrammatic representation of trophic levels in an ecosystem

24.1.1 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 that of a grass land. Not only the types of species are different in these two ecosystems 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).

24.5.4 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.



Notes

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.

24.4.3 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

- Each step in the food chain is called trophic level. In the above example grasses are first and eagle represents the fifth trophic level.
- Some more examples of food chain are given in Fig. 24.3.

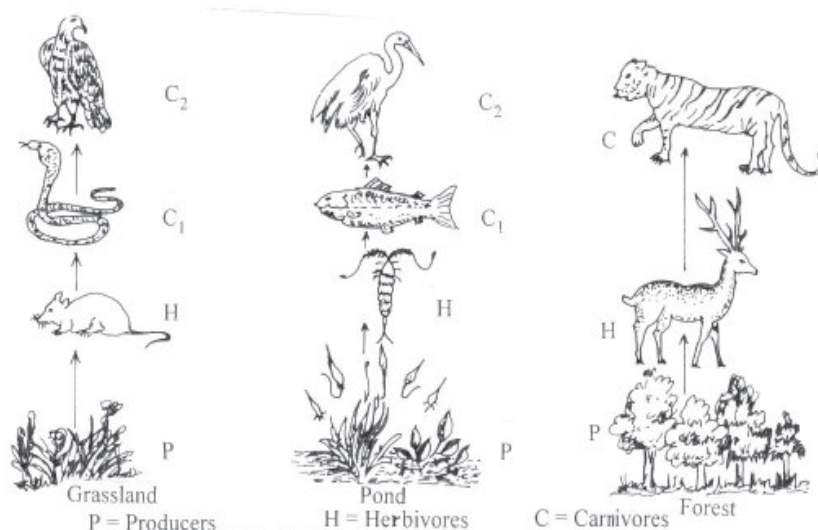


Fig. 24.3 Some examples of food chain.

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 :

- (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



Notes

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. They can be grouped into two classes: microdecomposers and macrodecomposers. Microdecomposers are very small microscopic organisms like bacteria, fungi, and protozoans. Macrodecomposers are large but less in number. They are visible to the naked eye e.g. springtails, 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?

24.4.4 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.

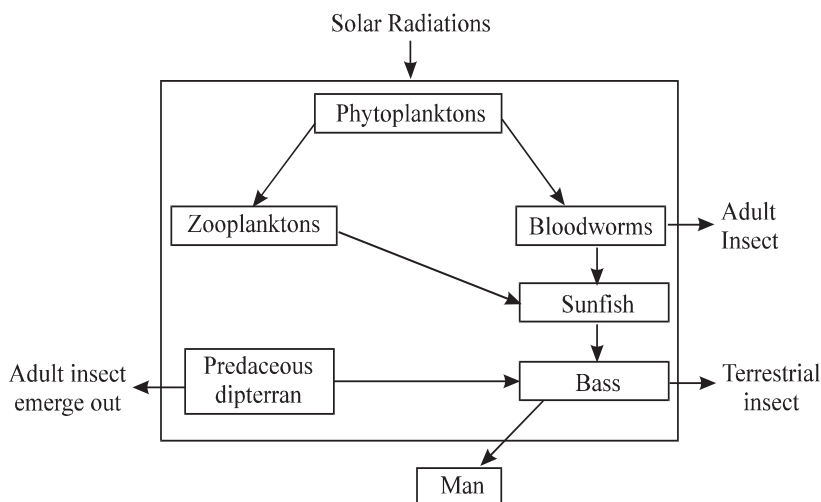


Fig 24.4 Simple food web in a pond ecosystem.(modified from Odum)



INTEXT QUESTIONS 24.4

1. Give one example of food chain.

.....

2. Name the trophic level frog belongs to.

.....

3. Snake can be both a secondary as well as tertiary consumer justify.

.....

24.4.5 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.*





Notes

All the functions of ecosystem depends on the flow of energy through it. In figure 24.5, 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 is lost (not utilized).
- Secondly a part of it is used up by the organisms 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.

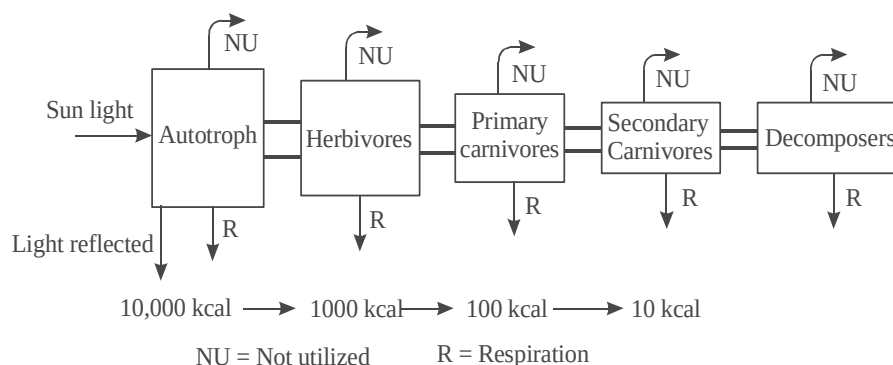


Fig. 24.5 Energy flow in a ecosystem. Boxes indicate the standing crop biomass and pipes indicate the energy flowing

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.

24.4.6 Ecological Pyramids Standing Crop

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,
- number or
- total energy fixed at each step at each trophic level.



Notes

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 of pyramids are given below :

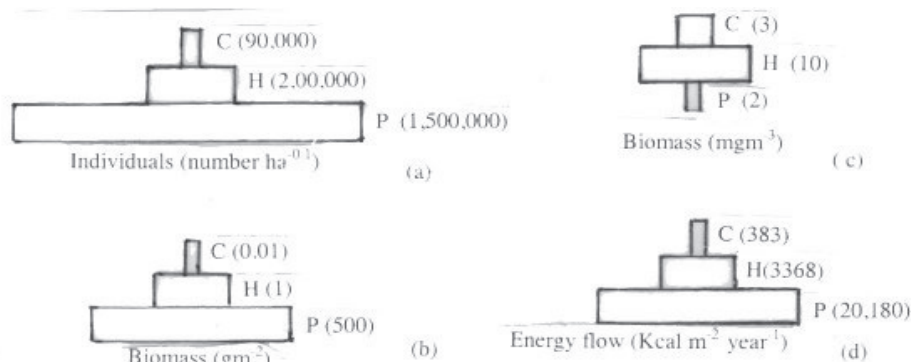


Fig. 24.6 Ecological Pyramids (P = producer; C1 Herbivores; C2 Primary carnivores; C3 secondary carnivores)



INTEXT QUESTIONS 24.5

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?

.....

24.5 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



Notes

ecosystem, agro-ecosystems, aquaculture and spaceship are some examples of the human modified ecosystems.

24.6 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

24.6.1 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 (Ever green) Forest : These are in the tropical region showing very high rain fall. These forests occur between tropics of cancer and capricorn. 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 **turn over** of the nutrients is very high leading to high productivity and have highest standing crop and biomass.

- The vegetation includes brood evergreen trees of about 200 feet like bamboos, ferns, shrub etc. Epiphytes and woody vines (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* (lying 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.



Notes

- 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, hickory, bass wood, chest nuts, pitch pine, cypress. 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



Notes

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. The height of grasses ranges from 0.2 to 3 meters depending upon the annual rain fall Trees are less than 10 m in height. Animals are very 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.



Notes

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 24.6

1. Define alpine tundra ecosystems.

.....

2. Give two examples of plants of tundra.

.....

3. Give two common characteristics of tundra and desert biome.

.....



Notes

4. Names of three main types of forests.

.....

5. Where are savannas found?

.....

6. What are deciduous trees?

.....

24.6.2 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, *lemma*, *Azolla*
- (iii) Rooted plant : Hydrilla, vallisnaria, lotus, 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 like terrestrial and land.* 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 24.7

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.
.....

24.7 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.



Notes



Notes

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.

There are two important components of a biogeochemical cycle :

1. **Reservoir pool** : Where atmosphere or rock large stores of nutrient are present e.g. Bulk of nutrients are stored in these abiotic reservoirs.
2. **Cycling pool** : Plants and animals make the cycling pool. They are relatively short-term stores and form only a smaller active fraction of the nutrient in the biosphere. On the basis of the type of reservoir these cycles are classified into two types :
 - (i) **Sedimentary cycles** : In these cycles main reservoir is rock or soil (lithosphere) e.g. Sulphur and phosphorus cycle
 - (ii) **Gaseous cycles** : Atmosphere is the main reservoir in gaseous cycles. Those nutrients that have a prominent gas phase e.g. nitrogen and carbon show this type of cycle. The nutrients are replaced in them as fast as they are utilized. You can understand the events of a biogeochemical cycle from the following two examples

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 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 CO₂ 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 CO₂ is bading to green house effect and global warming.



Notes

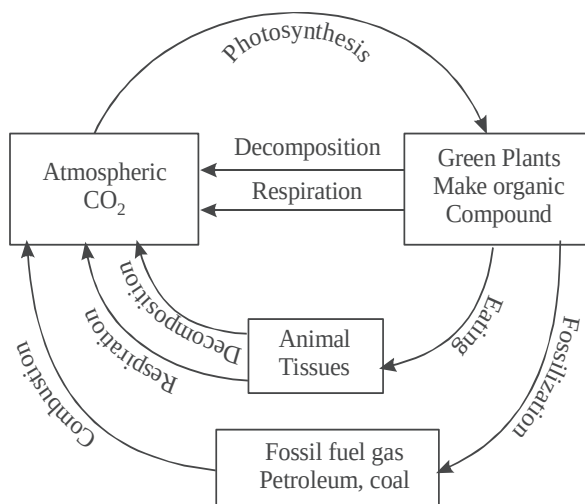


Fig. 24.7 Carbon cycle

(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 % 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.



Notes

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.

Evaporation from Oceans, Earth and Leaf Surface

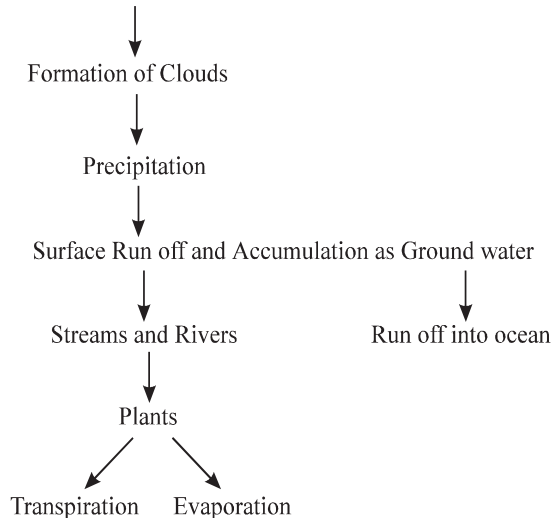


Fig. 24.8 Water cycle

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. Because on land evaporation is 16% and precipitation is 23%.



INTEXT QUESTIONS 24.8

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 CO₂.

.....

5. Name the reservoirs for water cycle.

.....

**WHAT YOU HAVE LEARNT**

- Earth is 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 defined as the study of relationship between organism and their environment. Ecology deals with various form of interaction between the organisms and their environment.
- The levels of organisation is the living system starts 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 producers consumers and decomposer are its biotic components.
- These biotic components of ecosystem interact with each other go give a physical character. These represents 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 and 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.

**Notes**

MODULE - 4

Environment and Health



Notes

Principles of Ecology

- The quantity of energy flowing through the successive trophic level decreases. This is because a part of the energy is lost 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 as 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 examples.
- Photosynthesis, respiration, decomposition and combustion are the important processes in carbon cycle.
- Evaporation, condensation and precipitation are the important processes in water cycle.



TERMINAL QUESTIONS

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 ecosystem?
7. What are the benefits of natural ecosystems?
8. Give two differences between energy flow and biogeochemical cycle in an ecosystem.



ANSWER TO INTEXT QUESTIONS

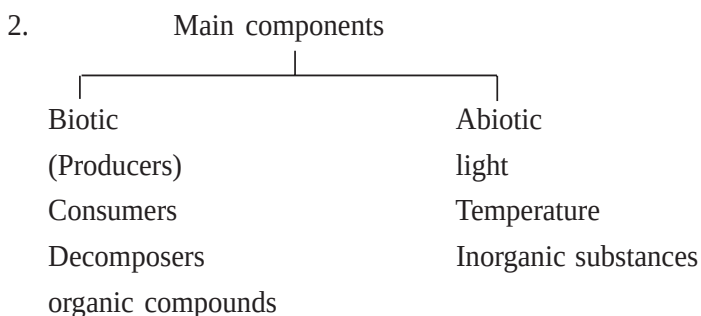
- 24.1**
1. Ernst Haeckel
 2. Genes → Cell → Organ → Organism → Population → Community
 3. Study of animals and plants in relation to their habit and habitat.
 4. Atmosphere, lithosphere and hydrosphere



Notes

- 24.2** 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.

- 24.3** 1. Ecosystem is a unit to study ecology/functionally independent unit to stud. The interrelation between biotic and abiotic components.



3. to breakdown products of dead animals and plants tissue.

- 24.4** 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.

- 24.5** 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.

- 24.6** 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.

MODULE - 4

Environment and Health



Notes

Principles of Ecology

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.
- 24.7**
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)
- 24.8**
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.



25

CONSERVATION AND USE OF NATURAL RESOURCES

Nature provides us the basic needs like food, shelter, clothes, etc. for our survival. 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 the nature will be available for our use. The growing population, rapid industrialisation and urbanisation have created heavy demand on all these materials. It is feared that unless proper steps are taken to conserve them in time, we will face tremendous hardship in future. Let us know all about them in detail in this lesson.



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.*

25.1 NATURAL RESOURCES

The term “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 the 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 are of two types:



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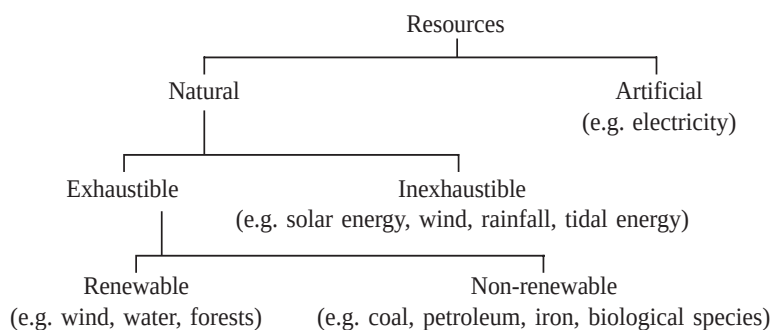
- (a) Natural resources and
- (b) Artificial resources.

All that the nature has provided such as soil, air, water, minerals, coal, **sunshine** (sunlight), animals and plants, etc., are known as **natural resources**. Human being uses these directly or indirectly for survival and welfare. The resources, which have been developed by human being during the growth of civilization, are called **artificial resources**. For example, biogas, thermal electricity, plastics, etc are man-made resources. These man-made resources are generally derived from some other natural resources. For example, plastics and many other chemical products are ultimately derived from the natural resource of petroleum.

What are the natural resources used to generate electricity?

25.1.1 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. The quantity of these resources is depleting day by day.



● Inexhaustible Resources

The resources which cannot be exhausted by human consumption and other uses, 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. Petroleum is another important exhaustible resource.

● Renewable Resources

Some of the exhaustible resources are naturally regenerated after consumption and are known as **renewable resources**. e.g. The living beings (both animals and plants) reproduce and can thus, replace the dying or killed individuals. However, if the consumption of these resources exceeds the rate of regeneration they may also get totally exhausted. Some 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 the wildlife species (rare plants and animals) belong to this category.



INTEXT QUESTIONS 25.1

- Given below are certain wrong statements. Identify the mistake and write the correct statement below each.
 - Plastic is a natural resource.
.....
 - Forest is an exhaustible non-renewable resource.
.....
 - The exhaustible resources, which are not replaced after consumption are known as renewable resources.
.....
- 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
.....		
.....		

25.2 CONSERVATION OF NATURAL RESOURCES

As the human population is continuously growing the consumption of natural resources is also increasing. With the increasing industrialisation and urbanisation of the modern human society, the use of all the resources is rising. If they are not properly used and well managed, a serious scarcity will result. Therefore we need to conserve the natural resources. This 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.

25.2.1. Need for Conservation of Natural Resources

We know that nature provides us all our basic needs but we tend to overexploit it. If we go on exploiting the nature, there will be no more resources available in future. There is an urgent need to conserve the nature. 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 generation.
- to ensure the survival of human race.



Notes



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25.2.2. Conservation 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 the nature and natural resources. Natural resources were conserved in the form of sacred groves/forests, sacred pools and lakes, sacred species etc. In our country the conservation of natural forests is known from the time of Lord Ashoka. Sacred forests are forest patches of different dimensions dedicated by the tribal to their deities and ancestral spirits. Cutting down trees, hunting and other human interferences were strictly prohibited in these forests. This practice is wide spread particularly in peninsular, central and eastern India and has resulted in the protection of a large number of plants and animals and. 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 us for their plantation. History recalls numerous instances where people have laid down their lives in protecting the trees.

Recent Chipko movement in India is one of the best examples. This movement was started by the 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 the sensitive water catchment area. Similar movements also occurred in some other parts of the country.



INTEXT QUESTIONS 25.2

1. Why should we conserve the natural resources? State any two reasons.
 - (i)
 - (ii)
2. 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)

We discussed about the different types of natural resources and classified these. Now we will know about some of these resources in details. Let's begin with the 'soil' as a natural resource.

25.3 SOIL

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 microscopic ones 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 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.

25.3.1. Soil Erosion

Erosion literally means “to wear away”. You might have noticed during the summer, when wind blows it carries away sand and soil particles from one place to another. 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.** You know that 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.

25.4.2. Causes of soil Erosion

Now we shall discuss the causes of soil erosion. There are several causes of soil erosion, these include:

- (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, which have no vegetation, carry away the loose top soil. Similarly in areas with no or very little vegetation, the 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, 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.

**Notes**



Notes

Stubble : The short, stiff stalks of grain or hay remaining on a field after harvesting

2. **Poor farming methods:** Improper tillage and failure to replace humus after successive crops and burning the stubble 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.

25.4.3 Conservation of Soil

In the previous section we learnt about the various causes of soil erosion. Soil loses its fertility due to erosion. So we need to conserve the soil. Soil conservation means checking soil erosion and improving soil fertility by adopting various methods. Let us know some of these 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 the areas meant for it and not on agricultural land.
3. **Reforestation:** Planting of trees and vegetation reduces soil erosion by both water and wind.
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 25.3

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

25.4 WATER – A PRECIOUS RESOURCE

Let us now discuss another most important natural resource, Water. You know it very well that water is essential for survival of all living organisms. It is the most



Notes

important component of all life forms and necessary for sustaining life. It regulates climate, generates electricity and is also useful in agriculture and industries.

About 97% of the water on earth is saline in nature, which is found in seas and oceans. The remaining 3% is fresh water, and most of which is stored in ice caps and glaciers, and just about 0.36% is distributed in lakes, rivers, ponds, etc.

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 agricultural, and for industrial purposes. Fresh water is a renewable resource as it is continuously being produced through hydrological cycle (evaporation, condensation and precipitation). You may recall and revise water cycle from lesson 24.

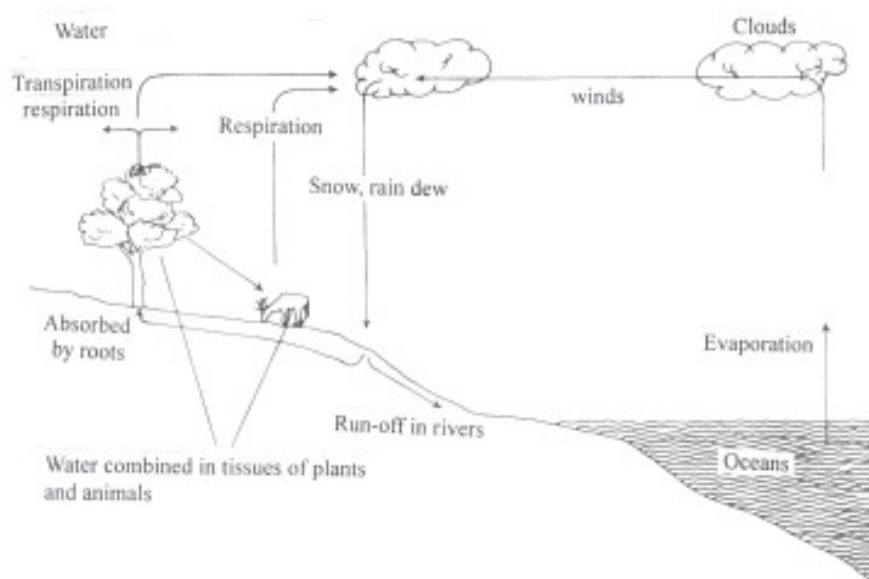


Fig. 25.1 Hydrological cycle

25.4.1.Degradation of Water

Degradation of water is the decrease in quality and quantity of water on the earth surface. 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.
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 flow down the surface water bodies and ground water bodies and they get polluted.



Notes

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.

25.4.2. 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 generating 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 25.4

1. Why do we consider fresh water as a renewable resource?
.....
2. Give three methods of water conservation.
.....

25.5 BIODIVERSITY

When we observe our surrounding, we find different types of plants, ranging from small green grasses to large trees. Large variety of animals, from tiny insect to human being 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 surrounding.

So **biodiversity can be defined as the flora and fauna i.e. variety of all plants, animals and microbes of a region.**

25.5.1 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. quinins used for treatment of malaria is obtained from *Chinchona 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.
- It is essential for maintenance of ecosystem.
- It is required for disposal and pollination in plants, formation and conservation of soil and purification and conservation of water.

25.5.2. 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 lead to culture of single crop 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.

Hyacinth : A bulbous Mediterranean plant (*Hyacinthus orientalis*) having narrow leaves and a terminal raceme of variously colored, usually fragrant flowers, with a funnel-shaped perianth.



Notes



Notes

25.5.3 Conservation of Biodiversity

Now you have an idea of the importance of biodiversity for our survival and how it is destroyed. Let us know how to protect the 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 25.5

1. Some of the following points 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	(.....)

25.6 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 the 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:



Notes

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 belladonna
3. Orchids
4. Nilgiri Lilly
5. *Ginkgo biloba* (Maiden hair tree)

25.7 WILDLIFE

Now we shall know about an important resource of the nature called the wildlife. At home you may have a pet dog or a cat, even some may have cows, buffalos, sheeps, goats etc. In your garden you may grow different types of vegetables and flower plants. In addition to these, there are other plants and animals, which are not cultivated or reared by you. **The plants, animals and microorganisms other than the cultivated plants and domesticated animals constitute the wildlife.**

Animals and plants living in their natural habitat constitute **wildlife**. The 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.

25.7.1 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.

25.7.2 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.



Notes

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 25.6

- What is Red Data Book?
.....
- Define the term Wildlife.
.....
- Below are certain incomplete words. Complete them by taking clues from the statement given below for each. Each blank represent the letter only.
 - A _ _ or _ _ _ at _ on
(Tree planting programme)
 - Be _ _ ado _ _ a
(An endangered Indian plant)
 - Rh _ no _ _ r _ _
(An endangered animal)

25.7.3 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 Kashmir) – 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



Notes

25.7.4 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

- Indian Board for Wildlife (IBWL) advises state government on wildlife protection.
- Constitution of India includes forest and wildlife protection.
- 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”.
- International Union for Conservation of Nature and Natural resources (IUCN), World Conservation Union (WCU) is engaged in protection of wildlife and their habitats.
- 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.

25.8 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 25.7

1. Expand the following.

- WWF
- CITES
- IUCN

MODULE - 4

Environment and Health



Notes

Conservation and Use of Natural Resources

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

25.9 SUSTAINABLE DEVELOPMENT

Till now we discussed how we have manipulated the existing natural resources using the advanced science and technology to create our own environment. Thus, in the process of overexploitation of natural resources, we have not only changed the natural environment but in some cases, destroyed it. The modern industries, factories, cities, towns, roads, railways, dams etc. have replaced the natural habitats of plants and animals. Thus, the natural resources are depleting gradually and a day will come when most of these 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 it for the future generation.

So we should leave water, air, soil and other natural resources as pure and unpolluted as when it came on earth.

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.
- plant more trees.
- green grassy patches to be interspersed between concrete buildings.
- use more environment friendly material or biodegradable material.
- use of technologies, which are environmental friendly and based on efficient use of resources.



INTEXT QUESTIONS 25.8

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?

.....



Notes

2. Mention any two activities which will help in sustainable development.

.....

25.10 ENERGY RESOURCES

We have always been using different form of energy obtained from various sources for our daily activity 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.

25.10.1 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 25.2 below summarises the list of both the above categories of energy resources.

Table 25.2 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



Notes

25.10.2 Conventional Sources of Energy

Let's first discuss about the conventional sources of energy. These have been in use since ancient times. Most important among them are the fossil fuels. So we shall know details about 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 town 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 petroleum refineries



INTEXT QUESTIONS 25.9

1. Coal is a non-renewable source of energy whereas wood charcoal is renewable. Why ?
.....
2. How the followings are useful in our day to day life?
 (i) CNG
 (ii) PNG
 (iii) LPG



Notes

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?

.....

25.10.3 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. We will discuss about some of these energy sources.

1. Solar Energy

Solar energy is the ultimate source of all energies 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

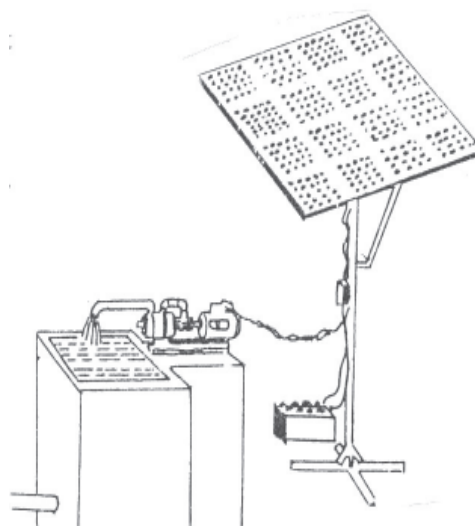


Fig. 25.2 Solar battery that can run a water pump or put to any other use.



Notes

(vi) Solar desalination systems

(vii) Solar batteries (Fig. 25.2).

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. 25.3).

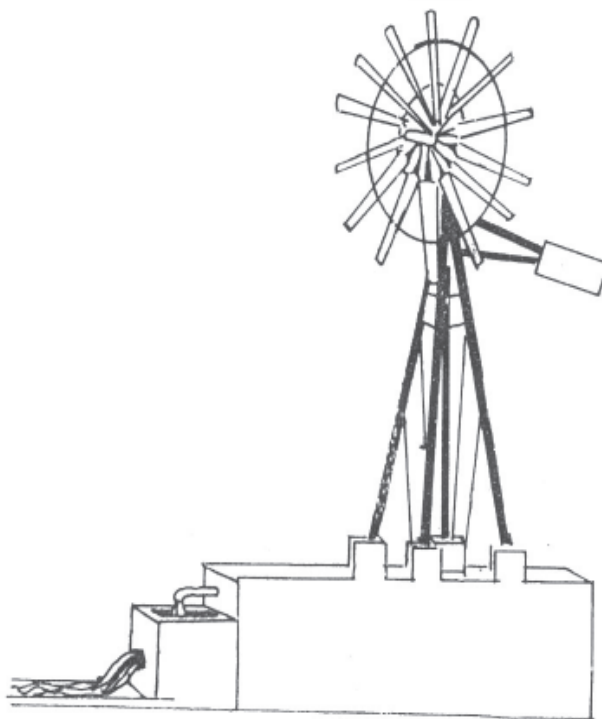


Fig: 25.3 Windmill

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.



Notes

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,

**Notes**

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. These plants belong to families Euphorbiaceae, Asclepiadaceae, Apocyanaceae, Urticaceae, Convolvulaceae and Sapotaceae. 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, karanja, 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.

25.10.4 Conservation of Energy Sources

We have already learnt 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



Notes

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.
- More use of bio-mass based energy.

**INTEXT QUESTIONS 25.10**

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.



Notes

**TERMINAL EXERCISE**

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 QUESTIONS**

- 25.1 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

MODULE - 4

Environment and Health



Notes

Conservation and Use of Natural Resources

- | | | | |
|----|---------------|-----------|----------------|
| 2. | Inexhaustible | Renewable | Non- renewable |
| | Air | Fish | Iron |
| | Sand | Forest | Petroleum |
| | Wind | Pearls | Gold |
| | Clay | | |
- 25.2 1. (i) To maintain ecological balance for supporting life.
(ii) To preserve different kinds of species.
2. (i) Chipko
(ii) Tulsi
(iii) Khecheopalri
- 25.3 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 |
- 25.4 1. It is produced continuously through hydrologic cycle.
2. (i) Constructing dams and reservoirs
(ii) Rainwater harvesting
(iii) Judicious use
- 25.5 1. (i) C (ii) T (iii) T (iv) C (v) C (vi) T
- 25.6 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
- 25.7 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)



Notes

25.8 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

25.9 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.

25.10 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.



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 in class 10. However, the environment has undergone many changes over the period of time. Population explosion in the recent times has resulted in a number of environmental problems. The population of India has crossed the figure of 1.4 billion and the world population is estimated to have touched the 6 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 has 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 pollution, 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 human body.*

26.1 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 give out smoke in the air. Agricultural activities may dump fertilizers and pesticides in the environment. **The addition of unwanted substances in wrong 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**.



Notes

26.2 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

26.2.1 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 the working of highly mechanized industries contribute to air pollution.

26.2.1a Sources of air pollution

The sources of air pollution can be divided into two categories (i) natural, and (ii) man-made

(i) Natural sources

- (i) Ash from burning volcanoes, dust from storm, forest fires
- (ii) Pollen grains from flowers in air

(ii) Anthropogenic (human-made) sources

- (i) Power stations using coal or crude oil
- (ii) furnaces using coal, cattle dung cakes, firewood, kerosene, etc.
- (iii) Steam engines used in railways, steamers, motor vehicles, etc.
- (iv) Motor and internal combustion engines which run on petrol, diesel, kerosene. etc.



Notes

- (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 contribute to 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) **Arise in atmospheric temperature due to greenhouse effect.**
- (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) **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, due to its high affinity for haemoglobin, it replaces oxygen. It also causes giddiness, headache and interferes with normal function of the heart.

Fluorides

On 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

The suspended fine particles in the air are known as aerosols. Aerosols contain chlorofluoro carbons (CFCs) and fluorocarbons. 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 (CO₂), sulphur dioxide (SO₂), etc. The pollution due to these pollutants causes suffocation, eye and lung diseases and low visibility.

26.2.1b Effects of air pollution

Major effects of air pollution on human health, plants and other animals is given in table 26.1.

Table 26.1 : 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
Sulphur compounds (SO ₂ and H ₂ S)	power plants and refineries Volcanic eruptions	● Respiratory problems in humans ● loss of chlorophyll in plants (chlorosis) ● Acid rain
Nitrogen Compound (NO and N ₂ O)	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



Notes



Notes

SPM (Suspended Particulate matter)
(Any Solid or liquid particles suspended in the air, (fly ash, dust, lead)

Fibres
(Cotton, wool)

Thermal power plants.
construction activities,
metallurgical processes and automobiles

Textile and carpet weaving industries

- 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
- Lung disorders

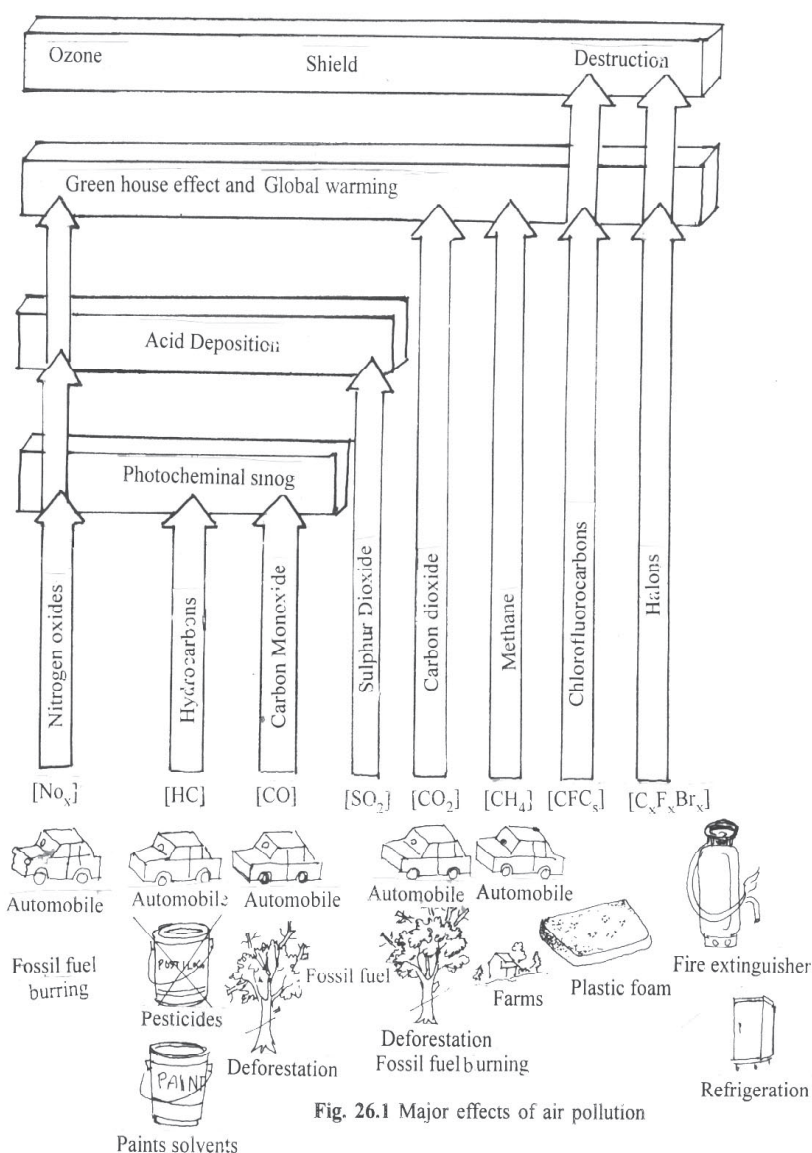


Fig. 26.1 Major effects of air pollution

Fig. 26.1 Major effects of air pollution



Notes

26.2.1c 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.



Notes

26.2.1d 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 26.1

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.
.....

26.2.2 Water pollution

Addition of undesirable substances in water is called **water pollution**. Water pollution could be due to natural or human activities.

Natural sources are soil erosion, leaking of minerals from rocks, and decaying of organic matter, while **man-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.

26.2.2a 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**
- **Disposal of urban and industrial waste matter**

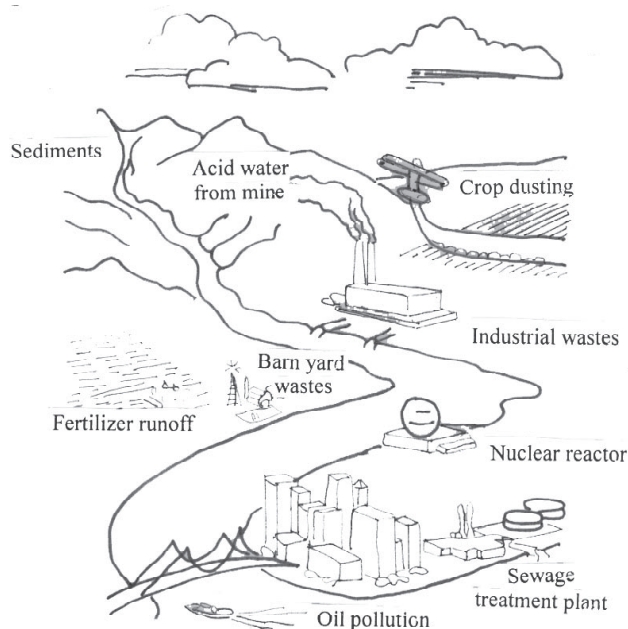


Fig. 26.2 Water pollution due to human activities.



Notes

26.2.2b 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 26.2

Table 26.2 : 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. 26.3) 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.

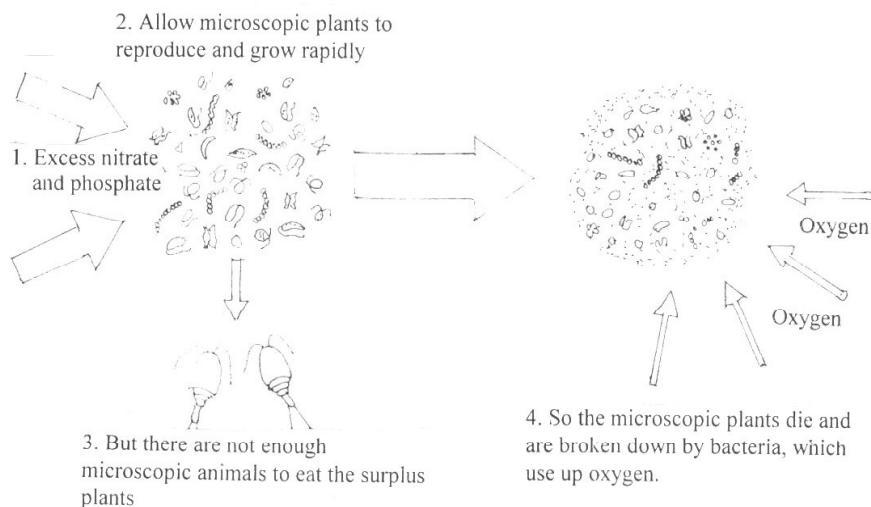
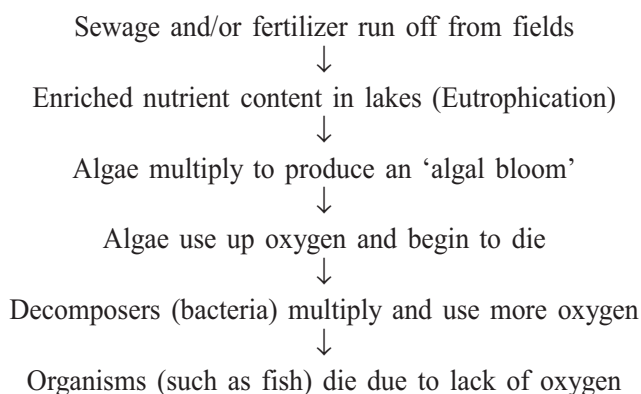


Fig 26.3 Sequence of events that may occur as a result of eutrophication

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**.



Notes



Notes

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 → Algae → Fish → 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. 26.4).

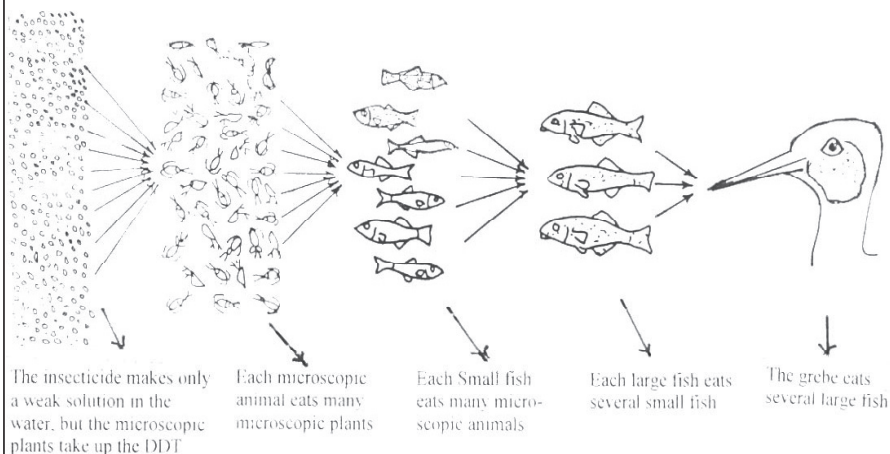


Fig. 26.4 How pesticides affect food chain

Table 26.3 and 26.4 show respectively the industrial sources of water pollution and sources and effects of some water pollutants.

Table 26.3 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,

Notes



Table 26.4 Some water pollutants, their sources and effect on human health

Pollutant	Source	Diseases in man
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

26.2.2c 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**



Notes

- **Maintenance or safety standards** for the effluents discharged into the water system

26.2.2d Treatment of sewage

The sewage can be treated by a modern technique involving three steps— primary treatment, secondary treatment and tertiary treatment. (Fig. 26.5)

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.

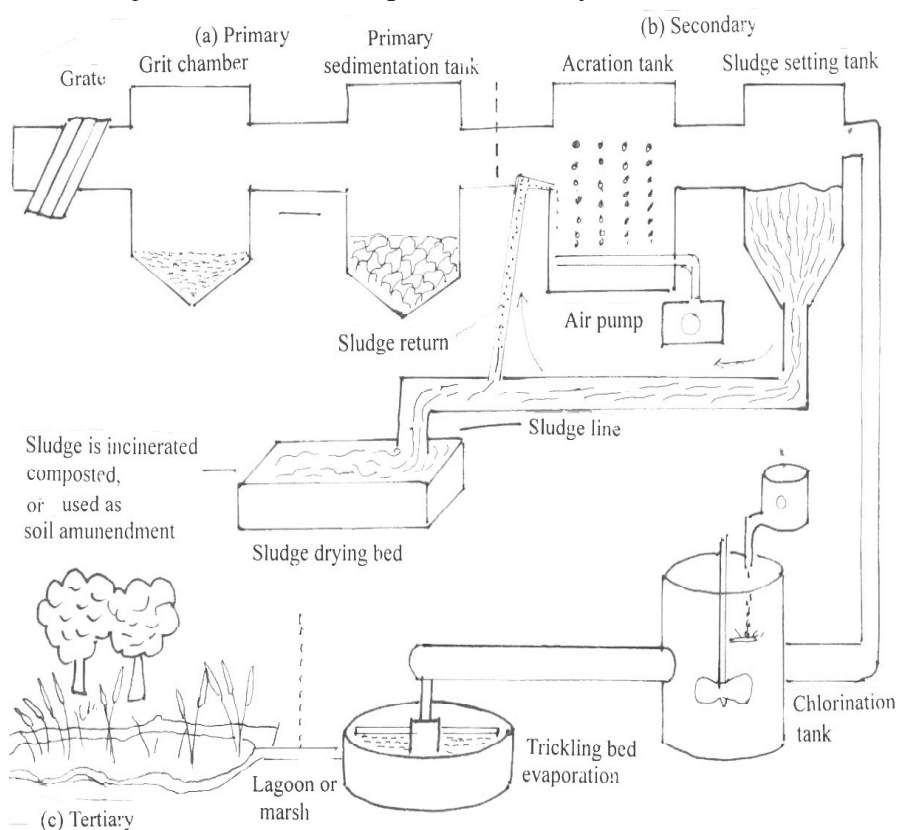


Fig. 26.5 Treatment of sewage

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 are removed. Then, the chlorination, evaporation and exchange absorption methods are employed to obtain clean water.



INTEXT QUESTIONS 26.2



Notes

- Give two examples of natural sources of water pollution.
 -
 -
- What is biomagnification?

.....
- Give the technical term for enrichment of water bodies with nutrients coming from fields.

.....
- Give one source of and one disease caused by from the following pollutants
 - lead
 - Tin
 - Nickel

26.2.3 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**.

26.2.3a 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

26.2.3b 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.



Notes

- 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.

26.2.3c 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 mountainous 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





Notes

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. If 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 26.3

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 be 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.



26.2.4 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.*

26.2.4a 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

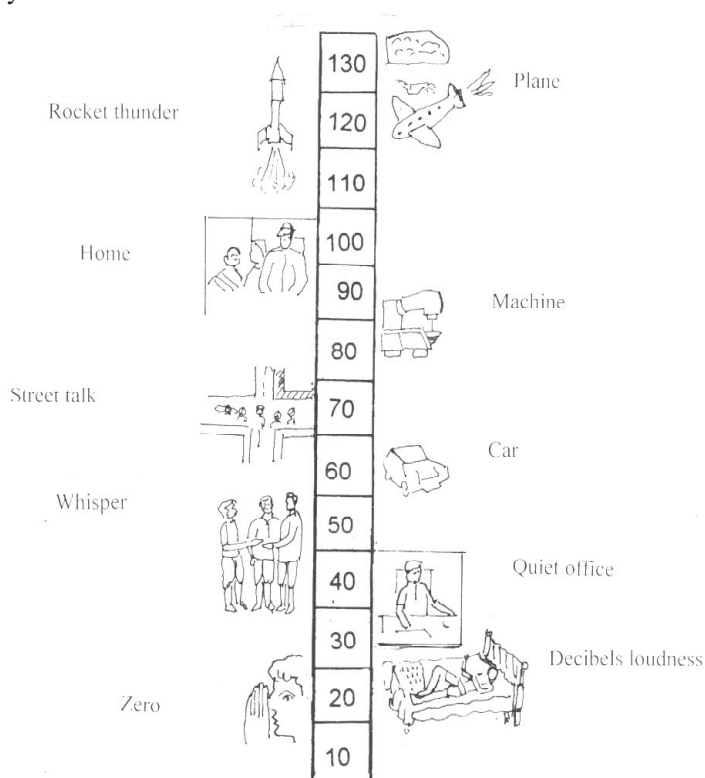


Fig. 26.6 Sources of noise pollution



Notes

26.2.4b 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.

26.2.4c 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.

26.3 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.

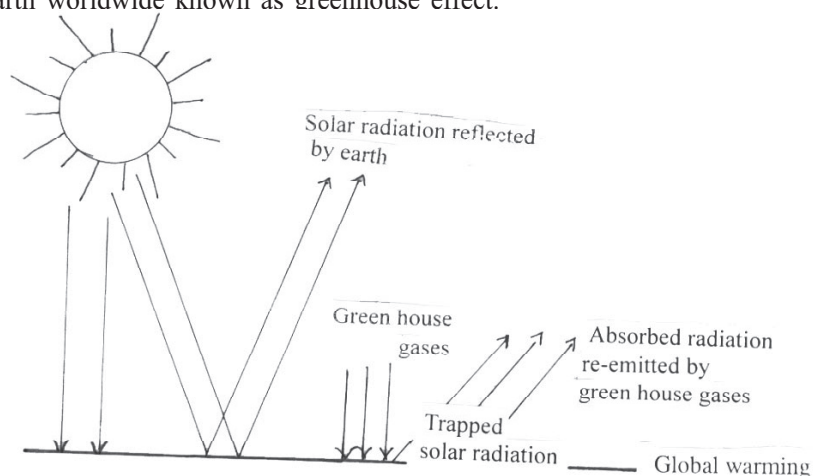


Fig. 26.7 (a) Green house effect

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.



26.3.1a 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**.

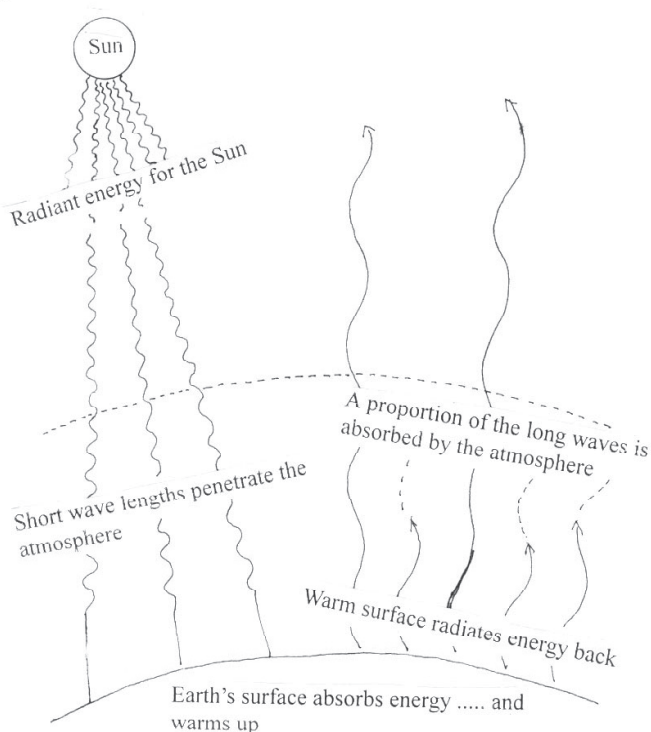


Fig. 26.7 (b) Global warming

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.



Notes

- 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.

26.3.1b 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.

26.3.1c 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.
- 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, newspapers, cardboards, glass and metals. By doing so we can reduce the CO₂ emission by 850 pounds annually.
- planting more and more trees. By planting more and more trees we can reduce the amount of CO₂ in the atmosphere.

26.3.2 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 (O₂) layer splits the ozone molecule to form oxygen (O₂). 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.

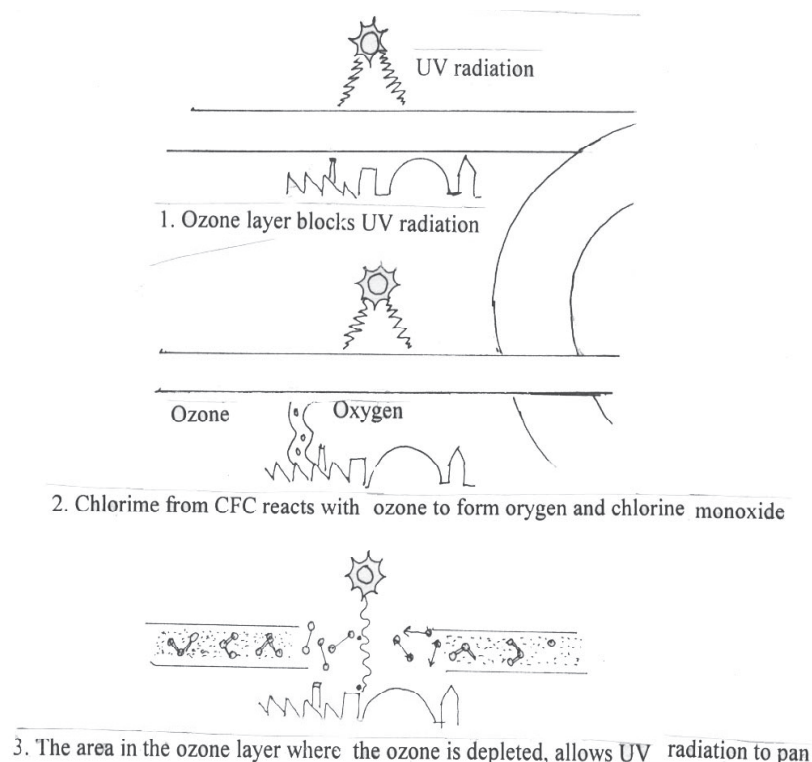


Fig. 26.8 Depletion of the ozone

26.3.2a 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 at sea and forests

26.3.2b 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.

26.3.3 Acid rain

Acid rain occurs when Sulphur dioxide (SO_2) and oxides of Nitrogen (NO_x) 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



Notes



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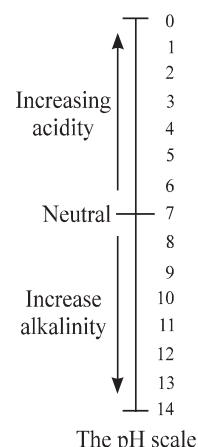
increase the acidity of the soil, and affect the chemical balance of lakes and streams. Thus, acid rain is defined as any type of precipitation with a pH that is unusually low. A pH of less than about 5 is used as a definition of acid rain. Acid rain is a serious environmental problem that affects large 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.



26.3.3a 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 (NO_x) emissions is the combustion of fuels in motor vehicles, residential and commercial furnaces, industrial and electrical-utility boilers and engines, and other equipments.

26.3.3b Effects of acid rain

It causes acidification of lakes and streams and contributes to the damage of trees and 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, sulphur dioxide (SO_2) and nitrogen oxide (NO_x) 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 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.

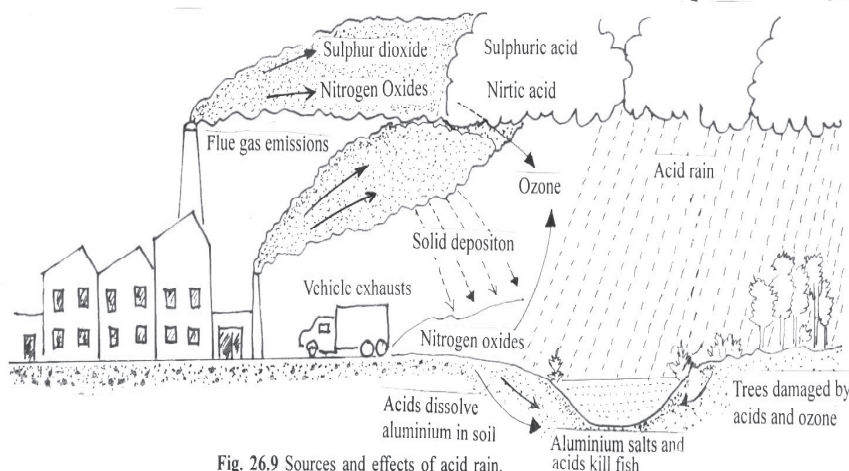


Fig. 26.9 Sources and effects of acid rain.

Fig. 26.9 Sources and effects of acid rain.

26.3.3c Prevention of acid rain

There are several ways in which sulphur dioxide and nitrogen oxide emissions can be



Notes



Notes

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 QUESTIONS 26.4

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?

.....

26.3.4 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 26.5)

Table 26.5 : 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 and internal organs	● Only superficial tissues are damaged

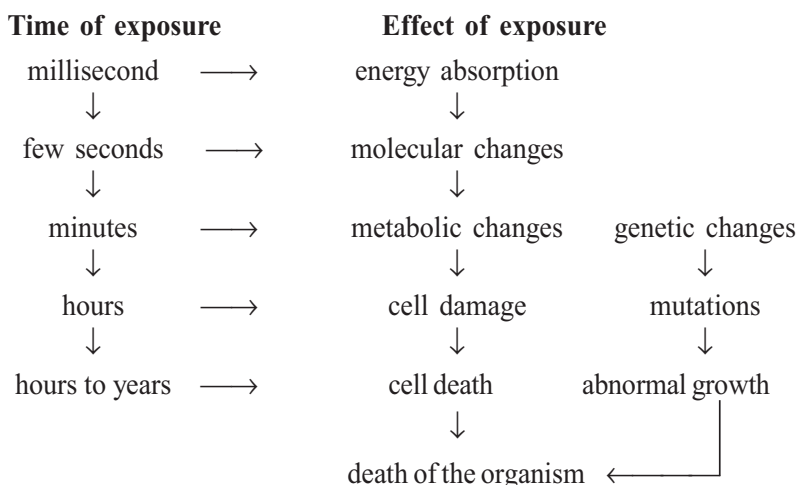
● Breakage of chromosomes ● Gene mutation and genetic variations ● Cancer of bone marrow (Leukaemia) ● Loss hair ● Male sterility	● Kills micro-organism and egg of fish and amphibians ● Prevents synthesis of DNA and RNA, Cell division ● Skin cancer in humans
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Notes

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



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 marrow/ 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 man and animal.

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



Notes

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 26.6. 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 26.6 : 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 26.5**

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 should be used for the disposal of nuclear wastes.

.....
4. List any two harmful effects of nuclear radiations.
 - (i)
 - (ii)

Notes

**WHAT YOU HAVE LEARNT**

- Pollution is the addition of undesirable pollutants in the environment.
- A pollutant is a constituent 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.



Notes

- 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 be 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 (green house effect), and has resulted in increased earth's temperature.

**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 huge rocks and gets damaged. Is 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 a 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 causes least pollution?



ANSWER TO INTEXT QUESTIONS



Notes

- 26.1** 1. Addition of unwanted substances to the environment which have adverse effects on organisms.
 2. Air pollution, water pollution, land pollution, noise pollution.
 3. Respiratory problems in humans, chlorosis (loss of chlorophyll in plants).
- 26.2** 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 26.3
- 26.3** 1. Detachment and removal of soil particle by flowing water and blowing wind.
 2. Wind erosion, sheet erosion, Gully erosion.
 3. Wind, water
- 26.4** 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. Nitrogen oxides, methane, carbon dioxide, chlorofluoro carbons. (any two)
 4. When harmful gases like SO_2 and NO_x in the atmosphere dissolve in water to form acid during rains.
- 26.5** 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.



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 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 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.*

27.1 WHAT IS FOOD

Food is any substance which performs the following functions in the body :

- (i) yields energy for life processes,
- (ii) builds up new cells (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 27.1)

- (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 oxidation in the body. Example : cereals, sugar, fats, oils, jaggery etc.
- (ii) **Body building foods** : These are rich in proteins and help in the formation of new tissues etc. 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 regulation of internal metabolism in the body. Example : green leafy vegetables, fruits, amla, guava, citrus, oranges etc.

Table 27.1 The three food groups

Food group	Major nutrients	Food sources
Energy providing food	Carbohydrate and fats	• Cereals (rices, wheat etc.) • 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 etc. • Amla, guava, citrus, orange, etc.

27.2 NUTRITION

Nutrition is the sum of the processes by which an organism takes in, metabolises and utilises food substance.

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



Notes



Notes

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 oxidation

Let us learn in some detail about these nutrients.

27.2.1 Carbohydrate

Carbohydrates are the chemical compounds made up of carbon, hydrogen and oxygen. They release energy on oxidation. They are the cheapest source of energy. Complete oxidation of one gram of carbohydrate yields about 17 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 = $1/4.18 \times 1000$ 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 27.2)

Table 27.2 Carbohydrates required in our diet

Carbohydrates			
Sugar		Starch	Cellulose
Monosaccharides	Disaccharides		
Glucose (found in molasses, honey and sweet fruits like grapes)	Sucrose (found in sugarcane and sugar beet)	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)
Fructose (Found in honey and ripe fruits)	Maltose (found in sprouted cereals)		
	Lactose (found in milk)		

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, cereals etc.

- **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 27.3 below :

Table 27.3 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 help in bowel movement.
- Glucose is the only source of energy for the central nervous system.



Notes

**Notes****27.2.2 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, benzene etc. Chemically fats are triglycerides.

One gram of fat on oxidation gives about 9.0 kcal (37 kilojoules) of energy.

Sources :

Animal sources : Ghee, butter, fish oil, meat, egg, milk, cheese.

Plant sources : Vegetable oil from the seeds of coconut, mustard, sunflower, safflower etc, nuts, soyabean.

Functions of fats

- fats are the richest source 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 thus protecting 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.

27.2.3 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 organism are made. Nutritionally, amino acids belong to two categories :

- (a) **Essential amino acids** : Certain amino acids 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.



Notes

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, meat, liver, etc. contain adequate amount of essential amino acids.

Plant sources : Whole cereals (wheat and maize), pulses, nuts grams, legumes, bean, etc.

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

- Protein are required for building and maintaining body tissues.
- Proteins are found in many enzymes. Trypsin, pepsin and rennin are some enzyme proteins.
- Some proteins as hormones, 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.
- Transport protein carries different substances from blood to the tissues in the body. Haemoglobin is a transport protein.

27.2.4 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 27.4 lists the vitamins and their sources as well as the daily requirements, deficiency diseases and symptoms for 13-15 year old boys and girls.



Notes

Table 27.4 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 meantal 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 metabolism. 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 (Cyanocobalamin)	0.2-100 mg	Blood formation, Nervous tissue metabolism, Nucleic acid synthesis.	Liver; fish; cheese; milk; eggs; meat.	Pernicious anaemia.	Paleness of skin; breathlessness; 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 keratonol acid. Dry skin	Cannot see in dimlight, (night blindness) Retarded keratinization of epithelia

Vitamin D (Calaciferol)	200 IU	Keep teeth and bones healthy, absorption of calcium and phosphorus	Milk; cheese; egg yolk; cod liver oil, fish; butter; exposure to sunlight.	Rickets in children; (Fig. 27.1)	Failure of growing bones to calcify; bow legs pigeon chest; softening of bones
				Osteomalacia in adults	Painful bones; spontaneous fracture.



Notes

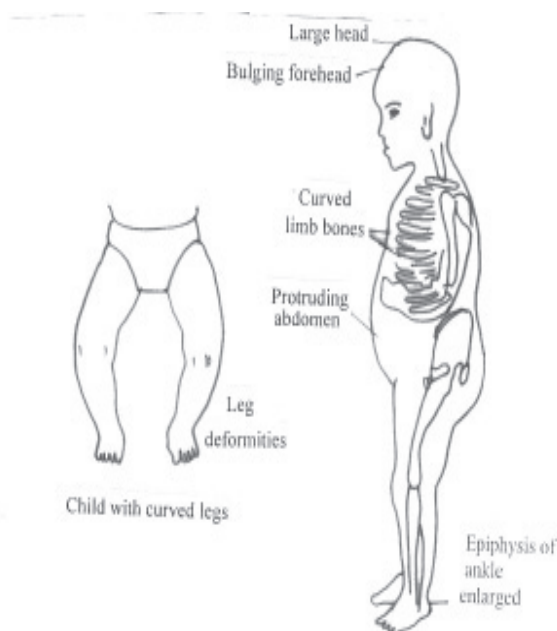


Fig. 27.1 Child with rickets

Vitamin E (Tocopherol)	Trace	antioxidant; ageing vitamin	Grains vegetable oil, green leafy vegetables, nuts, liver	reproduction failure in males and females	Sterility in males, miscarriage, or death of embryos during pregnancy in females.
Vitamin K (Phylloquinone)	Trace amount	Clotting of blood	Green leafy vegetables; soyabean; tomatoes.	Faulty blood clotting; haemorrhage.	Delayed blood clotting.

27.2.5 Minerals

Minerals are micronutrients required in varying amounts for proper functioning, normal growth and keeping good health of our body. They are inorganic elements, occurring 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.



Notes

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.

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 within cells.
- Zinc, copper and magnesium regulate a host of vital reactions in our body.

Table 27.5 Lists the minerals, their sources, function, deficiency diseases and symptoms

Table 27.5 Minerals required by 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; Oestomalacia	Softening of bones; deformities; pain in bones; loss of teeth 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 Oestomatlacia;	Softening of bones; bowlegs; pigeon chest.



Notes

4. Iodine	Metabolic control of hormone thyroxine; controls growth and mental ability.	Iodized salt; sea food; fish; green leafy vegetable	Goitre (Fig. 27.2)	Enlargement of thyroid gland; retarding of physical and mental growth.
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Fig. 27.2 Patient with goitre

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 disturb.	Severe malnutrition; high blood pressure; fatigue; loss of appetite; vomiting.
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27.2.6 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.



Notes

27.2.7 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 digestive tracts and protects 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 27.1

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?
.....

27.3 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 27.6 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)	3300
		during lactation (upto 1 year)	3700

Notes



Growing children, persons engaged in hard physical work (labourers), pregnant women, lactating mothers, sportsman, persons recovering from illness and person working in cold weather require more energy.

27.4 BALANCED DIET

You have studied that our diet consists of all the nutrients in varying amounts. (Fig. 27.3)

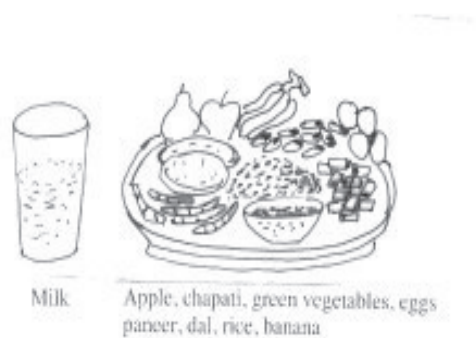


Fig. 27.3 Sample of a balance meal.



Notes

To maintain proper health, one needs the right type of food in right quantity. The need generally vary with age, sex, type of work and state of body, etc. (See Table 27.6).

A balanced diet is one that contains all essential nutrients in suitable proportion and amount to provide necessary energy and keep 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.

Box Recommended dietary requirements (in gram) according to age, sex and different physical activities

Food items	Adult man			Adult woman			Children		Boys	Girls
	Seden- tary	Moderate Work	Heavy Work	Seden- tary	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

27.4.1 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 occupation

Persons doing hard physical work like rickshaw pullers, labourers, carpenters, mill workers etc. 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 woman has to feed the developing embryo, therefore, has special need for extra nutrients.

The pregnant woman 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.

27.5 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 condition of the body or a part of it in which functions are disturbed or damaged. Disease literally means not as 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.



Notes



Notes

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 them.

27.5.1 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. 27.4a)



Fig. 27.4(a) A child suffering from marasmums

Symptoms

- wasting of muscles reduces the child to skin and bones.
- folded skin.
- sunken eyes, thin face, thinning of limbs and abdominal walls.



Notes

- 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. 27.4b)



Fig. 27.4(b) A child suffering from kwashiorkor

Symptoms :

A child suffering from Kwashiorkor disease shows the following symptoms

- under weight
- has protruding belly
- 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.

27.6 MINERAL DEFICIENCY DISEASES

Common deficiency diseases of iron, calcium and iodine are given below:

Anaemia (Iron deficiency) : Iron is important for the formation 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.



Notes

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 27.2)

- (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, green leafy vegetables, etc.

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. 27.3).

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

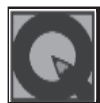
Cure : Use of iodised table salt and eating sea food, fish.

Cretinism

The person suffering from cretinism shows stunted growth, retarded mental growth, delayed puberty and low metabolic rate.

27.7 VITAMIN DEFICIENCY

If the diet is deficient in one or more vitamins like A, B complex, C, D, E and K, it lead to a variety of disease as given in table 27.3

**INTEXT QUESTIONS 27.2**

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.
.....

27.8 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 tend 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

**Notes**



Notes

- (iii) not to take saturated fats like ghee and vansaspati hydrogenated vegetable oils. Instead this, 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

Effect 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 (Hypervitaminosis)

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 the body is called **hypervitaminosis**.

Hypervitaminosis A

Excess vitamin A accumulating 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 27.3

1. List any two causes of obesity.

- (i)
- (ii)



Notes

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 an important component of our diet.
- Food has six major components
- Food can be classified into three types : Energy giver-carbohydrates and fats, body building-protein, protective/regulatory-mineral 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 soluble 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.



Notes



TERMINAL QUESTIONS

- Differentiate between
 - Marasmus and Kwashiorkor.
 - Rickets and Osteomalacia
 - Essential and non-essential amino acids
 - Body-building and protective foods.
 - Water soluble vitamins and fat soluble vitamins.
- Give reasons why do children of 1-5 years develop **PEM**.
- Why one should include more than one type of proteins in the meals?
- What is the importance of water in the diet ?
- What is a balanced diet ? Why does a pregnant women or a nursing mother needs special diet ?
- Why should food contain roughage ? Name two sources of roughage in our diet.
- Why is polishing of rice not advisable ? If a person always consumes polished rice, what is he likely to suffer from ? Give two symptoms.
- State **four** important functions of food.
- If a child is not able to see in dim light, which two food stuffs will you advise him to eat. Give reasons.
- Name **two** sources rich in

(i) Vitamin A	(ii) Calcium	(iii) iron
(iv) Vitamin B12	(v) starch	(vi) Glucose
- What are minerals ? Name any two minerals and their sources.
- What are deficiency diseases ? Name two diseases caused by the deficiency of protein and carbohydrates. Also write the symptoms of these deficiency diseases.



ANSWER TO INTEXT QUESTIONS

- 27.1** 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

- 27.2** 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)

- 27.3** 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.

4. Excess presence of vitamins in the body. vitamin A and D.

**Notes**



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.

28.1 DISEASES

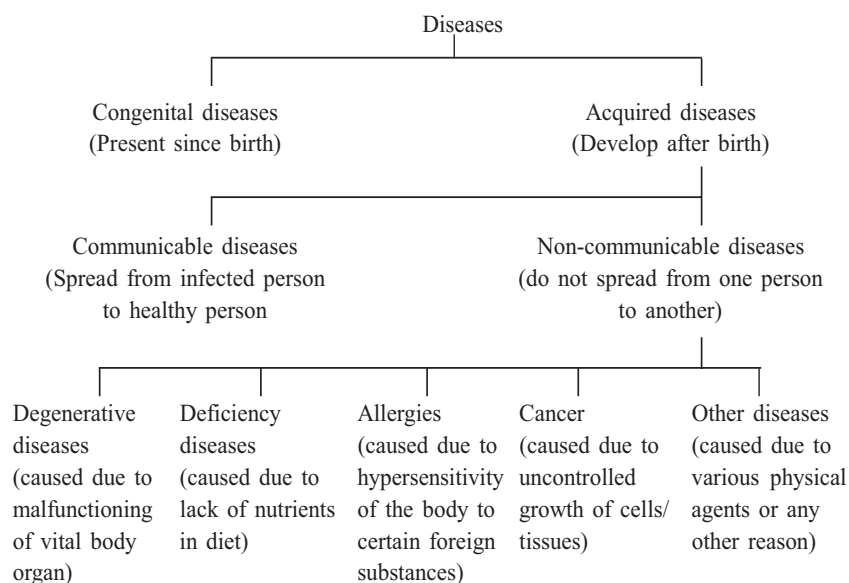
28.1 What is a disease?

Any condition 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.

28.1.1 Types of Diseases

The diseases may be classified into two broad categories (Table 28.1).

Table 28.1 Classification of human diseases



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 :

- Infectious diseases :** The diseases which can be transmitted from person to person e.g. measles.
- Degenerative diseases :** The diseases caused by the malfunction of some vital organs of the body e.g. heart failure.



Notes



Notes

- (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 28.2).

- (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 28.2 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, helminths (worms) etc.	Caused to some specific factor, such as malfunctioning of some vital organ, deficiency of nutrients, etc.
2. Spread from one person to another through contact, water, air, food, etc.	Do not spread from one person to another by contact.
3. The concern of society as these are related to community health.	The concern of the individual only.

28.1.2 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, bacteria etc.
- (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.



Notes

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 (Fomite borne)** : Many diseases are transmitted through the use of contaminated articles, such as clothes, utensils, toys, door handles, taps, syringes and surgical instruments, etc.
- (iv) **Water borne** : If potable water (drinking water) is contaminated with pathogens of diseases such as cholera, diarrhoea, hepatitis or jaundice, it reaches a healthy person upon consuming such water.

28.2 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 : A large number of parasitic organisms present 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 pathogen in large numbers and does not suffer itself.

Epidemic : Spreading of a disease among a large number of people 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.



Notes

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 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 expressions which appear on the diseased and help in the identification of the disease.



INTEXT QUESTIONS 28.1

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?
.....

28.3 COMMUNICABLE DISEASES (INFECTIOUS DISEASES)

The diseases which spread from one person to another through contaminated food, water or contact or through insecticides, animals etc. are called the communicable diseases. These are caused by different causative agents (pathogens).

28.3.1 Diseases caused by viruses

1. Chicken pox

Pathogen : Chicken pox virus (varicella)

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 vessicles 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, utencils, etc. 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 occur.

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.



Notes



Notes

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 hygiene 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 anemia.
- (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 etc. 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



Notes

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 etc., 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 platelets counts also drastically reduce 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, wells etc.

- (iii) Destroy discarded objects like old tyres, bottles, etc. 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 28.2

- How does chicken pox spread?
.....
- Mention the most obvious symptom of measles.
.....
- Which organ system of the body is affected by the polio virus?
.....
- Name the causative organism of hydrophobia.
.....
- Which mosquito spread dengue?
.....

28.3.2 Diseases caused by Bacteria

1. Tuberculosis

Pathogen : A bacterium (*Mycobacterium tuberculosis*).

Mode of Transmission : airborne-discharged through sputum, cough, sneeze, etc. 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.





Notes

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 surroundings.
- (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 crowded and areas with poor sanitary conditions.

Pathogen : Comma shaped bacterium (*Vibrio cholerae*)

Mode of transmission : Contaminated food and water. House - fly is the carrier.

Incubation period : 6 hours to 2-3 days.

Symptoms

- (i) Acute diarrhoea, rice 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, etc.) 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 (*Corynebacterium diphtheriae*)

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.



Notes



INTEXT QUESTIONS 28.3

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.
.....

28.3.3 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



Notes

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.

28.3.4 Diseases caused by worms (helminths)**1. Filariasis**

Pathogen : Filarial worm (*Wuchereria bancrofti*)

Mode of transmission : Bites of mosquitoes - *Aedes* and *Culex*.

Symptoms

- (i) Fever
- (ii) Collection of endothelial cells and metabolites in the wall of lymph vessels.
- (iii) Swelling takes place in certain parts of the body like legs, breasts, scrotum, etc.
- (iv) Swelling of legs which appear as legs of elephant, so this disease is also called elephantiasis (Fig. 28.1)

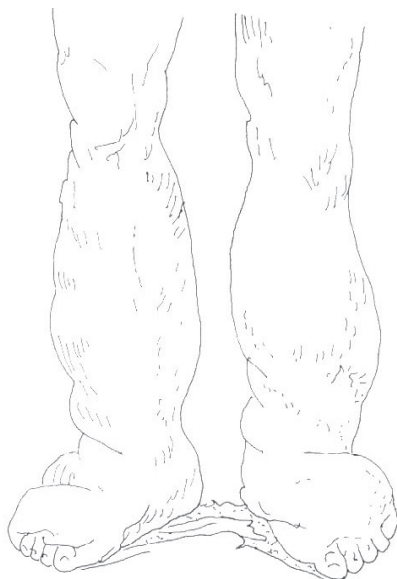


Fig. 28.1 Patient suffering from Elephantiasis.

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.



Notes

- (iii) Sprinkling of kerosene in ditches, etc.
- (iv) Drugs may be administered.



INTEXT QUESTIONS 28.4

1. Which mosquito carries stages of life history of the malarial parasite?
.....
2. Which protozoan causes amoebic dysentery?
.....
3. Name the disease cause by Wuchereria bancrofti.
.....

28.4 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, 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 advise.

(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.

BIOLOGY



Notes



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- (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 fractures.
- (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

It 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 hypersensitiveness 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, etc.
- (v) Allergens may be pollen grains, feathers, some animals or insects, drugs, medicines, odour etc.

**INTEXT QUESTIONS 28.5**

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.
.....

28.5 SEXUALLY TRANSMITTED DISEASES

The diseases that are transmitted through sexual contact are known as sexually transmitted diseases. Sexually transmitted diseases are those infections that are transmitted via the mucous membrane and secretions of the sexual organ, throat and the rectum. Syphilis, gonorrhoea, AIDS, etc. are some sexually transmitted diseases.



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28.5.1 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 disorder 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 lead to the development of a cellular immune deficiency which makes the patient susceptible to wide variety of infections.

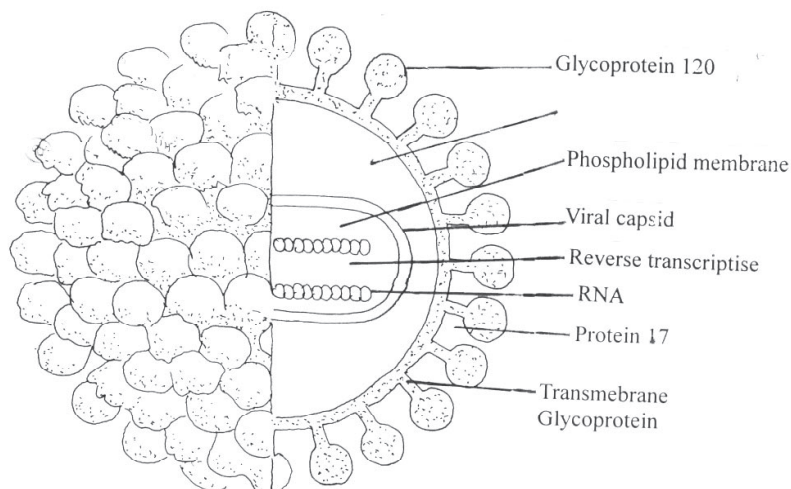


Fig. 28.2 Human Immunodeficiency Virus (HIV)

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 as that of 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 effected.
- (iv) Brain is badly damaged with the loss of memory, ability to speak and to think.

- (v) The number of platelets (thrombocytes) become 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 does not transmit by being near to someone, touching someone or working with someone who is suffering from AIDS.

**INTEXT QUESTIONS 28.6**

1. How is HIV transmitted? Mention any three ways of infection.
-



Notes



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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.

.....

28.5.2 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) Practicing abstinence, and use condoms.
- (iv) Taking appropriate medical treatment, and maintaining personal hygiene.



Notes

28.5.3 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 bacteria, *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 urithral 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).

28.6 DRUG ABUSE AND ITS PREVENTION

What is a drug

A drug is a chemical substance that changes the way our body and mind work. When pharmaceutical preparation or a naturally occurring substance is used primarily to alter the physical or mental functioning of an individual, it 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.



Notes

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 begun 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 cases 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.



**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.



Notes

**Some Basic Facts****Is it possible for a person to have an STI and not know it?**

Symptoms of STIs in men are visible, and hence they become aware that their sexual organs have been infected.

However, STIs in women 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 an STI.

**INTEXT QUESTIONS 28.7**

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 person to person and degenerative diseases are due to malfunctioning of some organs.
- Cancer is uncontrolled growth of cells.



Notes

- 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 person to 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 QUESTIONS

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 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 symptoms of syphilis.
14. State the means which 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



Notes

- 28.1** 1. Any condition which interferes 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.
- 28.2** 1. Contact or scabs
 2. Appearance of rashes on the body
 3. Nervous system
 4. Rabies virus
 5. *Aedes aegypti*
- 28.3** 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.
- 28.4** 1. Female *Anopheles*
 2. *Entamoeba histolytica*
 3. Elephantiasis or Filariasis
- 28.5** 1. It is passed down from parents to offspring.
 2. The blood pressure remains persistently high.
 3. Benign does not spread to other parts of the body, whereas malignant tumor cells spread to other parts of the body.
- 28.6** 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.
- 28.7** 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.

9. HUMAN PARASITES

I. ENTAMOEBA HISTOLYTICA

Phylum : Protozoa

Subphylum : Sarcomostigophora

Class : Rhizopodea

Entamoeba histolytica was discovered by Lambell in 1859. The name *Entamoeba* was proposed by Casagrandhi and Barbogallow in 1895. It is an intestinal parasite inhabiting the colon and rectum of man. It causes **amoebic dysentery** or **amoebiasis**.

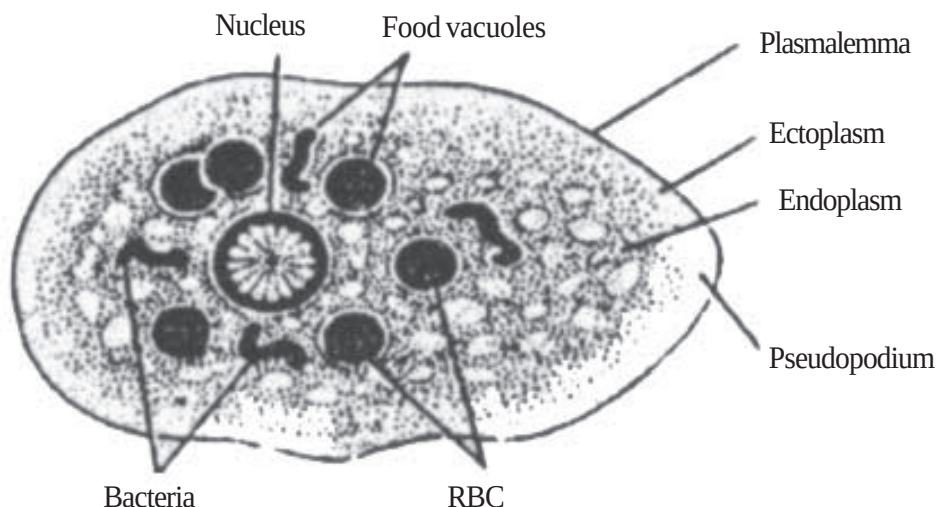
OBJECTIVES :

After studying this lesson, you know the :

- 1 Structure of *Entamoeba histolytica* (trophozoite)
- 1 Life cycle of *Entamoeba histolytica*
- 1 Pathogenicity of *Entamoeba histolytica*

STRUCTURE :

The **trophozoite** stage (feeding stage) measures about 20 - 30 microns in size. It is surrounded by the membrane called plasmalemma. Cytoplasm is divided into an outer non - granular **ectoplasm** and inner granular **endoplasm**. It possess a short, blunt and finger like **pseudopodium** in the advancing end. It has a vasicular nucleus in the centre of the endoplasm. A small endosome (nucleolus) lies in the centre of the nucleus. Fine filaments of nucleoplasm radiate like the spokes of a wheel from the endosome to the peripheral beads. This gives the nucleus a **cartwheel appearance**. Mitochondria is absent. It reproduces asexually by binary fission in the wall of the gut of the man.

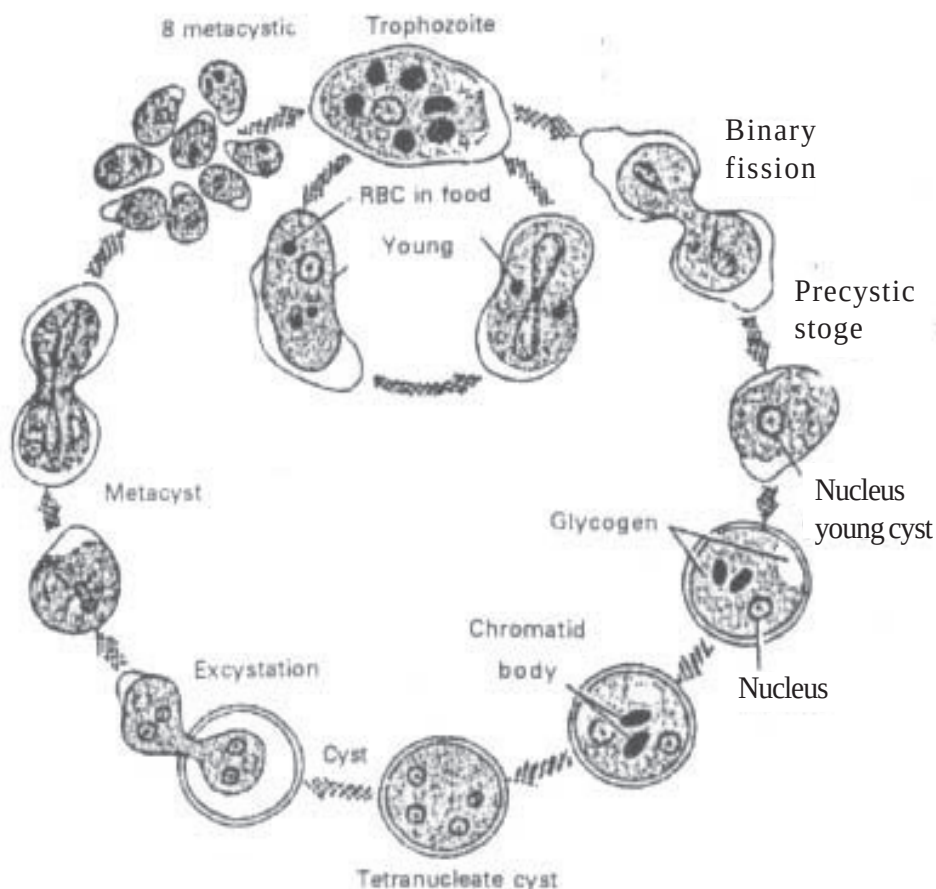


LIFE CYCLE :

Entamoeba histolytica completes its life cycle in a single host, i.e., man. Mode of infection is through contamination of food and water. Portal of entry is mouth.

Trophozoites living in the intestine undergo binary fission and produce two types of daughter amoebae. Some of the daughter amoebae transform into trophozoites and the other daughter amoebae become round or oval shape after reaching lumen of host's alimentary canal. This stage is called **Precystic stage**. Later they lose the food vacuoles and pseudopodia and become round, forms a cyst around. This process is known as **encystment**. Soon after encystment the nucleus of the parasite undergoes two successive mitotic divisions to form four smaller nuclei called **tetranucleate cyst**.

The tetranucleate cyst is the infective stage. They discharge along with the faeces of the host. Infection of new human host occurs by the tetranucleate cysts, when a man ingests contaminated food or drinks water containing these cysts. Houseflies and cockroaches also act as agents for the transmission of these cysts. The tetranucleate cysts ingested by man enter the small intestine. Here the wall of the cyst dissolved by the action of the enzyme trypsin. This process of removal of cyst wall is called **excystation**. After excystation, the parasite is called as metacystic form. The four nuclei of the metacyst divide into eight nuclei and forms eight - uninucleate daughter amoebulae. These amoebulae enter the large intestine and transforms into trophozoites in the wall of the colon or rectum of man.



PATHOGENICITY :

Entamoeba histolytica causes **amoebiasis** . The symptoms are, discharging of blood and mucus in the faeces of the host (Amoebic dysentery). The typical symptoms of amoebic dysentery are acidic stools containing blood and mucus, severe pain in abdomen etc., It also causes peritonitis and appendicitis.

In some cases, *Entamoeba histolytica* does not cause any ill effects. Such persons are called **Carriers** as their stools contain cysts and spread the parasite to the other persons. Presence of *Entamoeba histolytica* can be identified by the presence of tetranucleate cysts in the stools of the infected man.

Intext Questions :

1. Why the nucleus of *Entamoeba histolytica* is called as cartwheel nucleus ?

.....

2. Define encystment

.....

3. Which stage of *Entamoeba histolytica* is infective stage to Man.

.....

4. Define excystment

.....

What you have learnt ?

- 1 *Entamoeba histolytica* is an intestinal human parasite found in the wall of the colon and rectum. Trophozoites are pathogenic.
- 1 Trophozoites are covered by plasmalemma. Cytoplasm is divided into outer ectoplasm and inner endoplasm. In the centre of the endoplasm, a cartwheel like nucleus is present.
- 1 *Entamoeba histolytica* is a monoxenous parasite. Trophozoites reproduces asexually by binary fission in the wall of colon and rectum.
- 1 Tetranucleate cyst is the infective stage to human being. They enter through contaminated food, water or drinks to new host where they excyst and release the metacystic forms. Each metacystic form divides further and forms eight daughter amoebulae which develop into trophozoites.
- 1 *Entamoeba histolytica* causes amoebiasis or amoebic dysentery.

Terminal Questions :

1. Describe the structure of a trophozoite of *Entamoeba histolytica*.
2. Explain the life cycle of *Entamoeba histolytica*.
3. Explain the pathogenicity of *Entamoeba histolytica*.

Answers for intext Questions :

1. Fine filaments of nucleoplasm radiate like the spokes of a wheel, from the endosome to the peripheral beads. This gives the nucleus an appearance of cart wheel. That's why it is called as cart wheel nucleus.
2. The process of formation of a cyst wall around the precystic stage of *Entamoeba histolytica* is called **Encystment**.
3. Tetranucleate cyst is the infective stage to human being.
4. The process of removal of cyst wall around the tetranucleate cysts by the action of trypsin is called **Excystment**.

MODULE-V
EMERGING AREAS IN BIOLOGY

Lesson 29. Biotechnology

Lesson 30. Immunobiology : An Introduction

29



BIOTECHNOLOGY

At home we prepare food items such as yoghurt (curd), cake, bread, idli and dosa etc. by the action of tiny microorganisms, the bacteria and fungi. Brewers use yeast (a kind of 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.*



Notes

29.1 BIOTECHNOLOGY

The word biotechnology has come from two words namely **bio** (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, genetic engineering, etc. 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, DNA finger-printing for forensic purposes etc.

29.1.1 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), influenza, etc. 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 polymyxa* is used to produce polymyxin B antibiotic (used to cure urinary tract infections), fungus *Penicillium notatum* is used to produce penicillin (used to cure fever, pneumonia, etc.)

Treating genetic disorders : Disease can occur when genes become defective due to mutations. With advance in biotechnology it will in the near future 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, Thalassemia.

In forensic science : With the help of new techniques such as **DNA fingerprinting**, it has now become easy to identify criminals and have many other applications.

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 and fungi, and enzymes are used to break down toxic and hazardous substances present in the environment.

3. Agriculture

Biotechnology has helped in production of crops with improved disease resistance; herbicide-tolerance and insecticide-resistance. Plants with improved nutritional value for livestock etc. have also been bred 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 cannot produce next generation.

Manufacturing and bio-processing : With the help of new biological techniques it has become possible to grow on large scale, the plants that produce compounds for use in detergents, paints, lubricants and plastics etc.

Food and drinks : With biotechnology, it has now become easy to process foods and their products. 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, alcohol, etc.

29.1.2 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
- yoghurt (curd)
- proteins
- antibiotics and monoclonal antibodies
- vitamins, steroids and enzymes
- 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.

29.1.3 Production of Alcohol – Containing Beverages

Fermentation

Fermentation is a process by which carbohydrates such as sugar are converted into alcohol.



Yeast and bacteria are 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 fermentation.





Notes

Bakers use yeast to leaven (raise) dough to make bread. Yeast is grown on molasses and is also 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.

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. 29.1).

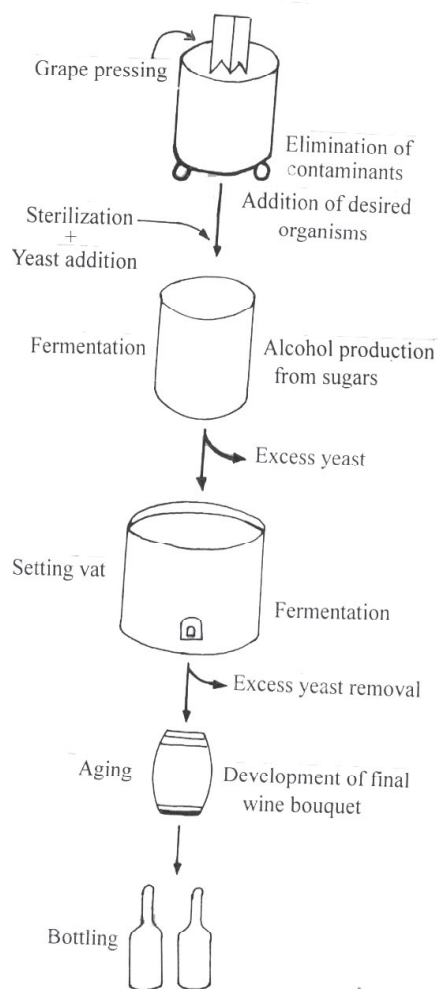


Fig 29.1 Obtaining wine from grapes by fermentation by Yeast

Some alcohols manufactured by yeast fermentation are : Ethyl alcohol, butanol and glycerol. The same method also yields **lactic acid** and **acetic acid** (vinegar).

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 29.1

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

1. Bioreactor
2. Steaming under pressure
3. Alcohol

Column B

- (a) Butanol
- (b) Fermentation tank
- (c) Autoclave

29.2 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 29.1) 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. This method is not so popular any more.

Whether by bacteria or by “rennin” when milk is ‘curdled’, milk protein casein, separates from the liquid which is called whey. Lactic acid bacteria 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*, *Leuconostoc* is added to the milk when butter, yoghurt or cheese are made.



Notes



Notes

Table 29.1 Fermenting microbes used for dairy products

Fermented product	Fermenting microorganism	Description
Yoghurt	<i>Streptococcus thermophilus</i> and <i>Lactobacillus bulgaricus</i>	Product made from low or non-fat milk and stabilisers like gelatin added.
Butter	<i>Lactococcus lactis</i>	Cream is incubated till desired acidity achieved followed by churning, washing and salting

29.2.1 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 - 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 earlier sensitive.

Sources of antibiotics

Some of the common antibiotics and their source organisms are given in table 29.2.



Table 29.2 Major antibiotics and their sources

Antibiotic group	Source
Tetracyclin	<i>Streptomyces sp</i>
Chlorotetracycline	<i>Streptomyces auriefaciens</i>
Chloramphenicol	<i>S. venezuelae</i>
Cycloheximide	<i>S. griseus</i>
Streptomycin	<i>S. griseus</i>
Cephalosporin	<i>Cephalosporium acremonium</i>
Penicillin	<i>Penicillium chrysogenum</i>

29.3 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 “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 termed “third generation vaccines”.

29.4 PRODUCTION OF VITAMINS

Vitamins are nutrients required in very small amounts for essential metabolic reactions in the body. Vitamins are produced using biotechnology. Vitamin C was the first vitamin to be produced during a fermentation process by using bacteria. B₁₂ or cyanocobalamin and B₂ or Riboflavin were obtained from liver extract. The production of B₁₂ involved fermentation by propionic bacteria. In nature B₂ is found in cereals, vegetables and yeast but the yield of B₂ can be enhanced hundred to three hundred fold by using microbes.

29.5 PRODUCTION OF BIOGAS

Biogas is a new conventional source of fuel. Its use can save fossil fuel (coal, kerosene, petrol etc.) 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 (CH₄). 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.



Notes

Any biodegradable (that which can be decomposed by bacteria) substance 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 fermentation parameters have to be maintained. 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. Other side of the reactor has an outlet for removal of biogas: What is left behind is called **slurry**. Gas gets stored above the slurry level. Slurry forms excellent manure.

Advantages of biogas

1. Biogas is a fuel used to cook food, light lamps etc.
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 29.2

1. Name the bacterium responsible for curdling of milk.
.....
2. Who discovered antibiotics?
.....
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?
.....

29.6 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**.

29.6.1 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, so 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.

Human 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, antibodies through genetic engineering. Researchers have isolated genes which can be used to produce effective vaccines. Researchers have also developed bacterial strains, through genetic manipulation, which can degrade harmful environmental pollutants.

29.6.2 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. 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.



Notes



Notes

- (ii) presence of specific restriction enzymes which attack and cut DNA at specific sites.

29.6.3 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”. Either they 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 which can seal one DNA fragment with another DNA segment, both 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. 29.2 a, c)
4. Same restriction enzyme cuts a matching DNA sequence from a plasmid (Fig. 29.2 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. 29.2 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 then 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) then obtained and preserved in a DNA library.
10. These DNA fragments are the cloned DNA.

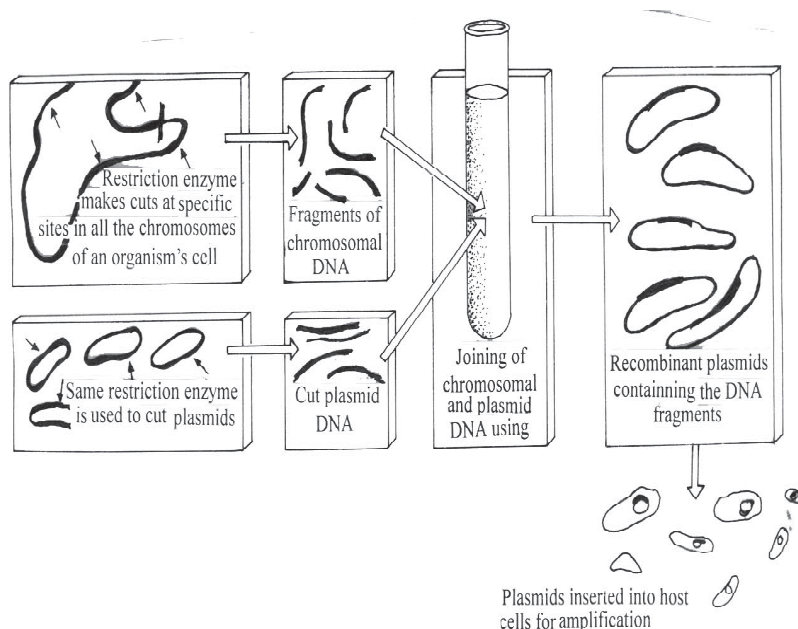


Fig. 29.2 Steps in formation of multiple copies of recombinant DNA for DNA library



INTEXT QUESTIONS 29.3

1. Define genetic engineering.
.....
2. What is a clone?
.....
3. What do you mean by the term recombinant DNA?
.....



Notes

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 a recombinant plasmid?
.....

29.6.4 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, alcohol, etc. and more recently antibiotics, etc. 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. 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 29.3 gives the names and uses of some of these:

Table 29.3 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 29.4 gives the names of such enzymes and their uses:

Table 29.4 The names of enzymes and their uses

Enzymes	Used in
Proteases	manufacture of detergents, meat tenderisers.
Amylases	manufacture of beer, bread and textiles
Glucosylomerases	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 29.4

- Name any two proteins and two enzymes obtained by recombinant DNA technology.
(i) (ii)
- How is recombinant DNA technology useful for pharmaceutical companies?
.....
- Name any two diseases for which bioengineered vaccines have already been developed.
(i) (ii)

29.8 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.



Notes



Notes

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 from female parent cell.
- (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. 29.3). 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 recipient 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.

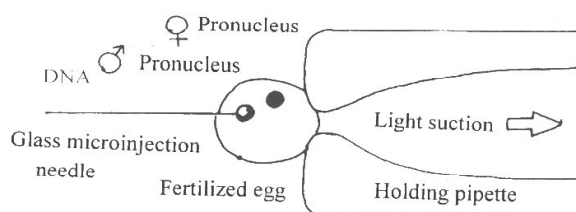


Fig. 29.3 Microinjection of input DNA into male pronucleus

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.



Notes

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. 29.4) in several plants. The information for production of galls is present on a plasmid, (T_1) in the bacterium. A segment of DNA from the plasmid can be transferred into plant cell and transform them. In the T_1 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 normally be expressed (Fig. 29.4).

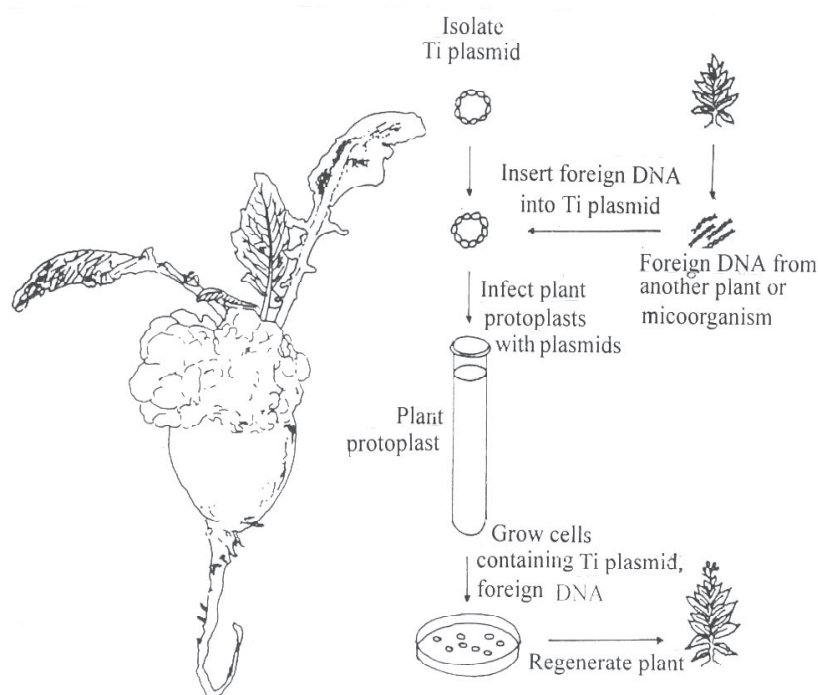


Fig. 29.4 Gall caused on turnips by bacteria carrying T_1 plasmid

Examples of transgenic plants

- (i) Cotton which can resist attack by worms.
- (ii) Corn and soybean which are more tolerant to draught 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.



Notes

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 little mates. This was because rat gene got integrated into mouse DNA and was being expressed. (Fig. 29.5).



Fig. 29.5 Transgenic mouse compared to normal mouse

Goats : Transgenic goats have been developing from a fertilised egg injected with recombinant DNA consisting of goat gene sequences spliced with human genes for tPA (tissue plasmanogen 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 generated through the recombinant DNA technology in Chinese hamster eliminates the need to get it from human blood as also the risk of transmitting AIDS.

29.8.1 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 to harmless compounds.

Mercury resistant bacteria process metallic mercury (which damages the nervous system) into a nontoxic compound.

**INTEXT QUESTIONS 29.5**

1. Define a term transgenic.
.....
2. Name the gall producing bacterium and the plasmid which can be conveniently used to produce transgenics.
.....
3. What is bioremediation?
.....

Notes

**29.9 HUMAN GENE THERAPY**

Many people are born with and suffer from diseases such as sickle cell anaemia, haemophilia, severe combined immuno deficiency (SCID), colour blindness etc. 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.

29.9.1 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 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 :

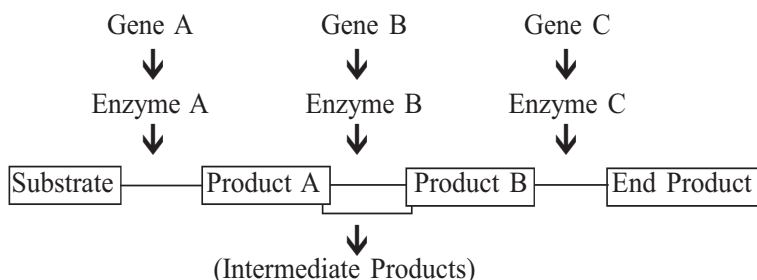
- (i) accumulation of the metabolic substances that are toxic, or
- (ii) deficiency of a compound that is important for normal cell functioning.

There are mutations that can lead to disorders in any part of the body, including muscles, eyes, liver, bones, kidneys, nerves, blood system etc. Under normal conditions, genes work in total harmony completing their specific job of converting a raw material to a finished product, by synthesising specific enzyme.



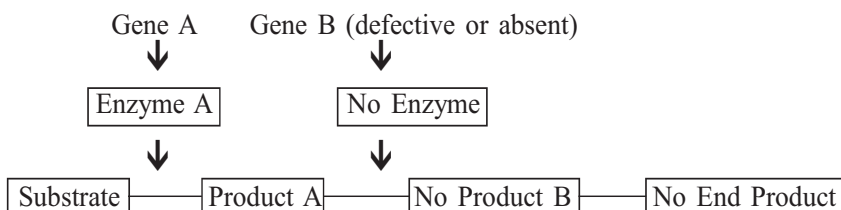
Notes

Normal gene functioning



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, or there will be a harmful collection of certain material.



This results in accumulation of unutilised product A and end produces is not produced.

You will be concerned to note that a number of human disorders are caused due to single gene defects., Following table 29.5 gives an idea of some such diseases, the missing or defective gene products and the symptoms.

Table 29.5 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)

29.9.2 Gene therapy

Most of the genetic disorders may result in serious complications, health problems and untimely death. If somehow defective genes could be manipulated to remove such ailments, it will be a great boon to the human society. Attempts are being made

to develop techniques that can replace the defective genes, or enhance their action. Word therapy means treatment and a way to treat defective genes can be called **Gene therapy**. Human gene therapy can be defined in a number of ways.

Gene Therapy is 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.

Gene therapy

Replacement and alteration of defective gene is called Gene therapy.

Human gene therapy (previously known as human genetic engineering) 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.

Gene therapy in a way regulates and restores the normal gene expression in response to the needs of the affected person. So far there had been no treatment for the genetic defects which can only be corrected by the gene treatment or the gene therapy.



INTEXT QUESTIONS 29.6

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.
.....
4. Define gene therapy.
.....

29.9.3 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.



Notes



Notes

(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 cells with gene defects from a patient.
2. Growing the isolated cells in culture.
3. Altering 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. 29.6).

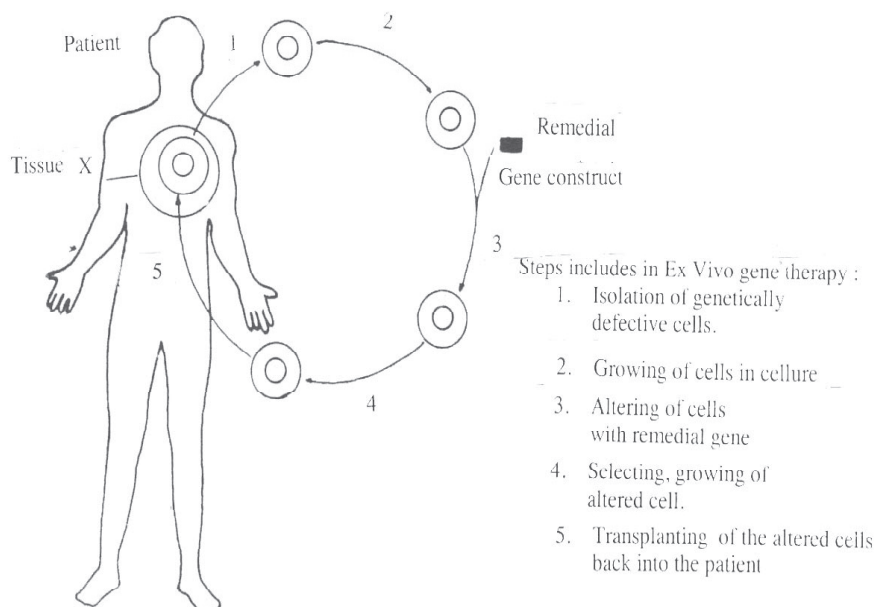


Fig. 29.6 Steps in the Ex-vivo gene therapy

Vectors such as retrovirus are used for the integration of normal gene in the host gene. 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



Notes

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, double stranded DNA virus, is being used as a vehicle for transferring the remedial gene, (Fig. 29.7). The viruses used are weak enough to cause any disease. These 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.

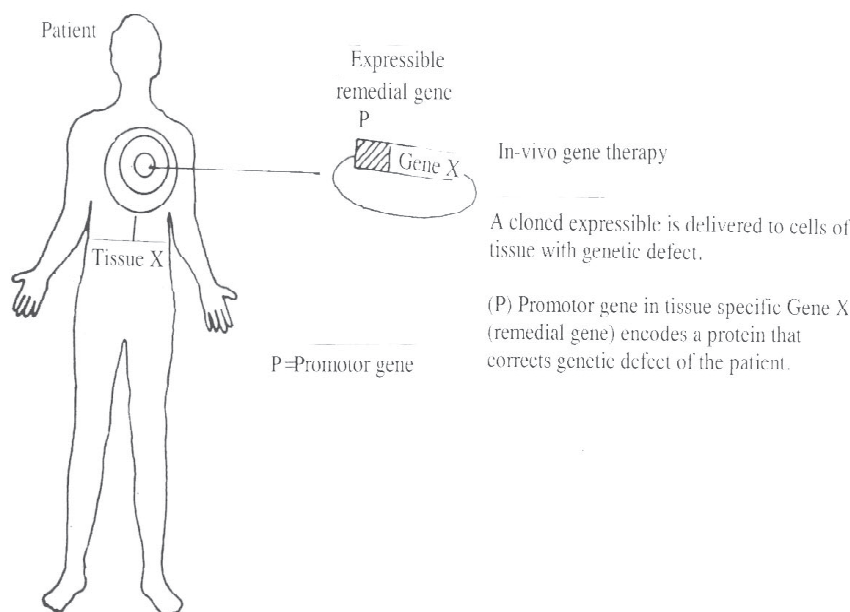


Fig. 29.7 Steps in In-vivo gene therapy

(c) Antisense Therapy

You have learnt the steps involved in protein synthesis - which are 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.



Notes

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. 29.8). 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. Flavr-savr tomato with a long shelf life has been produced by this technique.

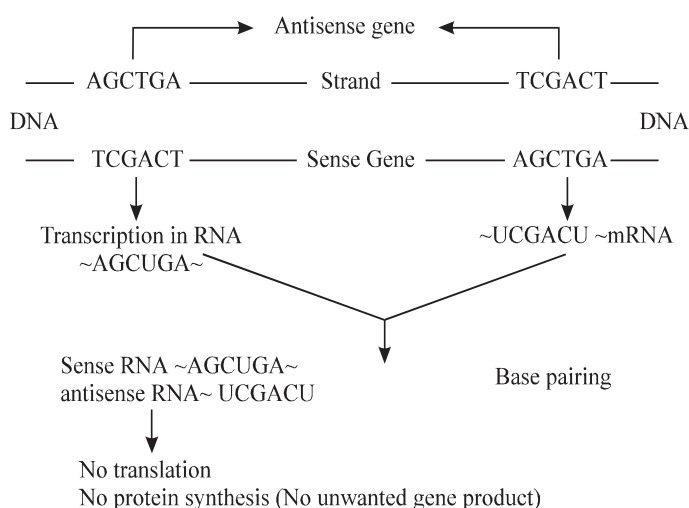


Fig. 29.8 Antisense gene therapy

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.

29.9.4 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 an expensive and time consuming therapy 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) Planned procedure 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.



Notes



INTEXT QUESTIONS 29.7

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, drugs etc.
- 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 CO₂ by bacteria and yeast.
- Fermentation by the yeast *Saccharomyces* yields beer and butter milk.



Notes

- 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 of 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 commercially proteins such as insulin, clotting factors, monoclonal antibodies, enzymes, antibodies and vaccines, etc.
- Genetically engineered organisms carrying foreign genes are called transgenics.
- Transgenic plants may be obtained by using the T₁ 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. Sick cell anaemia, Haemophilia, SCID etc. 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 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.

**Notes****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 has been successful so far and why?
13. Discuss in brief the different types of somatic gene therapy.

**ANSWERS TO INTEXT QUESTIONS**

- 29.1**
1. Fungi, yeast, bacteria
 2. Alcohol/antibiotics/curd/cheese/vitamins/vaccines/biogas (any three)
 3. Ethanol/Butanol/Glycerol (any two)



Notes

4. Support growth system and suspended growth system

5. 1-b, 2-c, 3-a

29.2 1. *Lactobacillus*

2. Alexander Fleming

3. Vaccines produced by the use of recombinant DNA technology

4. Vitamin C

5. Methanogenic bacteria

29.3 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 plasmid which can carry foreign DNA and divide along with the bacterium whose part it is.

29.4 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

29.5 1. An organism containing foreign DNA in its genome

2. *Agrobacterium tumefaciens* and T₁ plasmid.

3. Bioremediation is removal of pollutants in the environment with the use of genetically engineered bacteria.

29.6 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.

29.7 1. Somatic and Germ line cells

2. In-vivo gene therapy, Ex-vivo gene therapy and Anti-sense gene therapy

3. Thalassemia, certain types of cancer

4. In-vivo gene therapy

13. TISSUE CULTURE

Introduction :

Information gained regarding the plant growth and differentiation made it possible to culture individual plant cells, tissues and organs *in vitro* in the laboratory. The laboratory technique of growing, culturing and maintaining cells, tissues and organs *in vitro* on an artificial nutrient medium is known as "tissue culture". The basic principle on the tissue culture is based on the 'cellular totipotency'.

Objectives :

After completing this lesson, you will be able to :

- Explain the term 'cellular totipotency' and prove the formation of complete plant in the favourable conditions
- Describe the preparation of nutrient medium
- Explain that essential nutrients required for plant growth can be supplied through nutrient medium
- Describe the method of sterilization of culture medium
- Explain the method of preparation of explant
- Describe the inoculation of explants
- Justify the need for maintenance of controlled conditions for incubation for growth
- Explain the need for acclimatization of plantlets and transfer to pots.
- Describe the applications of tissue culture

Totipotency

Morgan (1901) coined the term 'totipotency' to describe the capacity of cell to develop into an organism by regeneration

Technique of tissue culture

The laboratory technique of growing, culturing and maintaining cells, tissues and organs *in vitro* on an artificial medium is known as 'tissue culture'. The tissue culture will be completed in the following six steps.

1. Preparation of nutrient culture medium
2. Sterilization of the culture medium
3. Preparation of an explant

4. Inoculation of an explant
5. Incubation for growth
6. Acclimatization of plantlets and transfer to pots

1. Preparation of nutrient culture medium

Natural conditions have to be provided for plant tissue culture in vitro. The nutrient culture medium is a mixture of various essential nutrients. In the preparation of nutrient medium macro and micro nutrients, amino acids, Vitamins, Carbohydrates are mixed in distilled water and the pH is adjusted to the required level (5.6 to 6.0)

For providing support during culture of plant parts, the medium is solidified by the addition of agar. Murashige and Skoog (MS medium) is the most popular medium in use.

The nutrient medium which does not contain growth regulators is called 'basal medium'. Basal medium is used for germinating seeds, for developing aseptic seedlings or for single callus cultures. Growth regulators are to be added to the medium for complete regeneration of the plant from the callus. For this growth regulation Auxins (Indole acetic Acid - IAA; 2,4-Dichlorophenoxy acetic acid-2,4-D), Gibberellins, Cytokins are used. The culture medium is poured in glass vessels (rimless culture tubes, flasks or bottles) and closed tightly with non-absorbent cotton plugs which allow the exchange of

2. Sterilization of the culture medium

The culture medium is rich in nutrients and therefore attracts the growth of microorganisms thereby contaminating and spoiling the medium. Therefore, the culture medium is sterilized to kill the microorganisms. The sterilization is carried out in a steam sterilizer called the autoclave. The culture medium is autoclaved for 15 min at 121°C at 15 pounds of pressure. They are checked for growth of microorganisms.

3. Preparation of explant

Explant

Any part of a plant which is introduced to culture medium to grow into a full fledged plant or organs in vitro is called explant

Any living part of plant such as axillary bud, leaf and stem segments, root tip, shoot tip, anther, ovary, can be used as explants.

The explants taken from garden or potted plant have many microorganisms on their surface. The explants therefore be cleaned with a liquid detergent in running water and later on with disinfectant solutions like sodium hypochlorite.

4. Inoculation of explant

The transfer of explants on to the sterilized nutrient medium taken in culture vessel is called inoculation. The inoculation of explant is carried out in the laminar air-flow chamber, which maintains an aseptic environment (Fig. 1)

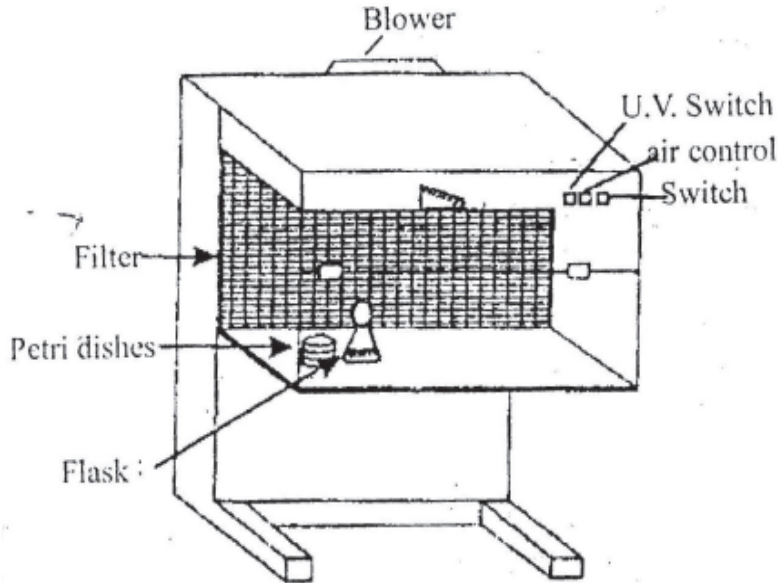


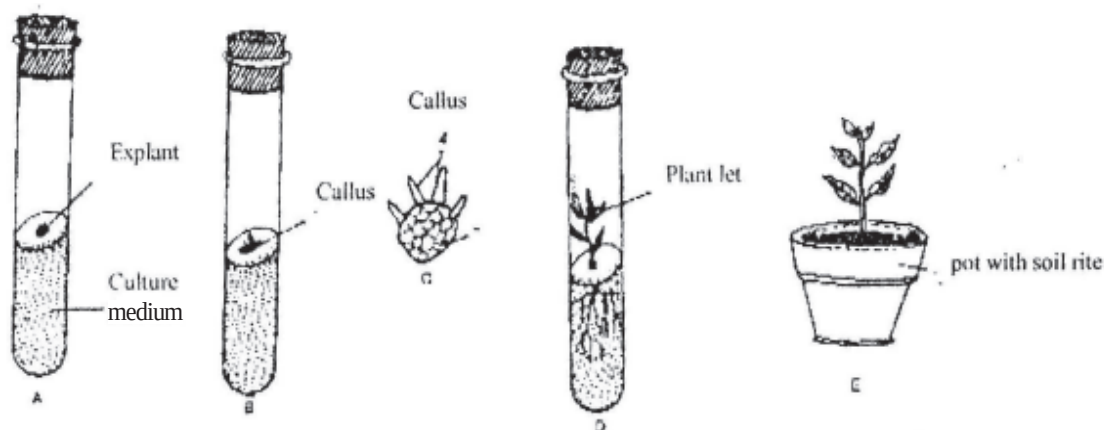
Fig 1. Laminar airflow used for aseptic manipulation of cultured tissue

5. Inoculation for growth

The culture vessels with inoculated explants are incubated under controlled conditions of temperature, illumination and humidity. The cultures are incubated for 3 to 4 weeks during which, the cells of explant absorb the nutrients, grow and undergo repeated divisions to produce a proliferating undifferentiated mass of cells known as 'callus' or it may produce shoots, or roots directly.

- Different combinations of auxins, cytokinins will produce shoots or roots and is called 'organogenesis'.
- High proportion of auxin and low proportion of cytokinin induce root development from callus and is called rhizogenesis.
- Low proportion of auxin and high proportion of cytokinin in the medium induce shoot development from the callus and is called 'Caulogenesis'
- Alternately, embryo like structures develop from callus and this phenomenon is known as 'somatic embryogenesis'.
- The somatic embryos can be encapsulated in sodium alginate for storage. The encapsulated somatic embryos are known as 'synthetic or artificial seeds' (Fig 2, 3, 4)

Fig 2. Procedure of Tissue culture



6. Acclimatization of plantlets and transfer to pots

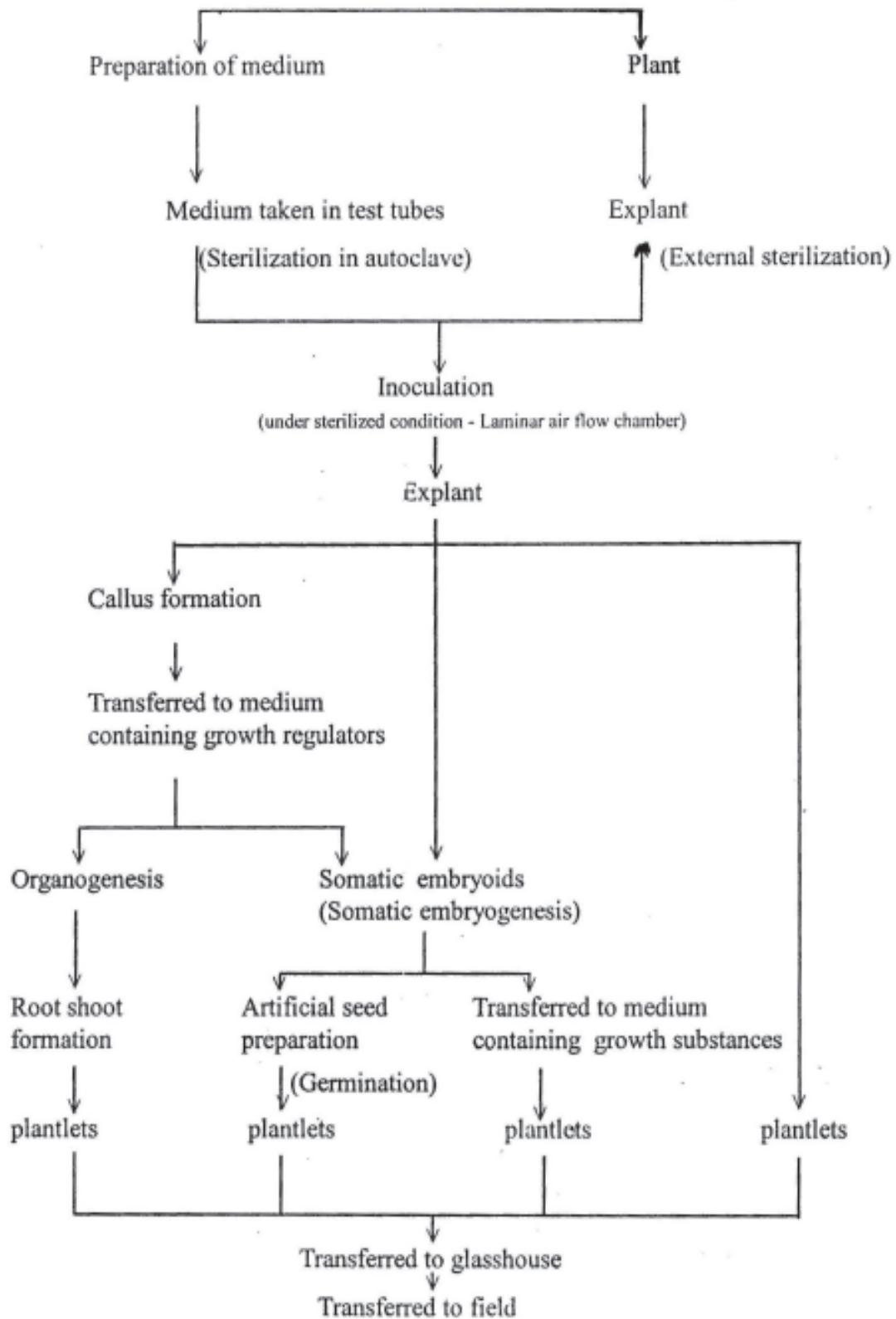
The plants regenerated through organogenesis or somatic embryogenesis need to be gently acclimatized before they are transferred to pots. They have to be planted in plastic pots containing soil rite. the pots are covered with polythene bags and maintained in the laboratory at room temperature for 1 or 2 weeks. The polythene bag is gently removed when the plant appears strong and healthy and it is transferred to a regular pot containing a mixture of soil and manure.

Applications of tissue culture

- Large number of plants can be produced within a short time.
- Plants regenerated through tissue culture show variations called 'soma clonal variations', which are used for crop improvement.
- Virus free plants can be produced from shoot - tip cultures of vegetatively propagated plants
- Artificial seeds can be produced
- Medicinal plants can be produced through tissue culture.
- The production of transgenic plants is dependent on plant tissue culture.

Flow chart of plant tissue culture technique

Flow chart of plant tissue culture technique



Intext Questions

1. What is meant by totipotency?

2. Define basal medium

3. The mostly used medium

4. Define explant

5. Define rhizogenesis and caulogenesis

6. What is meant by inoculation?

7. Define somatic embryos

8. What are synthetic seeds?

What you have learnt

- ✱ Technique of tissue culture involves six steps
- ✱ Part taken from plant grows into complete plant under controlled conditions
- ✱ Nutrient medium is required for tissue culture. Growth regulators are to be added in required proportion for inducing rhizogenesis and caulogenesis.
- ✱ For inoculation of explant complete aseptic environment is required
- ✱ Somatic embryos will also develop from callus
- ✱ Somatic embryos can be encapsulated for making synthetic seeds.

Terminal Exercises

1. Define totipotency?
2. What are the steps involved in tissue culture?
3. Define basal medium
4. Describe rhizogenesis
5. Explain caulogenesis
6. What are synthetic seeds?
7. Enumerate three applications of tissue culture.

Answers to Intext Questions

1. Capacity of cell to develop into an organism by regeneration
2. Nutrient medium prepared without growth regulators
3. Malashige and skoog (MS) medium
4. Any part of a plant introduced into culture medium
5. Inducing root development inducing shoot development
6. Transfer of explant into culture vessel
7. Embryo like structures developed from callus
8. Incapsulated somatic embryos

Glossory

In vitro	: Any process carried out in sterile cultures in glass or in artificial condition
Autoclave	: An instrument used for sterilization of glass ware and culture media
Callus	: An undifferentiated mass of plant cells capable of cell division and growth in vitro
Rhizogenesis	: Root induction from callus by hormonal treatment
Coulogensis	: Shoot induction from callus by hormoual treatment
Somaclonal variation	: The Variation exhibited by the plants derived from any form of somatic cell culture



30

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.*

30.1 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).

**Notes****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 being. 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 body of the host.

Let us now learn about the different ways by which the body defends itself from pathogens and other harmful substances.

30.2 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 (Haemostasis) and thus preventing 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 30.1**

- Who is considered as father of immunobiology?
.....
- What are the three main functions of immunological defence?
 -
 -
 -
- Define immunology.
.....

**Notes****30.3 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'** and spread throughout the connective tissues of non-lymphoid organs.

1. Tissues and Organs involved in the Immune System

Lymphoid organs are divided into two groups :

- Central lymphoid organs or primary lymphoid tissue. Example : Thymus and bone marrow.

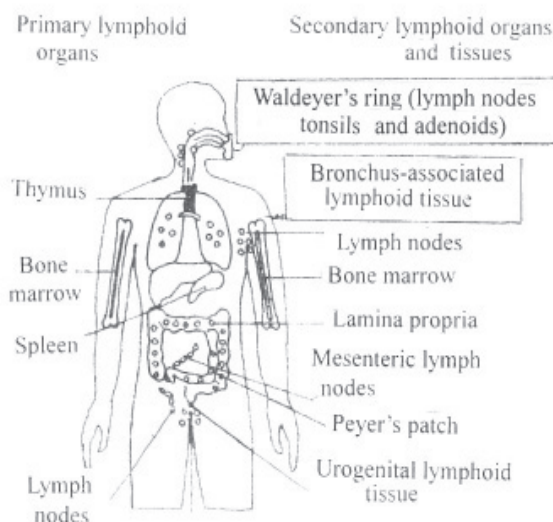


Fig. 30.1 Major lymphoid organs and tissues.



- (ii) Peripheral lymphoid organs or secondary lymphoid tissue. Examples spleen, Payer's patches, tonsils, lymph nodes and mucosa-associated lymphoid tissue (MALT), which is associated with the respiratory system, urogenital and alimentary canal (Fig. 30.1).

2. Cells of Immune System

(i) Lymphocytes (Lymphoid cells)

All these are initially derived from the hemopoietic (blood cell producing) stem cells of bone marrow. Stem cells mean undifferentiated cells which can undergo unlimited division and can give rise to one or several different cell types. 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 the immune functions. About 10^{12} lymphocytes constitute the mature lymphoid system in humans. Functionally, lymphocytes are divided 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 early development 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 are initially generated 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 the life (Fig. 30.2).



Notes

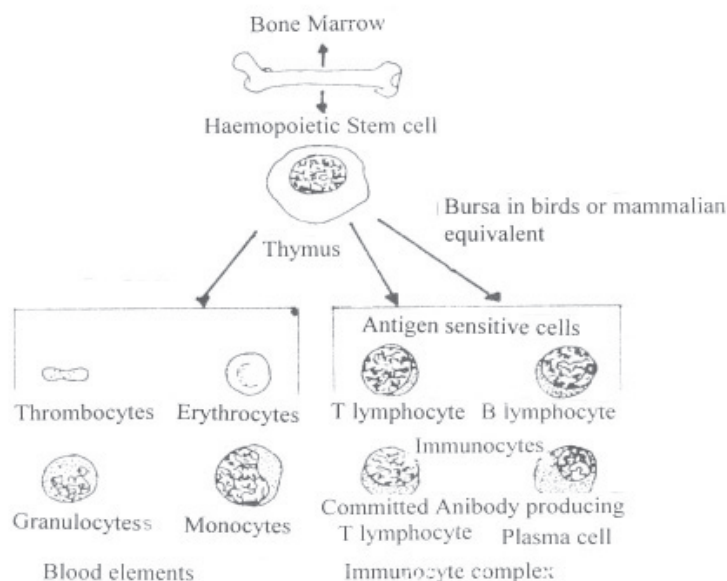


Fig. 30.2 Origin of B and T Cells

Characteristics of B-cells

- (i) B-cells display **immunoglobulin** as an integral proteins 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. 30.3). You will learn about 'antigen' and 'antibody' in the next section of this lesson.

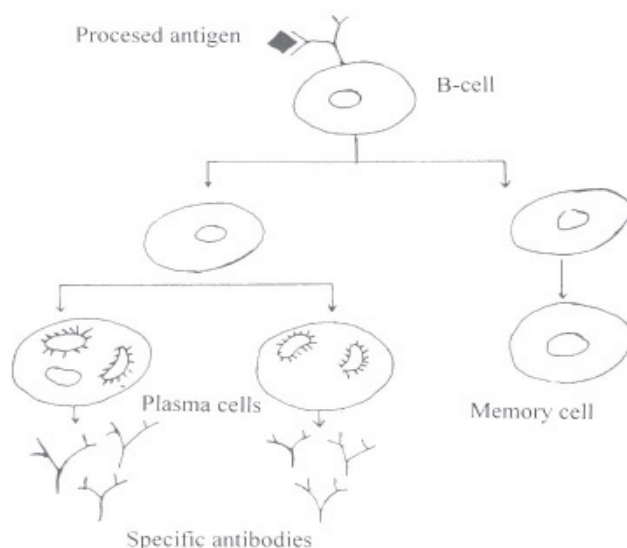


Fig. 30.3 B-cell differentiation and antibody production.



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 this organ, 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 virally infected cells and tumour cells.

3. Suppressor T-cells (T_S)

Suppress helper T-cells and may also be B-cells to limit/regulate activity of the latter.

Thus we see that T-cells mediate two general types 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). B-cells and T-cells work in cooperation.



INTEXT QUESTIONS 30.2

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?

.....

30.4 ANTIGEN AND ANTIBODY

While discussing about ‘self’ and ‘non-self’, we got a broad idea of **antigen**. Let us learn more about it.

30.4.1. 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.

30.4.2 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 site vary from antibody to antibody in a given class (Fig. 30.4)

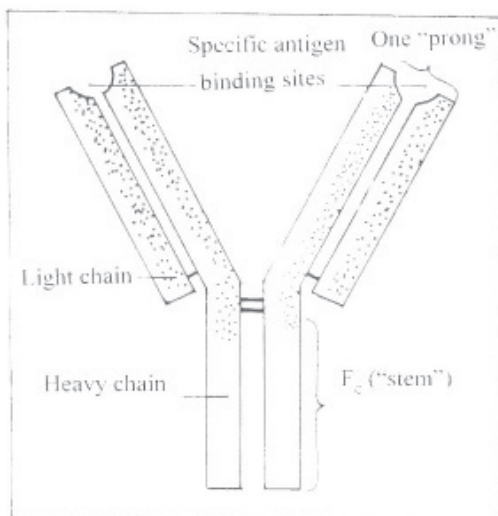


Fig. 30.4 Antibody structure

30.4.3 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, IgA, IgE, IgG and IgM (1g = Immunoglobulin)
- They also differ in their molecular weight and function.
- IgG is found in highest concentration (almost 75% of the total immunoglobulins 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 (Fig. 30.5) and then direct an attack (by phagocytes cells which eat up foreign material) and complement that eliminate the antigen or the cells bearing them.

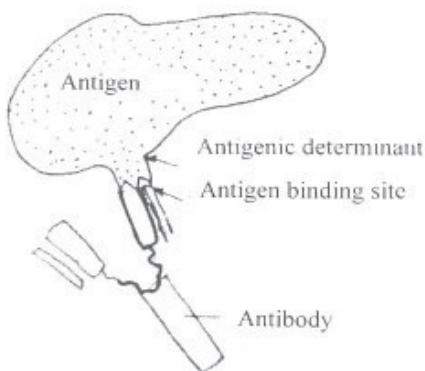


Fig. 30.5 Antigen-antibody binding



Notes

30.5 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'. They 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 protection against bacteria and viruses in the extracellular fluid.

The above two differ from each other as shown in Table 30.1

Both cell mediated and antibody mediated immune responses are facilitated by helper T-cells and inhibited by suppressor T-cells (Fig. 30.6)

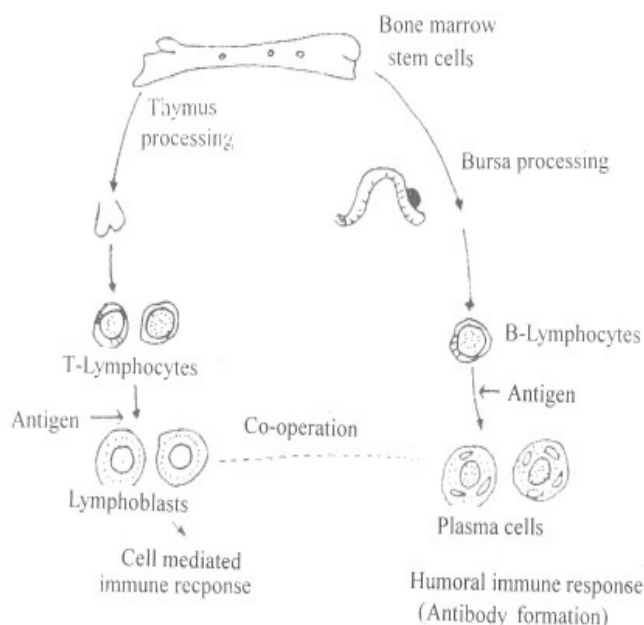


Fig. 30.6 Cell-mediated and humoral immune responses



Notes

Table 30.1 : 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 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 30.3

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?
.....

30.6 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 himself from 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)



Notes

(i) Physical Barriers

It is the first line of defence. It means preventing the entry of pathogens into the body. (Fig. 30.7).

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, etc.).

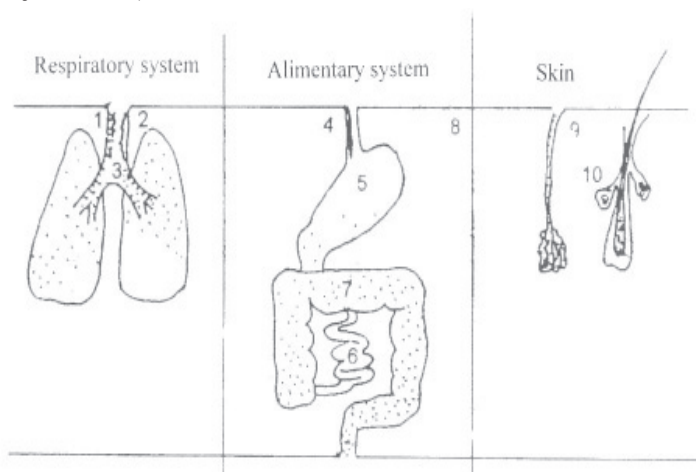


Fig. 30.7 Natural physical barriers to infections

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** and **macrophages**.



Notes

- **Microphages** are the polymorphonuclear leucocytes (or neutrophils which are white blood cells) smaller in size and short-lived.
- **Macrophages** are mononuclear phagocytes large in size and long-lived. These are found in virtually all the organs and tissues. But particularly these are found in large numbers in lung, liver and spleen.

Important features of phagocytic cells

1. They are actively phagocytic.
2. They contain digestive enzymes to breakdown engulfed material.
3. They are an important link between innate and acquired immunity (described below). These pass on antigen or their products to the lymphoid cells for their further processing.

(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 **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 life time 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.



Notes

(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.

30.7 ACTIVE IMMUNIZATION (VACCINATION)

People had observed in the past that individuals who recovered from certain diseases are protected for life time 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 introduce the attenuated germs into the body. The body then generate 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.

30.7.1 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: diphtheria and tetanus.

Toxoid is a chemically or physically modified toxin that is no longer harmful but retains immunogenicity.

30.7.2 Important Vaccines – BCG, DPT and MMR

- BCG = Bacille Calmette Guerin (Calmette and Guerin were the scientists who contributed in the development of tuberculosis vaccine).
- DPT is a triple vaccine (or antigen) for diphtheria 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



Notes



INTEXT QUESTIONS 30.4

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 QUESTIONS**

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

**ANSWER TO INTEXT QUESTIONS**

- 30.1**
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.
- 30.2**
1. (i) Central or primary lymphoid organs.
(ii) Peripheral or secondary lymphoid organs.
 2. Bursa of Fabricius.

**Notes**

MODULE - 5

Emerging Areas in
Biology



Notes

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.

30.3 1. Epitope

2. Five

3. Immunoglobulin G

4. Cell-mediated immune response

30.4 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.

GLOSSARY

LESSON 18 TO 30

Abscission	: The detachment of older parts from the main body.
Acid Rain	: Rain containing high acidic content (usually with pH lower than 5).
Aerosol	: Suspended fine particles in air.
AIDS	: Acquired Immuno Deficiency Syndrome.
Allergen	: Substances that cause allergy.
Analgesic	: A pain reliever which does not induce loss of consciousness.
Anthropogenic	: Created by human beings
Antibody	: Is a protein molecule produced the animals in response to an antigen.
Antigen	: Is any foreign molecule that can trigger a specific immune response.
Auxanometer	: A specially designed equipment used to measure the length of plant.
BCG	: Bacillus of Calmette and Guérin (Prophylactic against tuberculosis).
Biodegradable	: A substance that can be decomposed by microbes.
Biodiversity	: Variety of all plants, animals and microbes of a region.
Biological stress	: Pressure on plants due to change in environmental conditions.
Biomagnification	: Increase in the concentration of non-biodegradable substance at each higher trophic level in a food chain.
Biome	: A large ecosystem maintained under a particular climate with wide geographic distribution.
Biotechnology	: Use of Biological organism in Industrial Genetic Engineering
Birth rate (natality)	: The number of live births per 1000 individuals of population per year.
Carcinogen	: Substance which may cause cancer.
Cell division	: A process in which the number of cells increases due to mitosis.
Cell enlargement	: Increase in size of cells after cell division.
Census	: Is the official data of registered number of people in a selected area.

Central Dogma	: The transfer of information from genes to the site of protein synthesis constitutes central dogma.
Cistron	: The gene or fragment of DNA which carries the code for synthesis of a complete polypeptide (protein) is termed a cistron.
Clone	: Is a collective term for genetically identical individuals.
CNG	: Compressed Natural Gas.
Codon	: A sequence of three nucleotides on DNA and mRNA which determines one amino acid.
Codominance	: When both the alleles of a gene are equally dominant.
Conservation	: Judicious use of a natural resource to derive benefits from it and to prevent its destruction or degradation.
Death rate (mortality)	: The number of deaths per 1000 individuals of population per year.
Decibel	: A unit for measuring intensity of sound.
Demography	: Is the scientific and statistical study of human population.
Differentiation	: Process of change in cells, tissues or organs to carry out different functions.
Disease	: A condition which interferes with the normal functioning of the body or a part.
DNA fingerprinting	: Is a technique which could distinguish the DNA of a person from that of another.
DNA replication	: Defined as a mechanism for transmission of genetic information to generation after generation.
Dormancy of seeds	: A period in which no growth occurs in the seeds.
DPT	: Diphtheria Pertussis Tetanus, (prophylactic against diphtheria, whooping cough and tetanus).
Edaphic	: Physical and chemical nature of soil
ELISA	: Enzyme Linked Immuno Sorbent Assay Test (A test for AIDS).
Embryo	: The structure developed from a zygote prior to hatching or birth.
Endangered species	: Those which have been reduced in number to a critical level and facing a high risk of extinction in the near future.
Epigeal germination	: A type of seed germination in which hypocotyl elongates and cotyledons come out above the soil.
Eutrophication	: Enrichment of water with nutrients such as nitrates and phosphates that triggers the growth of green algae.
Fauna	: Characteristic animal life of a region.

Fertilization	: The fusion of nuclei of the male or female gametes during sexual reproduction to form a zygote.
Flora	: Characteristic plant life of a region
Florigen	: A hormone responsible for initiation of flower in plants
Gene bank	: Is a storage of preserved human or other genes in various clones.
Gene cloning	: A technique of producing many identical copies of a particular gene.
Genetic code	: The genetic code refers to the information for the structure of a particular protein to be synthesis, coded in a DNA molecule.
Genetic Counselling	: Means advise given regarding a genetic disorder so that the couple knows whether to have any more children if their first child suffering from a genetic disorder.
Genome	: A set of all the genes of an organism.
Genomics	: Is the analysis of the genome data, that is finding out the functional nucleotide sequences (genes) in the DNA of an organism.
Genotype	: The genetic constitution of an organism.
hnRNA	: Heterogenous nuclear RNA. Precursor of mRNA which after processing is converted into mRNA.
Human population	: The sum total of human beings on earth.
Hyper Vitaminosis	: Effect of excessive intake of vitamins.
Hypogeal germination	: A type of seed germination in which hypocotyl elongates and cotyledons remain below the soil.
Immunobiology	: Study of organisation and functioning of immune system.
Immune system	: Is a complex network of cells, tissues and soluble factors providing immunity.
Immunity	: 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.
Inducible genes	: Are the ones which switched on when a particular substance is present in the environment.
Lethal gene	: A gene which causes the death of an organism.
Macronutrients	: Nutrients required in large amounts.
Macrophage	: A mononuclear phagocyte, large in size and long lived. Found in all organs and tissues, lung, liver and spleen.
Malnutrition	: The condition resulting from lack of nutrients.

Menstruation	: Cyclical discharge of blood, mucous and endometrial tissues of the uterus, in the reproductive life of the females, at an average interval of 28 days.
Micronutrients	: Nutrients required in small amounts.
Microphage	: Is the polymorphonuclear leucocyte, smaller in size and short lived. Found in all organs and tissues, lung, liver and spleen.
Micropropagation	: Is the technique of culturing plant cells, tissues or an organ.
Morphogenesis	: Process of development of shape and structure of an organism.
Mutagens	: Agents that cause mutation in the genetic material are called mutagens.
Mutation	: A heritable change that can be passed down to the next generation.
Nastic movement	: Movement due to difference in the rate of growth on opposite sides of an organ.
Non-biodegradable	: A substance that cannot be decomposed by microbes.
Non-point sources of pollution	: Sources of pollution without any specific location.
Oil slick	: Thin film of oil formed on the surface of water (usually due to leakage of oil from the oil tanker).
Ovulation	: Release of ovum from a mature graafian follicle.
Pandemic	: Disease found around the world.
Parthenocary	: When fertilization fails, seeds are not formed. But in certain plants the ovary develops up a fruit e.g. grapes, banana etc. Formation of seedless fruits without fertilization
Phenotype	: The external appearance of an organism.
Photoperiodism	: The effect of duration of light on the growth of plants.
Phytochrome	: A light absorbing pigment who perceives the presence of light.
Phytohormone	: Hormones produced by plant itself for its growth.
Placenta	: A temporary flat organ which consists of both embryonic and maternal tissue and enables the foetus to depend entirely on maternal system for obtaining oxygen and nutrients, as well as, removal of waste products.
Planktons	: Free floating microorganisms.
Plasmids	: Extrachromosomal DNA in bacteria used as vectors in genetic engineering.
Pollination	: Transfer of pollen grains from anther to stigma.
Pollutant	: An agent that causes pollution.

Pollution	: An undesirable change in the physical, chemical and/or biological characteristics of the environment.
Population density	: The number of individuals per square kilo metre (km^2) at any given time.
Population growth rate	: The difference between the birth rate and the death rate.
Recombinant DNA	: Is the modified DNA molecule carrying DNA from two different sources.
Red data book	: A book listing endangered plants and animals of the world; published by world conservation union.
Repressible genes	: Are those which shut off in the presence of a specific substance in the environment.
Reproduction	: The process by which living organisms produce their offsprings for the continuity of the species.
RNA	: Ribonucleic acid
Senescence	: A process which leads to complete loss of organization and function of the plant.
Sigmoid curve	: A curve that shows the different phases of plant growth.
Smog	: A mixture of smoke and fog.
Stratification	: Horizontal and vertical distribution of plants in an ecosystem.
Sustainable development	: It is the development that meets the needs of the present generation and conserves it for the future generation.
Transgene	: Gene which is being transferred to another organism.
Transgenic	: Genetically engineered organisms carrying foreign genes.
Translation	: Messenger RNA carrying information move out of nucleus into cytoplasm, joins ribosomes to convert the information in terms of a protein is called translation
Transcription	: The flow of genetic information from cistronic DNA to mRNA is called transcription
Tropic movement	: Movement plants or any part of the plants towards some environmental factors like light, gravity etc.
Turgor movement	: Movements are due to change in the volume of water inside the cell.
Vernalisation	: means low temperature treatment which stimulates early flower formation.

NOTES