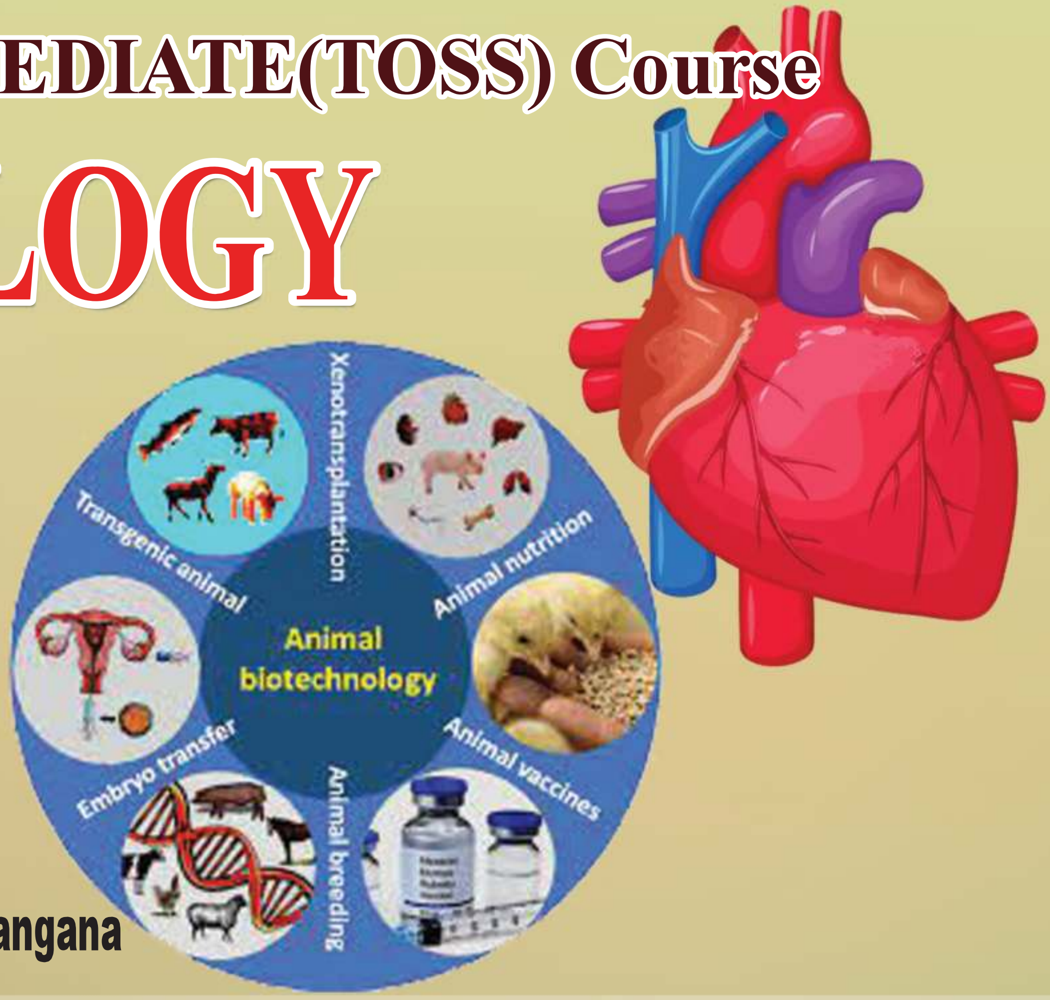
INTERMEDIATE(TOSS) Course

BIOLOGY



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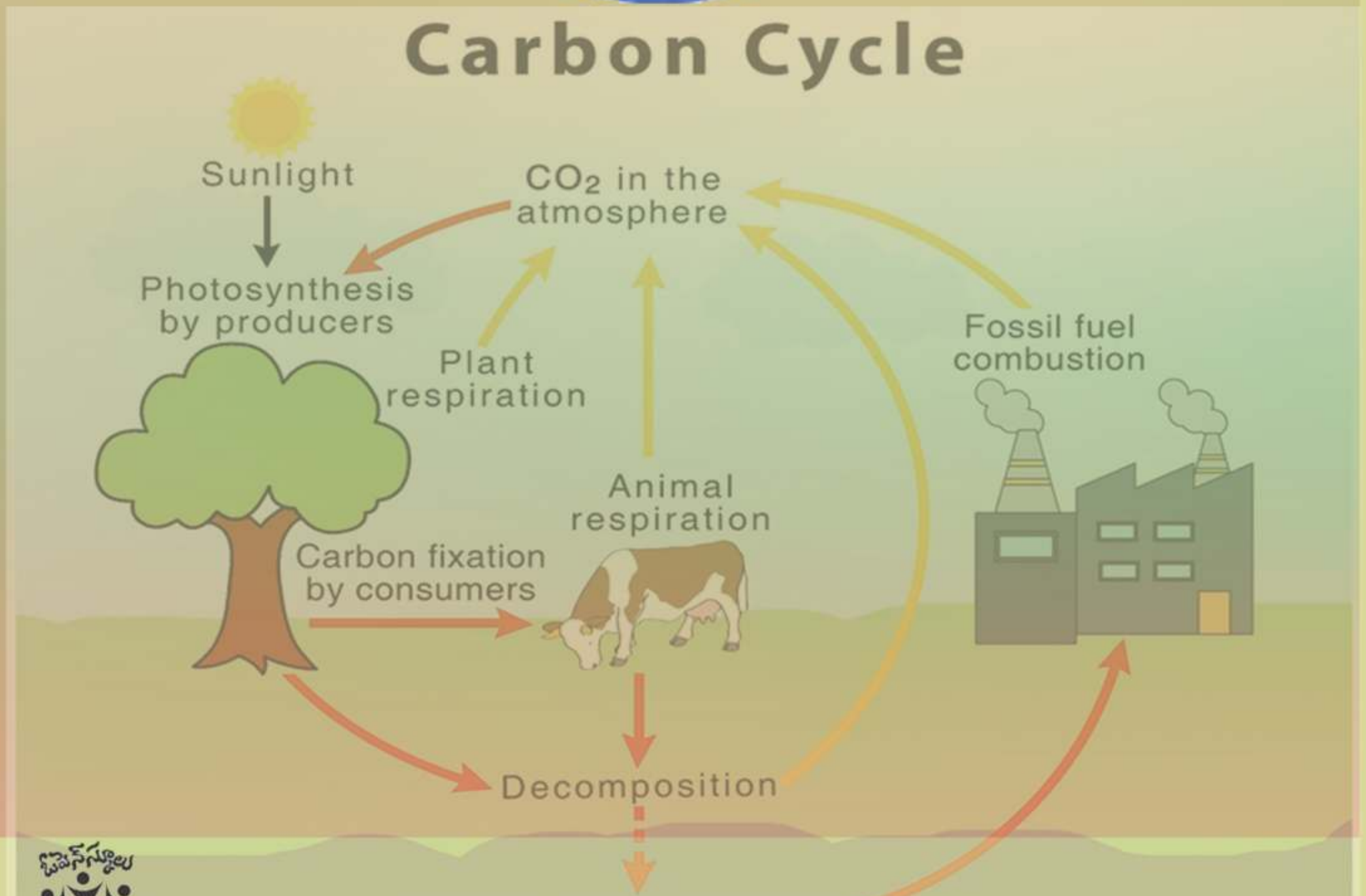

TELANGANA OPEN SCHOOL SOCIETY YHYDERABAD

INTERMEDIATE (TOSS) COURSE BIOLOGY-2

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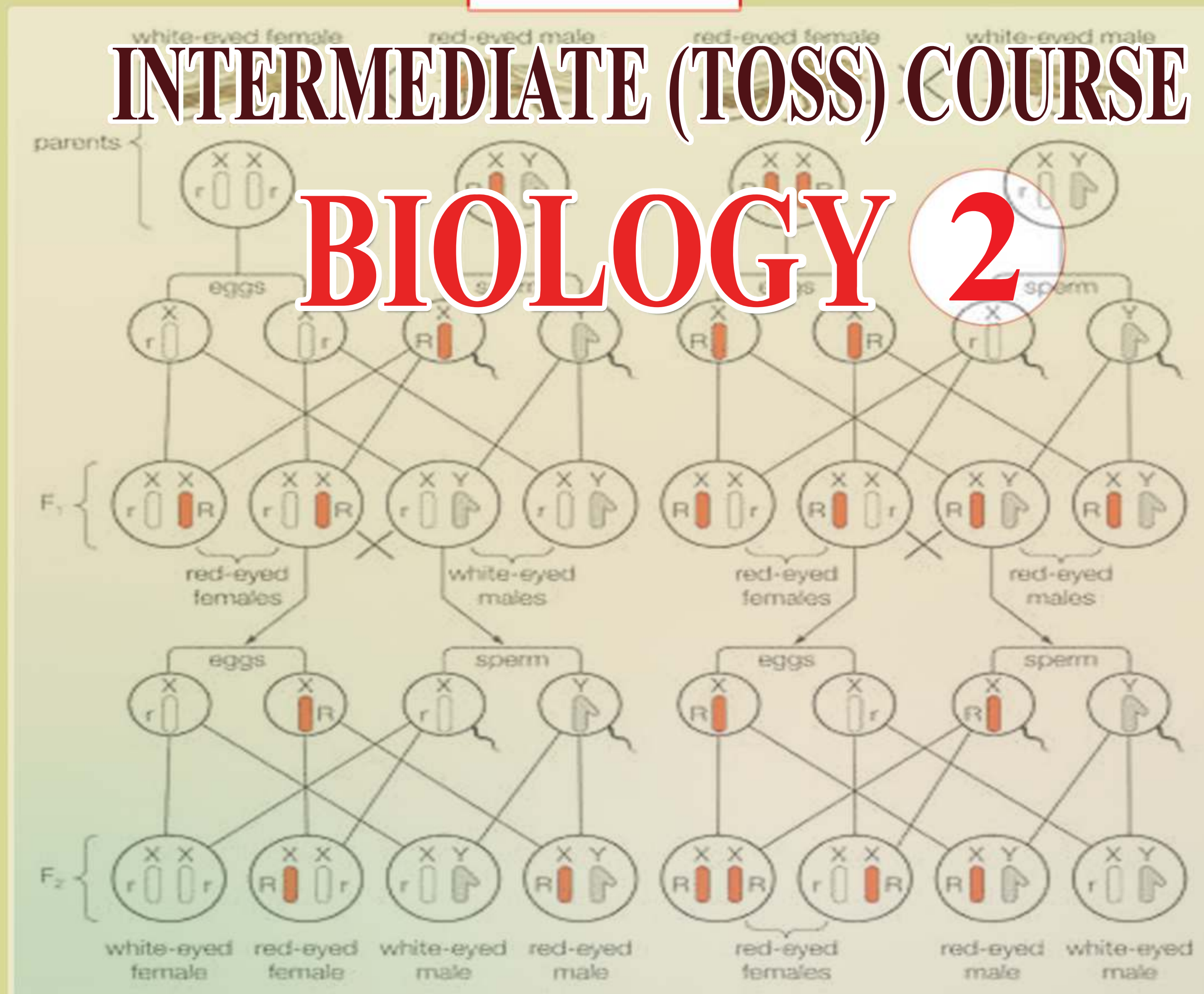
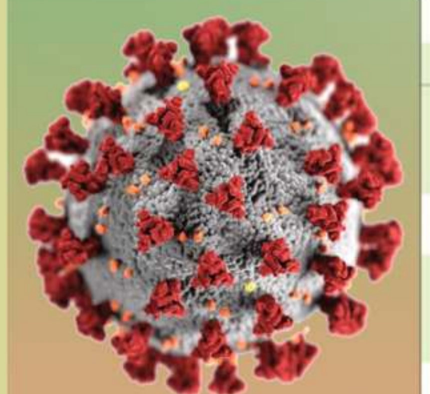
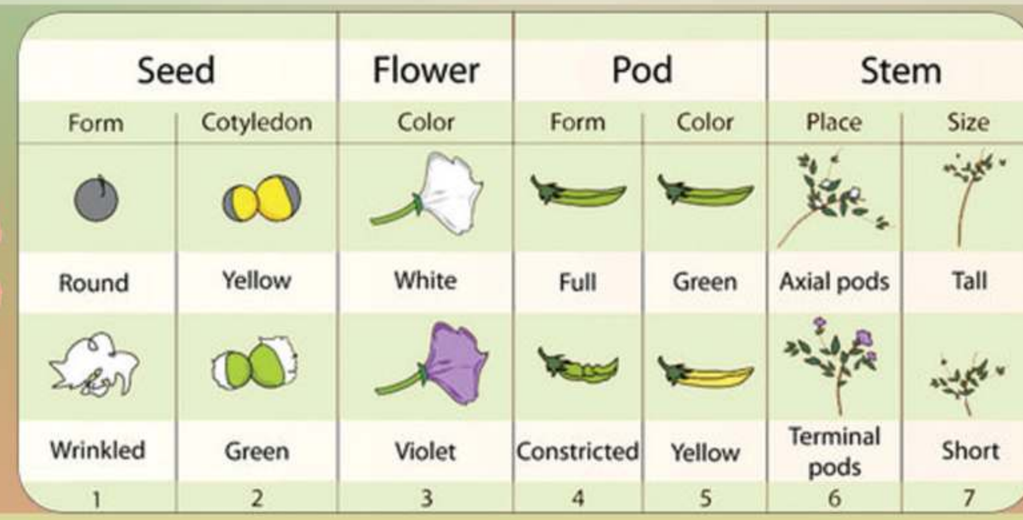
INTERMEDIATE (TOSS) COURSE

BIOLOGY 2







TELANGANA OPEN SCHOOL SOCIETY YHYDERABAD

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BIOLOGY - 2

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Foreword

Providing education to children is a fundamental right, and it's essential for the overall development of society. The government of Telangana plays a crucial role in ensuring that education is accessible to all, and they often establish institutions like the Telangana Open School Society (TOSS) to cater to children who may be unable to access formal education due to various reasons.

To provide quality education to learners studying Intermediate Education in Telangana Open School Society starting from the 2023 academic year, the textbooks have been revised to align with the changing social situations and incorporate the fundamental principles of the National Education Policy 2020. The guidelines set forth in the policy aim to enhance the overall learning experience and cater to the diverse needs of the learners. Earlier Textbooks were just guides with questions and answers. TOSS has designed the textbook with a student-centric approach, considering the different learning styles and needs of learners. This approach encourages active engagement and participation in the learning process. The textbooks include supplementary teaching materials and resources to support educators in delivering effective and engaging lessons.

Biology plays a valuable part in general education and needless to justify its study in fact directly useful to you in finding employment opportunities as a biology teacher, lecturer, or employment in Pharmaceutical, Animal Biotechnology, Plant Biotechnology and other similar industries. You can be accommodated as a field expert in Agriculture, Horticulture, Forestry and Healthcare sector. Marine and Freshwater Biology Research areas offer plenty of opportunities to young graduates these days. Our Revised Biology Course of Telangana Open School System is based on the National Institute of Open School (NIOS) and the National Common Core Curriculum. It's also worth mentioning that The Revised Curriculum is made very simple and suits exactly to the needs and requirement of the students those who are pursuing. This course is having 3 volumes consisting both theory and practical with special focus on applied biology. I hope you will find the new material interesting and exciting with a lot of activities to do. Further, we also welcome suggestions and inputs for further improvement.

We are indeed very grateful to the Government of Telangana and the Telangana State Board of Intermediate Education. Special thanks to the editor, co-coordinator, teachers, lecturers, and DTP operators who participated and contributed their services tirelessly to write this text book.

Date: 18.11.2023 **Director, TOSS,**

Place: Hyderabad. **Hyderabad.**

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18 REPRODUCTION IN ANIMALS

The ability to reproduce is one of the essential characteristics of living beings. It involves 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 fusion of gametes (sexual reproduction).

Objectives

After completing this lesson, you will be able to:

- Define reproduction and differentiate between asexual and sexual reproduction
- 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

Reproduction: Reproduction is the ability of living organism by which they produce off spring of their own kind. Asexual reproduction involves the production of an offspring from a single organism without the formation of gametes. It is a common mode of reproduction in bacteria, protista, lower plants and lower animals. Sexual reproduction is the production of offspring by the formation and subsequent fusion of gametes. During fertilization, the male and the female gametes unite to form a zygote which develops into an organism. Most animals and higher plants multiply by sexual reproduction.

REPRODUCTION IN HUMANS

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

(a) Reproductive system,

(b) Fertilization, and development.

(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, both primary and secondary reproductive organs grow and attain maturity. Along with these changes, secondary sexual 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. During adolescance, the secondary sexual characters 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 auxiliary and pubic hair, widening of pelvis and hip, enlargement of breast 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.

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

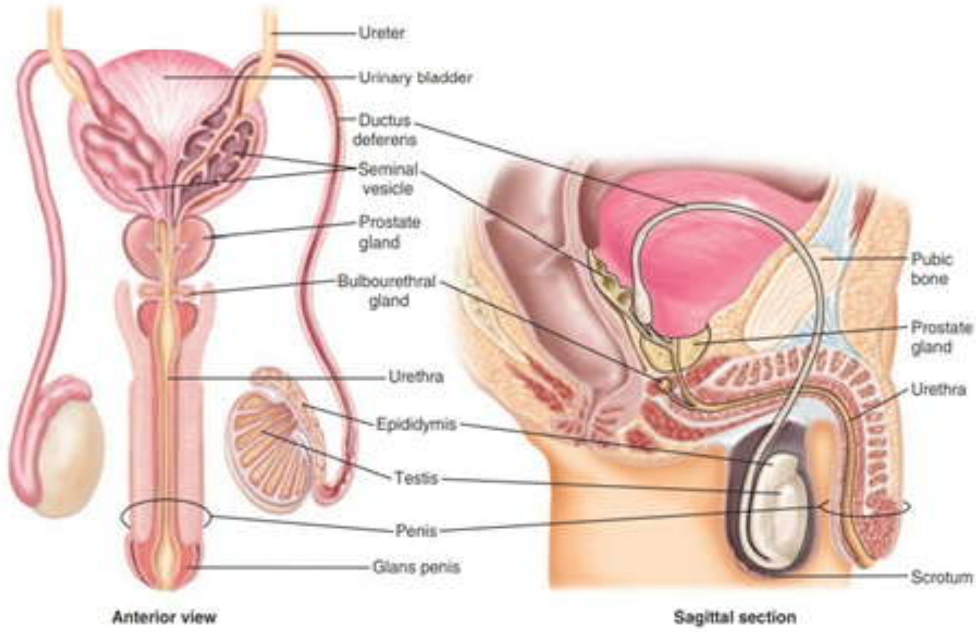


Fig: Male Reproductive System

I. 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. 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 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 serves as a common 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.

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

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

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

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

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 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 20-150 million sperms are discharged.

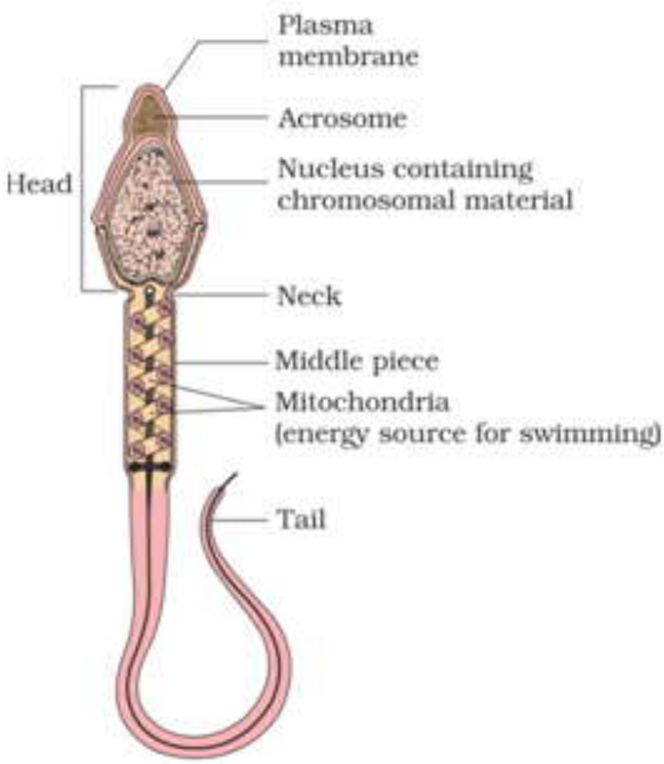


Fig: Structure of sperm

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 genital organs

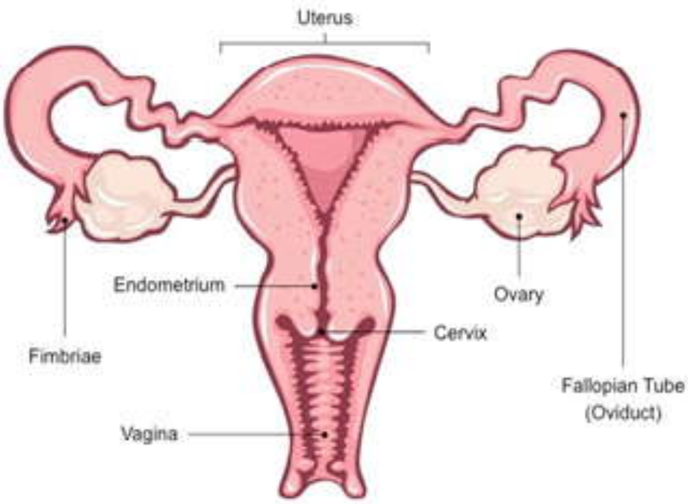


Fig : Female Reproductive System

(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 considered as a mature egg and called Graffian follicle. The egg then gets released (ovulation) from the ovary leaving the empty follicle called corpus luteum.

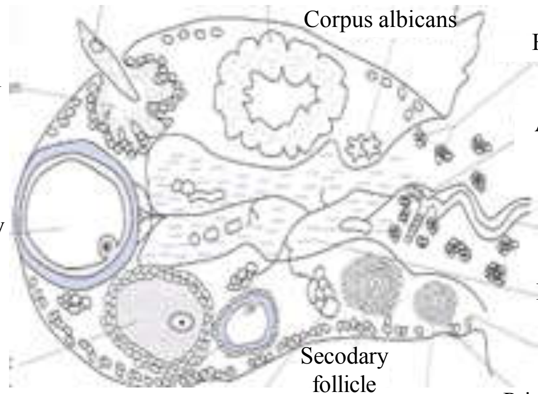


Fig : Ovary showing microscopic structure

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

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

(iv) Vagina: 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.

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

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.

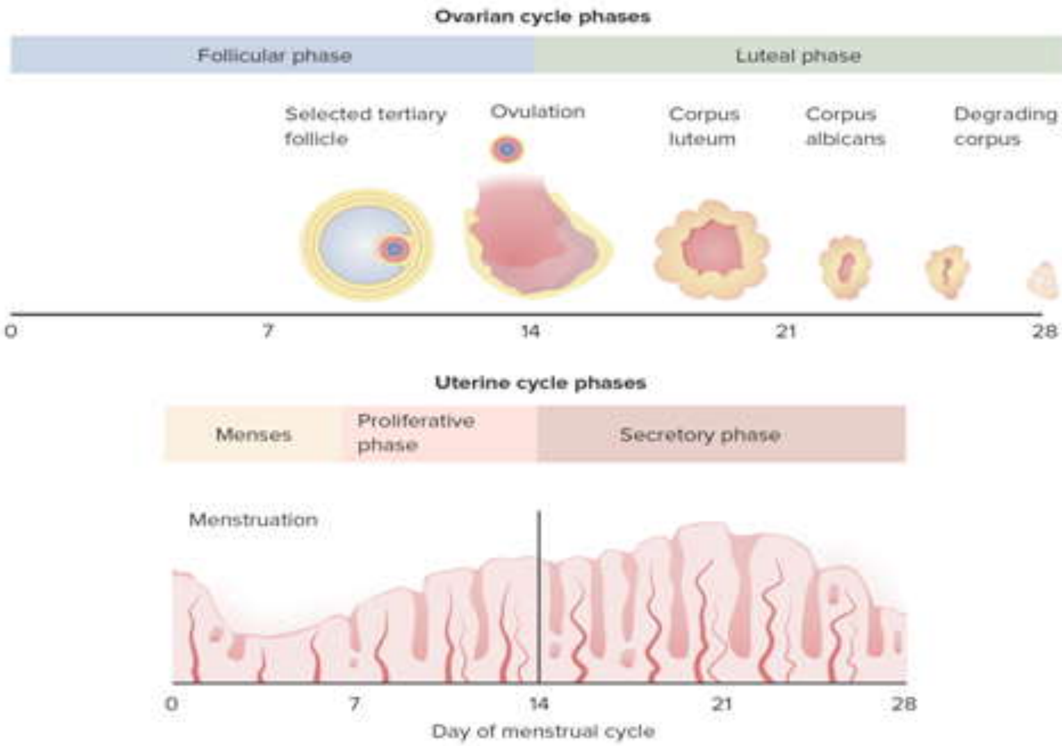


Fig : Graphical representation of mensural cycle

INTEXT QUESTIONS

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 ________________________

Fertilization and implantation: Spermatoza remain viable in the female genital tract from 24 to 72 hours. For fertilization, sperms are introduced into the female body and one sperm fuses with the ovum in the fallopian tube. If the ovum happens to meet a sperm, the two unite to form a zygote. 13-14 days after onset of menstruation are most favourable for conception (pregnancy). The zygote immediately begins to divide and passes down the fallopian tube to the uterus and fixes itself to the wall of the uterus. This fixing of the embryo in the wall of the uterus is called implantation and the female is said to be pregnant. Implantation takes place about a week after fertilization.

Placenta : Placenta is an association between maternal and foetal tissue meant for some extremely important physiological functions. The developing embryo is attached to the uterus by a tissue called placenta. The 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.

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.

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.

Summarizes the steps in fertilization of human egg, its implantation and development in the uterus up to birth

Sperms from male are deposited into the female reproductive system

↓

Egg released from the ovary

↓

Union of the sperm and egg in the fallopian tube

↓

Fertilization and formation of zygote (Day 1)

↓

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

↓

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

↓

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

↓

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

↓

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

↓

Birth of human infant (about 40 weeks)

INTEXT QUESTIONS:

1. State the main function of placenta.

   ____

2. Define the following terms.

   (i) Implantation ____

   (ii) Placenta ____

   (iii) Amnion ____

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

   ____

TERMINAL EXERCISE:

1. 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

2. 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

3. Match the terms of Column I with those of Column 11 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

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

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

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

7. Name the following.

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

(ii) The male gamete in humans.

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

8. Draw the outline of the male reproductive system.

(i) Label the following parts

(a) testis

(b) epididymis

(c) seminalvesicles

(d) vas deferens

(ii) Name the hormone produced by the testis.

(iii) Why are sperms produced in large numbers?

REPRODUCTION IN PLANTS

Reproduction is one of the most important characteristics of all living beings. It is the production of one's 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 offspring's for the continuity of the species is called reproduction.

The modes of reproduction vary according to individual species and available conditions. Reproduction can be done easily, as in unicellular organisms, by dividing the parent cell, fragmenting the parent body, forming buds and spores, or it can be quite complex and involve the development of both male and female reproductive organs (stamens and pistils). All living things reproduce by passing on their hereditary material (genetic makeup) to their progeny, regardless of the mechanism of reproduction. You will learn about the method of plant reproduction in this session.

Objectives

After completing this lesson, you will be able to :

- define reproduction
- differentiate between vegetative, asexual and sexual reproduction
- describe the methods of asexual and sexual reproduction in unicellular lower plant (Chlamydomonas) and filamentous green alga (Spirogyra)
- describe the mode of reproduction in flowering plants
- explain the parts of a dicot flower and their functions
- describe stages of microsporogenesis

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

MODES OF REPRODUCTON

The various modes by which plants reproduce are:

(a) Vegetative

(b) Asexual

(c) Sexual

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

- single parent is involved
- Offsprings are genetically identical to the parent.

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

(i) Vegetative reproduction: It involves formation of new plantlets from vegetative (somatic) cell, buds or organs of the plant. Here, a vegetative part of the plant

(Root, stem, leaf or bud) gets detached from the parent body and grows into an independent plant. It is similar to asexual reproduction in that it also requires only mitotic division, no gametic fusion is involved, and newly-formed plants are genetic clones of the parent plant. We will discuss the different types of vegetative reproduction in angiosperms later in this lesson.

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

(iii) Fission: 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. Ex: Bacteria

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

(b) Asexual Reproduction

(i) Spore Formation

In lower plants including bryophytes and pteridophytes, special reproductive units develop asexually on the parent body. These are called spores. They are microscopic and covered by a protective wall. When they reach the suitable environment they develop into a new plant body e.g. in bread moulds, moss, fern.

(ii) APOMIXIS

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

$$\text{OVULES} \xrightarrow{\text{without fertilization}} \text{SEEDDS}$$

(c) Sexual reproduction:

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

INTEXT QUESTIONS

1. Define reproduction.

   ____

2. How is asexual reproduction different from sexual reproduction?

   ____

3. What is a gamete?

   ____

4. Name two types of vegetative reproduction.

   ____

5. Defne Apomixis

   ____

REPRODUCTION IN LOWER PLANTS

The different types of reproduciton in lower plants, one is unicellular alga (*Chlamydomonas*) and the other multicellular filamentous alga (*Spirogyra*).

Chlamydomonas (A Unicellular Alga)

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

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

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

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

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

(vi) Chloroplast contains a single pyrenoid.

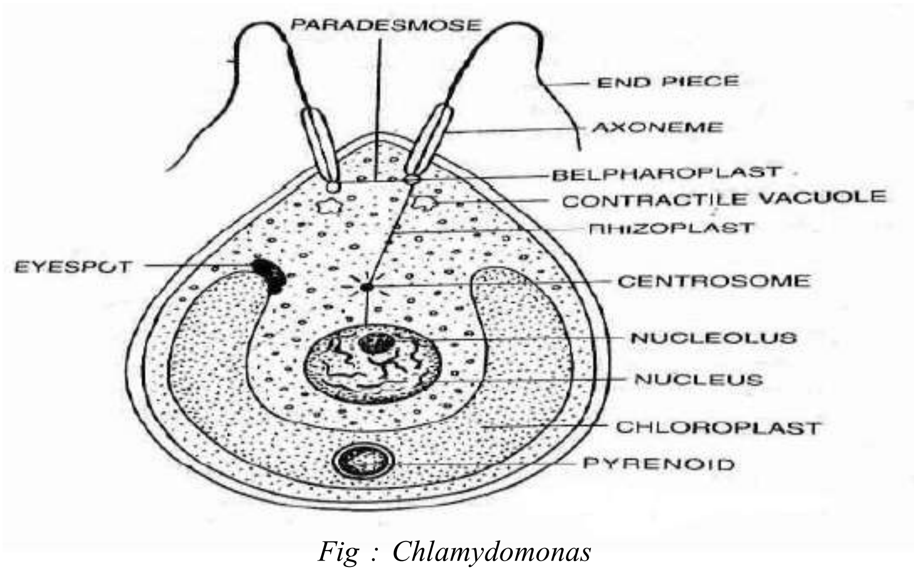


Fig : Chlamydomonas

Reproduction

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

Asexual Reproduction by Zoospores :

- If plenty of water is available for free swimming, *Chlamydomonas* reproduces by flagellate thin-walled spores, called zoospores.
- Chlamydomonas cell loses flagella and becomes non-motile.
- Its protoplasm (cytoplasm and nucleus) divides mitotically and forms 2-16 daughter protoplasts, each of which develops flagella, and is called a zoospore.

- The parent cell wall is ruptured and zoospores are released.
- Each zoospore develops a cell wall and grows into an adult cell.
- After release of zoospores the parent cell does not exist, any more.

Asexual Reproduction by Aplanospores and Hypnospores :

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

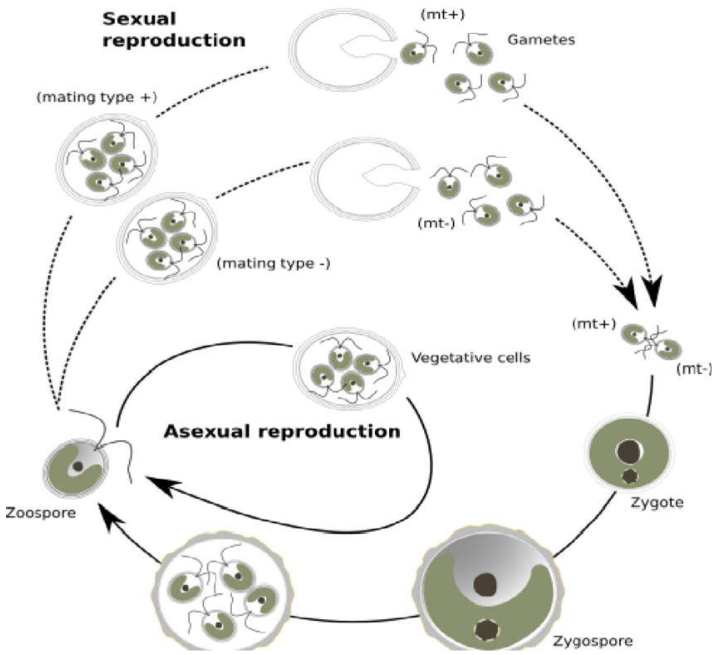


Fig : Chlamydomonas Sexual and Asexual reproduction

B. Sexual Reproduction

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

Sexual Reproduction by Isogamy

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

Sexual Reproduction by Anisogamy

- Anisogamy is exhibited by *Chalamydomonas braunii* where Male and female cells lose flagella and become non-motile.
- In male cell, protoplast divides repeatedly to produce 32-64 biflagellate gametes but in female cell, protoplast divides to produce 8 to 16 biflagellate gametes.
- Both male and female gametes are released in to water.
- When larger female gametes lose flagella and become non-motile, each one is fertilized by a smaller motile male gamete.
- After fertilization, the fusion product loses flagella, becomes spherical and develops thick wall to become a resting zygote.

- On return of favorable conditions of water, temperature and light, the zygote undergoes meiosis and produces four haploid zoospores each of which grows into an independent Chlamydomonas plant.

Sexual Reproduction by Oogamy

- Oogamy is exhibited in *Chlamydomonas ooganum.*
- Here, female and male cells lose flagella and become non-motite.
- All the contents of female cell act as female gamete or egg, but the protoplasm of male cell divides to produce 32-64 biflagellate gametes.
- The biflagellate gametes are liberated in to water and swim around in search of female gamete.
- Two or more flagellate gametes enter each female cell having nonmotile egg but only one fertilizes the egg and others degenerate, contributing nutrition to the young zygote.
- The fusion product of egg and a motile gamete is called zygote that develops Heredity a thick, pigmented wall to enter into resting phase.
- On return of favourable conditions of water, temperature and light, the zygote undergoes meiosis to produce four haploid biflagellate zoospores, each of which on liberation from zygote, grows into an independent plant of Chlamydomonas

INTEXT QUESTIONS

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

   ____

2. Where does meiosis occur in Chlamydomonas ?

   ____

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

   ____

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

   ____

5. Define the term zoospore and aplanospore.

   ____

Spirogyra (A Multicellular Algae)

Structure

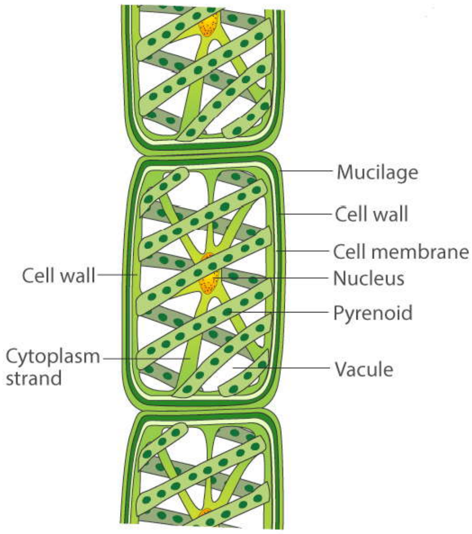


Fig: Spirogyra cell structure

(i) It is a free floating algae found in fresh water ponds with a row of cylindrical cells joined end to end (filamentous form).

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

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

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

Reproduction

A. Vegetative Reproduction by fragmentation:

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

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

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

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

- Two filaments come to lie very close to each other so that the cells of the two filaments pair septum to septum and face to face to contact with the help of a tube called the conjugation tube.
- Cytoplasmic contents of each cell round off to act as a gamete.
- Gamete from one cell (male) passes to the other cell (female) through the conjugation tube, by amoeboid movement.
- The cells of each filament acts either as male or female.

- The contents of two gametes fuse in the female cell and form a diploid zygote. Consequently, after the sexual fusion of gametes, all the cells of male fitament are empty whereas each cell of the female filament has one thick-walled diploid zygospore.
- The zygospore develops a thick wall around itself and develops dark brown to black pigment to tide over the unfavourable period.
- On the return of favourable conditions the diploid nucleus divides by meiosis into four haploid nuclei. Three of these nuclei degenerate.
- On germination, wall of the zygospore ruptures and a small tube like structure, containing one haploid nucleus comes out.
- The small tube develops into a long filament by repeated mitotic cell divisions.

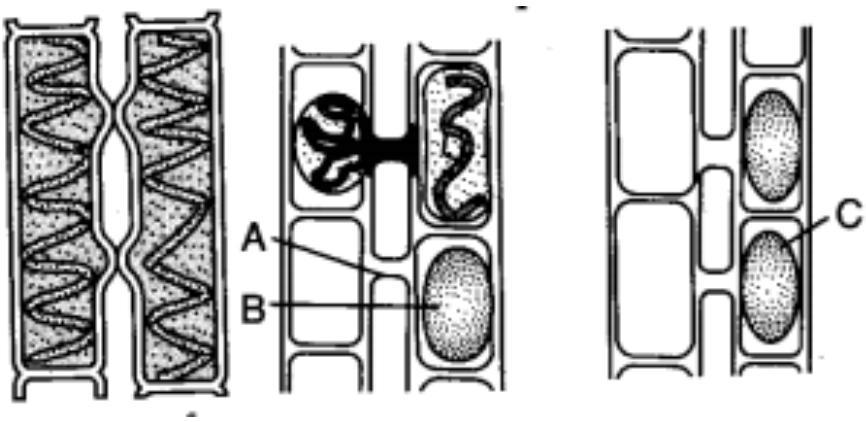


Fig : Conjugation in Spirogyra.

(A) Contents of one cell (male gamete) migrate to the other through the tube and fuse to form the zygote. (B) Zygote develops thick wall and form a zygospore (C) The zygospore germinates.

Lateral Conjugation :

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

to produce only one independent plant, because 3 haploid nuclei after meiosis, degenerate.

- The cell in the main plant body form the gametes without meiosis, therefore Chlamydomonas and Spirogyra are gametophytes (haploid).
- Gametophyte Produce gametes Gametophyte Always Haploid.

INTEXT QUESTIONS

1. Vegetative reproduction in Spirogyra takes place by means of

   ____

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

   ____

3. When does meiosis occur in Spirogyra ?

   ____

4. How many filaments are involved in lateral conjugation ?

   ____

REPRODUCTION IN ANGIOSPERMS (FLOWERING PLANTS)

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

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

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

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

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

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

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

Initiation of flowering

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

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

Factors Affecting Flowering

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

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

Photoperiodism : It is the biological response, in growth and flowering, to the duration of light and dark period received by a plant in a specific sequence.

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

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

Parts of a flower :

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

(a) Calyx - consisting of sepals.

(b) Corolla - consisting of petals

(c) Androecium - consisting of stamens

(d) Gynoecium or pistil - consisting of carpels.

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

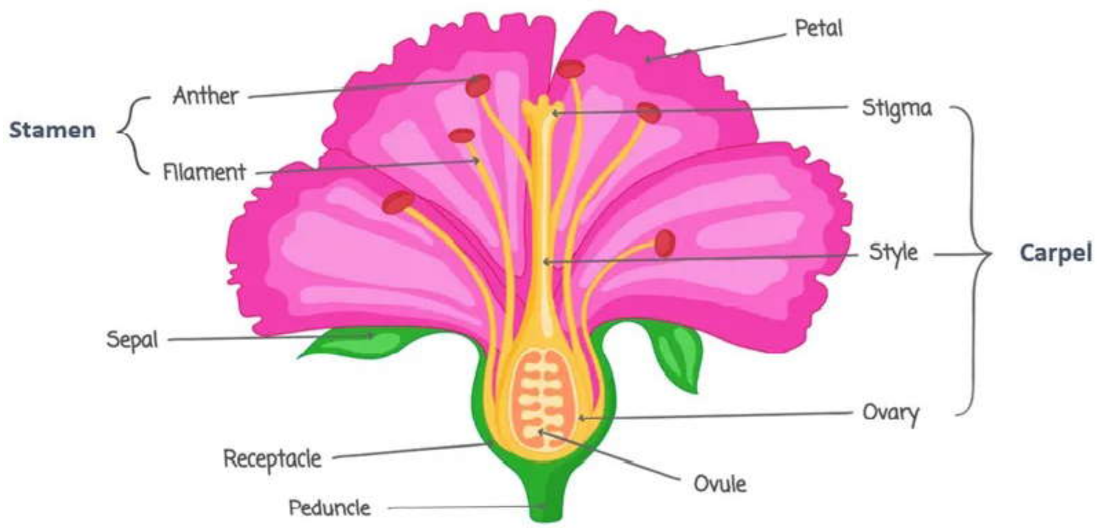


Fig Angiospermic flower L.S

INTEXT QUESTIONS

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.

   ____

STAMEN, MICROSPORANGIA AND POLLEN GRAIN

Stamen: The pollen producing part of a flower, usually with a slender filament supporting the anther. Anther is the part of the stamen where pollen is produced is also called microsporangium.

Microsporangium is having lobes (Mono/Bi-lobed) that function as pollen sacs. The structure of Microsporangium consists of a round circular outline, covered by four layers. They are

1. A singular epidermis elongates and eventually falls off the plant when it reaches the stage of maturity.
2. Endothecium- cells contain fibrous endings.
3. Middle Layers- these usually break off in fully developed and matured anther.
4. Then comes the layer of uninucleate (single), binucleate (two) or multinucleate (many) layers of the innermost cell layer in the anther, also called the tapetum used for nutrition.

The outermost layers of the Microsporangium protect the microspores and also involving releasing of Pollen grains.

As the anther develops, the sporogenous tissue present in the centre of the anther undergoes meiotic division to form microspore tetrads. Each sporogenous tissue we called as pollen mother cell or microspore mother cell. The process of formation of microspore from the pollen mother cell is known as microsporogenesis. Usually, microspores are arranged in the form of tetrads. The pollen grain is released when the anther matures and dehydrates.

* pollen grains also called male gametophyte or microspore, which are haploid status.

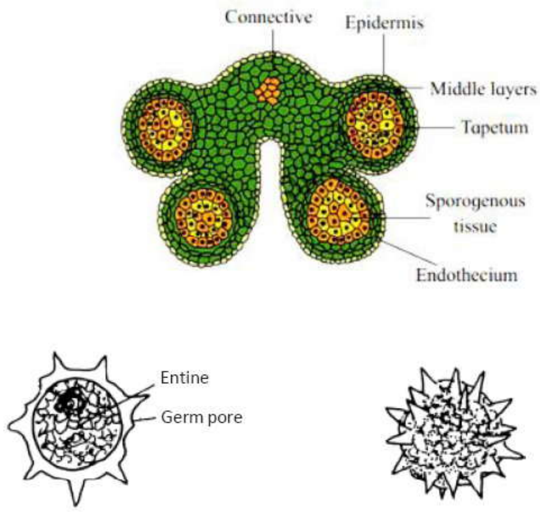


Fig : Anther T.S. and Pollen Grains

Pollen grains or Micro spore or Male gametophyte

The pollen grain surrounded by two layer the outermost layer is called Exine which made up with sporopolenin, the inner most layer is called intine which made up with cellulose and pectin.The pollen grains that have reached maturity contain two distinct types of cells. These cells are both generative and pollen tube cells. After germination of pollen on stigma. the tube cell dissappears and Generative cells which divides to form two gametes or sperm inside the tube.

The pistil, megasporangium and embryo sac

The ovule is enclosed by two integument and by leaving an aperture called micropyle. The ovule is attached to ovary wall by a stalk called funiculus. The region of the ovule opposite to the micropyle is called Chalaza

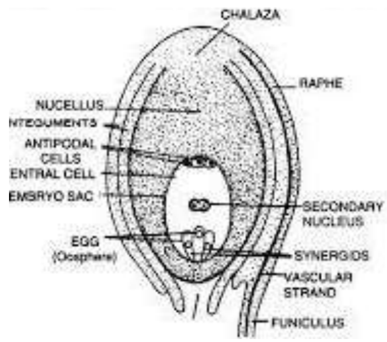


Fig : Ovule or megasporangium and embryo sac

Female gametophyte :

The gynoecium or pistil represents the female reproductive part in the flower. Eachpistil consists of a stigma, style and ovary. The ovary contains one or more ovules which after fertilization, gives rise to the future seeds. The integuments surround the nucellus all around but leave narrow passage called micropyle.

Within the nucellus, a single hypodermal cell (below the epidermis) enlarges and becomes the megaspore mother cell, which undergoes meiotic division and gives rise to four haploid megaspore cells, usually three of them degenerate and the remaining one becomes the functional megaspore. The functional megaspore enlarges and its haploid nucleus undergoes three successive mitotic divisions. As a result 8 haploid nuclei are formed. This enlarged oval shaped structure with eight haploid nuclei is referred as the young **embryo sac**. out of eight nuclei, initially four remain towards the micropyle end and the other four towards the chalazal end. One nucleus from each pole then moves towards the centre and forms a pair of polar nuclei . These nuclei fuse together and form 2n nucleus, the definitive nucleus. It is also known as polar fusion nucleus or secondary nucleus. . The three nuclei of the micropylar end form the egg apparatus and the rest three at the chalazal end are called antipodal cells. In the egg apparatus, each nucleus is surrounded by viscous mass of cytoplasm without any wall, of which the middle one is the largest and called egg, and the rest two (one on each side of the egg) are the synergids. The antipodal cells have viscous mass of cytoplasm, covered by cellulosic wall. In this condition the ovule awaits fertilization which must be preceded by pollination.

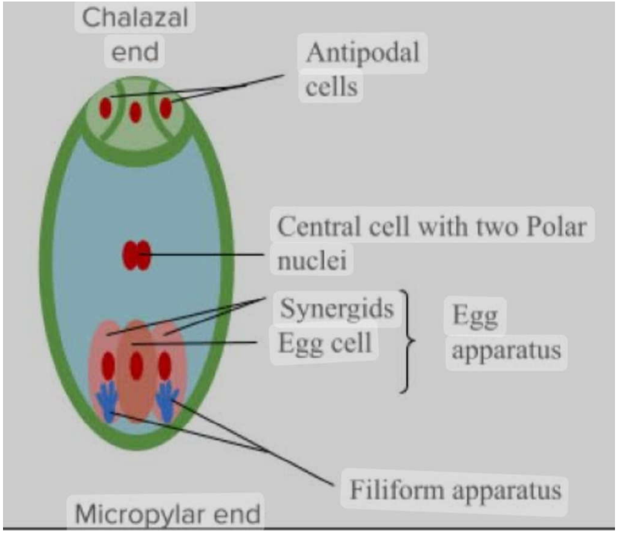


Fig : Embryo Sac

Function of embryo sac cells:

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

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

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.

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

INTEXT QUESTIONS

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

   ____

2. Name the organ where pollen grains are formed

   ____

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

   ____

5. What is the Secondary nucleus?

   ____

6. What is the function of Synergid cells

   ____

POLLINATION

Transferring pollen grains from a flower's male anther to its female stigma is called pollination.

Simply the pollination is Transfer of pollen grains from the anther to the stigma of a flower.

Pollination types

Pollination is two types 1. Self Pollination, 2. Cross pollination

Self pollination: Self pollination is when pollen grain from the anther of a flower falls directly on the stigma of the same flower. Ex: Pea

Cross pollination: Transferring pollen grains from a flower to the stigma of another flower of another plant belonging to the same species is called cross pollination. Ex: maize

Based on the pollination vectors Pollination is following types:

(i) Anemophily - Pollination by wind. Ex: Grasses

(ii) Entomophily - Pollination by Insects. Ex: *Salvia*

(iii) Hydrophily - Pollination by water. Ex: *Hydrilla*

(iv) Zoophily - Pollination by Animals. Ex: *Canna*

INTEXT QUESTIONS

1. What Is The Pollination?

   ____

2. Define Cross Pollination?

   ____

3. What is the Entomophily?

   ____

FERTILIZATION

- Pollen grains on reaching the right stigma become three-celled (if they are not3-celled bearing two male garmetes and one tube cell or vegetative cell) andbegin to germinate.
- Each pollen grain forms a small tube like structure called pollen tube which emerges through the germ pore. The contents of the pollen grain move into the tube and the tube nucleus occupies the tip of the pollen tube.
- Pollen tube grows through the tissues of the stigma and style and finally enters the ovule through the *micropyle*.
- Vegetative nucleus or the tube nucleus degenerates and the two sperms (or male gametes), now occupy the tip of the pollen tube.
- Tip of pollen tube passes through one of the synergids and bursts to release the two sperms into the embryo sac.
- One sperm fuses with the egg (syngamy) and forms a diploid zygote. The other sperm fuses with the secondary nucleus to form the primary endosperm nucleus which is triploid in nature. Since two types of fusion, syngamy and triple fusion take place in an embryo sac, the process is termed as **double fertilization**.
- After triple fusion, the triploid primary endosperm cell develops into anendosperm. Endosperm provides food to the developing embryo.
- The synergids and antipodal cells also degenerate to contribute nutrition to the young embryo.

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 changes

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

Post Fertilization changes :

Ovary	Fruit
Ovule	Seed
Integuments	Seed coat
Zygote	Embryo
Primary Endosperm Nucleus	Endosperm

Ensosperm:

After fertilization primary endosperm nucleus repeatedly undergoes mitotic divisions and form Endosperm.

Endosperm types:

a) **Nuclear Endosperm**: It is the most common type of endosperm found. In this typePEN divides mitotically without cell wall formation. It results in the formation of a large number of free nuclei in the cell. A large central vacuole is formed and nuclei get arranged at the periphery. There are more nuclei at the chalazal and micropylar end, compared to the sides. At this stage, cell wall formation takes place from the periphery towards the centre and multicellular endosperm is formed. Examples: maize, rice, wheat, cotton, sunflower.

At this stage, cell wall formation takes place from the periphery towards the centre and multicellular endosperm is formed. Examples: maize, rice, wheat, cotton, sunflower

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

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

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

Development of embryo

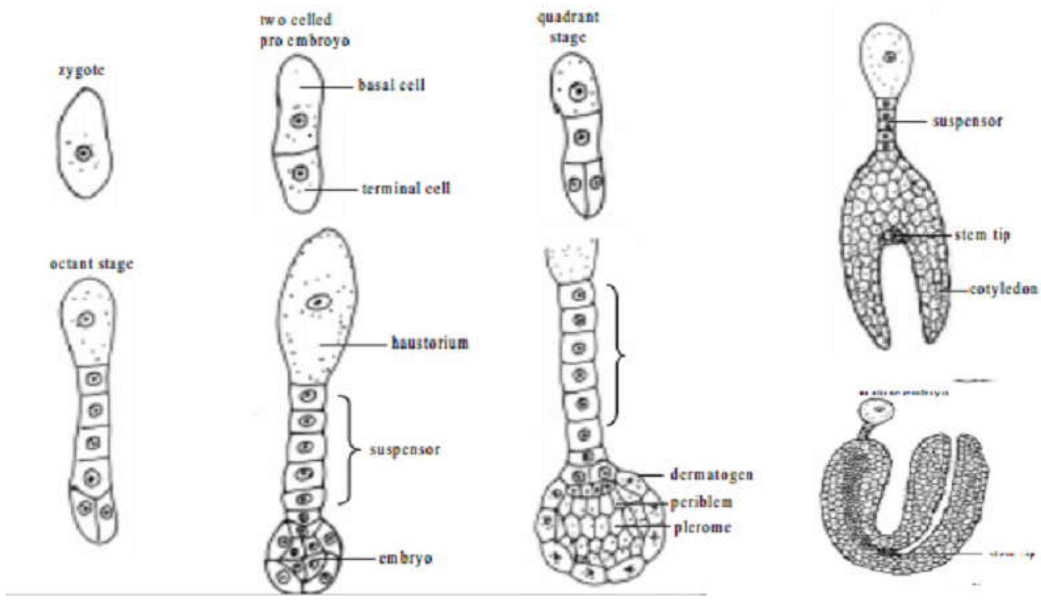


Fig : Devlopment of Embryo

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

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

(iii) The suspensor cell push the embryo in to endosperm to get nutrients

(iv) The embryonic cell divides many times and forms three parts they are radicle, plumule and cotyledons.

(v) The integuments hardened and turn to seed coat to protect seed.

(vi) Thus seed have may be dictylednous with two cotyledons (pea, gram) or m Monocotyledonous with one cotyledon (wheat, rice).

POLYEMBRYONY

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

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

2. The zygote may divide to give rise to two or more cells each of which develops

Into a separate embryo. This is called **cleavage polyembryony.**

SEED

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

The seed may have three parts

a) Seed coat: it have two layers namely Testa and Tegman

b) Embryo: Embryo divided into parts, namely: 1. embryonic axis, which is further divided into plumule and radicle, 2. Cotyledons: one or two; if one was present, we called it monocotyledon seed; if two were present, we called it dicotyledon seed.

c) Endesperm: Some seeds have endosperm; such seeds are called almunious seeds.

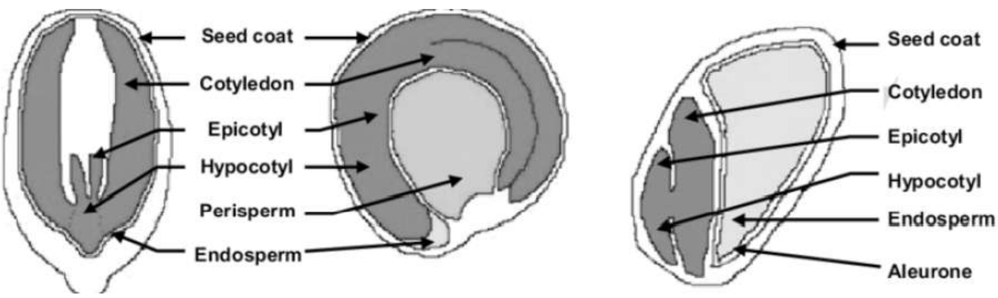


Fig : Dicotyledon Seed *Monocotyledon Seed*

Importance of Seed

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

FRUIT

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

Significance of Fruit :

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

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

(i) Starch is converted into sugar.

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

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

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

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

INTEXT QUESTIONS

1. Define seed
2. What part of Flower turns as a fruit?
3. List of the parts mature seed.
4. Development of an embryo from a cell of embryo sac other than egg is an example of……….
5. What is the Parthenocarpy?

SEED GERMINATION

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

Steps of germination

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

Germination can be of two types

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

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

VEGETATIVE REPRODUCTION IN ANGIOSPERMS

Reproduction of new plants arises from vegitative parts of plant, which is very common in angiosperms. It is called vegitative reproduction. Stems, roots, leaves, and even buds are able to produce new plants; this is called "natural vegetative reproduction.

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

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 offset (*Pistia*) and sucker (*Chrysanthemum*) are also used for vegetative propagation.
2. Similarly, tuberous roots (*Asparagus* and sweet potato) can also be used for propagation as these roots have adventitious buds which grow into a new plant.
3. Sometimes even leaves contribute to propagation of plants for example, leaves of *Bryophyllum* and *Kalanchoe* have buds on the margin and these buds grow into small plantlets. When detached from the mother plant they grow into independent plants.
4. In plants like *Agave* and *Oxalis* multicellular bodies called bulbils develop from flower-buds. These are called bulbils which when fall on the ground, grow into new plant.

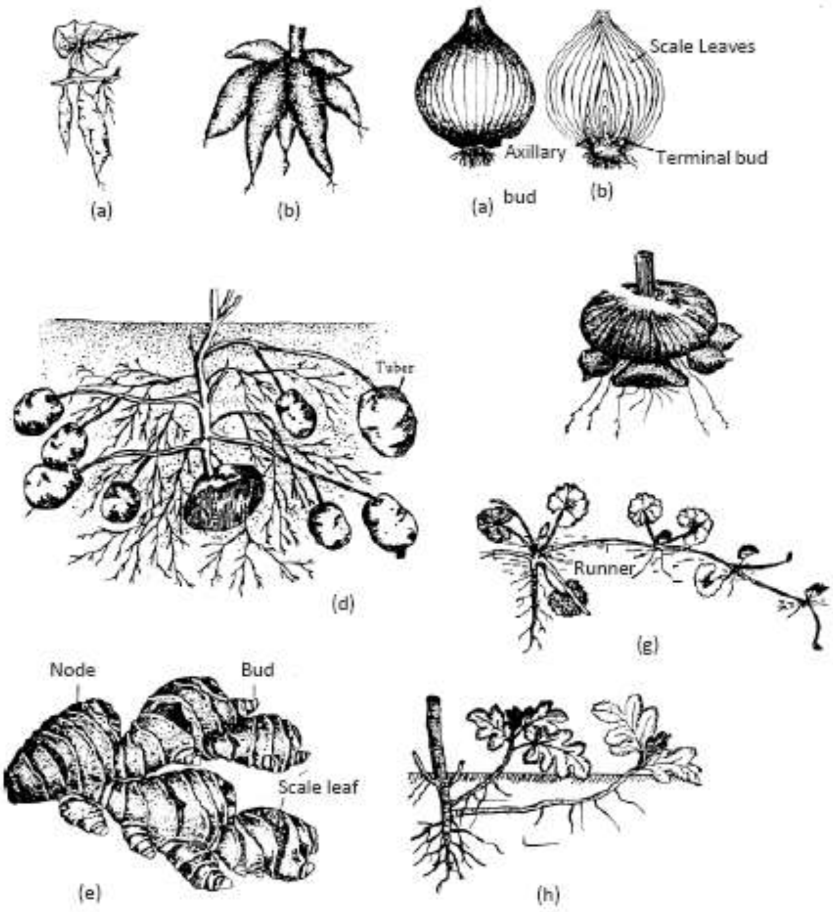


Fig: Organs modification involving vegitative propagation

a) Sweet potato **b)** Dahlia **c)** (a) Bulb of onion (b) L.S. of bulb **d)** Tuber of potato **e)** Rhizome of Ginger **f)** Corm of colocasia **g)** Runner of grass **h)** Sucker of Chrysanthemum

ARTIFICIAL METHODS

we use the vegetative parts for propagating crops or ornamental plants it is termed as **artificial vegetative propagation**.

The following methods are using in Artifisial vegtative reproduction.

a) **Cuttings:** Cutting is a detached vegetative part of a plant, which on separation and planting is able to itself into a new plant. It is an easy and quick method of propagation. The method is named after the part of plant used for cutting, e.g., stem, root and leaf. Many plants like rose, *Bougainvillea*, *Croton*, Coleus, money plant,and sugarcane are grown through their stem cuttings.

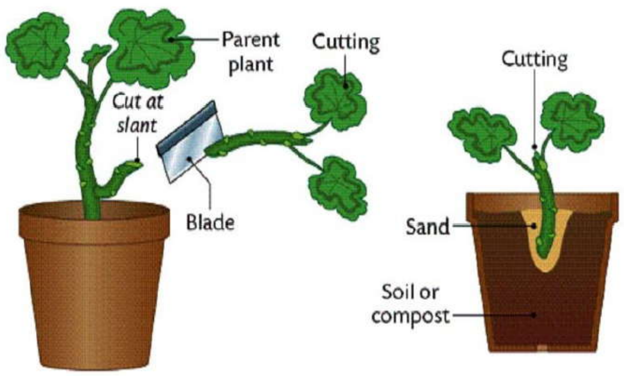


Fig: Cuttings

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 bentdown 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. EX: Jasmine

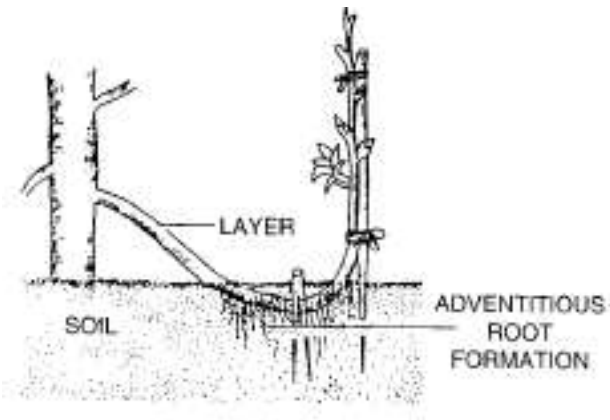


Fig: Layering

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

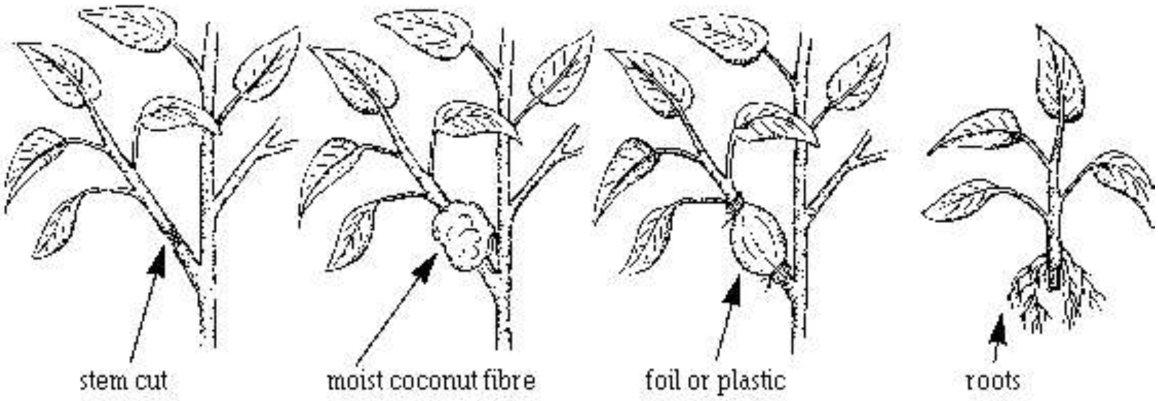


Fig: Aerial Layering

d) **Grafting :** It is especially important for propagation of seedless varieties of plants. It consists of inserting a small branch into a rooted plant. The rooted plant, taken as a stock is resistant to diseases and is physically sturdy. In this stock a branch is inserted which is known as scion or graft. This scion or graft is the stem cutting from the desired plant. Usually the grafted end of stock and scion fit well with each other and are bound firmly with tape or rubber-band until their tissues unite and vascular continuity is established. Grafting is mostly practiced 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.

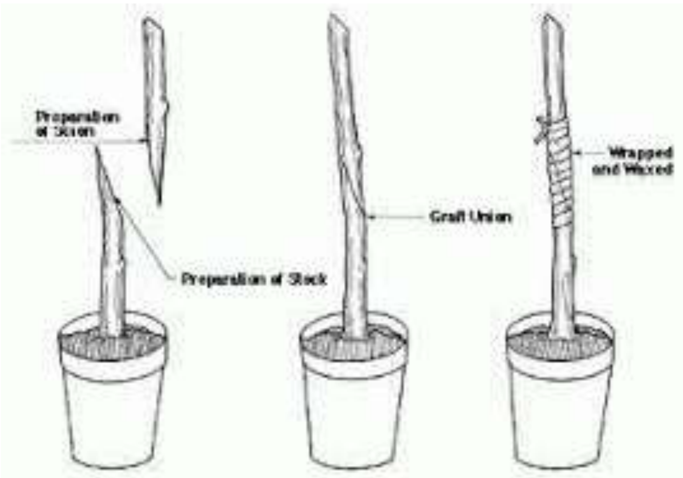


Fig: Grafting

Advantages and Disadvatages of Vegetative Reproduction

Advantages

a) Rapid means of reproduction and spread.

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

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

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

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

Disadvantages

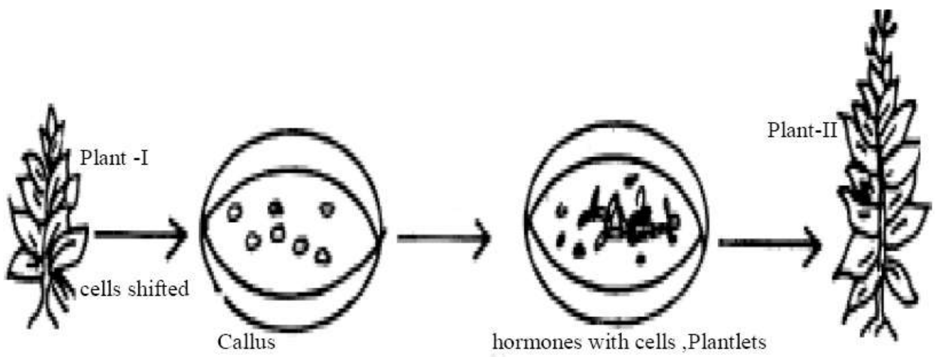
(a) Over crowding and competition for space unless separated artificially.

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

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

THE MICROPROPAGATION

The technique of plant tissue culture is utilized for propagation of plants. The process is explained below with the help of diagrams. A small piece of tissue, organ or even a single cell is taken from a plant and is transferred to a sterilized container with nutrient medium in aseptic conditions. The tissue grows very-very fast into an unorganized mass, called **callus**. The callus can be maintained and multiplied for an indefinite period. When small portions of the tissue are transferred to another specialized 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.



Steps of micro propagation

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 and *Chrysanthemum* micropropagation is being successfull and used in commercial scale.

INTEXT QUESTIONS

1. What is the difference between natural vegetative and artificial vegetative reproduction?
2. Give two examples for a)cuttings, b) Layering, c) Grafting
3. What is the Micropropagation.
4. Give two examples of plants propagated through micropropagation.

What you have learnt

- Chlamydomonas reproduces asexually by zoospores and sexually by isogamy, anisogamy and oogamy.
- *Spirogyra* reproduces by vegetative fragmentation, and sexually, by lateral conjugation and scalariform conjugation.
- In angiosperms flowers are the organs of sexual reproduction.
- Temperature and light are two main factors which influence flowering.
- Stamens and carpels are the male and female reproductive organs, respectively.
- Male gametes are produced in pollen grains, formed inside the anther, and pollen grains, are regarded as the male gametophytes in flowering plants.
- Female gamete is produced in the embryo sac in the nucellus of the ovule. The mature embryo sac is the female gametophyte of flowering plants, having 3-celled egg apparatus, three antipodal cells and a secondary cell having diploid secondary nucleus.
- Egg cell fuses with one of the male gametes received from pollen grains. Secondary nucleus fuses with the other male gamete. Occurrence of two such fusions is called two flowers borne on the same plant or on two **double fertilisation**.

- Pollination is the transference of the pollen grains from anther to stigma. It may be in the same bisexual flower of a plant (self pollination) or in different plants (cross-pollination).Wind, water, insects and animals are agencies of cross pollination.
- Wind pollinated flowers have light pollen grains or winged pollegrains and the stigma is usually large, hairy and projecting out of the flowers.
- Insect pollinated flowers are usually large, brightly coloured, scented and with nectar.
- Most plants have devices to favour cross pollination.
- The zygote develops to produce an embryo.
- The embryo is present in the ovule which later becomes seed and fertilized ovary on maturity becomes fruit.
- Development of fruit without fertilisation is called parthenocarpy.
- Ripening of fruit involves chemical changes in the stored food and pigments of the fruit wall.
- Vegetative reproduction is the production of new plants from plant parts other than flower and seeds.
- Specialised plant parts which bring about vegetative reproduction are as follows

(a) Roots - tuberous root of *Dahlia*

(b) Stems - runners and suckers near ground surface, rhizomes, tubers, corm and bulb are underground parts.

(c) Leaves - adventitious buds in leaf notches as in *Bryophyllum*.

(d) Bulbils - Modified buds in the inflorescence of pineapple called bulbils are also used for vegetative propagation.

- All the above kinds of parts have been used by man in agriculture and horticulture as artificial methods of vegetative propagation.
- Micropropagation by tissue culture enables production of little plants on a large scale.
- Vegetative reproduction is rapid, easy and cheap. The plants produced are genetically identical to the parent plant.

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.
4. Give significance of pollination.
5. Draw a labelled sketch of a mature ovule.
6. Give a labelled diagram of a mature pollen grain.
7. Mention important characteristics in Anemophilous and Hydrophilous plants.
8. Give the significance of fertilisation.
9. Mention the changes that take place when the fruit ripens.
10. Define the following terms :

    (a) Corm (b) Scion (c) Callus

    (d) Micropropagation (e) Vegetative reproduction
11. In what ways do plants reproduce vegetatively without human assistance ?
12. In what ways do plants reproduce vegetatively with human assistance?
13. Define and give an example of each of the following:

    (a) Rhizome (b) Stolon (c) Cutting

    (d) Layering (e) Grafting

    14. What are the advantages and disadvantages of vegetative reproduction?

15. In what way is vegetative reproduction simple?
16. Write short notes on

    (a) Runner (b) Sucker (c) Bulb (d) Tuber
17. In brief describe the various steps of micropropagation.

19. What is the significance of micropropagation ?

19. If a branch of dasehri mango is grafted on a tree producing desi mango. What type of mangoes will be produced on the grafted branch and on other branches of the tree?

19 GROWTH AND DEVELOPMENT IN PLANTS

If you sow a seed in your garden or in a pot, you will notice a tiny seedling growing from the seed within a few days. The little seedling grows in size, the number of leaves rises, and eventually it matures and produces flowers and fruits. This is the growth and development process. 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 completing 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.

GROWTH AND DEVELOPMENT

Growth is a characteristic of living organisms; it is a permanent change in the size, weight, and volume of the plant.

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

Growth in living organisms is not uniform throughout the life span. Growth takes place at a faster rate till the plants or animals attain maturity. Then it slows down and at a particular time it stops. Later in life death occurs. All these changes that occur in an organism starting from its beginning till its death may collectively be termed as development.

Development is associated with morphogenesis and differentiation. Morphogenesis is the process of development of shape and structure of an organism; and differentiation is the process of change in cells, tissues or organs to carry out different functions.

STAGES OF CELLULAR GROWTH

The growth of an organ or an organism occurs in three successive stages. They are

(i) Cell division : The number of cells increases due to mitosis

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

(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.

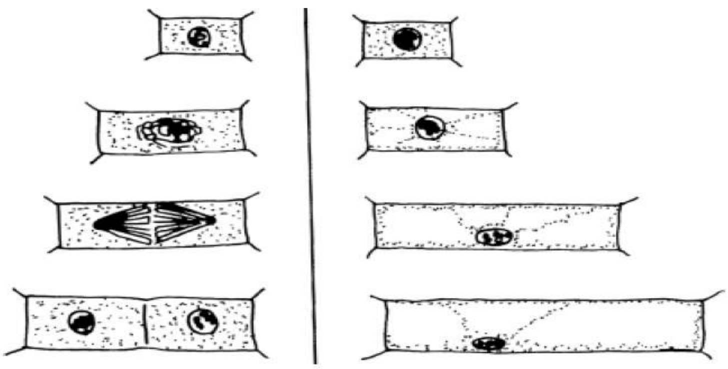


fig : (a)Cell Division *(b) Cell Enlargement*

Comparison of cell division and cell enlargement

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

GROWTH CURVE

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

This curve has three phases of growth.

(i) Lag Phase

This is the initial phase of growth when the rate of growth is very slow.

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

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

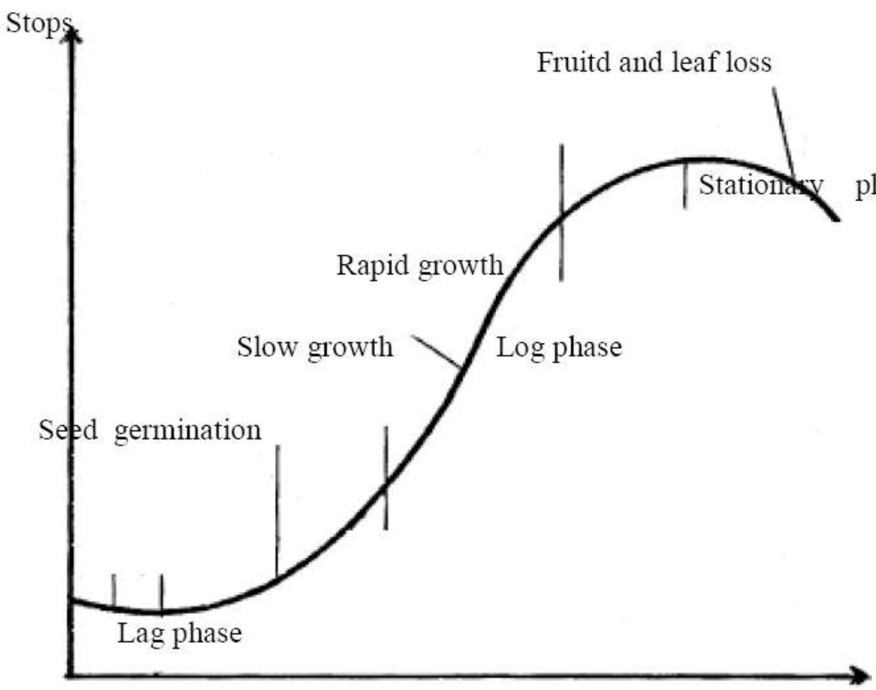


Fig : Sigmoid curve

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

Measurement of growth

Let us know how to assess growth in plants once we know about the many stages of growth. Plant growth is a quantitative phenomenon that may 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.

DIRECT METHOD

We know that most plant growth occurs at the apical area. As a result, increase in length can be directly quantified using an ordinary measuring scale at any giventime interval.

ACTIVITY

Aim

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

What do you require?

Thread, a piece of stone and a measuring

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?

Prepare a table and record measurements.

No of the Week	Length in cms
1	
2	
3	

AUXANOMETER

We can use a specially designed tool called an auxanometer to measure length more accurately. It can be used to calculate the rate of growth of plant shoot length. A thread is attached to the tip of a potted plant's stem and suspended on the auxanometer's pulley. The thread's opposite end is attached to a weight. A long needle slides over a graded arc to secure the pulley. The weight of the stem pulls the thread down as it develops in length. The arc scale is used to read the movement of the needle.

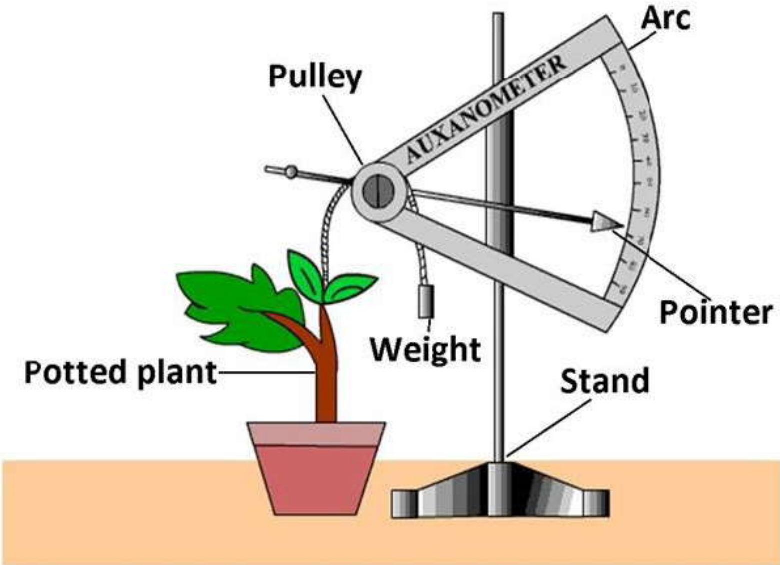


Fig : Auxanometer

FACTORS AFFECTING PLANT GROWTH

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

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: Light is essential for photosynthesis, the process by which plants convert sunlight into energy. Besides photosynthesis, light is also essential for seed germination, growth of seedling, differentiation of various tissues and organs, and reproduction

(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: Adequate water is crucial for plant growth as it serves as a medium for nutrient uptake and is involved in various physiological processes like photosynthesis and other biochemical processes. Insufficient water can lead to wilting and hinder nutrient transport, while excessive water can cause root rot or suffocation due to lack of oxygen.

(iv) Mineral Nutrients: Plants require a range of essential nutrients for proper growth and development. These include macronutrients like nitrogen, phosphorus, and potassium, as well as micronutrients like iron, zinc, and magnesium. Imbalances or deficiencies in nutrients can lead to nutrient disorders, yellowing leaves, and poor growth.

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.

Plant development can also be regulated by synthetic compounds that are structurally and functionally similar to plant hormones. These are known as growth regulators. Plants do not make them 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

(i) Auxin

Auxin is a plant hormone that promotes growth and is typically produced by the growing apex of the stem and root in plants. It plays a crucial role in the elongation of shoot and root tips located behind the apical meristem. The naturally occurring auxin in plants is called Indole-3-Acetic Acid (IAA). However, synthetic auxins produced through chemical synthesis can also exhibit similar physiological responses to natural auxin.

Some examples of synthetic auxins include Indole-3-butyric acid (IBA), 2,4-Dichlorophenoxy Acetic Acid (2,4-D), and Naphthalene acetic acid (NAA). These synthetic auxins can mimic the effects of natural auxin and promote growth in plants.

The term "auxin" is derived from the Greek word "auxein," which means "to grow." Interestingly, auxin was first isolated from human urine.

An important experiment conducted by Fritz Went on oat seedlings demonstrated the effect of auxins. In this experiment, the tip of the oat coleoptile (early shoot) was removed, causing growth to stop. The removed tip was then placed on an agar block, which is a gelatinous material derived from seaweed, for approximately an hour. Subsequently, the agar block containing the tip was positioned on the cut end of the seedling. It was observed that the growth of the seedling resumed. This indicated that there was a substance present in the cut tip that transferred to the agar block and facilitated the restart of growth. This substance was named "auxin," which is now known to be a plant hormone involved in various growth processes.

Functions of Auxin

1. It promotes cell elongation;
2. 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.
3. NAA (Naphthalene acetic acid) is used for preventing fruit drop in apples before they are ripe.
4. 2, 4-D (2, 4-dichlorophenoxy acetic acid) acts as a dicot weedicide.

(ii) Gibberellin

Gibberellin or Gibberellic Acid (GA) was initially isolated from a fungus Gibbe

Functions of Gibberellins

1. It helps in elongation of stems in genetically dwarf plants. By using gibberellin the height of the dwarf plants can be increased.
2. It breaks dormancy of seeds and buds.
3. It induces parthenocarpy. (Formation of seedless fruits without fertilization) or provides stimulus received by pollination.

(iii) Cytokinins :

Cytokinins were extracted from coconut milk. Heredity Cytokinins are synthesized in root apex, endosperm of seeds, and young fruits where cell division takes place continuously.

Functions of Cytokinins

1. They stimulate cell division, cell enlargement and cell differentiation.
2. They prevent aging of plant parts.
3. They inhibit apical dominance and help in growth of lateral buds into branches.

(iv) Ethylene

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

Functions of Ethylene

1. It induces ripening of fruits.
2. It promotes senescence and abscission of leaf, and flowers.
3. In cells it only increases the width not the length.

(v) Abscissic acid

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

Functions of Abscissic acid:

1. It induces dormancy of buds and seeds as opposed to Gibberellin, which breaks dormancy.
2. It promotes the senescence of leaf, i.e., fall of leaves happen due to abscissic acid.
3. It inhibits seed germination and development.
4. It causes closing of Stomata.

PRACTICAL APPLICATION OF GROWTH REGULATORS

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

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

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

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

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

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

(vi) Weed Control: Growth regulators can be employed as herbicides to control weed growth. Herbicides like 2,4-D (2,4-dichlorophenoxyacetic acid) and dicamba are examples of growth regulators used for weed control.

Differentiation, Dedifferentiation and Redifferentiation

In plants, the processes of differentiation, dedifferentiation, and redifferentiation are essential for growth, development, and regeneration. These processes involve changes in the specialization and function of plant cells.

Differentiation: Differentiation is the process by which cells become specialized to perform specific functions. During plant development, cells undergo differentiation to adopt distinct cell types, such as root cells, leaf cells, or flower cells. Differentiation involves changes in gene expression, morphology, and metabolism to give rise to specific cell types with specialized structures and functions.

Dedifferentiation: Dedifferentiation refers to the process in which specialized cells revert back to a less specialized or undifferentiated state. This process allows cells to regain their ability to divide and initiate cell growth. Dedifferentiation often occurs in response to injury, stress, or during plant regeneration processes, such as tissue culture or wound healing. Dedifferentiated cells are often referred to as "totipotent" or "pluripotent" because they have the potential to develop into different cell types and regenerate into whole plants.

Redifferentiation: Redifferentiation is the process in which dedifferentiated cells re-establish their specialized structures and functions. After dedifferentiation, cells undergo redifferentiation to regain their specific cell type and function. This process involves reactivation of specific genes and reorganization of cellular structures to restore the specialized features of the cell type. Redifferentiation is crucial for tissue regeneration and the formation of new organs or structures in plants.

INTEXT QUESTIONS

1. Name the plant hormones concerned with the following:

   (i) Elongation of cell ______________________

   (ii) Shedding of leaves ______________________

   (iii) Breaking seed dormancy ______________________

2. Mention two functions of Auxin

   (i) ______________________

   (ii) ______________________

3. What is the difference between dedifferentiation and redifferentiation?

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

5. Write a Function of Ethylene it useful to farmers

SEED GERMINATION

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 favorable 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.

Types of Seed Germination

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

(a) Epigeal germination; and

(b) Hypogeal germination.

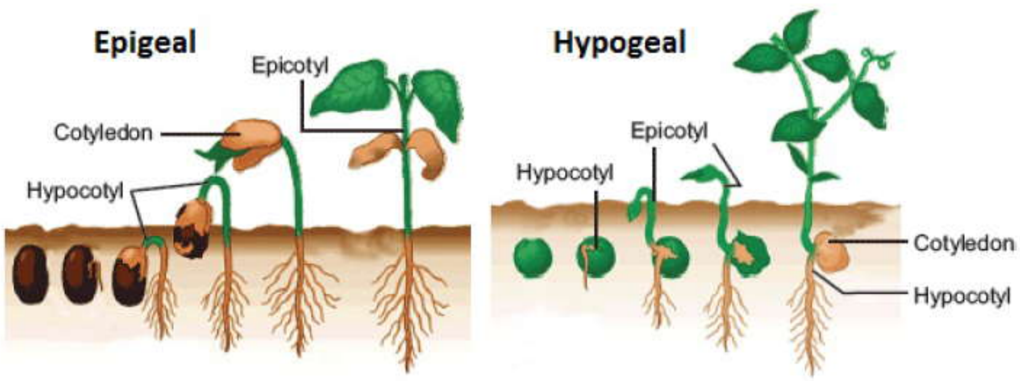


Fig : Seed Germination

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

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

** Some plants, which grow in marshy places show a special type of germination called Vivipary . 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.

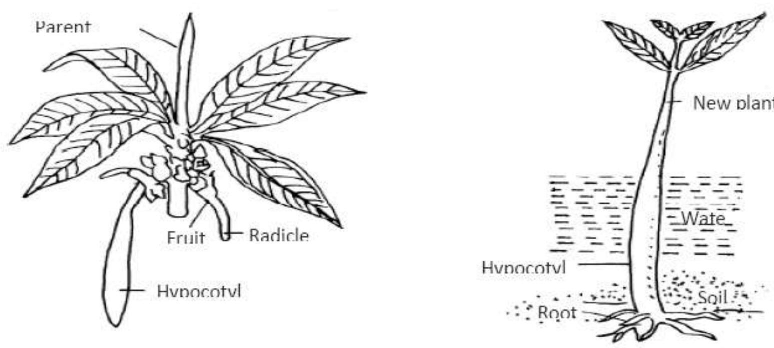


Fig : Viviparous plants

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.

Factors Affecting Seed Germination

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

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

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

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

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

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

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

SEED DORMANCY

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

Seed dormancy is a state of inhibited germination in viable seeds, where conditions necessary for germination are not met, even though the seed is physiologically capable of germinating. Dormancy is an evolutionary adaptation that allows seeds to survive unfavorable conditions and germinate when environmental conditions are more favorable for plant growth and survival.

PHOTOPERIODISM – RESPONSES DUE TO LIGHT EXPOSURE DURATION

Photoperiodism in plants refers to the response of plants to changes in the duration of daylight and darkness, which influences their growth, development, and reproductive processes. Plants have evolved to sense and utilize photoperiod as a crucial environmental due to determine the appropriate timing for various physiological events, such as flowering, germination, dormancy, and leaf senescence.

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

Based on their response to day length, plants can be categorized into three main groups:

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

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

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

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

ROLE OF FLORIGEN AND PHYTOCHROME IN FLOWERING

After the discovery of effect of light on flowering, the scientists tried to find out the hormone responsible for flowering in plants. It is hypothesized that a plant hormone called **Florigen** is responsible for initiation of flowering in plants.

Florigenis a hypotheticals flowering stimulus synthesized in the leaves under favourable photoperiod, which migrates to shoot apex where flowering occurs.

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

$$\mathrm{r} \underset{\textit{Far-red light}}{\overset{\textit{Red Light}}{\rightleftarrows}} \mathrm{fr}$$

Inter-conversion of the phytochrome into Pr and Pfr

VERNALISATION—APPLICATION OF LOW TEMPERATURES

Vernalization is a process in which the exposure of plants to a period of cold temperatures induces or enhances their ability to flower. It is a phenomenon commonly observed in many biennial and winter annual plants, but it can also occur in some perennial plants.

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

Practical Utility of Vernalisation

Vernalisation has some practical applications like:

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

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

SENESCENCE/AGING OF PLANTS

Senescence, also known as aging, is a natural and programmed process in the life cycle of plants. It refers to the gradual deterioration and eventual death of plant organs or the whole plant itself. Senescence occurs in various parts of the plant, including leaves, flowers, fruits, and the entire plant during its reproductive phase.

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

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

ABSCISSION – SHEDDING OFF

Abscission is the natural process by which plants shed or drop leaves, flowers, fruits, or other plant organs. It is a tightly regulated and controlled process that allows plants to discard old, damaged, or unnecessary structures.

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.

Plants, like any living organisms, can experience various types of stress. Stress in plants refers to adverse environmental conditions or physiological imbalances that disrupt normal plant growth, development, and function. These stressors can be biotic (caused by living organisms) or abiotic (caused by non-living factors). Here are some common types of stress that plants can face:

(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 enlargementis 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, andcauses blackening of root tips and yellowing of leaves.

(b) Salt Stress

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

PLANT MOVEMENTS

Plants exhibit various types of movements in response to external stimuli. While they lack the ability to actively move from one location to another, they have evolved mechanisms that allow them to respond to their environment. Here are some notable plant movements:

a) Tropic Movement (directional response or growth movements)

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

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

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

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

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

(b) Nastic Movement Heredity

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 wateris 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 :

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

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

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

4) Seed pods of some plants open on maturity, vigorously expelling their seed.

   Example - Balsam (Gulmehandi).

INTEXT QUESTIONS

1. Distinguish between Phototropism and Geotropism

   ....

2. Give two examples of turgor movement

   ....

WHAT YOU HAVE LEARNT

- Growth in living organisms results from increase in the number and size of a cell, organ or whole organism.
- Development is the whole series of qualitative and quantitative changes (growth, differentiation, maturation), which an organism undergoes throughout its life cycle.
- Growth of cells occurs in three successive stages i.e., cell division, cell enlargement, cell differentiation.
- Plants show three phases of growth - Lag Phase, Log Phase, Stationary Phase
- Auxanometer is a specially designed equipment used to measure the rate of growth of shoot length of plants.
- The external factors that affect the growth of the plant are light, temperature, Water and mineral nutrients.
- The internal factors responsible for plant growth are auxin, gibberellins, cytokinins, ethylene, and abscissic acid. These are substances produced in a small quantity in one part of plant body and capable of moving to other parts to influence the growth of that part.
- Seed germination is the return of metabolic activities and growth by the seed tissue to give rise to a new plant. The germination in seeds is mainly affected by factors like Water, temperature, oxygen, light, and hormone. Flowering plants show two types of germination, epigeal germination; and hypogeal germination.
- Photoperiodism is the biological response in growth, reproduction (flowering) of a plant to the duration of light, which falls on it per day.
- Florigen is a hypothetical plant hormone, which is responsible for initiation of flowering in plants.
- The method of accelerating the ability of flowering in plants by keeping them at low temperature for sometime is called vernalisation

- Senescence is a gradual process during which any plant part or the whole plant completely loses its function and ultimately dies.
- The process of detachment of any leaves, fruits, flower or any part of the plant from the main body after getting older is called abscission.
- Any change in the environmental conditions that may adversely affect the growth or development in plants is called biological stress. This stress occurs mainly due to temperature, water, salt, shade, light, and various pollutants.

TERMINAL EXERCISES

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

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1. **MENDEL EXPERIMENTS**
2. **SEX DETERMINATION**
3. **GENETICS AND HERIDITY**
4. **MOLECULAR INHERITENCE AND GENE EXPRESSION**
5. **GNETICS AND SOCIETY**

1. MENDEL EXPERIMENTS

PRINCIPLES OF GENETICS

The term Genetics was coined by" batson"in 1906 .The word genetics is derived from Greek word "Gen" which means "To become"or To grow into" it deals with the transmission of charectors from one generation to the next generation .The study of Heridity is called "Genetics"

This lession deals with Heridity ,Variations, Recombination and also includes a section on Hereditary disorders and Human karyotype.

Objectives

After completing this lesson , you will be able to;

- Define the terms mineral nutrition, macro and micro nutrients.
- Explain the terms heredity and variation
- Describe mendal's experiments on garden pea and the principles derived
- Define the term hybridization, allels, trait,dominance, recessive, homozygous, heterozygous, genotype, phenotype, mendel laws.
- The term incomplete dominance with the example of flower colour in 4 o ' clock plant(Mirabilis jalapa)
- Define the terms lethal genes and pleotropic genes
- Explain the quantitative(Polygenic) inheritance supported by the example of kernel colour of wheat and skin colour of humans
- Difference between monogenic and polygenic inheritance
- Explain the chromosome theory of heredity
- Define and give example of linkage, crossing over and criss cross inheritance

- Justify mitochondrial inheritance as a case of maternal inheritance
- Discribe the human karyotype
- Differentiate between sex chromosome and autosomes
- List and describe the causes and symptoms of same common genetic genetic disorders Colour blindness, heamophilia,Downs syndrome,Turners syndrome, Klienfelter syndrome
- Discribe the inheritance of Rh factorand explain its significance during pragnacy
- Explain ABD blood group
- Explain the diagnostic technic of aminocentesis and give its significance
- Give a brief idea of human genome.

HEREDITY AND VARIATION

HEREDITY: Whenever an infant is born in a family,the relative begin to surprise about the resemblance of the infant eyes, facial features, complex, colour of hair with those of parents, sibilings and grand parents,The source of such resemblances and differences are in the "Gens" that are transmitted from parent to offspring.This inheritance of genes is termed as "**Heredity"**.

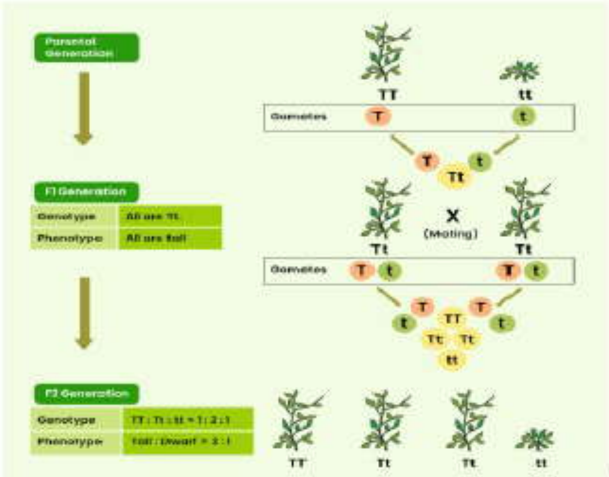
It is further observed that sibilings from same parents are unique and differ from each other except the twins. Such differences are called **Variations.**Variations arise due to **mutation or sudden change** in the genes.**Variations** also arises because genes get shifted and exchanged during the meiosis at the formation of gamates, giving rise to new gene recombinations.at fertilization there is a random mixing of parental chromosomes.such a source of variation which is most common is called recombination

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 plant (**Pisam sativam)** for his experimaents and he was the first person to explain the mechanism involved in the transmission of characters from parents to their offspring or from one generation to the next generation. Therefore he is considered as the pineer of modern genetics and he is called as **Father of Genetics.**

Mendel Experiments

MONOHYBRIDIZATION



Monohybrid cross:

The cross between two parents differing in a single pair of contrasting characters is called monohybrid cross and F1 offspring as the **hybrid**.which are **heterogygous** for a single pair of alleles.(fig.17.1)

Mendel done(experimented) a monohybrid cross between Homogygous(TT)tall and Homogygous(tt)dwarf pea plants.He got all hybrids were heterogygous tall plants inF1 (First filial generation).When F1 heterogygous tall plants were allowed to self pollination.After self pollination in F1 generation,both tall and dwarf plants appeared in F2 (second filial generation)generation.F2 generation consisted of three types of plants

1) Tall Homogygous (pure) plants-TT
2) Tall Heterogygous (hybrid)plants-Tt
3) Dwarf Homogygous (pure) plants-tt

TT (Homogygous Tall Plant) x tt (Homogygous Dwarf Plant)

↓ ↓

T t----------------Gamates

↘ Tt ↙ ------------F1(Generation)

Tt(Heterogygous Tall Plant) x Tt (Self Pollination)

	T	t
T	TT (tall homogygous)	Tt (tall heterogygous)
T	Tt (tall heterogygous)	Tt (dwarf homogygous)

F2 (Generation)

Phenotypic ratio— 1:2:1

Genotypic ratio : 3:1

Phenotype : Physical appearance of any particular characters or traits

Genotype : It is defined as the genetic constitution of an individual for a particular character or trait

TT –Homogygous(pure) tall plants- 1

Tt- Heterogygous tall (hybrid)plant - 2

Tt – Homogygous (pure) dwarf plant -1

In this way mendel tried to cross peaplants with seven such contrasting characters. These are

Sl no	**Character/trait**	**Dominant**	**Recessive**
1	Stem length	Tall	Dwarf
2	Flower position	Axial	Dwarf
3	Flower colour/seed coat colour	Violet	White
4	Pod shape	Inflated	constricted
5	Pod colour	Green	Yellow
6	Cotyledon colour	Yellow	Green
7	Seed form	Round	Wrinkled

Plants with such contrasting characters exist in varieties that are ”self pollination” So that generation after generation they express only one type of feature.Mendel also tried crosses involving two contrasting features, such as Tall and Red flowered with dwarf and White flowerd plant ,such a cross is called “**Dihybrid cross”**

Mendel’s priniciples (Laws) of inheritance

Based on the result of mendel’s experiments ,he postulated the following laws of inheritance,these are ;

1) Law of Segregation or Purity of gamates
2) Law of Dominance
3) Law of Independent assortment

1. Law of segregation or Purity of Gamates

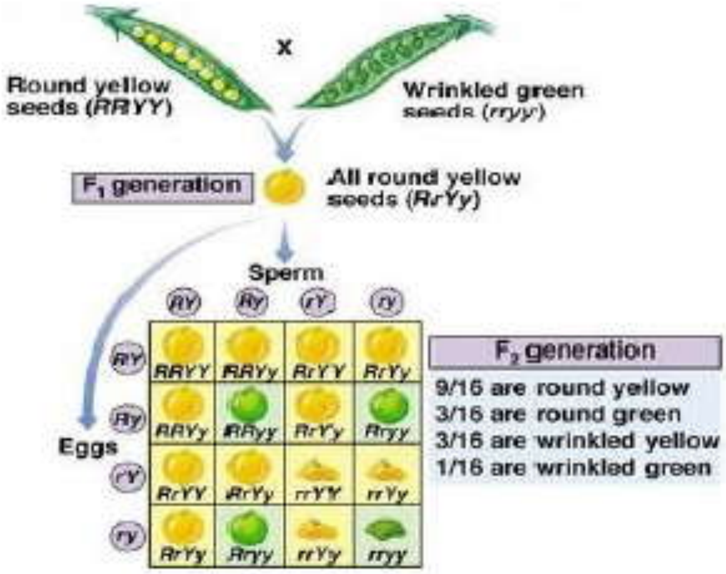
Based on the Monohybrid cross Mendel formulated the law of segregation .According to this law each individual possesses two factore(genes) for a particular character or trait,at the time of gamete formation ,each number of the pair of genes(factores) separate from each other.So that each gamete receives only one factor(gene).these gamates are always pure(Law of purity of gamates)

2. Law of Dominance

One gene which has a dominant (T) and recessive(t) alleles, which are pairup one trait, only dominant trait or character expressed itself in heterogygous condition(Tt)in F1 generation. So in F1 generation expressed character is considered as a dominant character and gene is considered as dominant gene.On the contrary, the character, the character for dwarfness, that could not express itself in the first filial generation (F 2 Generation)

3. Law of independent assortment

Law of independent assortment meaning whereby that in heritance of two features (each feature controlled by a pair of genes), genes for two different features are passed down into the offsring independently.



Self pollination of F1 generation hybrid Yellow and Round plants (YyRr) produce four types of gamates.these gamates, randomly combine to produce 16 possible combinations.

The end result of the dihybrid cross makes it very clear that segregation of the seed colour is independent of the seed shape,In the F2 generation both parental and new combination of the characters appeared, this is assortment of genes of one pair is independent of the other pair.

Phenotypic ratio in its offspring (F2) is 9:3:3:1

Genotypic ratio in the F2 generation is 1:2:1:2:4:2:1:2:1

Reasons for Mendel's success

Mendel selected garden pea,pisum sativam, for his experiments

- It has short life cycle
- It is easy to cultivate
- It has self pollinated bisexual flowers with closed corolla.So pollination can be controlled easily
- It has well-define discrete charecters.

Important terms in Genetics

FACTOR : The unit is responsible for the inheritance and expression of a particular character,the term factor was coined by Mendel.Now factor is 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 a gene or a factor are called Alleles.

TRAIT : It is the expressed character ,ex : colour of flower,shape of seed

DOMINANT TRAIT :Out of the two alternative forms a gene the one which expresses the character itself in a heterogygous condition in the F1 generation.F1 has a dominant character which is produced by dominant allele ,the character is called dominant character. For example in an individual with Tt, T(tallness) expresses itself in F1 generation and t can not, so "T" is dominant allele.

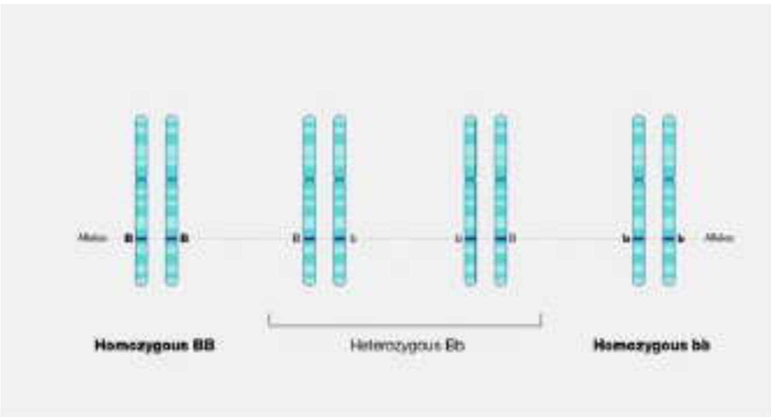
RECESSIVE TRAIT : Out of two alternative forms for a trait ,the one which is suppressed in the F1 hybrid is called recessive trait. Recessive allele expressed only in the homogygous recessive state only(ie tt).

GENOTYPE :The genetic constitution of an individual is called the genotype .ex.The genotype of pure rounded seed parent pea plant is RR.

PHENOTYPE : The outward appearance of an individual for any trait is called phenotype.ex: Round shape,Yellow shape.

HOMOZYGOUS : An individual possessing identical alleles for a trait is called Homogygous or pure for that for that trait.ex; plant with RR alleles is homogygous for the seed shape.

HETEROGYGOUS : An individual having dissimilar alleles for a trit is called heterogygous or impure for that trait. Ex;Rr alleles.



PARENT GENERATION

The parents used for the first cross represent the parent (or p1) generation.

F1 Generation

The progeny produced from a cross between two parents(p1) is called First filial or F1 generation.

F2 Generation

The progeny resulting from self hybridization or inbreeding of F1 individuals is called Second filial or F2 Generation.

MONOHYBRID CROSS

The cross between two parents differing in a single pair of contrasting characters is called monohybrid cross and F1 offspring as the hybrid

DIHYBRID CROSS

The cross between two parents in which two pairs of contrasting characters are studied simultaneoiusly for the inheritance pattern is called dihybrid cross.

HYBRIDISATION

Crossing organisms belonging to different species for getting favourable qualities in the offspring.

TEST CROSS

Cossing of the F1 progeny with the homogygous recessive parent .If F1 progeny is heterogygous ,then the 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 the first cross father was dwarf and mother tall ,then in the reciprocal cross, dwarf parent will be female and tall parent male.

SCIENTISTS IN GENETICS

SL.NO	NAME OF THE SCIENTIST	YEAR	CONTRIBUTION
1	Mendel	1865-1866	Laws of heredity and is known as father of genetics
2	De Vries	1901	The term mutation was coined by Devris
3	Sutton	1902	Advanced chromosomes theory of Heredty
4	Batson	1902-1909	Used the term genetics
5	Morgan	1911	Postulated chromosomal basis of linkage
6	Bridges	1926	Genic balance theory
7	JD Watson and F.H. Cick	1953	Double helical model of DNA

INTEXT QUESTIONS

1. Who is the founder of genetics and why?

___

2. Define heredity and variation

___

3. Give the monohybrid and dihybrid phenotypic ratio

___

4. Mention two sources of variation

___

5. Define the test cross and reciprocal cross

___

6. Match the following

i)	Genotypic ratio of monohybrid cross	1:2:1
ii)	Father of genetics	Batson
iii)	The term mutation coined by	Mendel
iv)	The term genetics coined by	De Vries

7. State one difference between
   - i) Homogygous and heterogygous
   - ii) Dominant and recessive
   - iii) Genotype and phenotype
   - iv) Monohybrid and dihybrid cross

2. SEX DETERMINATION

Sex determination refers to the biological process of distinguishing whether an individual is male or female this is determined at the time of fertilization by the sex chromosomes.

In most of the animals, a pair of chromosomes is responsible for the determination of sex these are called **allosomes** or **sex chromosomes** other than sex chromosomes are called **Autosomes/Somatic chromosomes** that are responsible for the Somatic traits.

'**Stevens**' and '**Wilson**' first Identified **Y-chromosome** as a sex determining chromosome in the mealworm **'Tene brio Molitor'**.They revealed that the chromosomal basis of sex depended on the presence or absence of the Y-chromosome.

Henking discovered the X-body in squash bug, 'p**urrhocoris**'.In the latter investigations this X-body is designated as X-chromosome.

Homogametic refers to individuals in a species that have sex chromosomes that are the same.

Typically females, For example in humans, females have two X-chromosome (XX)

If the two sex chromosomes are similar (XX)

The Individual is described as homogametic

Heterogametic

It refers to individual in a specific that have sex chromosomes that are different typically males. For example in humans Males have one X and one Y chromosome.

If the two sex chromosome are dissimilar (XY)

The individual is described as Hetrogametic

There are several types of explanations given for sex determination these are chiefly

i) Chromosomal theory of sex determination

ii) Genic balance theory of sex determination.

iii) Haplodiploidy method.

Chromosomal theory of Sex Determination

The process of sex determination by allosomes is called chromosomal sex determination.

Heterogametic Sex Determination

Heterogametic Sex refers to the sex of the species in which the sex chromosomes are not similar in the determination one of the sexes produce s similar gametes and other sex produce dissimilar gametes. The sex of young one is determined at the time of Fertilization.

Male Haterogametes

It is a type of chromosome sex determined where the sex is determined by the presence of either X or Y chromosome. In this system male have an XY chromosome configuration and female have XX chromosome configuration Male heterogametes is of two kinds

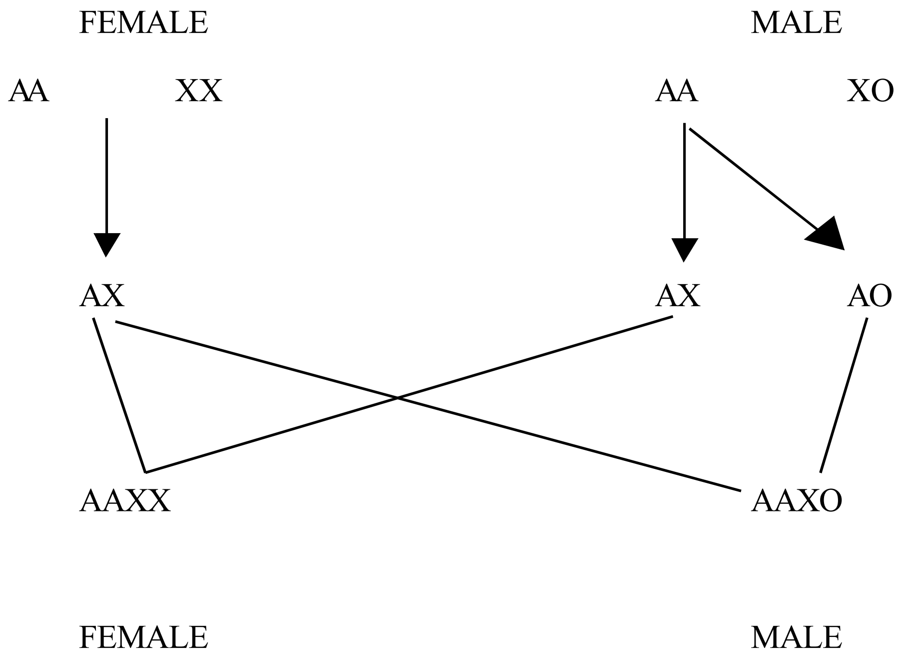
1) XX-XO TYPE

This type of sex determination found in Gross hoppers, bugs and cockroaches.

In XX-XO type, as in grass hopper; males have only one X chromosome (XO) and females have two (XX) chromosomes

All the ova contains AX complement of chromosomes and the sperms are of two types: One half the sperms have AX complement and the other half have 'A' complement of chromosomes.

The sex of the off spring depend on the type of sperm that fertilizes the ovum.



MALE GAMETES

	X	O
X	XX FEMALE	XO MALE
X	XX FEMALE	XO MALE

2) XX-XY TYPE

This type of sex determination found in the humans Drosophila

MALE GAMETES

	X	Y
X	XX FEMALE	XY MALE
X	XX FEMALE	XY MALE

Female Hetrogametes

In this method of sex determination female produce dissimilar gametes (Heterogametes) while males produce similar gametes (Homogametes)

a) ZO-ZZ type

This type of method found in moths, butter flies.

FEMALE GAMETES

	Z	O
Z	ZZ MALE	ZO FEMALE
Z	ZZ MALE	ZO FEMALE

b) ZW-ZZ

This type of sex determination found in birds, reptiles some fishes etc. In this type females are heterogametic with ZW allosomes, males are ZZ homogametic with ZZ chromosomes.

FEMALE GAMETES

	Z	W
Z	ZZ	ZW
Z	ZZ	ZW

Haplodiploidy

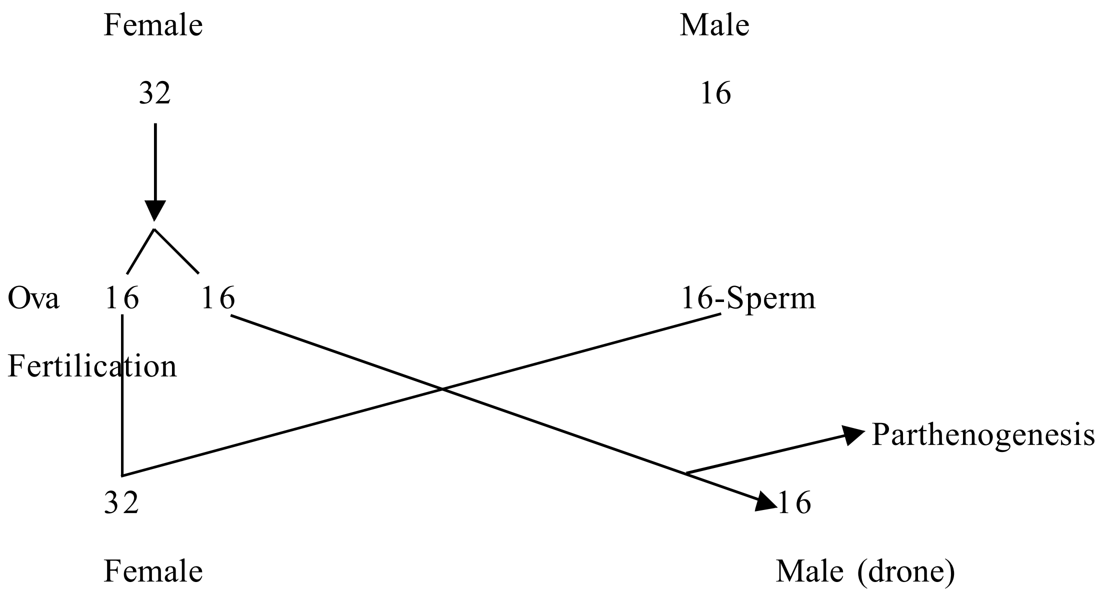
Haplodiploidy is a type of sex determination where males develop from unfertilized eggs and contain one set of chromosomes (Haploid),While females develop from fertized eggs and contain two sets of chromosome (diploid) this system is observed in some Insects ,Including honey bees (Apis Mellifera)

Honey bee Colonies are comprised of single Queen, many drones (males) and large number of worker bees (females)

The Queen bee mates with multiple drones and stores their sperm in a specialized organ called the spermatheca. she then uses this sperm to fertilizes eggs as she lays them, allowing her to control the sex of her off spring.

If the queen fertilizes an egg with a sperm cell , it will develop in a diploid female bee, However, if she lays an unfertilized egg, it will develop into a haploid male bee by (parthenogenesis).

Parthenogentic development of male honey bee is called Arrhenotoky.



Parthenogenesis in Honey bees

iii. Sex determination in Drosophila

Basically , sex determination in Drosophila is of XX-XY method. Calvin Bridges showed that Y chromosome has no role in sex determination in Drosophila. He proposed that both autosomes and X chromosomes together play an important role in sex determination. The ratio of number of X chromosomes and number of sets of autosomes is known as sex index ratio. Bridges stated that, if sex index ratio is 0.5 or less, the Drosophila becomes a male. If it is 1.0 or more than 1.0, the Drosophila becomes a female. If the ratio is in between 0.5 and 1.0, the individual is an inter sex. Y chromosome of Drosophila contains the genes for male fertility. Hence XO individual is a male but sterile.

Bridges crossed a triploid female Drosophila (AAA + XXX) and a normal diploid male Drosophila (AA + XY). The results are described here under :

AA + XY(normal male) **AAA +XXX(triploid female)**

Sperms 3/3=1.0 / ova 2/2=1.0	(AA + XX)	(A +XX)	(A + XX)	(A + X)
(A + X)	AAA +XXX / Intersex	AA + XXX / Metafemale	AAA + XXX / Tri.female	AA + XX / Female
(A + Y)	AAA+ XY / Metamale	AA + XXY / Female with extra Y	AAA +XXY / Intersex	AA +XY / Male

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

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.

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 because, 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 LEARNT

i) Chromosomes are two types, namely, allosomes and autosomes.

ii) Sex determination is by sex chromosomes and sexual differentiation by sex hormones.

iii) Stevens and Wilson discovered X and Y chromosomes.

iv) Calvin Bridges discovered that Y- Chromosome does not influence sex determination in Drosophila

v) In honey bees, fertilized ova (i.e., Zygotes)develop into females and unfertilized ova develop into males by Parthenogenesis

vi) Crew discovered sex reversal in fowls.

vii) 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 heterogamesis with examples.
2. How sex is determined in Drosophila.
3. Describe haplodiploidy in honey bees.
4. Write notes on hormonal control on sex determination.

3. GENETICS & HEREDITY

We all recognize that individuals of the same kind of plant or animal are mostly similar; Seeds of mango trees grow into mango plants, dogs give birth to puppies and humans give birth to human beings. But we also observe variation between individuals of same kind. Children resemble parents in most characteristics and how traits are passed from parents to their young ones? Genetics is the branch of biology that deals with the transmission of characters from one generation to the next generation. The word 'genetics' is derived from Greek word "Gen" which means "To become" or "To grow into". The term 'Genetics' was coined by Bateson in 1906. The principles of genetics are the concepts that explain the inheritance and variation of traits in living organisms. Some of the classical principles of genetics are based on Mendel's experiments with pea plants, which revealed the patterns of dominant and recessive traits, segregation and independent assortment of genes. This lesson deals with laws of heredity, and variation to improve our understanding on what is hereditary material, how genes control the general traits of any given organism, how variations arise and how some gene variations result in disorders.

Objectives

After completing this lesson, you will be able to:

- Highlight Human Curiosity And Consciousness For Healthy Progeny.
- Explain the terms heredity and variation.
- Describe Mendel's experiments on garden pea and understand the Mendel's laws of inheritance.
- Define the terms hybridization, alleles, trait, dominance, recessive, homozygous, heterozygous, genotype, phenotype.
- Understand the concept of incomplete dominance, lethal genes, pleiotropic genes and polygenic genes.

- Explain the chromosome theory of inheritance.
- Study the concept of linkage and crossing over.
- Differentiate between sex chromosome and autosomes.

HEREDITY AND VARIATION

Offsprings in a family show resemblance in most traits such as infant's eyes, facial features, complexion, colour of hair with those of the parents, siblings and grandparents. So, traits are inherited and although similar may show some differences. The source of such resemblances and differences are in the "genes" that are passed down from one generation to next and so on. The transmission of characters 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. Variations arise due to **mutation or sudden change** in the genes. **Variations** also arises due to random mixing of parental chromosomes (Segregation) or shuffling of genes on chromosomes (Recombination) during the meiosis at the formation of gamates.

MENDEL'S EXPERIMENTS AND PRINCIPLES OF INHERITANCE

Sir **Gregor Johann Mendel** (1822 to 1884) was **Austrian Monk** who used Garden pea plant (**Pisum *sativum***) for his experiments and he was the first person to explain the mechanism involved in the transmission of characters from parents to their offspring or from one generation to the next generation. Therefore he is considered as the pioneer of modern genetics and is called as **Father of Genetics.**

Mendel's Experiments

Mendel decided to experiment with pea plants to understand the variation in blending and inheritance of traits. Pea plants are a good choice because they are fast growing and easy to raise. He investigated several visible characteristics that vary in pea plants shown in the figure below. Pea plant is a naturally self-pollinating plant and Mendel was interested in the offspring of two different parent plants, so he had to prevent self-pollination. He performed several controlled pollinations and studied hybrids produced from these crosses.

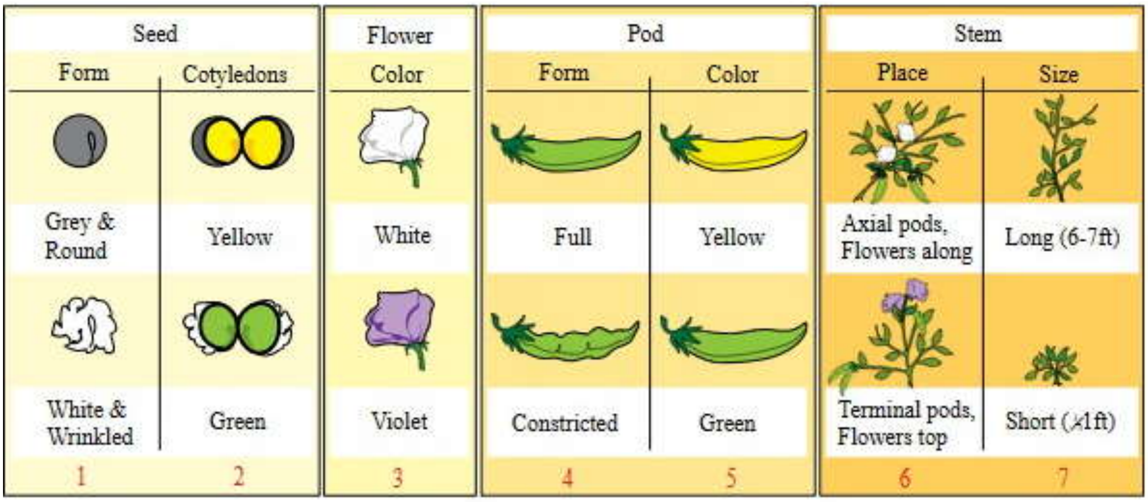


Fig: Traits in Pea plant studied by Mendel

Monohybrid and dihybrid cross

At first, Mendel experiments involved crossing of plants considering one characteristic at a time. The cross between two parents differing in a single pair of contrasting characters is called monohybrid cross. The cross involving two contrasting features is called "**Dihybrid cross"** such as cross between Tall and Red flowered plant with Dwarf and White flowered plant.

The parent plants in the experiments are referred to as the P (for parent) generation. The offspring of the P generation are called the F1 (for first filial, or "offspring") generation hybrid and offsprings of F1 generation are called F2 hybrids (second filial generation).

In one of the experiments, Mendel chose height of the pea plants and crossed plants that were true-breeding for Tall trait with plants true-breeding for dwarf trait (the P generation). The resulting hybrids in the F1 generation all were tall and none were dwarf. He wondered what has happened to dwarf trait. Surprisingly, in the offsprings of F1 plants when self-pollinated (F2 generation), he observed that both tall and dwarf had appeared. Approximately three-quarters of the plants were tall, while one-quarter were dwarf. Similarly, Mendel did the same experiment for all seven characteristics. In each case, one feature of the characteristic disappeared in the F1 plants and then showed up again in the F2 plants.

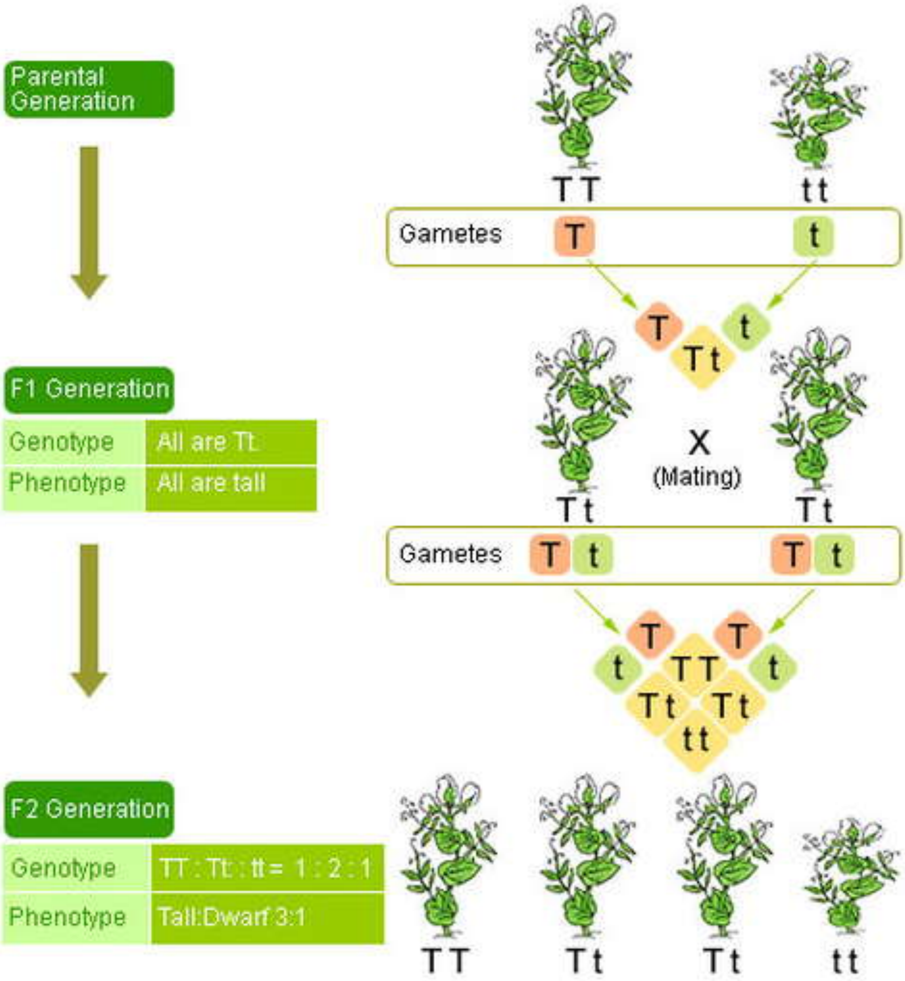
In view of blending in traits, Mendel considered that each trait is controlled by a 'factor' and each factor can be in two different forms (now alleles).

Accordingly, he categorized F2 generation with three types of plants

1) Tall Homogygous (pure) plants- denoted as ‘TT’

2) Tall Heterogygous (hybrid)plants- denoted as ‘Tt’

3) Dwarf Homogygous (pure) plants- denoted as ‘tt’



TT (Homozygous Tall Plant) x tt (Homozygous Dwarf Plant)

↓ ↓

T ——— Tt ——— t ....Gamates

.... F1 (Generation)

Tt (Heterozygous Tall Plant) x Tt (Self Pollination)…F2 generation

	T	t
T	TT (tall homozygous)	Tt (tall heterozygous)
t	Tt (tall heterozygous)	Tt (dwarf homozygous)

Phenotype ratio: Tall and dwarf plants is 3:1

Genotype ratio: Tall homozygous: Tall heterozygous: dwarf homozygous is 1:2: 1

IMPORTANT TERMS

Trait: It is the expressed character. Ex. colour of flower, shape of seed.

Parent generation: The parents used for the first cross represent the parent (or p1) generation.

F1 Generation: The progeny produced from a cross between two parents (p1) is called First filial or F1 generation.

F2 Generation: The progeny resulting from self-hybridization or inbreeding of F1 individuals is called Second filial or F2 Generation.

Monohybrid Cross: The cross between two parents differing in a single pair of contrasting characters is called monohybrid cross and F1 offspring as the hybrid.

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.

Hybridisation: Crossing organisms belonging to different species for getting favorable qualities in the offspring.

Test Cross: Crossing of the F1 progeny with the homozygous recessive parent. If F1 progeny is heterogygous, then the 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 the first cross father was dwarf and mother tall, then in the reciprocal cross, dwarf parent will be female and tall parent male.

Factor: The unit is responsible for the inheritance and expression of a particular character.

The term ‘factor’ was coined by Mendel. Now factor is 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 a gene or a factor are called Alleles.

Genotype: The genetic constitution of an individual is called the genotype. Ex. The genotype of pure rounded seed parent pea plant is RR.

Phenotype: The outward appearance of an individual for any trait is called phenotype. Ex. Round shape, Yellow shape.

Homozygous: An individual possessing identical alleles for a trait is called homozygous or pure for that trait. Ex. plant with RR alleles is homozygous for the seed shape.

Heterogygous: An individual having dissimilar alleles for a trit is called heterozygous or impure for that trait. Ex. Rr alleles.

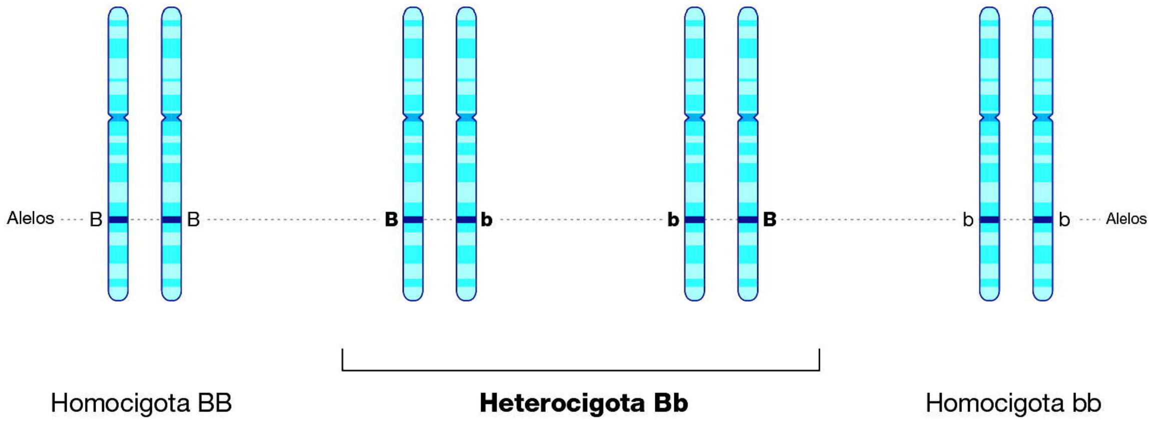


Fig: Homozygous and Heterozygous

MENDEL'S PRINCIPLES (LAWS) OF INHERITANCE

Based on the result of Mendel's experiments, he postulated the following laws of inheritance. These are:

1) Law of Segregation or Purity of gametes

2) Law of Dominance

3) Law of Independent assortment

1. **Law of segregation or Purity of Gametes**

According to this law, each individual possesses two factors (genes) for a particular character or trait. At the time of gamete formation, each number of the pair of genes (factors) separate from each other. Hence, each gamete receives only one factor (gene).These gamates are always pure (Law of purity of gamates).

In other words, a gene exists in more than one form of an allele and every organism inherits two alleles for each trait. When gametes are produced by meiosis, the allelic pairs separate, leaving each gamete with a single allele.

2. **Law of Dominance**

When parents with pure, contrasting traits are crossed together, only one form of trait appears in the next generation. The hybrid offsprings will exhibit only the dominant trait in the phenotype. This is called Law of dominance. In the example of plant height, only one trait or character is expressed in hybrid (in heterogygous condition -Tt) in F1 generation and is considered as dominant trait (Tall-T allele). On the contrary, the character for dwarfness that could not express itself in the first filial generation is regarded as recessive trait.

For a trait, the two alleles of a pair are different, i.e., one is dominant and one is recessive.

3. **Law of independent assortment**

When inheritance of more than one trait is considered, it is observed that the allele received for one gene does not influence the allele received for another gene. According to the law of independent assortment, the alleles of two more genes get sorted into gametes independent of each other.

For example, self-pollination of F1 generation hybrid Yellow and Round plants (YyRr) produce four types of gametes. These gametes, randomly combine to produce 16 possible combinations. The end result of the dihybrid cross makes it very clear that segregation of the seed colour is independent of the seed shape, In the F2 generation both parental and new combination of the characters appeared, this is assortment of genes of one pair is independent of the other pair.

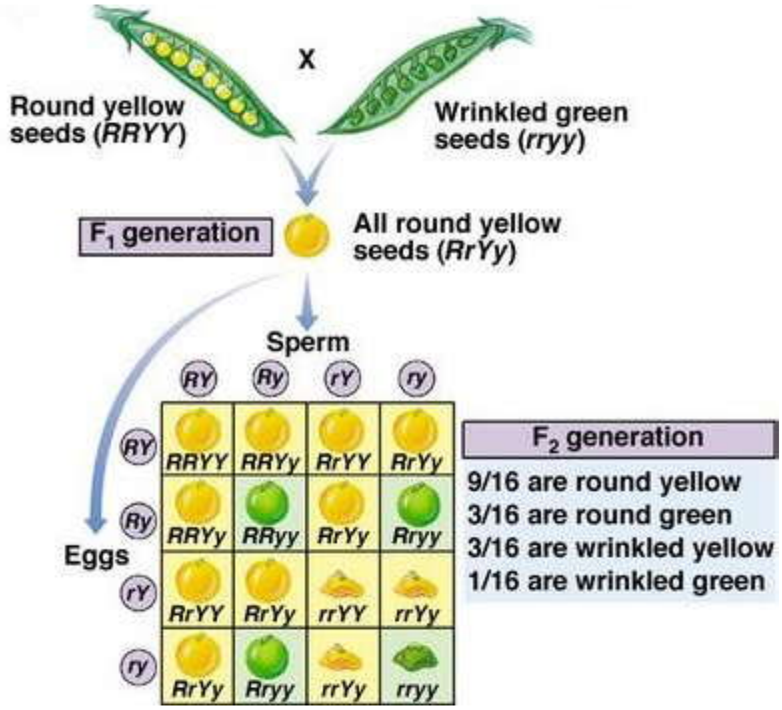


Fig: Dihybrid cross results demonstrating Law of Independent Assortment

Phenotypic ratio in its offspring (F2) is 9:3:3:1

Genotypic ratio in the F2 generation is 1:2:1:2:4:2:1:2:1

Reasons for Mendel's success

Mendel selected garden pea, Pisum *sativum*, for his experiments

- It has short life cycle
- It is easy to cultivate
- It has self-pollinated bisexual flowers with closed corolla. So pollination can be controlled easily
- It has well-define discrete characters.

Dominant Trait: Out of the two alternative forms a gene the one which expresses the character itself in a heterogygous condition in the F1 generation. F1 has a dominant character which is produced by dominant allele, the character is called dominant character. For example in an individual with Tt, T(tallness) expresses itself in F1 generation and t cannot, so "T" is dominant allele.

Recessive Trait: Out of two alternative forms for a trait, the one which is suppressed in the F1 hybrid is called recessive trait. Recessive allele expressed only in the homogygous recessive state only (ie tt).

SCIENTISTS IN GENETICS

SL.NO	NAME OF THE SCIENTIST	YEAR	CONTRIBUTION
1	Mendel	1865-1866	Laws of heredity and is known as father of genetics
2	De Vries	1901	The term mutation was coined
3	Sutton	1902	Advanced chromosomes theory of Heredty
4	Batson	1902-1909	Used the term genetics
5	Morgan	1911	Postulated chromosomal basis of linkage
6	Bridges	1926	Genic balance theory
7	JD Watson and F.H. Crick	1953	Double helical model of DNA

INTEXT QUESTIONS

1. Who is the founder of genetics and why?
2. Define heredity and variation
3. Give the monohybrid and dihybrid phenotypic ratio
4. Mention two sources of variation
5. Define the test cross and reciprocal cross

6. Match the following

   i) Genotypic ratio of monohybrid cross 1:2:1

   ii) Father of genetics Batson

   iii) The term mutation coined by Mendel

   iv) The term genetics coined by De Vries

7. State one difference between

   i) Homogygous and heterogygous

   ii) Dominant and recessive

   iii) Genotype and phenotype

   iv) Monohybrid and dihybrid cross

DEVIATION FROM MENDEL'S LAWS

There were significant inconsistencies with regard to Mendel's laws in subsequent discoveries made. Mendel ratios were found to be deviated due to many factors which include phenomenon like incomplete dominance, co-dominance, multiple alleles, epistasis, polygenic inheritance and linkage. These were regarded as extensions to Mendel's laws. Sometimes phenotype variations are influenced by environmental factors too.

Incomplete Dominance: The law of dominance is not followed in certain traits. In the four O'clock plant Mirabilis *jalapa* and Snapdragon or Antirrhinum, when a homozygous red flowered plant (RR) is crossed to a homozygous white flowered plant, all flowers in the F1 are pink when F1 plants are self -pollinated, the phenotypic ratio is found to be 1 : 2 : 1. The heterozygous (Rr) plants have a new phenotype, an intermediate colour pink. Neither of the alleles controlling the trait are dominant in F1, instead the F1 hybrid has combination of both indicating partial dominance. This phenomenon is called incomplete dominance.

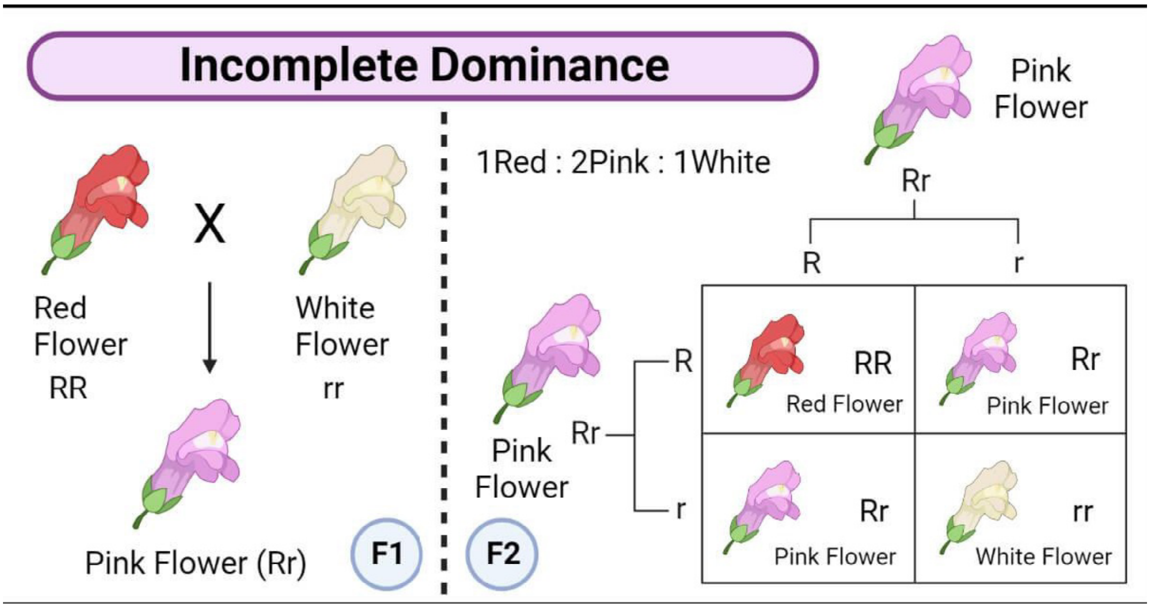


Fig: Incomplete dominance

Both F2 phenotypic ratio: 1 Red : 2 Pink : 1 White and F2 genotypic ratio: 1 RR : 2 Rr : 1 rr are same.

Co-dominance: Like incomplete dominance, this concept also shows deviation from law of dominance. In certain cases, the alleles of a trait express fully and F1 heterozygote resulting from pure parental cross has both the traits. Neither of them dominate over the other.

Ex: Cross between pure red Bull and pure white cow results in F1 hybrid showing a new phenotype, roan as red and white traits are both fully expressed and equally dominant.

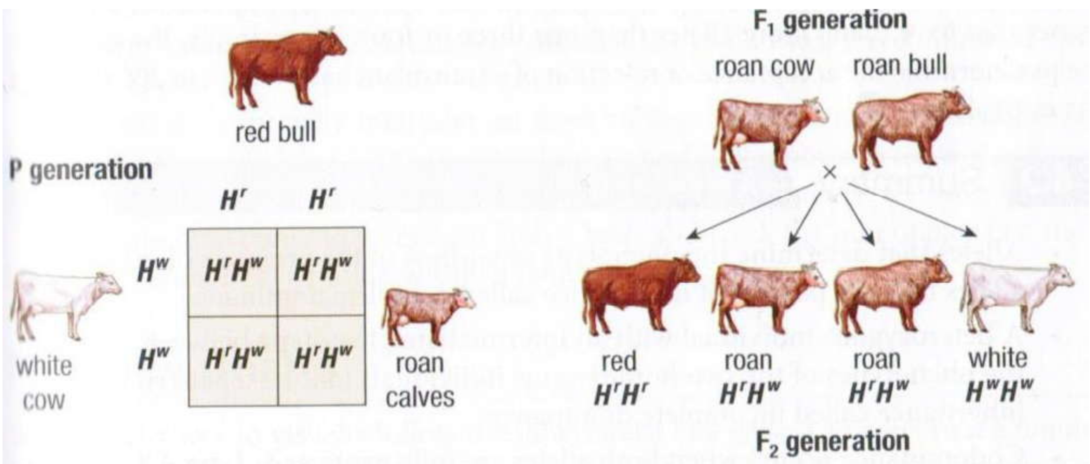


Fig: Codominance

Multiple alleles: Traits with alternate/contrasting forms were discussed so far (Tall or dwarf, red or white, brown eyes or blue eyes, etc.) and Mendelian ratios are consistent in such traits. However, some traits may have more than two forms (or alleles), referred as multiple alleles.

Ex: Blood group in human, coat color in rabbits, etc.

- Human blood group is determined by three alleles - IA, IB and I0.
- IA and IB are both co-dominant, while I0 is recessive to both Ix and IB.

Blood group	Genotype
A	$I^A I^A$ or I^A I^0
B	$I^B I^B$ or $I^B I^0$
AB	$I^A I^B$
O	$I^0 I^0$

(The genotype $I^0 I^0$ is a honozygous recessive)

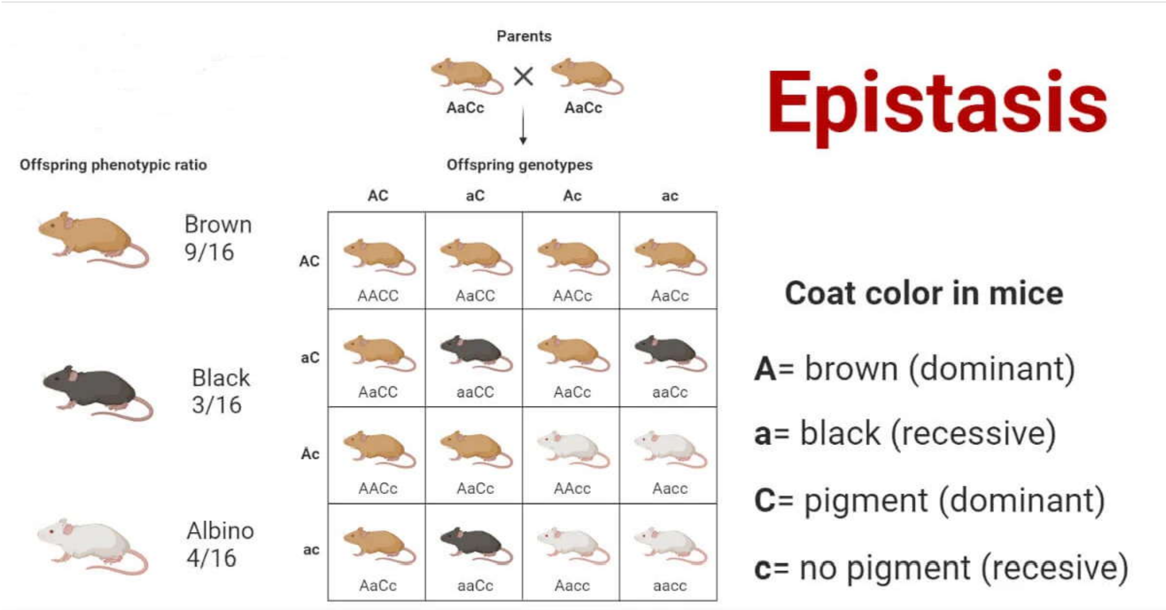
Blood Type	Genotype		Can Receive Blood From
A	$i^A i$ $i^A i^A$	AA AO	A or O
B	$i^B i$ $i^B i^B$	BB BO	B or O
AB	$i^A i^B$	AB	A, B, AB, O
O	$i\ i$	∞	O

Fig: Multiple alleles-Blood group in Human

Epistasis: Dominance of trait forms deals with alleles of one factor controlling it and reveal phenotype due to either complete dominance, incomplete dominance or codominance. The interaction of allele forms of different traits can also influence the phenotype involving masking of trait forms. The phenomenon wherein one factor/trait can mask or interfere with the other is called Epistasis. These interactions can cause distortion of Mendelian proportions or transmission patterns for certain traits and result in unfavourable allelic combinations. In Epistasis, less than four phenotypes can occur in F2 indicating different kinds of epistasis interactions.

(i) Dominant Epistasis. (12:3:1)
(ii) Recessive eistasis. (9:3:4) (Supplementary interaction)
(iii) Duplicate Recessive Genes (9:7) (Complementary Genes)
(iv) Duplicate Dominant Genes. (15:1)
(v) Duplicate Genes with Cumulative Effect (9:6:1)
(vi) Dominant Recessive Interaction (13:3)

Eg: Coat color in mice showing 9:3:4 F2 ratio



Polygenic or quantitative inheritance: When a trait (feature or character) is controlled by a single factor (gene) it is termed monogenic inheritance. Most 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. 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.

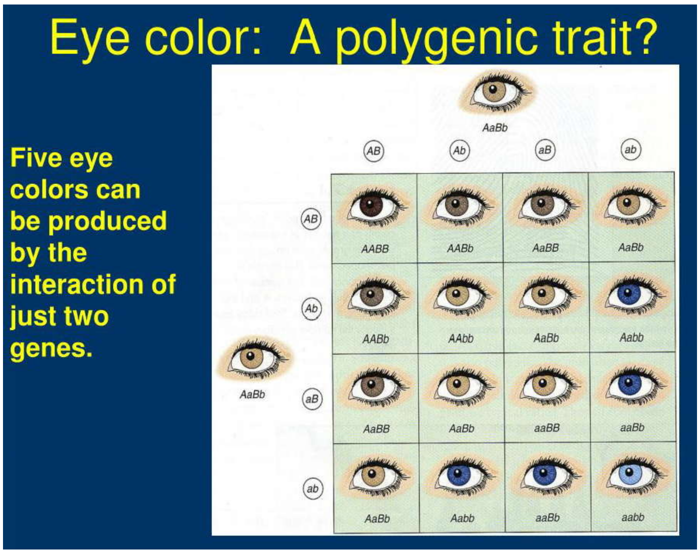


Fig: Polygenic inheritance -Eye color trait

CHROMOSOMAL THEORY OF INHERITANCE

In the 1850s, Gregor Mendel deduced that the units of inheritance are discrete (factors), occur as pairs, and can exist in alternative forms. There was no idea of chromosomes and meiosis at that time. In 1902 and 1903, Sutton and Boveri proposed chromosome theory of inheritance according to which chromosome is the genetic material responsible for Mendelian inheritance. In order to explain the law of independent assortment, Sutton and Boveri suggested that different genes were in different chromosomes completely independent of one another. It was observed that 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. Chromosomes from two parents come together in the same zygote and again separate out during the formation of gametes. The behaviour of chromosomes during meiosis can explain why genes are inherited according to Mendel's laws. This concept led to chromosomal theory of inheritance.

The salient features are:

- In somatic cell, the chromosome or gene occurs in pairs because one chromosome is from father and other from mother to form homologous pair.
- During meiosis or gametogenesis, homologous chromosome pairs segregates independent of other chromosome pairs. ie. a gamete contains only type of chromosome or only one of two alleles of particular trait.
- The sorting of chromosomes from each homologous pair is random and is similar to Mendel's law of independent assortment.
- Chromosome number in an organism is fixed and chromosmes are transmitted from one generation to another. The gametes combine during fertilization to produce offspring with the same number of chromosome number as their parents

Later In 1910, **Thomas Hunt Morgan** performed experiment on *Drosophila melanogaster* to explain this theory.

GENETIC LINKAGE AND CROSSING OVER

It was concluded that pairs of genes assort independently of one another. But genes characterizing two different traits not always present on two chromosomes. When two or more genes reside on the same chromosome, they are said to be linked and their transmission pattern is called **linkage**. They may be linked together on the autosomes or on the sex chromosome. Genes present on different non-homologous chromosomes are called unlinked genes. Linked genes (genes on the same chromosome), however bends to stay together during the formation of gametes. Thus, the results of test cross and self-cross involving two genes yield different results, depending on whether the genes are linked (on same chromosomes) or unlinked (on different chromosomes)

Transmission pattern i.e. linkage of linked genes can be complete or incomplete. Suppose that two genes- A and B are located on the same chromosome. So, in dihybrid cross between AABB and aabb, genes A and B and their allele a and b will segregate in the following way:

Because genes are located on the same chromosome, thus they tend to remain together and do not exhibit Independent assortment. However, gametes formed by F1 progeny (AaBb) have two possibilities; First, all gametes are of parental type i.e. AB and ab (no recombinant type i.e. Ab and aB gametes would be produced). A gamete that shows the same combination as the parent is referred to as parental type and where the combination is altered, it is referred to as a recombinant type. In this case, genes a and b are completely linked and zero percent recombinant is found. So the linkage is considered as **complete linkage.**

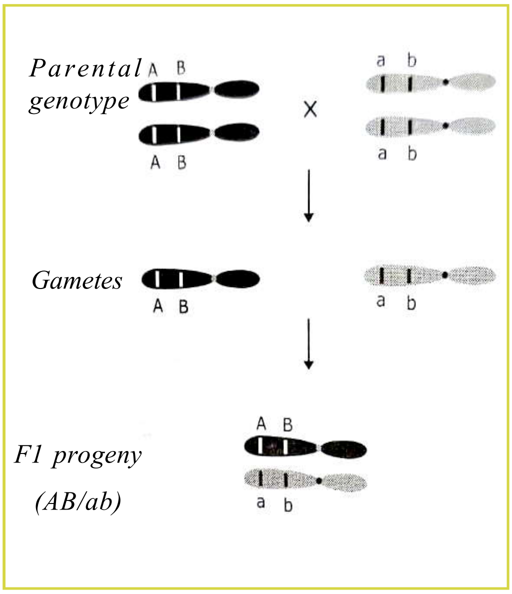


Fig: Inheritance of linked genes A and B

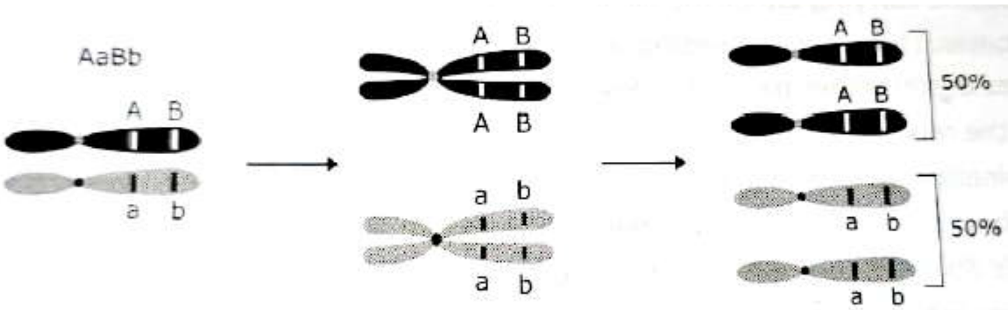


Fig: Genes located on same chromosome may show complete linkage

Second, two genes located on the same chromosome, give not only gametes with parental type but also with recombinant type. Due to the process of crossing over, even the genes present on the same chromosome gives recombinant combination ranging from 0 to 50% (in contrast, two unlinked genes present on two different chromosomes that undergo independent assortment produce 50% recombinants). The 0% denotes complete linkage and no crossing over between two loci and 50% if far apart on the same chromosome. In this case, the linkage is considered as **incomplete linkage.**

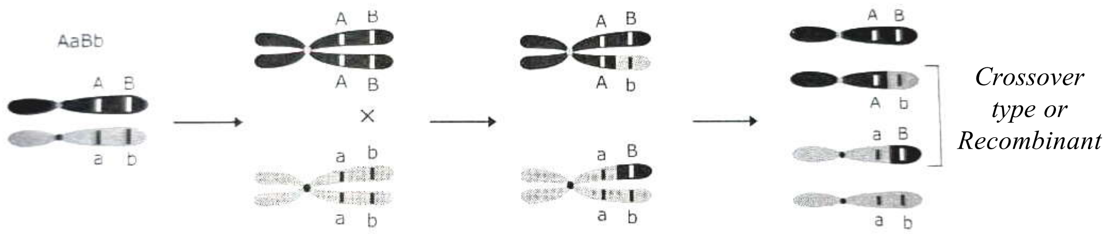


Fig: Illustrating the occurrence of crossing over between two genes

Therefore, recombinants are produced by two different cellular processes: Independent Assortment and Crossing Over. Independent assortment always produces 50% recombinant. Crossing over also can produce recombinants. However, crossing over does not occur between two specific genes in all meioses, but, when it occurs, half the products of that meiosis are recombinant. Meiosis with no crossover between the genes under study produces only parental genotypes for these genes. Genes with percent recombination less than 50% are present in the Same chromosome (linked). Whereas two genes with a percent recombination value equal to 50%, either are in nonhomologous chromosomes (i.e. unlinked) or are located far apart on a single chromosome.

INTEXT QUESTIONS

1. Differentiate between imcomplete dominance and codominance.

 ____

2. Define epistasis.

 ____

3. What is Linkage?

 ____

4. Name two types of Epistasis.

 ____

5. Match the following:

A. Blood group	a. Polygenic inheritance
B. Flower colour in Mirabilis *jalapa*	b. Multiple alleles
C. Skin colour in human	c. Incomplete dominance

4. MOLECULAR INHERITANCE AND GENE EXPRESSION

All organisms inherit the traits from parents to offsprings. Likewise, all cells arise from preexisting cells, so the hereditary material must be replicated and passed from parent to progeny cell at each cell division. A zygote has the information for development and differentiation in its genes. Genes dictate the cellular structure and function in any organism. But what are these genes and how do they function? How genetic information is replicated and transmitted from cell to cell and organism to organism? Consequently, the discoveries that led to the identification of DNA as the genetic material formed the foundation for our current understanding of biology at the molecular level.

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:

- *K*now 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;
- Understand about types of RNA and their functions;
- Describe the modes of gene transfer, transformation, transduction and conjugation;
- Explain the concept of central dogma;
- Understand the process of replication of DNA;
- Describe the sequence of steps during transcription and translation for protein synthesis;
- Basic understanding on regulation of gene expression;
- Gain knowledge on gene mutations and their impact.

Previously, we have learnt that Sir Gregor Mendel had proposed key principles of inheritance of traits and traits are known to be controlled by pair by factors (now called genes). Within a cell, nucleus contains chromosomes which bear genes. During reproduction, the inherited factors (now called alleles) regulating a trait are separated into reproductive cells by a process called meiosis and randomly reunite during fertilisation. The gene can be defined as a functional unit of heredity which occupies a specific place (locus) on a chromosome, is capable of reproducing itself exactly at each cell division and directs the formation of an enzyme or other protein. Cytological and genetic studies show that genes are regarded as indivisible units of the chromosomes on which they are located, like "beads on a string". The term gene was coined by W. Johannsen in 1909. Genes are made of segments of Deoxyribinucleic acid (DNA) molecules. Genes can mutate, can be assorted, can be shuffled in different combinations. Therefore, genes are regarded as the basis for modern interpretation of evolution.

DISCOVERY OF DNA AS THE GENETIC (HEREDITARY) MATERIAL

Genes are known as the hereditary material in the early twentieth century and that genes are segments of DNA became evident from the work of Griffith on bacterial transformation.

Various experiments which proved that DNA (and not protein) is the genetic material are as follows**:**

1. Griffith's experiment :

Frederick Griffith (in 1928) performed an experiment known as transformation experiment. He used two strains of Streptococcus pneumonia: type III-S (smooth)- that contained outer capsule made up of polysaccharide and type II-R (rough) strain-that did not contain capsule. The capsule protects the bacteria from the host's immune system. The S strain was disease-causing whereas the R strain was non-infective.

He observed that when rough strain of Streptococcus was injected into the mouse, the mice lived whereas when smooth strain of Streptococcus was injected, the mice died. When heat-killed smooth strain of Streptococcus was injected into the mice, the mice lived. In the last set of experiments, when both rough strain and heat-killed smooth strain were injected, the mice died.This proved that there was some substance present in heat-killed S strain that was converting or transforming the rough strain into virulent strain, leading to the death of the mouse. This transforming substance was later found to be DNA.

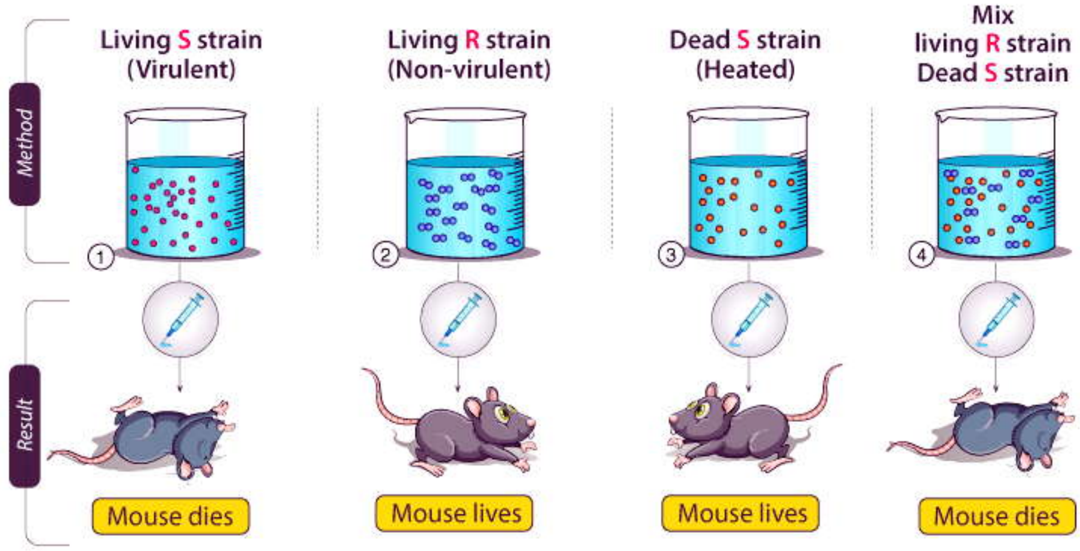


Fig: Griffith's experiment on bacterial transformation

In 1944, Avery, MacLeod and McCarty worked to determine the biochemical nature of transforming material in Griffith's experiment. They 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 DNAase and then mixed. Thus it became clear that DNA was the transforming principle.

Later Alfred Hershey and Martha Chase (1952) experiments on T2 bacteriophage (bacteria infecting virus) provided the proof that DNA is the genetic material. They grew some bacteriophages on a medium that contained radioactive phosphorus and some others on a sulphur-containing radioactive medium. The bacteriophages grown in the presence of radioactive phosphorus contained radioactive DNA. Radioactivity was not observed in the protein part. This is because DNA contains phosphorus but protein is devoid

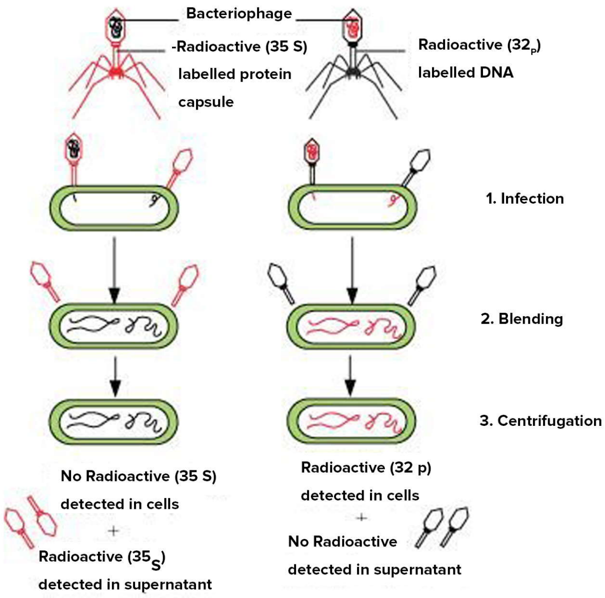


Fig: Hershey-Chase Experiment

of phosphorus. In the same way, bacteriophages grown on radioactive sulphur contained radioactive protein, but not radioactive DNA. This is because DNA does not contain sulphur. Radioactive phages were allowed to attach to E. coli bacteria. As the infection proceeded, phage coats were removed from the bacteria by centrifuging. The phage particles were separated from the bacteria by rotating them in a centrifuge. Bacteria which were infected with phages that had radioactive DNA were radioactive, indicating that DNA was the material that passed from the phage to the bacteria. These experiments confirmed that DNA is the genetic material.

INTRODUCTION TO DNA

The DNA is a bio polymer made up of repeating units of monomers (i.e.nucleotides) carrying the genetic material of all cellular organisms and most viruses. DNA contains all the information needed for the cell's growth, operation, and division into two similar cells.

STRUCTURE OF DNA

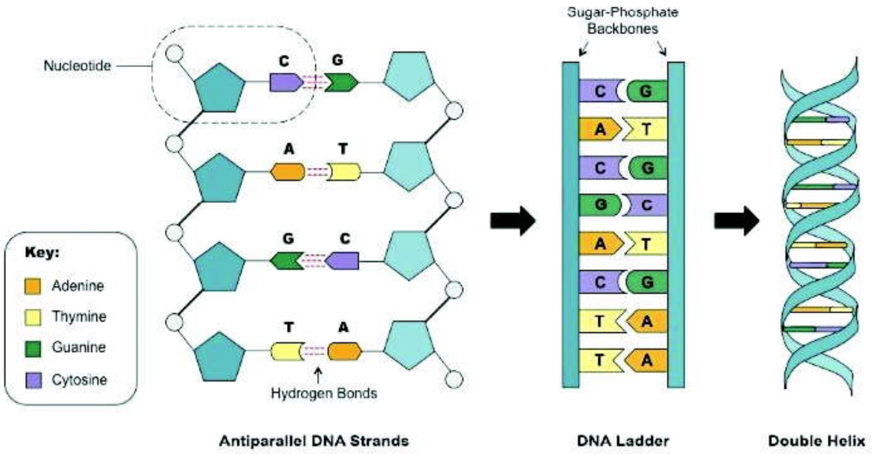
DNA (Deoxyribonucleic acid) is a double-stranded, helical molecule. Its structure was cracked by Watson and Crick (1953) based on the X-ray crystallography results provided by Maurice Wilkins and Rosalind Franklin. DNA is a polynucleotide, a macromolecule (macro = large) made of units called nucleotides. Each nucleotide consists of three subunits: (i) a pentose (5 carbon) sugar called deoxyribose (ii) 4 nitrogenous bases Adenine (A), Guanine (G), Thymine (T) and Cytosine (C); (iii) a phosphate group (PO4) positioned on the sugar.

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

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]

The negative charge on DNA is due to the presence of the negatively charged phosphate groups. A nitrogenous base is linked to the pentose sugar through the N-glycosidic linkage. Two nucleotides are linked through 3'-5' phosphodiester linkage. A polymer formed in such a manner has a free phosphate group at 5'-end of ribose sugar, which is referred to as 5'-end of polynucleotide chain. The other end of the polymer has a free 3'-OH (hydroxyl) group of the deoxyribose sugar. This is the 3'-end of the polynucleotide chain. The bonding between sugar and phosphate groups forms the backbone of a polynucleotide chain. The nitrogenous bases are linked to sugar moieties and project from the sugar-phosphate backbone.



The Chemical Structure of Double Helix DNA

The Chemical Structure of Double Helix DNA

The characteristic features of the double helical structure of DNA are as follows:

- Two polynucleotide chains wrap around each other, where the backbone is constituted by pentose sugar and phosphate, and the bases project inside.
- The two DNA chains run antiparallel to each other. It implies that if one chain has the polarity 5'-3', then the other has 3'-5'.
- The bases in the two strands are paired through hydrogen bonds between the base pairs. Adenine forms two hydrogen bonds with thymine whereas cytosine forms three hydrogen bonds with guanine.
- The two strands are coiled in a right-handed pattern.
- The plane of one base pair lies over the other in a double helix. This, in addition to H-bonds, gives stability to the helical structure.

Histones and the Importance of DNA molecule Packaging:

In prokaryotes, DNA is associated with nucleoid-associated-proteins (NAPs) and packaged into single circular chromosome located in the nucleoid region (a region of cytoplasm). In eukaryotes, it is organized into many linear chromosomes and the negatively charged DNA is associated with histone and non-histone proteins referred as chromatin. The length of DNA is very long. In order to fit the DNA into the nucleus, it needs to be packaged in compact and compressed manner as chromatin.

In the chromosome structure, DNA double helix represents first order of packaging. Around 146 base pairs (bp) of DNA helix wrap around a core octamer of histones called a nucleosome. The histone H1 binds the nucleosome at the entry and exit sites of the DNA, thus locking the DNA into place. Each nucleosome is connected with other by a small stretch of linker DNA (approximately 50 base pairs). This formation yields 10nm fibre appearing like beads on a string. Nucleosomes are further coiled and arranged as solenoid structure or zig-zag structure (30nm in diameter). These structures later form chromatin loops and chromatin fibres. During interphase, chromatin fibres when stained look like thread-like structures which condense to form chromosomes during mitosis.

The levels of DNA packaging are:

The first order of DNA packaging – Nucleosome.

The second order of DNA packaging – Solenoid fibre.

The third order of DNA packaging – Scaffold loop Chromatids Chromosome.

The fourth order of DNA packaging-Super coiled chromatin

The fifth order of DNA packaging-Metaphase Chromosome

Packaging involves formation of – Beads on string (11nm), Solenoid fibre (looks like coiled telephone wire, 30 nm diameter/300 Å), Chromatin fibre(700nm) and metaphase Chromosome(1400nm).

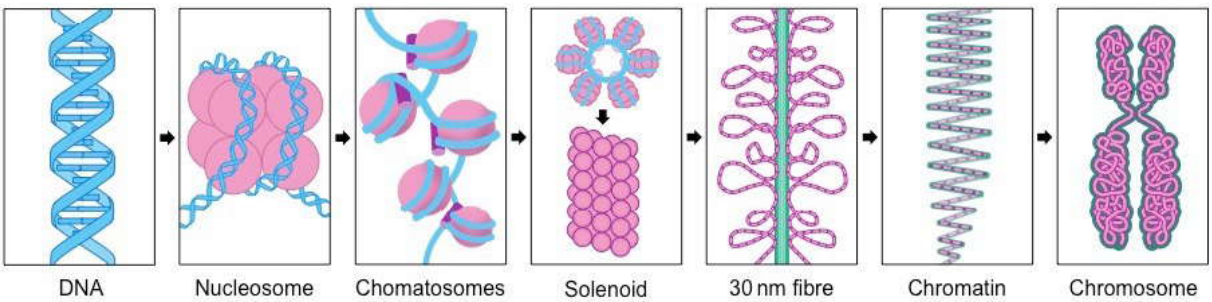


Fig : Packaging of DNA molecule in Chromosome

RNA

Ribonucleic acid (RNA) - It is the genetic material of certain viruses and the molecule that directs the middle steps of protein synthesis. In cellular organisms, although DNA carries the information needed for cellular activities, it cannot act alone and relies upon RNA to transfer this crucial information (translate) during protein synthesis. In RNA viruses, the RNA directs two processes – protein synthesis (production of the virus's protein coat) and replication (the process by which RNA copies itself).

The structure of RNA is similar to that of DNA and it is composed of a single string of ribonucleotides, each of which is composed of

- a pentose sugar (ribose sugar)
- a phosphate group
- a nitrogenous base (one of the two bases – adenine, guanine, uracil and cytosine)

These components are joined together in the same manner as in DNA molecule. But RNA differs chemically from DNA by being single stranded, having a D-ribose sugar instead of Deoxyribose sugar and having uracil as nitrogenous base instead of thymine. These nitrogenous bases can occur in any sequence.

TYPES OF RNA

There are three types of RNA classified based on their molecular functions. The smallest type of RNA is called transfer – RNA (tRNA), involved in protein synthesis. There are different classes of tRNA that read the codes of mRNA, pair with their bases and thereby carry specific amino acids to the ribosomes for their incorporation into a protein.

The second type of RNA is the ribosomal – RNA (rRNA), this is larger than tRNA and composes the ribosomes in the cytoplasm, the specialised structures that are the sites of protein synthesis.

The largest type of RNA is the messenger – RNA (mRNA). Messenger – RNA is a strand of RNA that is complementary to the DNA sequence for a gene and carries the genetic blueprint copied from the sequence of bases in a cell's DNA. This blue print specifies the sequence of amino acids in a protein. This is the only RNA that can be coded to protein.

All the types of RNA are formed as needed, using specific sections of the cell's DNA as template.

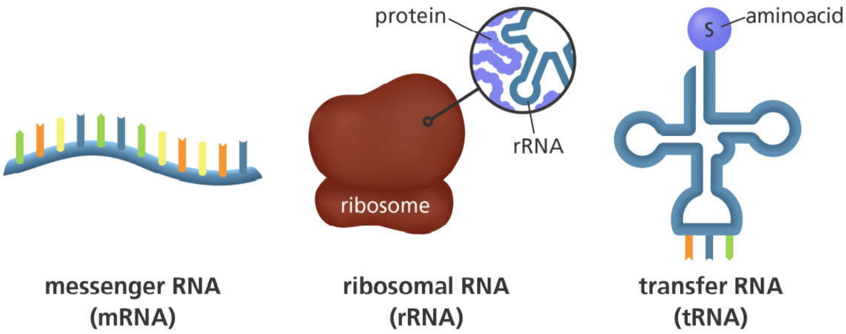


Fig: Types of RNA

Central Dogma of molecular biology

The central dogma of molecular biology states the flow of genetic information from DNA to RNA to protein. Three different processes are responsible for the inheritance of genetic information and for its conversion from one form to another. They include:

1. **Replication**: a double stranded nucleic acid is duplicated to give identical copies. This process perpetuates the genetic information.
2. **Transcription:** a DNA segment that constitutes a gene is read and transcribed into a single stranded sequence of RNA. The RNA moves from the nucleus into the cytoplasm.
3. **Translation:** the RNA sequence is translated into a sequence of amino acids as the protein is formed. During translation, the ribosome reads three bases (a codon) at a time from the RNA and translates them into one amino acid.

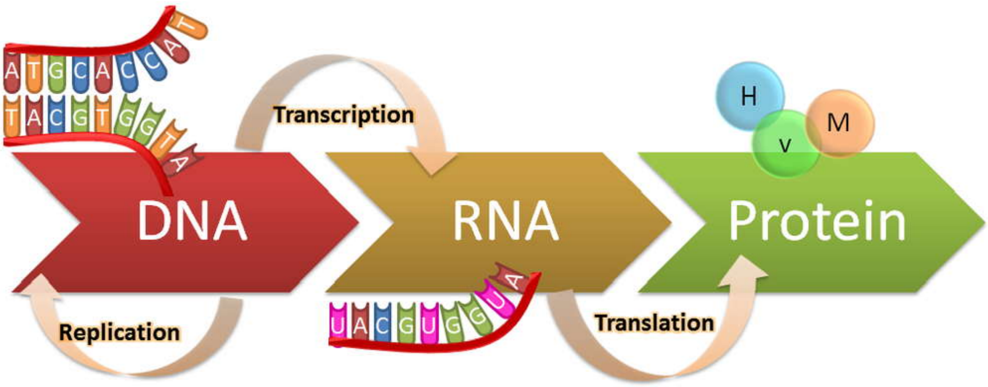


Fig: Central dogma –Flow of genetic information

DNA REPLICATION

DNA needs to be protected, maintained and inherited efficiently in every round of cell division. Replication is process to make DNA copies for its transmission to the daughter cell. During replication, an exact copy of the DNA is made; with the existing DNA being used as a template for the synthesis of new DNA strands in the cell nucleus.

The steps involved in DNA replication:

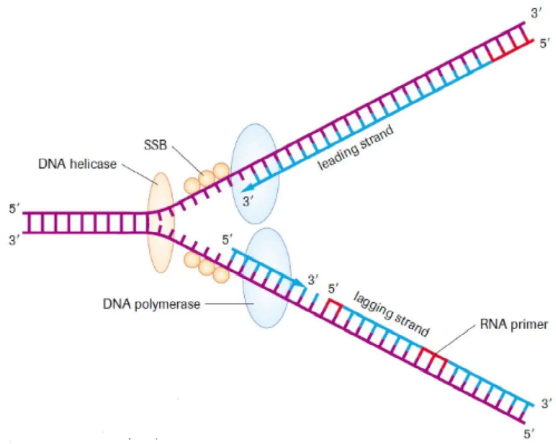
- Activation of Nucleotides
- Point of Origin or Initiation point
- Unwinding of DNA strands in the double helix
- Formation of Y-shaped replicating fork
- Synthesis of new strands
- Leading and Lagging strand
- Formation of daughter DNA molecules

Replication of a DNA molecule takes place in the cell nucleus and occurs just before the cell divides. During replication the parent double helix DNA molecule uncoils when the hydrogen bonds between the nitrogenous bases are broken, and as a result the double helix DNA begins to unzip and unwind. The unzipping creates two separate parent strands of DNA. Each parent strand becomes the template (pattern) for the creation of a daughter strand. The unzipping exposes chemical bonds on the purines and pyrimidines, the nucleoplasm is a reservoir of free nucleotides from which each A on the parent strand attracts a T nucleotide, and each C attracts a G nucleotide and so on. When the nucleotides are lined up they join together to form a polynucleotide chain, the DNA polymerase helps the nucleotides link up; by bonding the phosphate group of nucleotide to the sugar molecule of the adjacent nucleotide during the side rail of the new DNA molecule. After each daughter strand bonds to the parent strands, the molecules twist again into a double helix, forming two identical strands. Each new DNA molecule retains half of the original DNA material and pairing of bases occurs; this type of replication is semi conservative and complementary.

Enzymes and proteins involved in DNA replication:

- Phosphorylase
- Helicase

- Single strand binding proteins (SSBP)
- Primase
- DNA polymerase
- DNA ligase
- Super-helix relaxing enzyme
- DNA gyrase (Topoisomerase)



Process of Protein Synthesis:

DNA contains instructions for all the proteins your body, but only minute proportion of DNA carries the information for protein synthesis called coding DNA and the rest is known to have regulatory roles. Genes are the segments of DNA with instructions for making specific proteins or functional products. Generally, a typical gene constitutes regulatory segment called promoter, coding segments (exons) interspersed with non-coding segments (Introns) and terminal regulatory region. A protein cannot be made directly from a gene. The bridge between genetic information and protein synthesis is RNA. The synthesis of RNA from a DNA template occurs via a process called transcription. Later, the information on RNA is processed to form a polypeptide or a protein.

Transcription

(1) Transcription is the process of copying of genetic information from one (template) strand of DNA into a complementary single stranded RNA transcript.

(2) Occurs in the nucleus during G1 and G2 phases of cell cycle.

(3) Catalyzed by RNA polymerase:

(i) In Prokaryotes: One type of RNA polymerase.

(ii) In Eukaryotes:

RNA polymerase-I: Transcription of r-RNA.

RNA polymerase-II: Transcription of m-RNA and heterogeneous nuclear- RNA (or hnRNA).

RNA polymerase-III: Transcription of t-RNA and small nuclear-RNA (snRNA).

(4) Transcription Unit: Transcription unit (Each transcribed segment of DNA) consists of the promoter, the structural gene and the terminator.

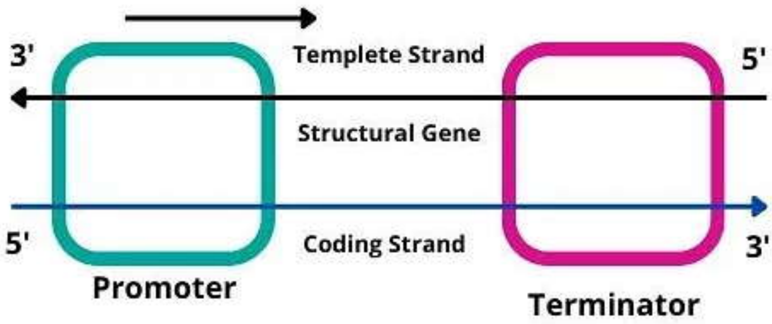


Fig: Transcription unit

During transcription, RNA undergoes various modifications like capping and polyadenylation to ensure stability of RNA. Later, the primary RNA strands are processed to form mature mRNA by process of splicing. There are different splicing mechanisms by which a single gene can produce more than one kind of protein.

Translation

Once mRNA is synthesized, it moves to the ribosomes in cytoplasm to be processed further for protein synthesis. Translation is the process in which sequence of codons on m-RNA is decoded and accordingly amino acids are added in specific sequence to form a polypeptide on ribosomes. It requires 20 different amino acids, m-RNA, t-RNA, ribosomes, ATP Mg++ ions, enzymes, elongation, translocation and release factors.

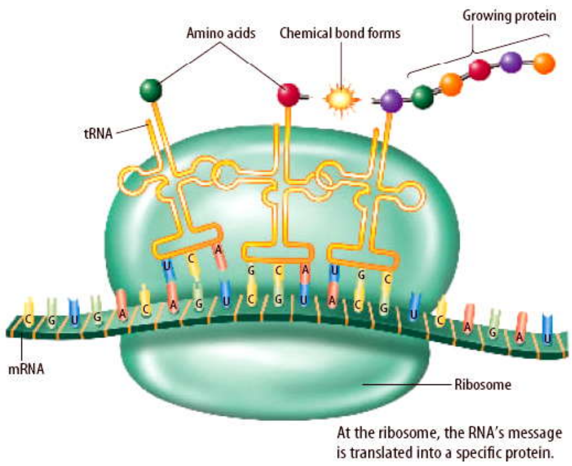


Fig: Process of ***Translation***

Translation mainly involves

- Activation of amino acids and formation of AA-t-RNA complex.
- Formation of polypeptide chain: initiation, elongation, termination.

Earlier, it was suggested that a single gene produces a single enzyme, which later affects an individual step in a metabolic pathway proposed by Beadle and Tautum in 1942. Later it was discovered that there are fewer number of genes as compared to wide variety of protein. It is important to understand the role of DNA in gene expression, gene function and its regulation.

Genetic Code:

Now, we are clear about the flow of information, but how the information on DNA or mRNA is understood by the transcription or translation machinery. The set of specific rules by which information is decoded during translation is called genetic code. The salient features of genetic codon are:

Polarity: Genetic code is always read in 52 -» 32 direction.

Non-overlapping code: Genetic code is triplet in nature and read as non-overlapping sequence of codons (Codon is a set of three successive nucleotides). Each single nucleotide is a part of only one codon.

Commaless: There is no gap between successive codons.

Degeneracy of genetic code: Two or more codons can specify the same amino acid. E.g. Cysteine has two codons, while isoleucine has three codons.

Universal code: In all living organisms the specific codon specifies same amino acid. E.g. codon AUG always specifies amino acid methionine.

Non-ambiguous code: Each codon specifies a particular amino acid.

Initiation codon: AUG, Codes for amino acid methionine.

Termination codons: UAA, UAG and UGA: They do not code for any amino acid. They stop the process of elongation of polypeptide chain.

Codon: A triplet of nucleotides present on DNA that codes for specific amino acid or stop signal. E.g. AUG is codon that codes for Methionine; UAA is a stop codon.

Anticodon: Triplet of nucleotides present on the anticodon loop of t-RNA, which is complementary to codon on m-RNA.

Gene Expression and its regulation

In multicellular organism every cell in the body has identical genetic information, individual cells have different structural and functional characteristics. Gene expression is the most fundamental level at which genotype gives rise to the phenotype. The genetic code stored in DNA in the form of nucleotide sequence is interpreted by gene expression, and the properties of the expression products give rise to the organism's phenotype. The genetic content of each somatic cell in an organism is the same. How is it that cells differ in their structure and function? Not all genes are expressed in every cell all the time. For instance, the expression of specific gene may be regulated differently in an eye cell or a liver cell. It is the differential gene

expression patterns that arise in different cells. All the genes are not activated constantly. Genes which have constant expression are called house keeping genes and these produce proteins required in large quantities: Eg-Histones. Most genes express only when proteins are needed. The expression of such genes is tightly controlled which involves the rate and manner of gene expression, when and in which cell a gene has to be activated, etc. These instructions are known to be controlled by regulatory genes. Genes are made to function only when required (switched on) and remain non-functional (switched off) at other times. The control of gene expression is extremely complex and regulated at different levels. Malfunctions in this process cause damage to the cell and can lead to the development of many diseases.

Prokaryotic versus Eukaryotic Gene Expression: In prokaryotes, gene transcription and translation happens simultaneously and primary way of regulation is to control transcription. In bacteria, genes encoding proteins of same functional pathway are arranged as cluster to form an 'operon'. Eg: Lac Operon. An operon consists of structural genes, operator genes, promoter genes, regulator genes, and repressor. The genes in an operon are transcribed into a single mRNA molecule and the genes can be controlled as a unit: either all are expressed, or none is expressed. Type of regulatory molecules (repressors and activators) can also affect gene expression. Francois Jacob and Jacques Monod in 1960, formulated a powerful model of the control of gene expression in bacterial cells, based on their investigation of enzyme synthesis in E. coli. Lac operon consists of Lac Z, Lac Y, and Lac A genes as structural genes. These genes code for specific enzymes. Lac Z codes for galactosidase, Lac Y codes for permease and Lac A codes for transacetylase. When repressor molecules bind the operator, the transcription process is inhibited. When the repressor does not bind the operator and instead inducer binds, transcription is switched on. In the case of lac operon, lactose is an inducer. So, binding of the lactose to the repressor, switches on the transcription.

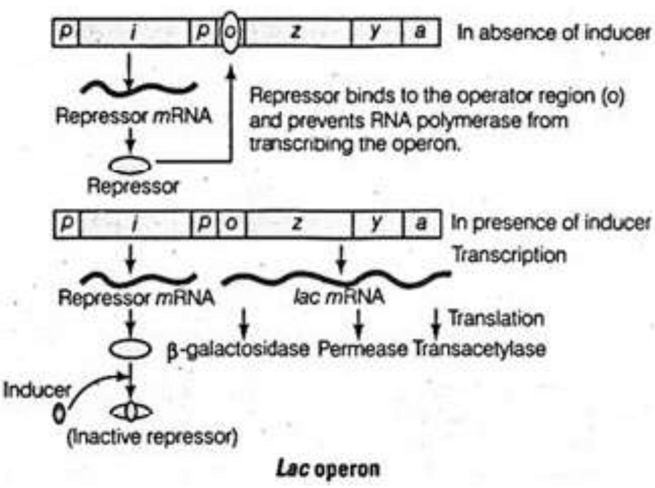


Fig: Lac operon-Regulation of gene expression in bacteria

In eukaryotes, the processes of transcription and translation are physically separate; transcription occurs only within the nucleus, and translation occurs only in the cytoplasm. Thus, the regulation of gene expression in eukaryotes can occur at all stages of the process. Gene expression can be regulated during transcription by type of RNA polymerases, presence of alternate promoters, interaction of specific transcription factors, involvement of enhancers or silencers, DNA binding proteins, etc. Similarly, expression may be influenced by RNA stability, transport, post-transcriptional modifications, and so on. Rate of translation, codon degeneracy and post-translational modifications may also impact the level of gene expression. There are several mechanisms of regulation to understand the expression of developmental genes (the type of alpha and beta haemoglobin molecules produced in fetal stage are different from adult stage in human), structurally/functionally similar proteins, genes for X-chromosome inactivation in female, why proteins needed for flower development are silenced until needed and so on.

IMPORTANT POINTS

Gene:	Basic unit of heredity, made up of small segments of DNA.
DNA:	DNA is the hereditary material which stores all the information needed for all the cellular activities. It involves replication, storage, transmission, and expression of information.
Nucleoside:	It consists of nitrogen base and sugar without phosphate group.
Nucleotide:	It is a unit of the DNA molecule, which contains a sugar, phosphate group, and Nitrogen base.
Chargaff rule:	In a DNA molecule, the amount of purines (A + G) and that of pyrimidines (T + C) in DNA is always equal.
Uracil:	It is a pyrimidine base, present in only RNA but absent in DNA.
Nucleosome:	It is a repeating subunit of chromatin that contains DNA and Histone proteins.
Histones:	Histones are basic proteins found in chromosomes. They help in packing and organisation of DNA helix in chromatin fibre in the nucleus.
t-RNA:	It is a type of small RNA. t-RNA stands for transfer RNA. It carries the amino acid from the cytoplasm to ribosomes during protein synthesis.

DNA Replication:	The process of copying and duplicating a DNA molecule.
Okazaki fragments:	These are small fragments of DNA synthesized opposite to the 3’-5’strand in a discontinuous manner during replication process.
Central dogma:	It states how genetic information flows from DNA to RNA, RNA to Protein.
Genetic code:	The sequence of nucleotides in DNA and RNA that determines the amino acid sequence of proteins.
Codon:	A codon is a DNA or RNA sequence of three nucleotides.
Transcription:	The synthesis of m-RNA from DNA molecule with the help of RNA polymerase. It occurs in Nucleus.
Translation:	It is a process, where the sequence of codons in m-RNA converts into sequence of amino acids. It occurs in cytoplasm.
Lac operon:	It is a cluster of three structural genes encoding proteins that regulated and involved in Lactose metabolism.

INTEXT QUESTIONS

1. Write five differences between DNA and RNA.
2. Explain the genetic code properties.
3. Describe the structure of double helix DNA.
4. Write a short note on types of RNA.
5. Explain about Hershey chase experiment?
6. List out the enzymes involved in DNA replication.
7. How many RNAs participated in protein synthesis? Name them.
8. Define the terms: i) Codon ii) Nucleoside iii)Nucleosome
9. Define Chargaff rule.
10. Define central dogma? Write the names of events in this process.
11. What is meant by semiconservative model of DNA replication?
12. Explain the following terms: a)Translation b)Okazaki fragments

5 GENETICS & 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.

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. Between1902 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, DNAwas established as the genetic material and structureand chemical nature of DNA was understood [recall the double helical structureof 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 aboutthe nucleic acid molecules and protein molecules and also about the genetics ofbacteria. The knowledge gained has led to the invention of technologies of genetic engineering, gene cloning, organismal cloning, DNA finger printing. Even morerecent 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 variousgenes explored. Knowing the human genome has opened up the possibilities for handling genetic disorders through gene therapy.

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 genesas did her mother as she was cloned from her mother.

In the Roslin Institute in Scotland, Ian Wilmut cloned "Dolly" the sheepfrom 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 storedand 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 bacteriummultiplies 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

1. Name any two recent techniques in genetics.

   ____

2. Define gene cloning

   ____

3. What is a gene bank ?

   ____

RECOMBINANT DNA TECHNOLOGY

One of the major applications of genetics is in “genetic engineering” which is also called recombinant DNA technology. In this technique the desired gene which is a DNA segment carrying a particular sequence of nucleotides is added to the DNA of another organism (usually a bacterium) with the help of a transferring agent or **vector**. The modified DNA molecule carrying

DNA from two different sources is called **recombinant DNA** or **rDNA.** The joining of two pieces of DNA is termed **DNA splicing** (Splicing in Latin means marriage).

The steps in the production of rDNA are as follows :

- The desired piece of DNA is cut from the cells (Ex. human cells) with the help of enzymes called **restriction endonucleases** or restriction enzymes. These enzymes are found in different bacteria. They recognise **specific nucleotidesequences** in a DNA molecule and cleave (cut) them.
- The same restriction enzyme cuts the same specific nucleotide sequence in aplasmid. 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 plastids 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.

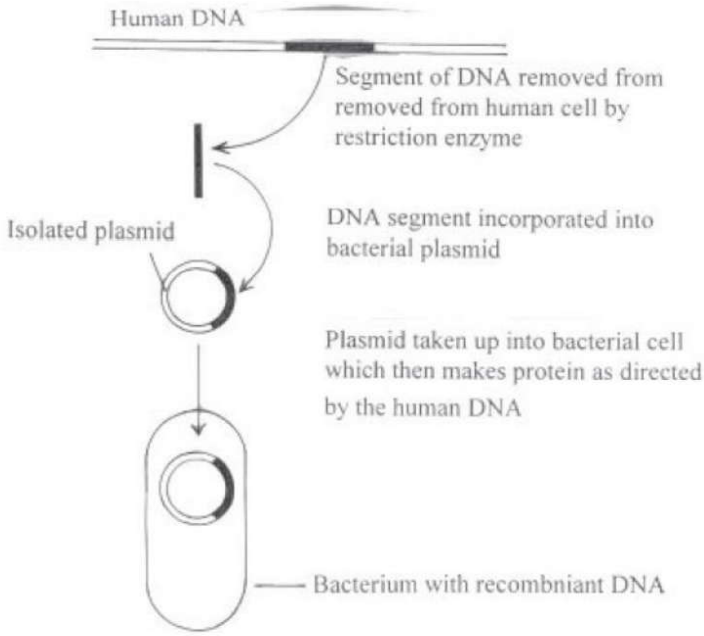


Fig : Major Steps in Genetic Engineering

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 rDNAtechnology.

INTEXT QUESTIONS

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?

   ____

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 speciesor another kind of organism. Transgenics are raised through recombinant DNAtechnology.

Transgenic microbes

Bacteria are easiest to be genetically modified by adding foreign gene into theirplasmids 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 extractingmetals 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.

Transgenic animals

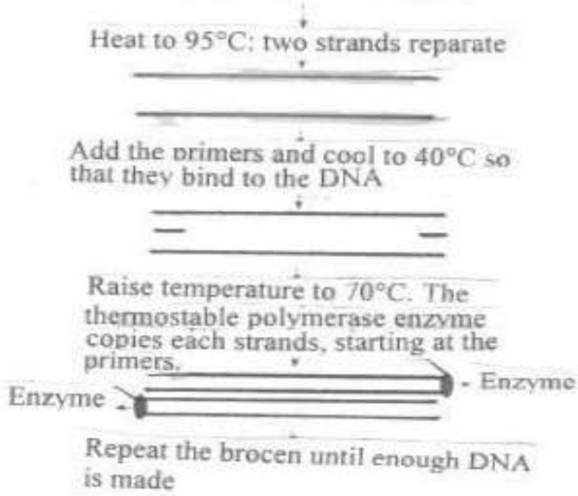
The gene for growth hormone from cattle have been inserted through genetic engineering to produce large fish, pigs and some other animals.Transgenic goats can produce a blood clotting protein in their milk. This may be useful for children suffering from disorders such as haemophilia in which blood does 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.

POLYMERASE CHAIN REACTION

You have learnt 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 smallamount 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.



DNA FINGER PRINTING

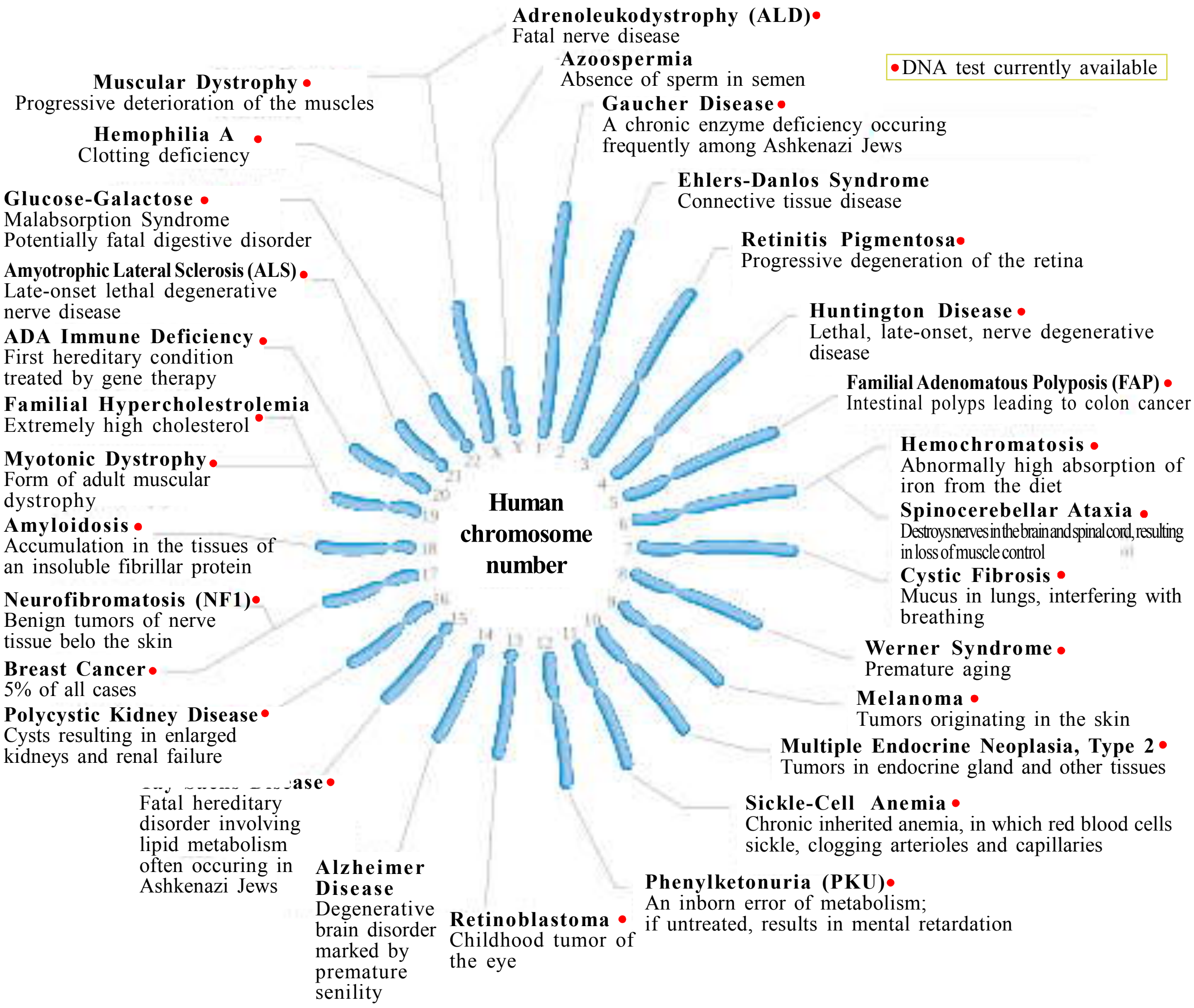
Like our fingerprints, the repeated sequences in our DNA are unique. You musthave heard that the police lifts fingerprints from the scene of crime to identify the culprit in case of rape, theft or murder.

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 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.

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.



Human Genome showing location of defective genes

The human genome has also been mapped in 2003. Humans have 23 pairs ofchromosomes (2n = 46) and the human genome has 3 ×109 nucleotide base pairs and if the sequence of nucleotides (genes) is known, it will be possible to pinpoint (i) defective genes (as shown in the figure in the box) and (ii) identify genes for correction of genetic disorders (gene therapy) and genetic counselling.

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 passdown 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 toknow 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.

INTEXT QUESTIONS

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?

   ____

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 anddate palm can be traced to earlier that 5000 BC.
- Modern genetics began after Mendel's laws of inheritance were accepted Soon after it become clear that genes are carriers of hereditary features and they are

present on chromosomes. That genes mutate also become known.

- The last fifty to sixty years have been an era of Molecular Genetics when it was confirmed that DNA is the genetic material and the mechanism of DNA replication and protein sysnthesis in a cell were discovered.
- In the last few years, many techniques such as rDNA technology, DNA fingerprinting have been put forth.
- Gene cloning means producing and preserving desired genes in a clone of bacteria through recombinant DNA technology. A gene bank is one where several clones of bacteria carrying different desired foreign genes (for example genes of humans) are preserved for future use of products of these genes.
- Genetic engineering, also called recombinant DNA technology uses specific restriction endonuclease from different bacteria to cut genes, that is, particular DNA sequences from DNA molecules of an organism (e.g. humans) and similarsequences from plasmids and join the foreign DNA to the plasmid and introduce the plasmid with foreign DNA into its host bacterium and raise a bacterial clone.
- Genetic engineering is useful for creating genetic libraries, gene therapy and genetically modified organisms.
- Genetically modified organisms are also called transgenics. Transgenic microbes, plants and animals carry in their genetic make up, gene or genes of another kind of organism. Transgenic bacteria are used for extracting metals and decomposing pollutants. Transgenic plants are herbicide and pest resistant. Transgenic animals are larger in size and transgenic goats may carry a human gene responsible for a particular protein which is then released in its milk.
- PCR or polymerase chain reaction is a technique to make many copies of a small amount of DNA.
- DNA fingerprinting is a technique to identify the DNA of a particular person. It is used to scientifically investigate a crime and identify the real criminal.
- Genomics is the analysis of a complete set of genes found in an organism. The complete set of genes is called a genome.
- Genetic counselling is the advise given by an expert on the chances of an unborn baby getting a genetic disorder.

TERMINAL EXERCISES

1. Name the three eras in the history of genetics.
2. Define gene cloning. What is the usefulness of a gene bank.
3. Give the various steps of recombinant DNA technology.
4. What are the benefits of genetic engineering?
5. What are transgenics? Give examples of a transgenic microbe, plant and animals.
6. Define genomics
7. Draw and explain a pedigree chart.
8. What is genetic counselling and why is it important?

21 PRINCIPLES OF ECOLOGY

Principles of ecology

The word "ecology" ("Ökologie") was coined in 1866 by the German scientist Ernst Haeckel. Ecology is the study of how living things interact with each other and with their environment. It is a major branch of biology but has areas of overlap with geography, geology, climatology, and other sciences.

Fundamental Concepts and Principles of Ecology

There are certain basic fundamental ecological principles which describe various aspects of living organisms e.g. evolution and distribution of plants and animals, extinction of species consumption and transfer of energy in different components of biological communities, cycling, and recycling of organic and inorganic substances, interactions and inter-relationships among the organisms and between organisms and physical environment, etc.

The Following are the fundamental concepts and principles in ecology, beginning with organisms and the environment.

Earth is the only planet in the solar system that Supports life. Why only the earth can support life, this is because of the balance between physical Systems on it, i.e. Soil, water, air.

The three factors Air,Water and Soil provide material, which is essential for life. All the living organisms differ from each other but are interdependent and interact with each other directly or indirectly.

In this lesson we will study The relationships between living things and their environment. and the different levels organization, the characteristics of Ecosystem and the major biomes.

Objectives

After completing This lesson you will be able to understand

- various components of the environment
- Biotic and abiotic components of the environment.
- Food chain and food web.
- Energy flow through the food chain
- Biogeochemical cycles such of Carbon and Nitrogen cycles.

Environment Ecology and Biosphere

Environment

- The term Environment denotes all the physical, Chemical and biotic conditions, which surrounding and influencing living organism.
- Favorable environment conditions are required to sustain life on Earth.

The environment can be divided in to two main Components.

1. A biotic : Physical factors, Edaphic factors Chemical factors.

   (nature of soil) (organic & inorganic components)

2. Biotic : All the organisms found in the environment and that includes plants animals and micro organisms.

we will discuss clearly about this factors in this lesson.

Ecology

Ecology is the scientific Study Study of the relationship between organism and their environment... The term ecology delivered from a Greek word oecologie where "oikos" meaning household and "Cogos" meaning is the study of organism at Home

These interaction can be studied at the various levels of organization in the living systems starting from the molecules such of DNA (genes) to a Biological Community.

Each step of independent interaction is called a level of organization. These are as follows.

Genes/DNA → Cells → Organ → Organism → Population → Community

Levels of Biotic organization showing a direct impact of Environment.

An organism is self reproducing system capable of growing and maintaining itself and is 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 it’s living i.e. known as it's habitat. The habitat of sunfish is pond and lion is forest.

Species: If you bring the Sunfish from two different ponds and put them in one pond, they can interbreed. So both the population of sunfish belong to one specie.

A species is defined as agroup of organismwhich can interbreed and produce a fertile offspring. These organisms may be separated in space and time into smaller group called population.

Biological community: it refers to the population of different species occupying a common place of living. For eg: all the living organisms in a pond belong to one community.

A biological community along with it’s non living environment i.e. energy and motter makes an Ecosystem.

The study of group of organisms in relation to their environment is called **synecology**.

Biosphere:

A thin layer on and around the earth which Sustain 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 each other as well as on the physical components of the earth. The physical components of the earth are atmosphere, Lithosphere, hydrosphere (air, land and water)

Atmosphere is a gaseous envelope surrounding the earth’s surface. It is made up of nitrogen, Oxygen, Co_2 and many other gases in very trace amounts.

Hydrosphere - is all the water supply to earth which Exist as liquid, vapor or frozen form of Lakes. Pond, Sea

Lithosphere comprise the soil and rock of earths Crust.

Ecosphere = Biosphere + Lithosphere + Hydrosphere + Atmosphere.

Ecosphere is very huge and cannot be Studied as a Single entity. It is divided into many distinct functional units called ecosystems."

INTEXT QUESTIONS

1. Who coined term Ecology.

   ____

2. Name the various level of organization.

   ____

3. Define term Ecology.

   ____

4. What the three physical systems, that support life on earth-organization.

   ____

COMPONENTS OF ENVIRONMENT

The environment has two basic components

(A) Abiotic (B) Biotic.

(A) Abiotic Components (Non living):

They can be classified in following 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 organism any one of these are excess or in lower amounts impact the growth of the organism.

2. Chemical components:

a) Inorganic Components: Substances such as carbon and carbon, nitrogen, oxygen, phosphorous, Sulphur, Zinc, water and other minerals are the inorganic nutrients which are essential for living things.

b) organic components: The complex molecules Such as carbohydrates, proteins, and lipids are the organic components in an ecosystem.

(b) Biotic Components (living)

The living organisms form the biotic components of the environment.

All the living things require energy for their life -process and material for formation and maintenance of their body Structure. Food meets both these requirements. Biotic components classified in to Producers, Consumers, decomposers.

1. Producers: only chlorophyll containing organisms can synthesize their own food by capturing solar energy from sun carbondioxide from atmosphere water from soil Therefore they are called producers. Plants also named as Autotrophs.

2. Consumers: Animals depends up on plants indirectly for their food, hence directly are called consumers.

- Their mode of Nutrition' is Heterotrophic.
- Consumers Can't be Herbivores, Carnivores, described later in this lesson

3. Decomposers: They feed on dead decaying matter. They are microscopic and macroscopic organisms and help in recycling of nutrients in the environment.

INTEXT QUESTIONS:

1. Name the major components of the environment

____

2. Enumerate the various physical factors of environment.

____

3. What is the role of decomposers in nature

____

4. Why are plants called autotrophs and animals called heterotrophs?

____

ECOSYSTEM

Ecosystem is a self sustaining unit of the nature. It is defined as functionally independent unit (of nature) where living organism interact among themselves of as well as with their physical environment. In nature three major ecosystems exist they are Terrestrial, aquatic and areal ecosystems.

Forests, Deserts and Grasslands are few examples of terrestrial ecosystem. Ponds, lake, ocean, wetlands are few examples of aquatic ecosystem. Aquatic ecosystem can be of two types they are fresh water and maraine water ecosystem. Fresh water ecosystem can be divided into two types they are Lentic (stagnant) and Lotic (flowing) Ocean is a large ecosystem pond is a Small ecosystem. Irrespective of their Size, all ecosystems share many Common characteristics. Later Study moderate Sized Pond ecosystem to understand its Structural and functional components..

Pond Ecosystem

Pond ecosystem is a freshwater ecosystem

The pond ecosystem falls under the category of Lentic ecosystem because the water remains Stagnant for a longer period.

- Pond is a shallow body of water. The plants enclose the Pond's boundaries, because sunlight can penetrate up to this Zone.
- In the middle level different consumers occupy this Zone for e.g. fishes, Frogs.
- In the bottom of the pond Decomposers are present.

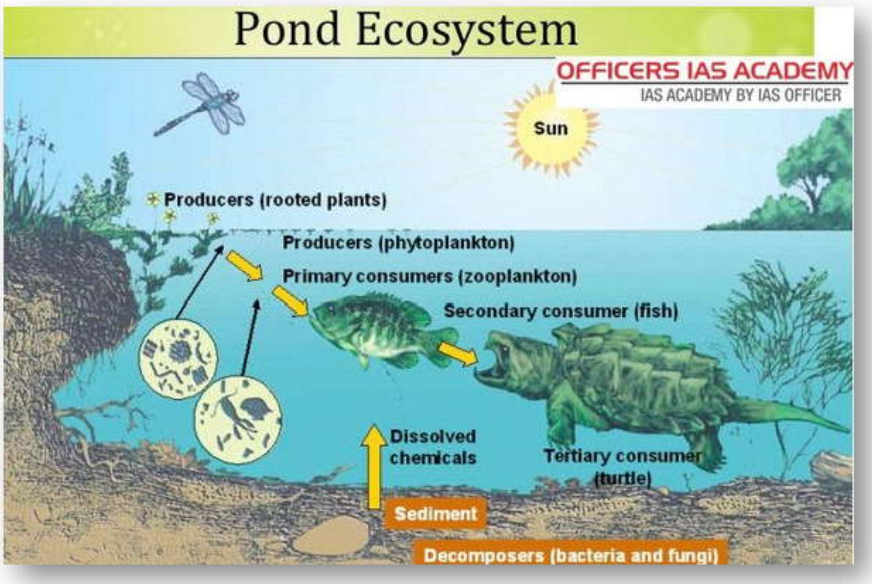


Fig : Pond Ecosystem.

Structure of pond Ecosystem

1. Physical or climatic factors: Pond receives solar radiation, which provides heat and light energy to Sustain life.

   Light: In case of shallow pond with clear water sunlight can penetrate up to the bottom. In deep ponds penetration of light depends on transparency of water.

   Temperature: Heating effect of solar radiation leads to diurnal (day) nocturnal (night) Seasonal temperature cycles. In the tropical regions there are no much temperature variations. At higher latitudes remarkable temperature variation are observed.

   Inorganic Substances: Carbon, Nitrogen, phosphorous, calcium and few other clements are present O_2 and CO_2 are present in dissolved state.

   Oganic Substances: commonly found organic Substance in the pond are amino acids, humic acid these are formed by the breakdown of dead and decaying matter. They are partially dissolved in water or remaining are accumlated as sediment

Biotic components:

1. producers or Autotrophs: They synthesize food for all the heterotrophs of the pond.

   They are following two types.

   (a) Floating plants. (b) Rooted plants.

(b) Floating plants: They are are called phytoplankton

Eg: Spirogyra, Ulothrix, diatoms and volvox.

(c) Rooted plants: These plants occur in concentric layers from periphery to deeper zones. Some Examples of Rooted plants are Typha, Sagittaria, Hydrilla, chara

(d) Consumers (or) Heterotrophy: Animals which directly feed on autotroph eg. Insect larvae, tadpole, Snails Herbivores.

(e) Animals which feed on other Animals - Sunfishes and other Animals. (Carnivores) Bass.

(f) Decomposers: They are distributed in the whole pond but are most abundant at the bottom of the pond.

Eg: Bacteria, Fungi, other microbes

INTEXT QUESTIONS

1. Define Ecosystem

   ____

2. What are the main components of Ecosystem.

   ____

3. Give reason, why are decomposers necessary in an ecosystem.

   ____

Food chain

Where one living organism eats another organism, and later that organism been eater by another larger organism. The flow of nutrients and energy from one organism to another at different trophic levels forms a food chain.

Grass → Grasshopper → Frog → Snake → Hawk

1. Each step in the food chain is called Trophic Level. In the above Examples Grasser occupied first Trophic level and eagle represents fifth Trophic level.
2. Some more Examples of food chain are given in

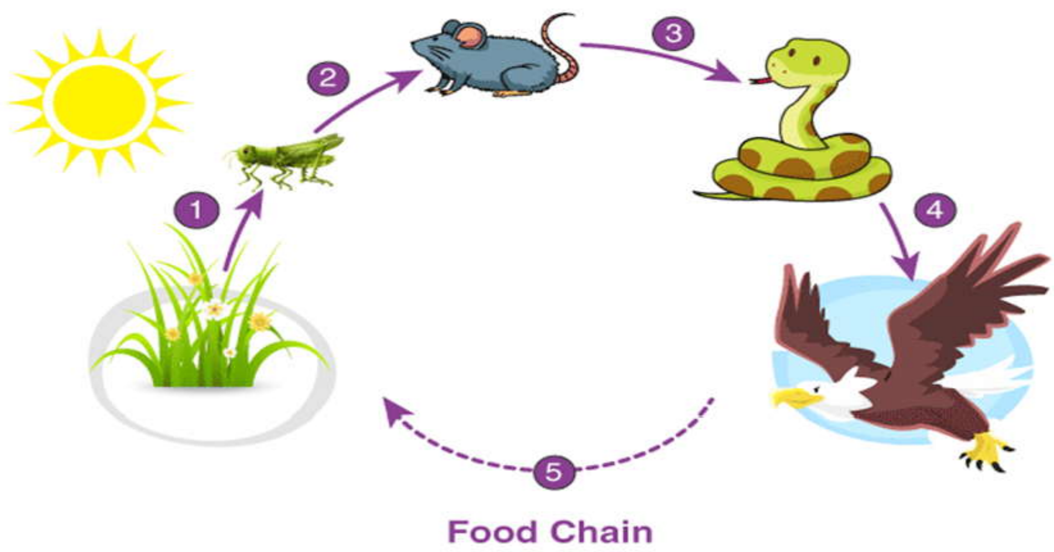


Fig : Food chain

Some Examples of food chain. Three important features you can note in these chairs are:

- weaker organism are attacked by the stronger organisms.
- Number of organisms is reduced at higher level but the size of organism is increased
- The number of Steps in food chain limited to 4-5 Trophic levels only.

A. A food chain consists of following trophic levels.

(i) (Producers) Autotrophs: They produce food for all other organisms of the ecosystem.

Autotrophs represent the first trophic level. They are largely green plants they convert inorganic substances in to organic Substances, i.e. food 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). A part of GPP is utilized by plants for their metabolism maintenance, reproduction. Energy required for all these functions is produced by the process of respiration. GPP = NPP+R

GPP-R = NPP. Net primary productivity. Remaining energy stored by the plants which is available to next trophic level i.e. for Heterotrophs or Consumer.

(ii) Primary consumers or Herbivores:

The animals which feed directly on the plants. They are the first level consumer and therefore they are also known as primary Consumer. They occupy second trophic level in the food chain. Eg: Grasshopper, insects, birds, Rodents, Ruminants.

(iii) Secondary consumers (or) Carnivores:

Carnivores are the animals that feed on other animals. Therefore they are secondary, territiary or quaternary level consumers - Frog is secondary level consumer as it feeds on herbivorous Grasshopper.

Frog, Dog, cat & Tiger are all carnivores Generally the size of the Carnivore increase at each trophic level.

(iv) Decomposers:

Decomposers are the organisms that feed on dead and decaying organic matter. Decomposers help in recycling of the nutrients.

Eg: Bacteria, fungi, Protozoans (Micro Decomposers)

Springtails, Mires, Millipedes (Macro Decomposers)

Special feeding groups (consumers)

(1) Scavengers (11) omnivores (iii) parasites.

Scavengers feed on dead plants and animals. Eg: Termites, beetles, vultures and hyena omnivores consume both animal and plants as Source of their food. Eg: Human beings.

Parasites They live and feed on other living organisms called host. Parasites cause diseases also.

Food web

In nature the food chains are neither isolated nor sequence but they are interconnected with one another. A network of food chain, which are interconnected at various trophic levels of the food chain to form a food web.

A Snake can feed on frog, rat or any other Small rodent also. Snake can eat 3-types of food.

Frog

Snake Frog — Rat

(Foodweb) Rodent

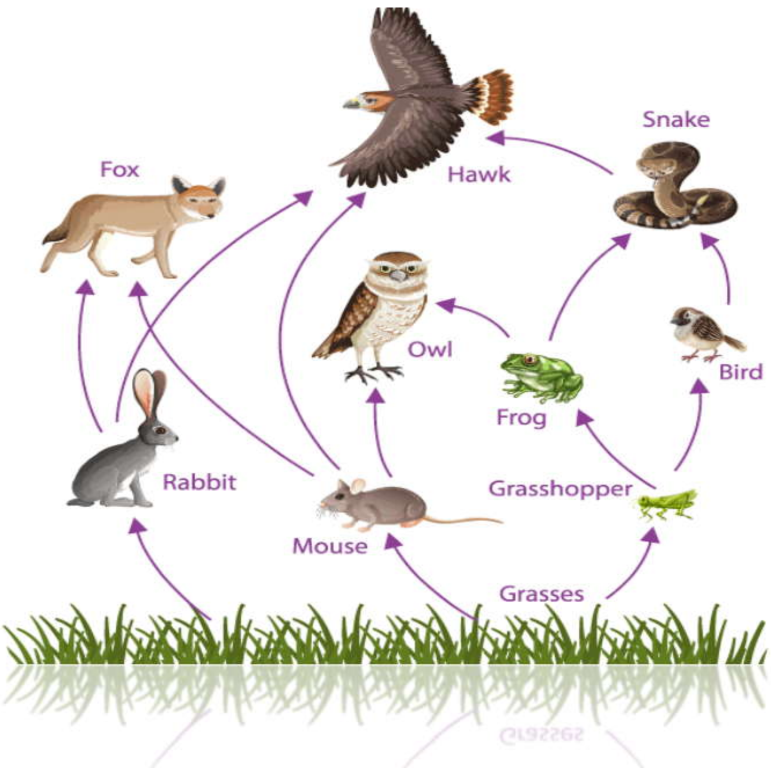


Fig : Simple food web.

INTEXT QUESTIONS

1. Give one Example for Food chain

____

2. Name the trophic level frog belongs to

____

3. Snake can be both a Secondary as well as tertiary Consumer Justify.

____

Energy flow through an ecosystem

The energy enters in to the ecosystem in the form of solar radiation and is converted into food by the producers. Food Stored by the plants .i.e Converted in to chemical form of energy. From the producers this Chemical form of of energy -Passes through various trophic levels in the food Chain is known as flow of energy.

All the functions of ecosystem depends on the flow of energy. through it. Boxer represent the trophic level and pipes depict energy flow in and out of each trophic level. The quantity of energy flowing through the successive trophic levels decrease as indicated the reduced size of the boxes and in the figure. This is because all the energy energy out each trophic level is not used for the production of biomass due to the following two reasons.

Firstly a part of energy is lost (not utilized) Secondly a part of it is used up by the organism for their own metabolism, through the process of respiration.

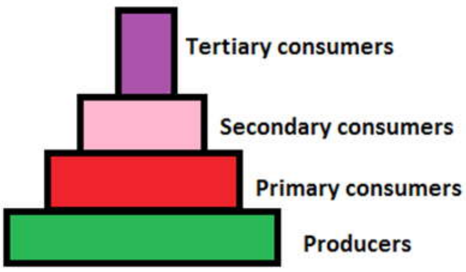
The herbivores Consumes 1000kcal. of plant in the form of food, only 100kcal is converted in to herbivore tissues, and 10 kcal, in to first level Carnivore and 1 k cal deal into second level Carnivore. This is known as 10% law (or ecological thumb rule) where by only 10%. of energy is transferred to next higher trophic level.

The entire process of energy flow can be summarized in the following four steps:

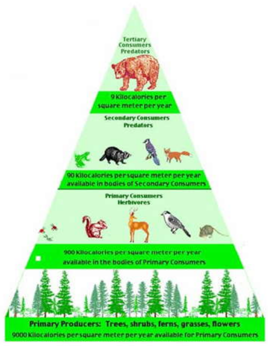
1. The flow of energy in an ecosystem is always linear on one way.
2. At every step in a food chain the energy received by the organism is also used for its own metabolism and maintenance.
3. It follows ecological thumb rule.
4. The number of steps are limited to four or five in a food chain for the transfer of Energy.

Ecological Pyramids (Eltonian pyramids)

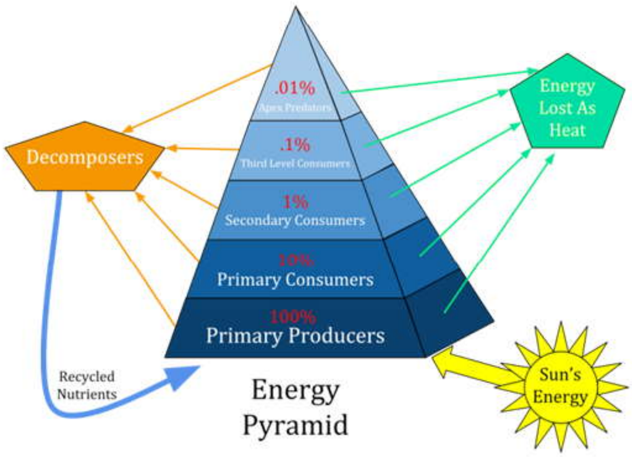
You must be familiar with the shape of a pyramid. The base of a pyramid is broad and it narrows down towards the apex. The trophic relationship is expressed in terms of numbers; biomass or energy arranged one on the top of its lower trophic level. resulting in a pyramidal shape. It is a graphical representation of the trophic structure and function of an ecosystem. The base of each pyramid represents the producers or the first trophic level, while the apex represents the tertiary or top level / top order consumer. The three types of ecological pyramids that are usually studied are (a) pyramid of number; (b) pyramid of biomass and (c) pyramid of energy. These pyramids were first represented by Elton, hence the name ELTONIAN pyramids/ Ecological pyramids.



Pyramid of numbers



Pyramid of Biomass



Any calculations of energy content, biomass, or numbers has to include all organisms at that trophic level. No generalizations we make will be true if we take only a few individuals of any trophic level into account. In most ecosystems, all the pyramids- of numbers, energy and biomass are upright i.e.. producers are more in number and biomass than the herbivores, and herbivores are more in number and biomass than the carnivores. Also energy (available) at a lower trophic level is always more than that at a higher level.

There are exceptions to this generalization. In the case of a parasitic food chain, the pyramid of numbers is inverted. A large tree (single producer) may support many

herbivores like squirrels, and fruit eating birds. On these herbivores many ectoparasites such as ticks, mites and lice (secondary consumers) may live. These secondary consumers may support many more top level consumers and also the hyperparasites. Thus in each trophic level from the bottom to the top, the numbers of organisms increase, and form an inverted pyramid of numbers.

The pyramid of biomass in sea is also generally inverted because the biomass of fishes far exceeds that of phytoplankton (Ref: NCERT Text Book). Pyramid of energy is always upright, and can never be inverted, because when energy flows from a particular trophic level to the next higher trophic level, some energy is always lost as heat (thus at every step). Each bar in the energy pyramid indicates the amount of energy present at each trophic level in a given time or annually per unit area.

It assumes a simple food chain, something that almost never exists in nature. ull it does not accommodate a food web, tv) moreover, saprophytes are not given any place in ecological pyramids even though they play a vital role in the ecosystem

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NUTRIENT CYCLES

Organisms need a constant supply of nutrients to grow. reproduce and regulate various body functions. The amount of nutrients, such as carbon, nitrogen, phosphorus, calcium, etc.. present in the soll at any given time, is referred to as the standing state. It varies in different kinds of ecosystems and also on a seasonal basis.

Nutrients are never lost from the ecosystems. They are recycled again and again, indefinitely. The movement of nutrient elements through the various components of an ecosystem is called 'nutrient cycling. Such cycles are called biogeochemical cycles (bio: living organism, geo: rocks, air, water).

Nutrient cycles are of two types:

(a) gaseous

(b) sedimentary.

In a gaseous cycle, elements move through the atmosphere. Main reservoirs are atmosphere and oceans (via evaporation) eg, carbon cycle and nitrogen cycle.

In a sedimentary cycle, elements move from the earth's crust to water and tosediment. Main reservoirs are the soil and sedimentary rocks, e.g. phosphorous cycle and sulphur cycle.

Carbon Cycle

The element carbon constitutes 49 percent of the dry weight of organisms and is next only to water. Among the total carbon quantity present on the Earth, 71 percent is found dissolved in oceans. This 'oceanle reservoir' regulates the amount of carbon dioxide in the atmosphere. It will be interesting to know that the atmosphere contains only about 1 percent of the total global carbon. Fossil fuels also represent reservoirs of carbon. Carbon cycling occurs through atmosphere, ocean and through living and dead organisms, carbon is fixed in the biosphere through photosynthesis. A considerable amount of carbon returns to the atmosphere as CO, through respiratory activities of the producers and consumers. Decomposers also contribute substantially to CO, pool by their processing of waste materials and dead organic matter of land or oceans. Some amount of the fixed carbon is lost to sediments and removed from circulation. Burning of wood, forest fires combustion of organic matter, fossil fuels, volcanic activity etc., are additional sources for releasing CO, into the atmosphere.

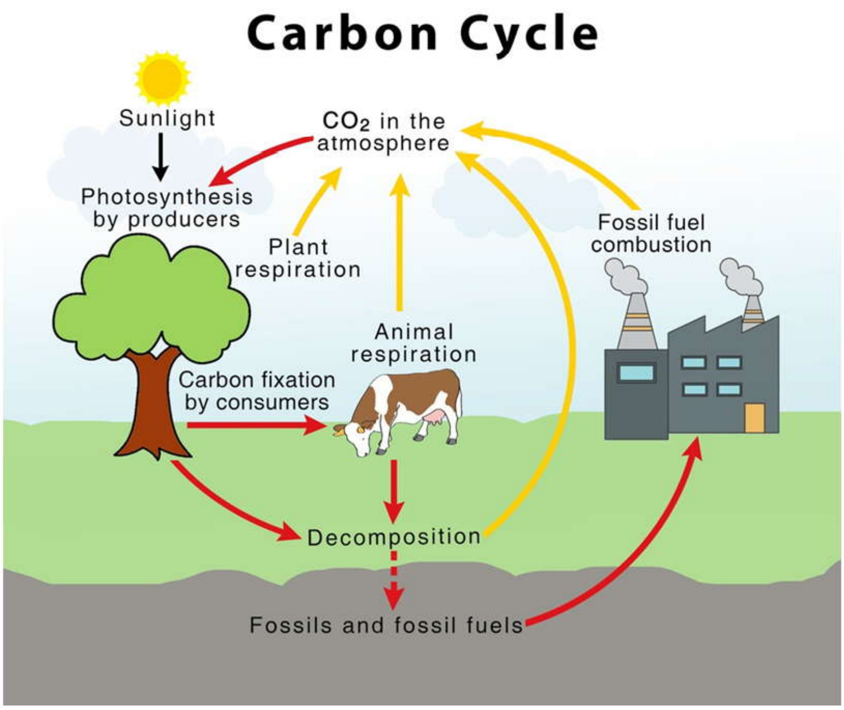


Fig: Carbon Cycle

Human activities have significantly influenced the carbon cycle. Rapid de- forestation and massive burning of fossil fuel for energy and transport have significantly increased the rate of release of carbon dioxide into the atmosphere. (see greenhouse effect at 8.8.4)

Nitrogen Cycle:

Apart from carbon, hydrogen and oxygen, nitrogen is the most prevalent element in living organisms. Nitrogen is a constituent of amino acids, proteins, hormones, chlorophylls and many of the vitamins. Plants compete with microbes for the limited nitrogen that is available in the soil. Thus nitrogen is a limiting nutrient for both natural and agricultural ecosystems.

Nitrogen exists in molecular state. The process of conversion of nitrogen (N) into nitrites and nitrates is called nitrogen fixation. In nature lightening and ultra violet radiation provide enough energy to convert nitrogen to nitrogen oxides. Industrial combustions, forest fires, auto-mobile exhausts and power generating stations are also sources for atmospheric nitrogen oxides. Decomposition of organic nitrogen of dead plants and animals into ammonia is called 'ammonification'. Most of the ammonia is converted into nitrites and nitrates by soil bacteria by the following reaction.

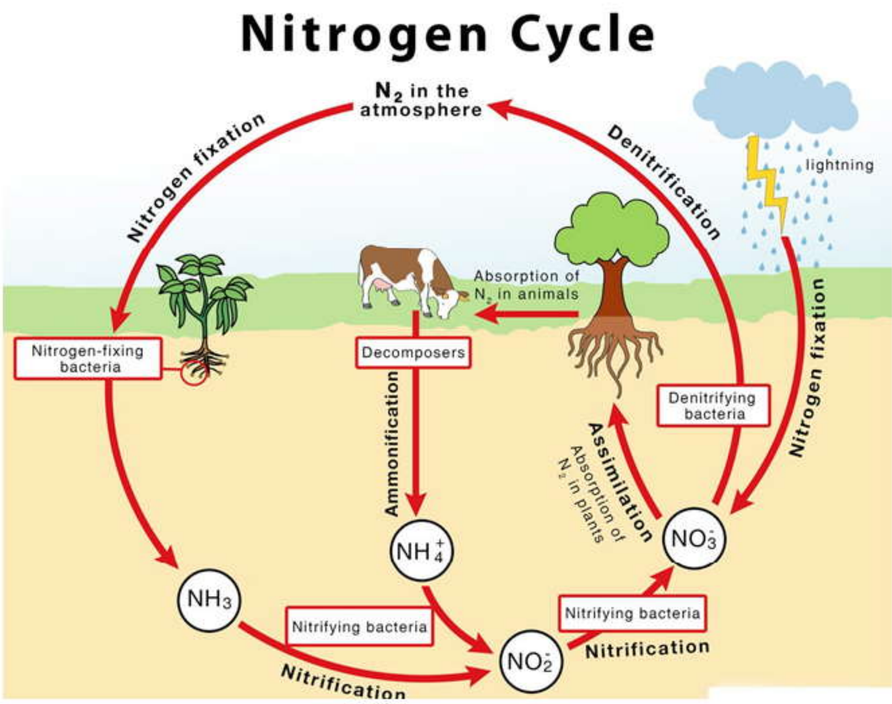


Fig: Nitrogen Cycle

Ammonia is first oxidized to nitrite by bacteria such as Nitrosomonas and Nitrosococcus. Nitrites are further oxidized to nitrates' with the help of bacteria such as 'Nitrobacter. These steps constitute 'nitrification. These nitrifying bacteria are chemoautotrophs..

The nitrate thus formed is absorbed by plants and is transported to the leaves. In leaves it is reduced to ammonia that finally forms the 'amine' group of amino acids. Nitrates present in the soil are also reduced to nitrogen by the process of 'denitrification'. Denitrification is carried out by bacteria such as Pseudomonas and Thiobacillus.

Phosphorus Cycle

Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer systems. Many animals also need large quantities of this element to make shells, bones and teeth. The natural reservoir of phosphorus is rock. which contains phosphorus in the form of 'phosphates. When rocks are weathered, minute amounts of these phosphates dissolve in soil solution and are absorbed by the roots of plants. Herbivores and other animals obtain this element from plants. The waste products and the dead organisms are decomposed by 'phosphate-solubilising bacteria' releasing phosphorus. Unlike carbon cycle, there is no respiratory release of phosphorus into the atmosphere.

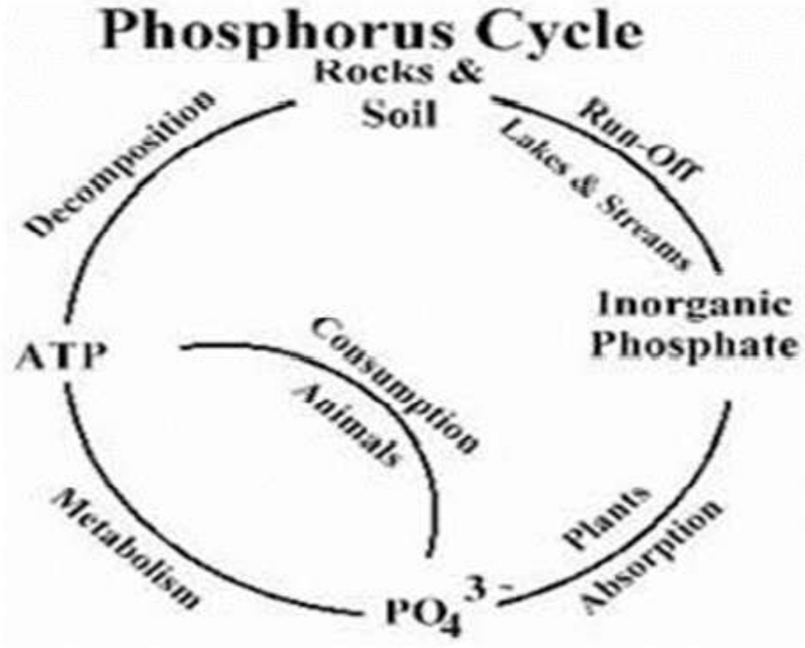


Fig: Phosphorus Cycle

INTEXT QUESTIONS

1. Can you Define 10% Law?
2. Why pyramid of energy always upright?
3. Give the names of Biogeo Chemicals Cycles?

22 CONSERVATION AND USE OF NATURAL RESOURCES

Nature provides us the basic needs like food, water, air etc. for our survival.We use 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 have to 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
- Describe the various conventional as well as non-conventional sources of energy
- 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

NATURAL RESOURCES

The term "resource" means any thing that we use from our environment to achieve our requirements. For example,we require bricks, cement, iron, wood etc. to construct a building. All these items are called the resources for the construction of a building.

A resource can be defined as 'any natural or artificial substance, energy or organism which is used by human being for one's welfare. These resources are of two types:

(a) Natural resources and

(b) Artificial resources.

(a) **Natural 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 use these directly or indirectly for their survival and welfare.

(b) Artificial resources: The resources, which have been developed by human being during the growth of civilization, are called artificial resources.

Eg: Biogas, Thermal Electricity, Plastics 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 - Petroleum.

Q: Define natural resources and give two examples .

1. Classification of Natural Resources

The air we breathe and the light we get from the sun are available in unlimited quantity. But what about coal, forest, and petroleum? The stock of these resources is limited and thier quantity is depleting day by day.

For example, Coal availability is limited and there will be no more coal available for our use. Petroleum is another. These are called non renewable resources.Based on this natural resources are classified into two types:

1) Renewable Resources 2) Non-renewable resources

NATURAL RESOURCES

RENEWABLE

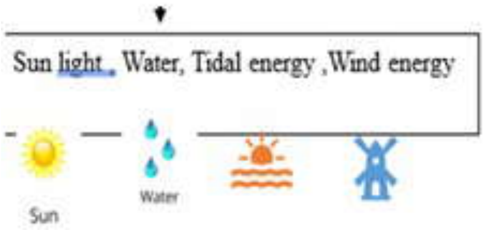
- Solar Energy
- Wind Energy
- Tidal Energy
- Hydropower
- Geothermal Energy
- Biomas energy
- Forests
- Wild Life

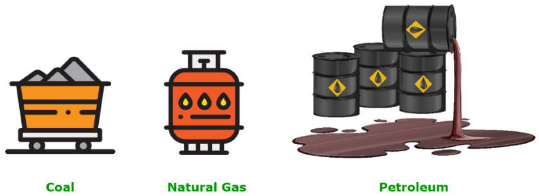
NON RENEWABLE

Fossil Fuels

(Coal, Petrol, Diesel, Kerosen)

Minerals






Minerals


Coal

Renewable Resources

Renewable resources are those that cannot be depleted even in continuous utility. These are naturally regenerated after consumption.These are always available and thus could be reused.

Some examples are fresh water, fertile soil, forest (yielding wood and other products), vegetation, wildlife etc.

Renewable resources are energy sources that can be replenished or renewed at a similar rate that humans can use it. Eg.-Wind energy, Solar energy, Geothermal energy, Hydropower, Hydrogen power, and Ocean energy.

Non-renewable Resources

Non-renewable resources are the natural resources that have a limited supply .Once they are used up, they cannot be replaced. These include minerals (copper, iron etc.) fossil fuels (coal, oil etc.), Ground water.

INTEXT QUESTIONS

1. Given below are certain wrong statements. Identify the mistake and write the correct statement below each.

   (i) Plastic is a natural resource.

   (ii) Forest is a non-renewable resource.

   (iii) The resources, which are not replaced after consumption are known as renewable resources.

2. Classify the following under the two respective categories of natural resources:

   Air, Iron, Sand, Petroleum, Wind, Clay, Fish, Forest, Gold.

Renewable	**Non- renewable**
....	....
....	....

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. People often waste natural resources. Animals are overhunted;Forests are cleared, exposing land to wind and water damage;Fertile soil is exhausted and lost to erosion because of poor farming practices. Fuel supplies are depleted. Water and air are polluted.We know that nature provides us all our basic needs but we tend to overexploit it.The essential things for the survival like food,water,air,and shelter come from natural resources. If they are not properly used and well managed a serious scarcity will result. This will also upset the ecological balance. Therefore there is an urgent need to conserve the natural resources.

Conservation is the long term protection , proper management of a natural resource to prevent its exploitation, damage or degradation.

It is the sum total of activities, which can derive benefits from natural resources but at the same time prevent excessive use leading to destruction.It is the sustainable use and management of natural resources.

Need for Conservation of Natural Resources

- to preserve different kinds of species (biodiversity),
- to maintain ecological balance for supporting life,
- to make the resources available for present and future generation needs,
- to ensure the survival of all life forms on the earth.

Methods of conserving natural resources

There are various methods.

- Trees plantation and protectionTrees plantation and protection
- Reducing usage of fossil fuels and shifting to environmental friendly non conventional energy sources -Hydrogen energy,biofuels,Solar energy,Wind energy,tidal energy.,Reducing usage of fossil fuels and shifting to environmental friendly non conventional energy sources -Hydrogen energy,biofuels,Solar energy,Wind energy,tidal energy.
- Conserving soil -by preventing soil erosion,reducing soil pollution,
- Conserving water and water resources
- Conserving soil -by preventing soil erosion,reducing soil pollution,
- Most recent is Adopting Most recent : Adopting Green technology,Green technology Sustainable forestry. Sustainable forestry

It is a technology which is environmentally friendly, developed and used in such a way so that it doesn't disturb our environment and conserves natural resources.

It is also known as environmental technology and clean technology

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 in the form of sacred groves/forests, sacred pools and lakes, sacred species etc.

Sacred forests: In our country the conservaton of natural forests is known from the time of king Ashoka.**Sacred forests** are the forest patches 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.

Sacred water bodies, e.g., Khecheopalri lake in Sikkim was declared sacred by people, thus, protecting aquatic flora and fauna.

Sacred Plants-Worshipping certain plants like Banyan, Peepal, Tulsi etc. has not only preserved them but also encouraged us for their plantation.

Movements for protection of Trees, Animals: History recalls numerous instances where people have laid down their lives in protecting the trees.

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 sq.km of the sensitive water catchment area. Similar movements also occurred in some other parts of the country.

INTEXT QUESTIONS

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.

SOIL

Soil is the uppermost layer of earth's crust, which supports growth of plants. It is the Most vital &often over looked natural resource. It takes hundreds of years to form through the process called weathering.

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 microbes like the bacteria and fungi).

Humus

A brown or black organic matter formed by the decomposition of plant and animal matter that provides nutrients for plants and increases the ability of soil to retain water. It is a kind of soil organic matter.

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 resource because formation of new soil may take hundreds and thousands of years.

Soil Erosion

Erosion literally means "to wear away". You might have noticed when wind blows or floods come they carry away sand and soil particles from one place to another.The process of removal of top layers of soil by wind or water is called soil erosion. Soil erosion occurs when soil is blown away by the wind or washed away by the rain

You know that top layers of soil contain humus and mineral salts, which are vital for the growth of plants and soil flora. Thus, erosion causes a significant loss of humus and nutrients, and decreases the fertility of soil.

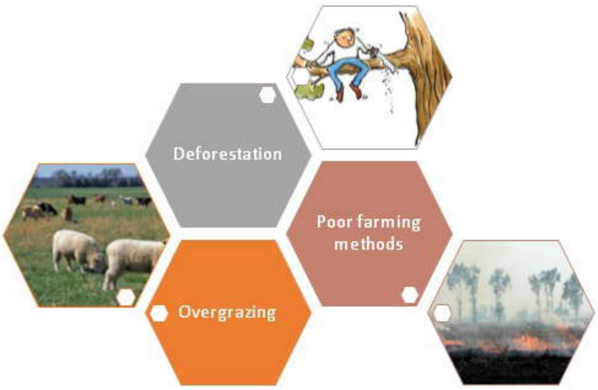
Causes of soil Erosion

(a) Natural Causes

Soil erosion can be caused by natural forces such as Wind,Water,Rain,Water run off. 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 or floods carry away the soil.

(b) Anthropogenic causes

Human activities that can cause soil erosion include : Deforestation, poor farming methods, Overgrazing, Construction, Logging, Mining.



Deforestation: It is the major cause. Forests are cut down for the timber, for farming purposes or other. Roots of the trees hold the oil in lace and leaves and branches reduce the force of wind and waterthus reduce the rate of soil erosion. soil no longer protected from the effect of falling rains. Consequently the fertile topsoil is washed away into the rivers and oceans.

Poor farming methods: Improper tillage, failure to replace humus after successive crops and burning the stubble of weeds reduce the water holding capcity of the soil.So soil becomes dry and can be blown away as dust.(b) Anthropogenic Causes of Soil Erosion

All these effects will loosen the soil and it will be removed easily by wind or water.

Conservation of Soil

Soil conservation means checking soil erosion and improving soil fertility by adopting various methods.

1. Afforestation: Afforestation means planting trees in areas where there was no recent tree cover thus creating a forest. Planting of trees along river-side, waste lands

and mountaineous slopes reduces excessive erosion of soil.

Reforestation: Planting of trees and vegetation in a forest where the no. of trees has been decreasing. It is the restoration of forest in an area where forests were destroyed.

Roots of trees hold the soil material together and bind the soil reduce the forces of wind and rain and stops the erosion. Therefore we should protect our forests,trees from being cutdown.

2. Maintenance of soil fertility-by adding manure and fertilizers regularly as well as by rotation of crop.
3. Control on grazing - Grazing should be allowed only on the areas meant for it & not on agriculture land.
4. Protected channels for water movement must be provided .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.

5. **Windbreaks:** which means planting a row of trees or shrubs to protect bare soil from the full force of wind. Windbreaks reduce the velocity of wind thereby decreasing the amount of soil that it can carry away.

6. **Terracing:** Dividing a slope into several flat fields to control the rapid run of water. It is practised mostly in hilly areas to conserve the soil.This helps in controlling the soil erosion, and using water resources more economically & effectively for growing cropson these terraces.

7. **Contour ploughing:** Ploughing at right angles to the slope allows the furrows to trap water and slowdown the flow of water and check soil erosion by rain water.

INTEXT QUESTIONS

1. How do the following cause soil erosion?

Wind : ____________________

Overgrazing : ____________________

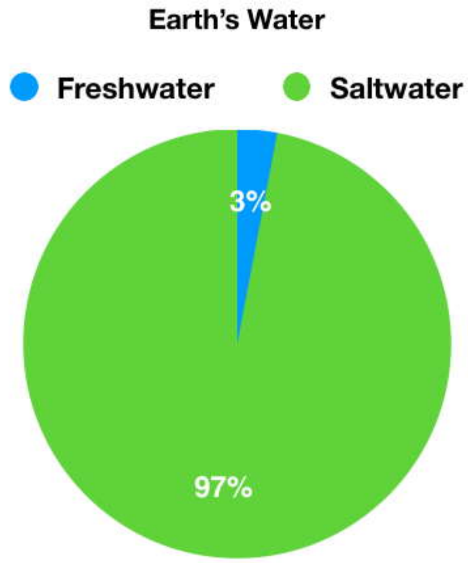
Water : ____________________

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) Cuttingdown forests
(iii) Deforestation	(c) Practised in hilly areas
(iv) Humus	(d) To wear away

WATER- A Precious resource

Let us now discuss another most important and vital natural resource Water. Water is essential for suvival of all living organisms on the Earth. It is the most 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.

Fresh water is needed by humans for drinking, cleaning, for agriculture, industrial purposes and also used by other animals.

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 sources : Rain is the primary source of fresh water and rivers, lakes,ponds,streams,glaciers,ground water are the secondary sources.

Fresh water is a renewable resource as it is continuously being produced through hydrological cycle.

Challenges and threats

1. **Water scarcity**- It is a lack of safe water supplies to meet the standard water demand.It is due to growing population,climate change, less rainfall.
2. Degradation of water quality due to pollution.

   Waste water from all industries, agriculture practices and households is released into the surface water bodies and ground water bodies and they get polluted.

   Recommended basic water requirements for human needs (per person)

Activity	Minimum, litres/day	Range / day
Drinking Water	5	2–5
Sanitation Services	20	20–75
Bathing	15	5–70
Cooking and Kitchen	10	10–50

Conservation of Water- Saving Water and the Earth

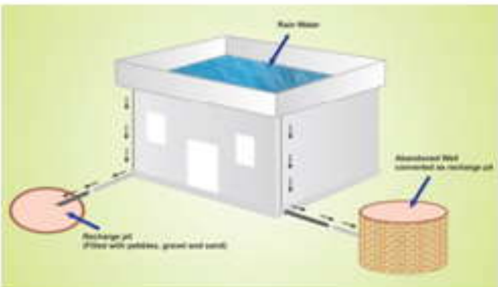
Water conservation is the careful use and preservation of the water supply, including the quantity and quality of water utilized. and this helps to save this precious resource.

Conservation and management of water are essential for the survival of mankind, plants and animals. This can be achieved through the following methods:

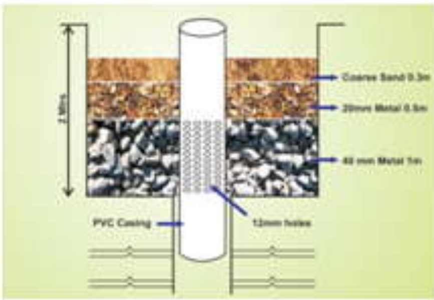
1. Growing vegetation in the catchment areas, which will hold water in the soil and allow it to percolate into deeper layers and contribute to maintain the ground waterlevel.
2. Constructing dams and reservoirs to regulate supply of water to the fields, as well as to enable generating hydroelectricity.
3. Waste water treatment- Sewage water and Industrial wastes (effluents) should be treated to prevent pollution of fresh water.
5. Careful usage of water in our day-to-day life.
6. Rainwater harvesting and watershed management practices.

Rain water harvesting(RWH)- is a process of collecting, storing rain water for later use or recharged into the ground water.

It can be done through various methods- Roof top rain water harvesting , creation of recharge pits, recharge wells, trenches, dug wells, check dams etc. And protection and conservation of open areas, parks and surface water bodies.



Roof top rain water harvesting



Recharge pit

INTEXT QUESTIONS

1. Why do we consider fresh water as a renewable resource?

2. Give three methods of water conservation.

BIODIVERSITY- Variety of life

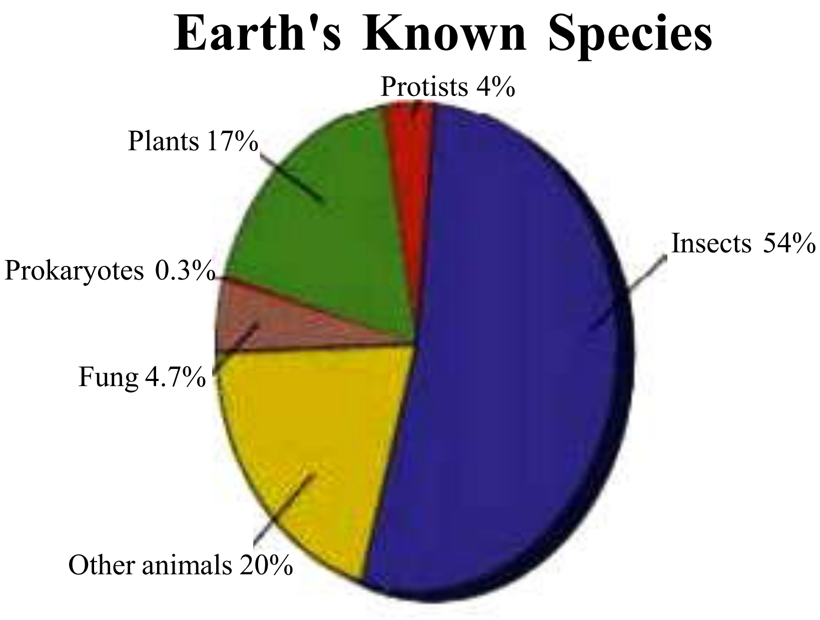
When we observe natural world around us, we find different types of plants, ranging from small green grasses to large trees,large variety of animals, from tiny insect to human being and many other big animals. Besides these there are micro-organisms in the soil, air and water.These varieties of plants, animals and microbes together form the biological diversity or biodiversity.Thus biodiversity refers to the numbers,variety,and variability of living organisms and ecosystems.

Biodiversity is one of the most precious and important things we have.It is essential for maintenance of health and stability of our planet.

Biodiversity can be defined as the variety of life on Earth at all its levels, from genes to ecosystems, encompassing the diversity of species, genetic diversity within those species, and the diversity of ecosystems. The term Biodiversity was coined by W.G.Rosen.

Without biodiversity, our entire support system for human, as well as animal life, would collapse. We rely on nature to provide us with food and clean water, medicines, and to prevent flooding and other extreme weather effects. So much is provided by the natural ecosystems around us – they're truly vital to life on earth. .

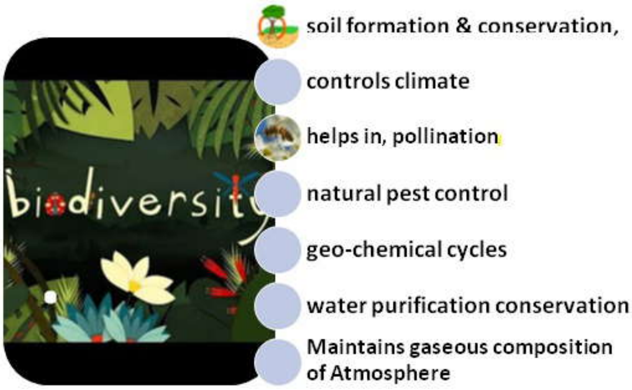
According to scientists, there are around 8.7 million plant and animal species on the planet. However, only about 1.2 million species have been recognised and described to date, with the majority of them being insects. This indicates that the existence of millions of other creatures is unknown.



Tropical rainforests have extremely high biodiversity

India is one of the recognized mega diverse countries of the world,having nearly 7-8% of the recorded species of the world, as it has diverse climatic and physical conditions. Out of 34 global biodiversity hotspots 4 hotspots are in India. It is home to 46000 plant species, 92000 animal species.

Importance of Biodiversity



Biodiversity plays very important role in maintaining food production, soil health, water quality, weather conditions and air quality. Biodiversity is vital for several reasons like Ecosystem stability, Human wellbeing,climate regulation etc. 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.

Ecosystem stability: Diverse ecosystems are stable,and better able to withstand environmental changes.

Human well being: Humabeings derive many benefits from biodiversity like food, medicines, clithing, energy, timber from various plant,animal,microbial sources.

Food : All kinds of food is derived from plants and animals. **Drugs and Medicines:** Most of the drugs are obtained from plants e.g. Quinines used for treatment of Malaria is obtained from *Cinchona officinalis.*;all antibiotics are derived from microbes.

Cultural and Aesthetic value: Aesthetic values such as softness of melodious songs of birds, refreshing fragrance of flowers, beautiful nature compel the human beings to preserve them.

The earth's natural beauty with it's colors,hues,thick forest,other landscpes, butterflies,, animals, birds and flowers , enriches our cultural,aesthetic experiences.. Eco-tourism is a source of income.

Religious values : Plants like Tulsi, peepal, banyan and animals like cows, ox, elephant are worshiped.

Ecosystems help in regulating climate.

The UN considers biodiversity our strongest natural defense against climate change. Land and ocean ecosystems currently absorb 60% of human-caused emissions, and they are the planet's only way of storing massive amounts of carbon dioxide.

Threat to Biodiversity

Though biodiversity is so important for our survival, we are destroying it knowingly or unknowingly. Biodiversity is threatened by factors like habitat loss, pollution, overexploitation, and climate change, making its conservation a global priority.

Fig : Hyacinth

Biodiversity — the inter connectedness of all forms of life on our planet is in trouble

Climate change and biodiversity are interdependent.If one is affected other will also get affected.

Nearly 1 million species are threatened with extinction right now. The rate of extinction is nearly 1000 times more than the normal. The main culprits are the human beings. **A** 2019 UN report found that we have altered 75% of the planet's terrestrial environment, 40% of its marine environment, and 50% of streams and rivers.

Every day we are destroying habitats and degrading massive amounts of soil ,water and air through industrial manufacturing and agriculture practices.

Let us know about them

(i) Destruction of habitat by cutting down trees, filling up the wetland, ploughing of grassland or burning a forest.

(ii) Construction of dams, roads and railways destroys huge patches of forests, grassland etc. thus, disturb the biodiversity.

(iii) Industrialisation and urbanisation has changed and destroyed the natural habitat of plants and animals.

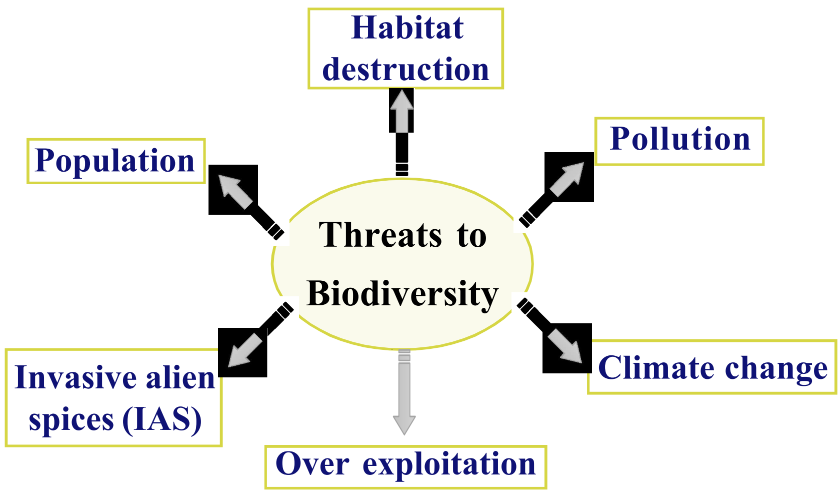
(iv) Pollution of soil, air and water changes the habitat quality and may reduce or eliminate sensitive species.

(v) Mining activities add to the pollution of air and water and threaten the survival of the animals in the nearby areas.

(vi) Indiscriminate killing (Over exploitation) of animals for different purposes has resulted in their reduction.

(vii) 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.

(viii) Introduction of exotic/foreign species (IAS) 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.



- Destruction of habitat by cutting down trees, filling up the wetland, ploughing of grassland or burning a forest.
- Introduction of exotic/foreign species in an area threaten the survival of existing natural biodiversity, ex: water hyacinth clogs rivers and lakes and threatens the life of many aquatic species in our country.
- Construction of dams, roads and railways destroys huge patches of forests, grassland etc. thus, disturb the biodiversity
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- Mining activities add to the pollution of air and water and threaten the survival of the animals in the nearby areas
- Industrialisation and urbanisation has changed and destroyed the natural habitat of plants and animals
- 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

Conservation of Biodiversity

Now you have an idea of the importance of biodiversity and how it is destroyed. Increasing population pressure and developmental activities have led to large scale depletion of the natural resources. such as forests and water. There is an urgent need, not only to manage and conserve the biotic wealth, but also restore the degraded ecosystems.

Conservation is the long-term protection of resources

Conservation is the protection, preservation, management, or restoration of wildlife and natural resources such as forests and water etc.

Through the conservation of biodiversity, the survival of many species and habitats which are threatened due to human activities can be ensured.

Let us know about conservation methods

Conservation is of two types:

1. In-Situ Conservation and
2. Ex-Situ Conservation

BIODIVERSITY CONSERVATION

In-situ Conservation

- → National parks
- → Wildlife Sanctuaries
- → Biosphere Reserves
- → Sacred Groves

Ex-situ Conservation

- → Zoological parks
- → Botanical Gardens
- → Gene Banks
- → Cryopreservation

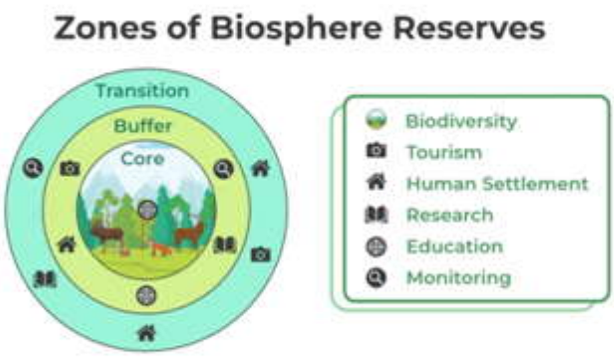
1. In-Situ Conservation

In-situ conservation is **on site conservation** or the protection of plants and animals within their natural habitats either by protecting or cleaning up the habitat itself, or by defending the species from predators.

The following methods are presently used for *in situ* conservation.

1. National parks
2. Wildlife sanctuaries
3. Biosphere reserves

Our country have about 600 protected areas, which includes nearly 108 National parks, over 553 Animal sanctuaries and 18 Biosphere reserves. About 4% of the total geographical area of the country is used for in situ conservation...



Source – geeksforgeeks.org

(ii) Ex-situ (off site) conservation is the conservation of plants and animals outside their natural habitats. These include Botanical Gardens, Zoo, Seed Banks, Gene Banks etc.

> **The Ramsar Convention is an international treaty for the conservation and sustainable utilization of wetlands**, A **Ramsar site** is a wetland site designated to be of international importance under the **Ramsar Convention** 75 **Ramsar Sites** listed in India.

INTEXT QUESTIONS

1. Some of the following points are related to conservation of biodiversity andsome are threat to biodiversity. Identify the points relating to conservation bymentioning '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 (......................)

2. What are the methods used for insitu conservation.

ENDANGERED SPECIES

You have already learnt about the various reasons due to which our biodiversity is under constant threat. 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 from the earth are called the extinct species and the phenomenon of disappearance is known as the extinction.

The species are those which have been reduced in number to a critical level and threatened by extinction in the near future. Species become endangered due to factors like :loss of habitat, loss of genetic variation, pollution etc.

International Union for the Conservation of Nature (IUCN) enlists endangered plants and animals in the Red Data Book. It categorizes plants and animals into various categories based on the level of their risk of extinction.

> **RED DATA BOOK**-A public document that records all endangered species of plants, animals and fungi in a country or state.

IUCN has listed 132 species of plants, animals from India as critically endangered.

Few endangered plants and animals are listed below

Endangered Animals	Endangered Plants
1. Asiatic Lion,	1. Pitcher plant
2. Green Sea turtle, loggerhead turtle,	2. Indian belladonna
3. Tortoise	3. Orchids
4. Marsh crocodile and Gharial	4. Nilgiris Lilly
5. Bengal Tiger	5. Ginkgo biloba (Maiden hair tree)
6. Asiatic Elephant	6. Red sandal wood tree
7. Rhinoceros	
8. Indian Python	
9. Great Indian Bustard	
10. Snow Leopard	
11. Nilgiri Tahr	

WILDLIFE

Now we shall know about an important resource of the nature called the wildlife.

At home you may have a pet dog , some may have cows, buffalos, 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 human beings.

The plants, animals and microorganisms other than the cultivated plants and domesticated animals living in their natural habitat (Forest or grassland or desert etc.) constitute wildlife.

It plays a major role in maintaining ecological balance. It is used for research and also 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.

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.

Methods of 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 money or other means.

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

1. What is Red Data Book?

____

2. Define the term Wildlife.

____

3. Below are certain incomplete words. Complete them by taking clues from the statement given below for each. Each blank represent the letter only.

   (i) A __ __ or __ __ __ at __ on
   (Tree planting programme)

   (ii) Be __ __ ado __ __ a
   (An endangered Indian plant)

   (iii) Rh __ no __ __ r __ __
   (An endangered animal)

Wildlife Reserves in India

106 National Parks and 567 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

Agencies Dealing with conservation of Wildlife

There are various agencies both at national and international levels which take care of conservation of wildlife. Some of them are given below

(i) Indian Board for Wildlife (IBWL) advises state government on wildlife protection.

(ii) 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".

(iii) International Union for Conservation of Nature (IUCN), World Conservation Union (WCU)

(iv) Convention of International Trade in Endangered Species (CITES) is an international organisation to check trade products from endangered animals.

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

The Biological Diversity Act, 2002

INTEXT QUESTIONS

1. Expand the following.

(i) WWF ____________________

(ii) CITES ____________________

(iii) IUCN ____________________

2. Match the items of column A with those of Column B.

Column – A		Column – B
(i) Periyar sanctuary	(a)	Rajasthan
(ii) Kanha National Park	(b)	Orissa
(iii) Similipal National Park	(c)	Uttaranchal
(iv) Bharatpur bird sanctuary	(d)	Kerala
(v) Corbett National Park	(e)	Madhya Pradesh

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 the resources 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.

The three goals of sustainable development are: “Minimizing the depletion of natural resources “Promoting development without causing harm to the environment" Making use of environmentally friendly practices.

The United Nations General Assembly adopted the 2030 Agenda for Sustainable Development in 2015. This agenda included 17 goals designed to create a globally equitable society alongside a thriving environment.

INTEXT QUESTIONS

1. A and B are two friends. In their daily life both have different opinion on certainA says - Polythene bags should be used to carry vegetables.

   B says – Jute bags should be used to carry vegetables.

   Who is right and why?

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

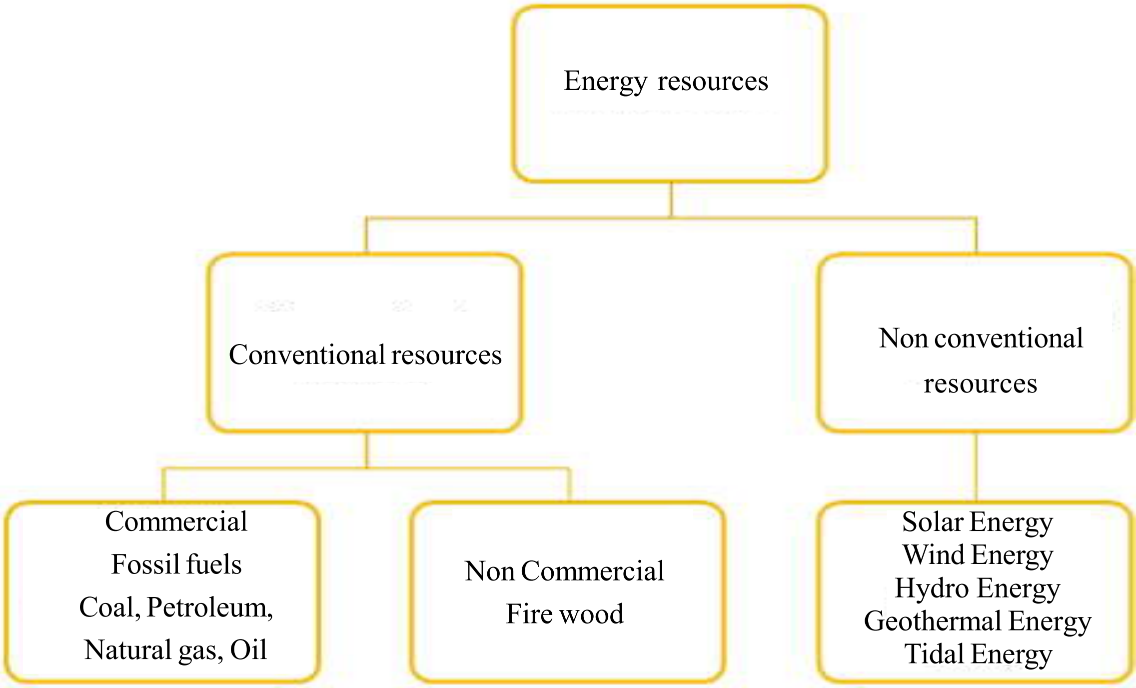
ENERGY RESOURCES

We have always been using different forms of energy obtained from various sources for our daily activity like cooking, heating, ploughing, transportation, etc.

For example, heat energy required for cooking purpose is obtained from firewood, kerosene, oil, coal, 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. We will discuss about the different forms of energy in detail.

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 widespread use since ancient times. Ex: Coal, Petroleum, Natural gas, Oil, Fire wood.

(ii) **Non-Conventional Sources of Energy** are other than the usual, or that are different from common sources. Ex: Solar Energy. These are renewable sources.

Conventional Sources of Energy

- These have been in use since ancient times. Most important among them are the fossil fuels.

Fossil Fuels

COAL

PETROL

NATURAL GAS

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 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. Petroleum reserves are supposed to last for another 100 years.

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.

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 Liquified 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. It is a by product of petroleum refinery.

INTEXT QUESTIONS

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 ....
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?

Non-Conventional Sources of Energy

We have already learnt known about conventional sources of energy, which are fast depleting and will not last long. Therefore, 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 the earth. Even today it will turn out to be the most important answer to problems of energy. The Sun is a powerful source of energy. At present we are able to harness only very little amount of that energy.

The international energy agency estimates that by 2050 the production of solar energy will account for nearly a quarter of the world's total energy use.

Solar energy is a renewable energy source that comes from the sun's light. It's the cleanest and most abundant renewable energy source. “Solar energy is harnessed using panels and mirrors. It can be used to: “Produce heat“Cause chemical reactions“Generate electricity“Cook food“Convert saline water into drinkable water“Power a wide spectrum of devices“The sun naturally regenerates its photovoltaic energy at a rate exponentially faster than humans can harvest that energy. The total amount of solar energy received on Earth is vastly more than the world's current and energy requirements. “Solar energy can be converted into electrical energy through: “Photovoltaic (PV) panels“Mirrors that concentrate solar radiation“The four main types of solar energy are: “Passive solar gain“Solar thermal (for heating)“Concentrated solar power (for electricity)“Solar Photovoltaics (electricity)

Advantages of Solar Energy

- Solar energy is clean and renewable energy source. It is abundant, everlasting and available almost everywhere.
- Once a solar panel is installed,solar energy can be produced free of charge
- Very little maintenance is needed to keep solar cells running.

Disadvantages of Solar Energy

- The intial cost of setting up solar panels is quite high.
- Solar cells can generate electricity only during daylight hours.

Pollution levels in the air can effects the efficiency of solar panels.

2. Hydel /Hydro Energy

The generation of electricity by using the force of falling water is called hydroelectricity 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. wind energy harvesting has grown by 25% every year over the last two decades. By 2030 wind power is expected to supply nearly 20% of the world electricity. 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.

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.

Advantages of Wind Energy

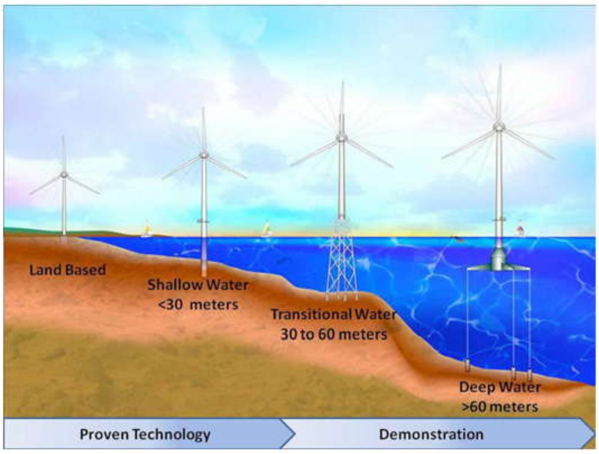
- Wind is a clean, non polluting source of energy. It is inexhaustible.

Disadvantages of Wind Energy

- Intial bulding and installation costs of wind turbines are high. Wind energy needs to be stored for full utilization.

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. Tidal energy uses the rise and fall of tides to convert kinetic energy of incoming and outgoing tides into electrical energy. It is dependent on the gravitational force of the earth and th moon. The generation of energy though tidal power is mostly prevalent in coastal areas. Huge investment and limited availability of sites are the major drawbacks of tidal energy. Tidal energy is one of the renewable sources of energy. South Korea has the largest tidal power plant in the world. France, U.k and Belgium are other countries which have plants. Areas where rivers flow into the sea experience waves and 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.



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5. Nuclear Energy

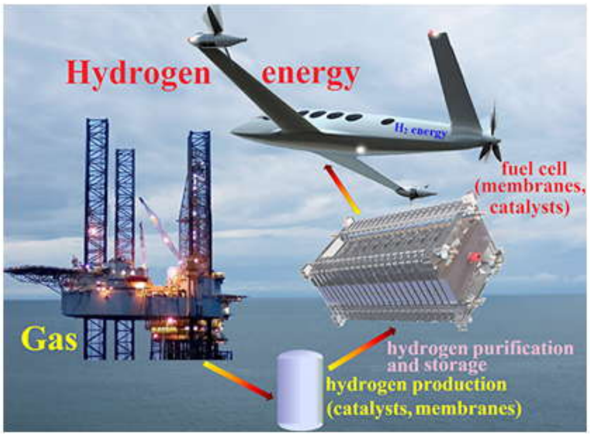
Radioactive elements like uranium and thorium disintegrate spontaneously releasing large quantities of energy. This energy can be trapped to produce electricity.

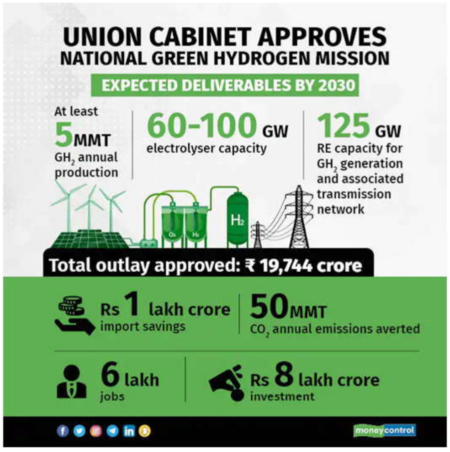
- Most advanced countries have nuclear power stations. We too have some in India, for example, Tarapur (Maharashtra), Kalpakkam (Tamil Nadu).

> Nuclear power or radioactive elements are stable only when in underground ,once they reach above ,they release harmful rays -Alpha,Beta ,Gamma rays,— which are dreadfully danger, If not carefully maintained, these also have an inherent risk of causing radioactive pollution.Better to avoid this.

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.





Source -.mathnet.ru

7. Geothermal Energy

Geothermal energy is the heat trapped in the Earth's core which is created by the slow decay of radioactive particles in rocks at the centre of the planet. By drilling wells, we are able to bring highly heated water to the surface which can be used to turn turbines and create electricity. This is a renewable resource. In volcanic regions, springs and fountains of hot water called "geysers" are commonly found. Hot steaming water can be used to turn turbines and produce electricity in geothermal power plants. 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

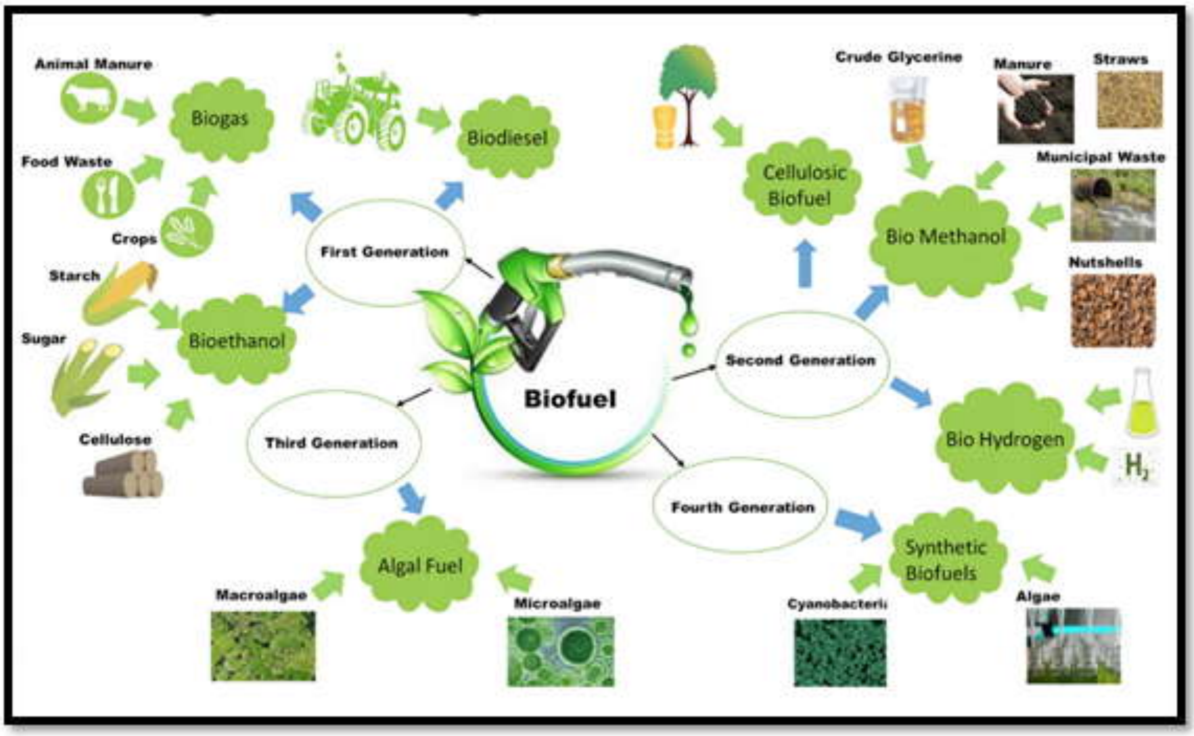
Another form of non-conventional energy is biogas. It is produced by the microbial activity on cattle dung in a specially designed tank called digester. A mixture of water and cattle dung is is poured in this digester where anaerobic decomposition takes place and biogas is generated. This gas contains 55 – 70% Methane which is inflammable and it is generally used as cooking gas and for generation of electricity. The "waste" left in the tank is used as manure. 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



Plant based biofuels-Jatropa,Maize etc.   Algal biofuels

You know that Among the traditional fossil fuels, consumption of liquid fuels is the highest.Their fast depletion and non-renewable nature has sent an alarm to look for alternative fuel.

So there are attempts to identify potential plant species as sources of liquid hydrocarbons, as a substitute for 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 petroplants. 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, karanjia, sunflower etc.

Advantages of Bio-diesel

Bio-diesel has several advantages; some of them are given below-

- It is an agriculture based fuel substitute.
- It can be made from both vegetable oil and animal fats.
- It can be used without major modifications in engines.
- It does not need separate infrastructure for storage and delivery.
- Handling bio-diesel is safer.
- Planting of Jatropha curcus will utilise wasteland in our country.
- It's combustion emits less carbon monoxide, sulphates, unburnt hydrocarbonsand particulate matters, thus reduces air pollution.

Conservation of Energy Sources

We have already leant about the different types of sources of energy and how they are useful to us. Now you think about your daily activities and the types of energy you are using in each activity. Make a list of the sources, which produce these energies. Everyday you and your family members are using four to five sources of energy. Similarly other people, industries and different establishments are using energy everyday. The demand for energy is increasing day-by-day and exploitation of the energy sources is on the rise. Thus, energy sources are depleting gradually.

There is an urgent need to conserve energy, else adequate energy will not be available in future. Some methods to conserve energy are:

Minimise exploitation of non-renewable energy resources.

- Emphasis on use of renewable sources of energy.
- Stop wastage of energy.
- Creating awareness among people regarding wise and judicious use of energy.
- More use of bio-mass based energy.

INTEXT QUESTIONS

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)..

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) renewable - solar energy, wind energy, tidal energy, etc. and (ii) non-renewable - soil, minerals, fossil fuels, 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 ofenergy; 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 dayby-day. Energy sources are depleting fast. There is an urgent need to conserve energy; else adequate energy will not be available in future.

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.

23 POLLUTION

The environment has undergone drastic changes over the period of time. Population explosion has resulted in a number of environmental problems. The world population have reached 804.5 crores and with 142.86 crore people, Bharath has overtaken China to become the most-populous country in the world .To meet the demands of food, housing and energy, environmental resources are being exploited at a fast pace. Over-exploitation of resources Industrialization,Urbanisation and various human activities has resulted in many environmental problems, such as deforestation, destruction of wild life, Air, Water, Soil and Noise pollution.Environment pollution adversely effecting Ecosystems, all living organisms,human health, climate. This issue has become a global concern due to the detrimental impact of pollutants like air ,water contaminants,plastic waste and chemical pollutants on our environment. 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 are the major challenges.Addressing polluton is crucial for sustainable and healthy future. 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
- Describe methods of control of air, water and soil pollution
- Describe the causes and effects of sound pollution
- Describe the causes and effects of radiation pollution, plastic pollution

We perform a number of daily activities such as bathing and washing of clothes, cleaning with soaps and detergents etc. 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, burning of crop residues, may give out smoke in the air. Industries release harmful chemicals including,heavymetals, nanoparticles, radioactive material which pollute air, water and soil. Agricultural activities may dump fertilizers and pesticides in the environment.

The addition of unwanted or harmful substances in to the environment 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.

Types of Pollution

Depending upon the area or the part of environment affected, pollution may be of the following types :

- Air pollution
- Water pollution
- Soil/Land pollution
- Noise pollution

Air pollution -An Invisible threat

We all breathe in air, we can feel, and even smell the air and say whether it is fresh or stale. Air pollution is the introduction of particulate or harmful gases/substances into the earth's atmosphere and cause harmful or undesirable effects on livingbeings and environment.

Causes

Air pollution is caused by solid and liquid particles—called aerosols—and certain gases that are suspended in the air. These particles and gases are harmful for the planet and for our health, so keeping track of them is important. Most air contaminants originate from combustion processes.

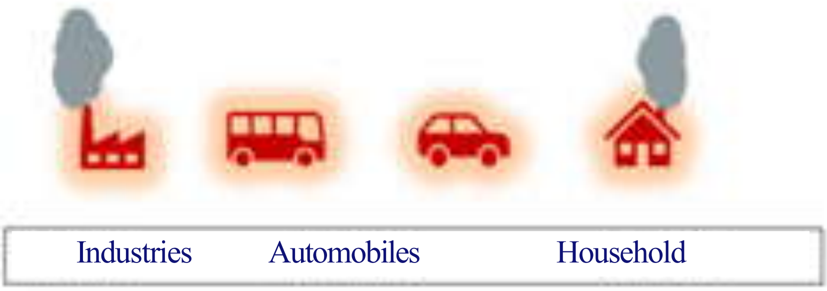
> Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere.

Sources of air pollution

The sources of air pollution can he divided into two categories (i) Natural, and (ii) Man made

SOURCES OF AIR POLLUTION

Natural Sources	Man made sources
i) Ash from burning volcanoes	i) Automobiles (cars, trucks, buses)
ii) Forest fires	ii) Motors, combustion engines-run on petrol, diesel Industries Power stations - using coal cruide oil
iii) Dust from storm, wind blown dust	iii) Furnaces-using firewood, kerosene, coal Burning of crop residues, firewood
iv) Pollen grains from flowers, microbes and their spores.	iv) Burning of fossil fuels-coal, petrol etc.



Based on their origin, pollutants may be Primary or Secondary pollutants.

Primary air pollutants :

Formed and emitted directly from the source (Eg.Factory/Power plant/Automobiles)

Ex: CO, CO_2, NO_2, SO_2, Particular matter (PM), VOCs.

Secondary air pollutants :

These are not directly emitted from the source, but forms when two or more primary pollutants react in the atmosphere.

Ex: Ozone, Sulfuric acid (H_2SO_4)

Sulfuric acid is produced from primary pollutant - Sulfur dioxide (SO_2).

Pollutants types

Particulate Matter	Gaseous pollutants	Heavy Metals
PM10 PM2.5	• Sulphur Dioxide (SO_2) • Nitrogen Dioxide (NO_2) • Nitrogen Oxide (NO_x) • Carbon Monoxide (CO) • Carbon Dioxide (CO_2) • Volatile Organic Compounds (VOCs)	• Cadmium • Lead • Mercury • Chromium • Zinc • Cobalt

Effects of air pollution

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

Pollutant	Source	Harmful effects
Carbon compounds (CO and CO_2)	1. Automobile exhausts (Vehicles) 2. Burning of wood, coal	• Respiratory problems
Sulphur compounds (SO_2 and H_2S)	1. Power plants and 2. Petroleum, Oil refineries 3. Volcanic eruptions	• Respiratory problems in humans • loss of chlorophyll in plants (chlorosis) • Acid rain
Nitrogen compounds (NO and N_2O)	Motor vehicle exhaust, atmospheric reaction	• Irritation in eyes and lungs • Low productivity in plants • Acid rain damages material (metals and stone)

Hydrocarbons (Benzene, Ethylene)	Automobiles and petroleum industries	• Respiratory problems • Cancer causing properties
SPM (Suspended Particulate Matter) (Any solid or liquid particles suspended in the air (fly ash, **dust**, lead)	Thermal powerplants Construction activities, Metallurgical processes and Automobiles	• Poor visibility, breathing problems • Lead interferes with the development of red blood cells and causes lung diseases and cancer.
Particulate Matter PM 2.5 - particles less than 2.5 microns size (PM<2.5)		• Smog (smoke+fog) formation leads to **poor visibility** and aggravates asthma in patients.
PM 10- Fibres (Cotton, wool)	Textile and carpet weaving industries	• Lung disorders

Some major air pollutants are discussed here. They are CO_2, CO, SO_2, Smog, Aerosol, Particulate matter (pollen. dust), Carcinogenic hydrocarbons.

Carbon dioxide (CO_2)

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, households, respiration of living beings etc. The increasing CO_2 in the atmosphere is likely to have the following effects:

(i) **Rise 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 - SO_2

Released from -Thermal Powerplants (produced by burning of coal), Petroleum, oil refineries, automobiles and domestic fuel usage.

Effects:

On Plants- It causes chlorosis and necrosis of plants,

On Human beings-irritation in eyes and injury to the respiratory tract (asthma, bronchitis)

On Buildings-discoloration and deterioration of buildings.

High concentration of SO_2 in the atmosphere dissolves in rain drops to form H_2SO_4 which causes acid rain.

Carbon monoxide (CO)

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.

And also released from mines, blast furnaces.

Carbon monoxide is more dangerous than carbon dioxide. It is a poisonous gas .It 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.

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.

Flourides

When Flouride containing rocks, clay, minerals are heated Hydrogen Flouride gas is released. This is an extremely toxic gas, which causes serious injuries.

Smog + Fog

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.

Biological agents

Allergens - 1) pollen grains from trees, weeds and grass 2) microbes and their spores are potential enough to cause allergy and respiratory discomfort. Its impact will be accelerated when they react with air pollutants.

Domestic air pollutants

Smoke from burning of fossil fuels, firewood, cow dung cakes, and tobacco smoke are major domestic pollutants. The common pollutants gases emitted are Carbon monoxide (CO), Carbon dioxide (CO_2), Sulphur dioxide (SO_2) etc.

These pollutants cause suffocation, eye and lung diseases and low visibility.

Tobacco smoke is harmful to smokers and passive smokers.

Aerosols

The suspended fine particles in the air are known as aerosols. Aerosols contain Chloro Fluoro Carbons (CFCs) and fluorocarbons. They cause depletion of the ozone layer.

PM2.5.

Deaths by air pollution are the direct result of exposure to fine particulate air pollution or PM 2.5.

PM2.5 are tiny airborne particles, 2 microns or less in diameter, composed of chemicals like Sulphur dioxide, Nitrogen oxides, Ammonia (NH_3), Carbon monoxide, and other volatile compounds. They cause the haze in the air, most often during warm, windless days. The biggest emitters of these particles are gasoline or diesel fuel sources — cars, generators, factories, and heaters.

smaller amounts of these particles found in dust, dirt, pollen, and wildfire smoke.

AQI- Air Quality Index

Air Quality Index depicts the extent of air pollution at a particular location

AQI value high ⟶ Air pollution high ⟶ higheir the health risk

EPA establishes an AQI for five major air pollutants regulated by the Clean Air Act 1981 (EPA-Environment Protection Agency)

They are ground-level Ozone,

Particle Matter (also known as particulate matter, including PM2.5 and PM10) Carbon monoxide, Sulfur dioxide, Nitrogen dioxide.

Each of these pollutants are major public health concerned so they have a national air quality standard set by EPA to protect public health:

Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple	Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Maroon	Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Types of Air Pollution

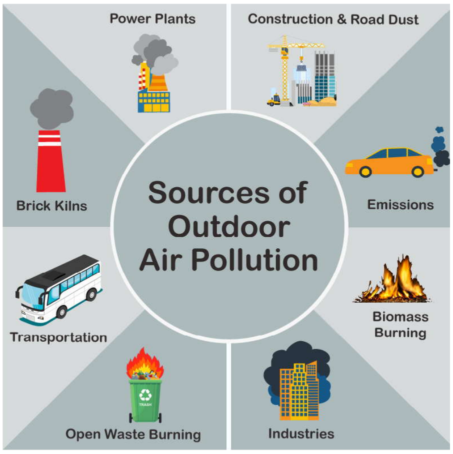
1) Outdoor and 2) Indoor air pollution

Outdoor air pollution is also known as Ambient air pollution. It is caused by Emissions from cars, trucks, industries construction sites and many more activities pollutants emitted from these are harmful to our health.

Common Out door air pollutants - are 1) Particulate Matter 2) Gaseous pollutants (SO_2, NO_2, CO, O_3, VOCs)

Ambient (outdoor) air pollution in both cities and rural areas is causing fine particulate matter which result in strokes, heart diseases, lung cancer, acute and chronic respiratory diseases.

Reddening of eyes, Pneumonia respiratory problems, Heart stroke.



Indoor air pollution

Indoor air pollution aslo called as household air pollution. It means contamination of air inside houses, building and work areas. Sources are Chulas, dust and smoke.

Common indoor air pollutants include: "Chemicals, Molds, Smoke, Pesticides, Gases, Asbestos, Biological pollutants, Carbon monoxide; Emissions from cookstoves and heaters Indoor air pollution can lead to: "Respiratory diseases "Premature death" Almost doubling the risk for childhood respiratory infection "44% of all pneumonia deaths in children less than 5 years old.

PM10: These pollutants get deposited in our respiratory pipe" PM2.5: These pollutants get deposited in our lungs and even smaller particles reach bloodstream through alveoli

Effects on human beings

Air pollution is now the world's fourth-largest risk factor for early death. According to the most recent State of Global Air report - which summarizes air pollution around the world - 4.5 million deaths were linked to outdoor air pollution exposures in 2019. and another 2.2 million deaths were caused by indoor air pollution.

Breathing polluted air puts you at higher risk of asthma. When exposed to ground ozone for 6 to 7 hours, people suffer from respiratory inflammation. It damages the immune system, endocrine, and reproductive systems.

A high level of air pollution increase heart problems.

Other harmful effects

The toxic chemicals released into the air are affecting the flora and fauna immediately.

Productivity of crops reduced, crops get damaged.

Aqatic and terrestrial life get disturbed sometimes even death occurs.

Air Pollution & Control

Some measures which can be adopted to control air pollution:

1. Use of unleaded petrol
2. Using fuels with low sulphur and ash content
3. Promotion of use of public transport
4. Sensitive locations (hospitals, schools, playgrounds etc.) should not be located along the busy streets
5. Vegetation cover should be increased along the roadside, busy traffic intersection points, and on the road dividers.
6. Industries and waste disposal sites should preferably be situated in outskirts of the city. However, control of contaminants at their source level is a desirable and effective method through preventive or control technologies.

Methods of controlling gaseous air pollutants

(i) Combustion. In this technique, the organic air pollutants are subjected to flame combustion technique (also known as catalytic combustion). Organic gases or vapours are converted into less harmful products and water vapour.

(ii) Absorption. In this technique, gaseous pollutants are passed through absorbing material like scrubbers, which 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 effluentsare passed through porous solid absorbent kept in containers. The gaseous pollutants stick to the surface of the porous material and clean air passes through.

CONTROL MEASURES IN INDUSTRIAL ESTABLISHMENTS

Control of gaseous pollutants

- → Absorption by liquids
- → Adsorption by solids
- → Combustion

Control of particulate pollutants

- → Gravitational settling chambers
- → Cyclone separators
- → Fabric filters
- → Electrostatic precipitators
- → Wet collectors or scrubbers

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.

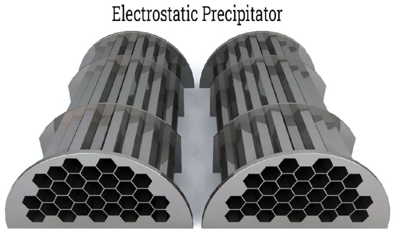
(ii) Mechanical devices. There are many mechanical devices that clean the air of pollutants either due to (i) gravity in which the particles settle down by gravitational force; or by (ii) sudden change in the direction of gas flow in which particles separate out due to greater momentum.

(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.

Control of air pollutants

PARTICULATES

- Cyclones
- Electrostatic Precipitators
- Fabric Filter
- Wet Scrubbers



GASES

- Absorption
- Adsorption Towers
- Thermal Incernation
- Catalytic Combustion

INTEXT QUESTIONS

1. Define pollution.

 ____

2. Name four types of pollution.

 ____

3. Name one effect on plants and one on human caused by excess SO2 in the air.

 ____

4. Green House gases are

 ____

5. Define AQI

 ____

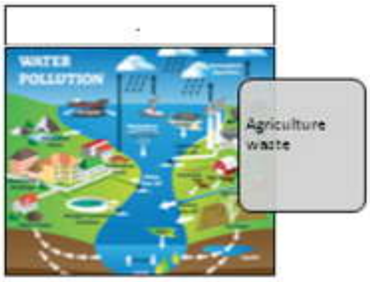
WATER POLLUTION

Water is the precious natural resource, essential for survival of living organisms. 2.5% of the total water on the earth is freshwater of which less than 1% is useful for human needs, which is present in rivers, streams, ponds, lakes, ground water. But after industrialization and economic development many waterbodies are polluted with wastes, harmful chemicals, garbage, plastics etc. which is posing adverse effects on human beings, other living beings and environment.

Addition of undesirable substance in water swhich reduce water quality – is called water pollution. Water pollution make the water unusable for any purpose. Polluted water is turbid, unpleasant, with bad odour, is unfit for drinking & other purposes and harmful.

> 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

Pollutants enter into the water bodies through different sources like



Natural sources are soil erosion, leaking of minerals from rocks and decaying of organic matter, volcanoes, floods etc.

Man made sources – Domestic, Industrial, Agricultural activities etc. Waste from these are disposed into the water bodies.

Types of water pollution

Surface water pollution

(Pollution of Rivers, ponds, oceans etc.)

Due to sewage, industrial effluents, oil heat, agrochemicals etc.

Ground water pollution

(due to deepwell injections, septic tanks, Water reaching ground through land fill, mining, percolation of soil pollution and water pollution

Common water pollutants are

1. Organic wastes 2. Inorganic substances 3. heavy metals 4.Garbage(mainly plastics) 5.Infectious agents like bacteria virus 6. mineral oils 7. Radioactive substances 8. heated effluents 9. Pesticides, Herbicides, Fertilizers 10. Silt, Sediments etc.

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

1. Spread of Diseases(epidemics)

Polluted water causes spread of epidemics such as Cholera, Typhoid, Dysentry, diarrhoea.

2. Health hazards

Toxic chemicals -heavymetals, plastics, oils, phenols, xenobiotics, & many toxic chemicals.These toxic materials in water cause serious health hazards in human beings and other animals.

Lead-Damage to liver, kidneys

Arsenic - Lung cancer, ulcers in gastrointestinal tract

Cadmium - diarrhea, kidney cysts, bone deformation

Mercury - Neurological disorders

Carbonates in pesticides - harm to central nervous system and may cause cancer

These toxic chemicals enter into food chain, transfered from one organism to the other.

Concentration of these toxic chemicals increase at each trophic level in food chain. This process is called biomagnification.

3. Agriculture discharges

Include fertilizers(phosphates, nitrates etc) pesticides, herbicides, manures which enter into water body and cause damage to aquatic plants, animals and also human beings.

Some major disturbances in the ecosystem due to water pollution

1. **Plant nutrients** like phosphates and nitrates that come from various chemical fertilizers, sewage, and manure- **cause Eutrophication**
2. **Oxygen-demanding** manures and agricultural waste resulted from sewage and agricultural run-offs- **cause death of aquatic animals**.
3. **Heated waters** used in several industries and power plants - **cause death of fish**.

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.

Effect on Agriculture-

The use of polluted water from lakes, ponds and rivers for irrigation damages crops severely and decreases the quality and quantity of agricultural production.

Effect on Soil -

The use of water contaminated with salts increases alkalinity of the soil.

Heavily polluted water decreases soil fertility and kills soil friendly organisms.

Effect on marine life -

Contamination of sea water due to oil spills caused by the leakage of crude oil from oil tankers causes ecological disasters which results in the death of sea organisms including fishes.

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 dishcharge	Respiratory and skin cancer.
		Nervous disorder.
Nickel Cadmium	Aerosols, industrial dust	Pulmonary disorders, dermatitis
	Industrial discharge	Kidney disorders,
		Pulmonary and skeletal diseases
Uranium,	Radioactive waste	Leucoderma, skin cancer
Throium		

Water pollution in natural water bodies can be identified and quantified on the basis of various parameters, such as, dissolved oxygen (DO), biochemical oxygen demand (BOD), coliform organisms, pH etc. As per the water quality criteria, the DO levels in drinking water should be = 6 mg/L and BOD levels should be < 2 mg/L. Moreover coliforms level should not exceed 50 MPN/100 mL in water which is safe for drinking purpose. If the water quality of any source is not complying with these criteria, the water can not be used for drinking purpose without undergoing complete treatment.

Eutrophication-

Eutrophication is the process in which entire body of water ,or part of it ,becomes progressively enriched with excess plant nutrients, particularly phosphorus and nitrogen, which leads to excessive algal growth & biomass production. Decomposition of these by bacteria deplete oxygen content in water and livingbeings in that water will die.

Sewage and/or fertilizer run off from fields into water body

↓

Enriched nutrient (N,P) content in lakes (Eutrophication)

↓

Algae multiply to produce an 'algal bloom'

↓

Algae use up oxygen and begin to die

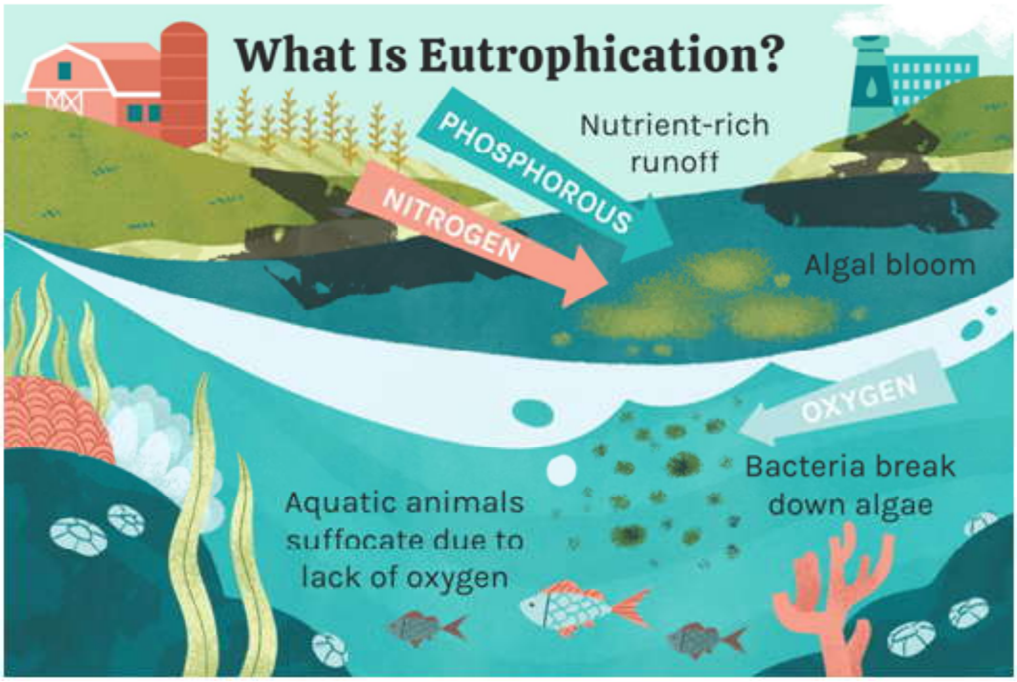
↓

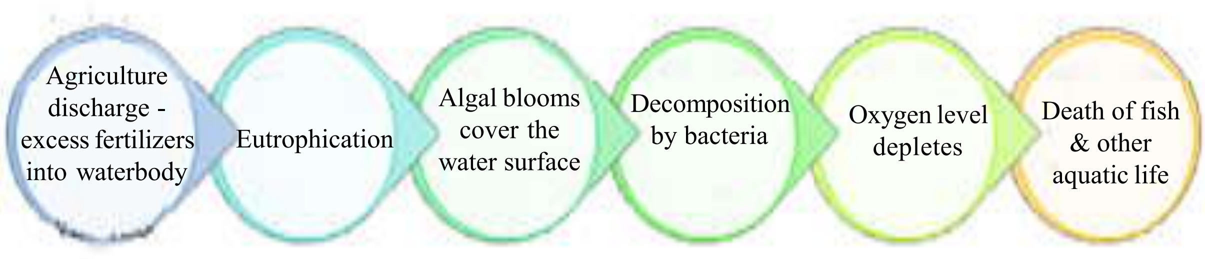
Decomposers (bacteria) multiply and use more oxygen

↓

Oxygen level depletes

Organisms (such as fish) die due to lack of oxygen





Control

Water pollution can be controlled by various methods

(a) Stop letting out of industrial effluents into water bodies.

Treating industrial effluents before discharging into water bodies.

Effluents from distillaries and solid waste containing organic matter has to diverted to biogas plants to generate energy

(b) Stop entry of sewage into water bodies

(c) Removal of biodegradable organic matter from water bodies using trickling filters or other methods.

(d) Reducing use of agrochemicals like fertilizers, pesticides and encouraging natural /Organic farming.

(e) Prevent run off fertilizers and manure(Washing away of fertilizers, ,manure into nearby water bodies or leaching into groundwater,)

(f) Removing pollutants from water using various methods – eg .Reverse osmosis, adsorption, etc.

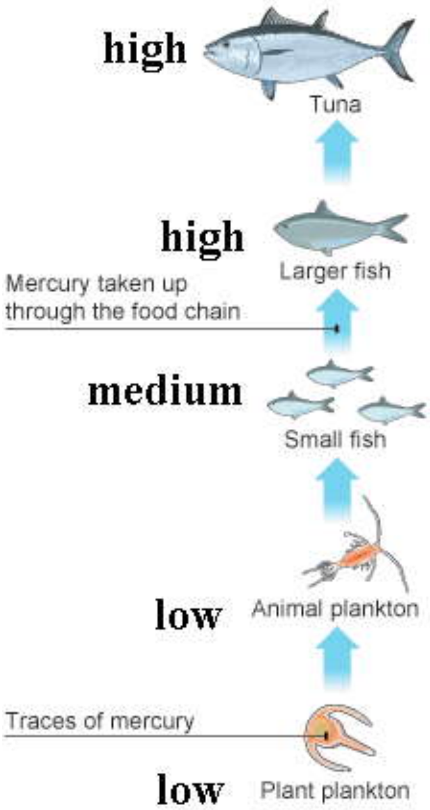
(g) Hot water should not be disposed directly into the river, as it adversely affects the life of aquatic **organisms. Thermal pollution can be reduced by employing techniques such as cooling, cooling ponds, evaporative or wet cooling towers and dry cooling towers.**

Maintenance of safety standards for the effluents discharged into the water

- Prevent 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 otherwastes

Biomagnification

Non-biodegradable pesticides, such as DDT widely used for crop protection. Once they enter the food chain , their concentration keeps on increasing with each trophic level (steps of a food chain). As a result, accumulation of these compounds takes place in the body of top consumers over a period of time.



Entry of harmful non-biodegradable chemicals in small concentrations and their accumulation in greater concentrations in the various levels of food chain is called biomagnification.

Consider the following food chain.

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 naturein the body of birds (top) consumer. This causes adverse effects, such as weake gg shells, resulting in decreased population.

Treatment of Sewage

Sewage contains a huge amount of organic matter which are toxic. Microorganisms are widely used in the sewage treatment plant for removing this toxic organic matter..

Wastewater and sewage is treated in three phases:

a) **Primary treatment (removal of solids),**

Through physical processes about 60-70% of suspended solids are removed from sewage.

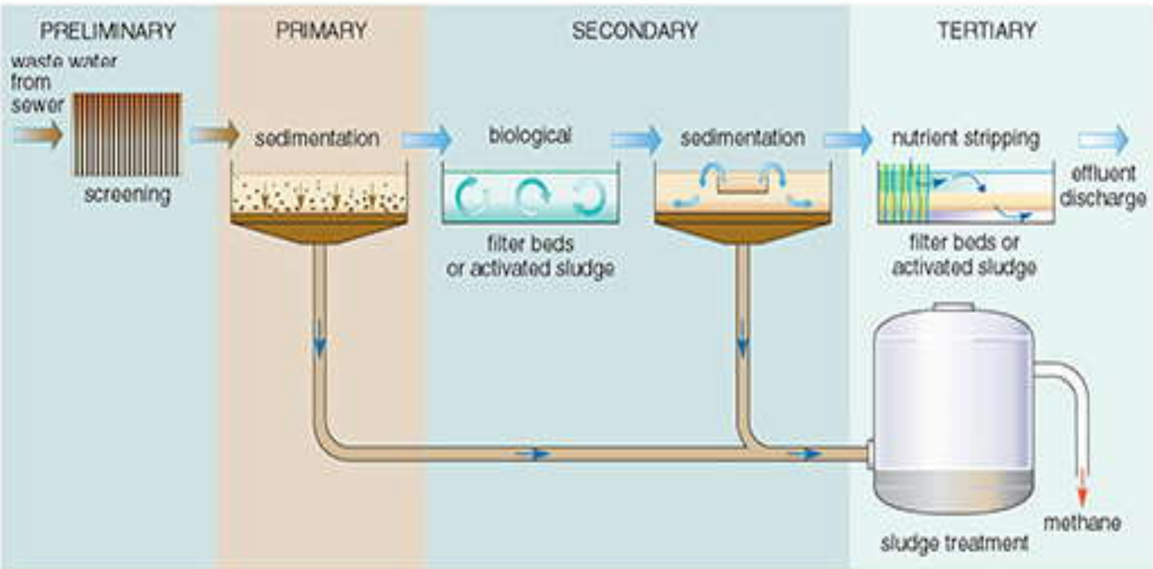
b) **Secondary treatment (bacterial decomposition),**

Aerobic microorganisms are inoculated into the sewage treatment plant. micro-organisms decompose the organic compounds, & reduce toxicity. This can be measured by BOD (Biological oxygen demand).

After the biological treatment, the sludge is pumped from the treatment plant into a large tank. This large tank consists of anaerobic bacteria which lead to the digestion of sludge. During digestion, biogas is produced and it is used as an energy source.

c) Tertiary treatment (extra filtration)- this water can be reused.

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 ion absorption methods are employed to obtain clean water.



Source- Open Edu

INTEXT QUESTIONS

1. Give two examples of man made sources of water pollution.

(i) ______________________________

(ii) ______________________________

2. What is biomagnification?

____

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

____

4. Give one source of and one disease caused by from the following pollutants

(i) Lead ______________________________

(ii) Arsenic ______________________________

(iii) Nickel ______________________________

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.

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

Control of Soil Pollution

- Careful use of chemical fertilizers and pesticides.
- Proper and appropriate irrigation practices
- Conversion of farm wastes into compost and much use of bio fertilizers and manure in farming.

  Ensure use of pollution free or treated waste water only for irrigation.
- Recycling of waste material for example plastic, metal and glass are recyclable and incineration of non recyclable, wastes.

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.

(ii) **Non-biodegradable waste** cannot he easily degraded. Aluminium cans, plastics, glass, DDT, etc,

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.

Radioactive wastes produced during nuclear reactions take a long time to decay and are harmful to human beings.

NOISE POLLUTION

Noise pollution

Noise can be simply defined as "unwanted sound". It is generally higher in urban and industrial areas than in rural areas. 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. Sounds that reach 85 decibels or higher can harm a person's ears.

Noise pollution is any unwanted or excessive disturbing sound that effect health and well-being of humans, other organisms (wildlife) and reduce environmental quality.

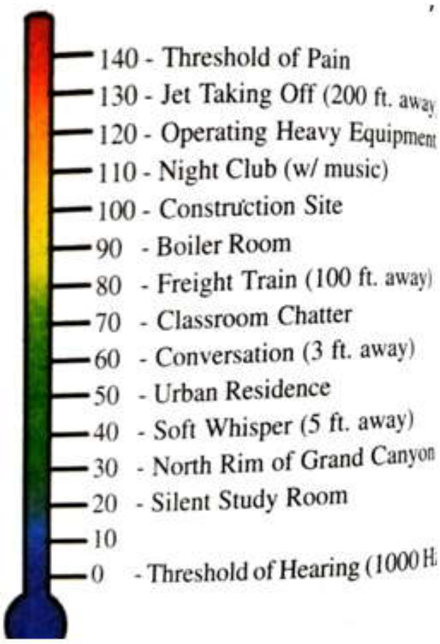
The World Health Organization (WHO) defines noise above 65 decibels (dB) as noise pollution.

Noise pollution is an invisible danger which is generally ignored. It cannot be seen, but it is present nonetheless, both on land and under the sea.

Noise becomes harmful when it exceeds 75 decibels (dB) and is painful above 120 dB.

Sources of Noise Pollution

Typical sound Levels



Ambient Air Quality Standards in respect of Noise recommended by CPCB

Area code	Category of Area	Noise level in dB	
		Day	**Night**
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silent zone	50	40

Noise pollution effects millions of people on a daily basis. Stress related illnesses, high blood pressure, speech interference, hearing loss, sleep disruption, and problem in communication.

Auditory Effects

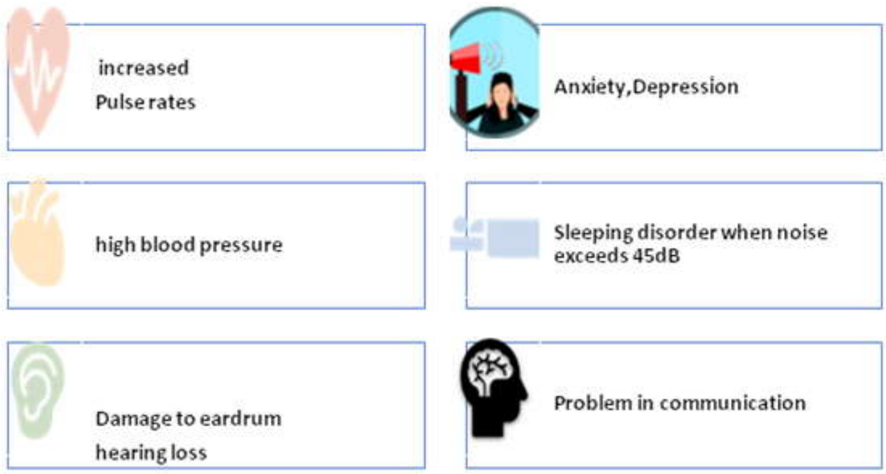
Noise Induced Hearing Loss (NIHL) is the most common and often discussed health effect. Single exposure to high-intensity sound or long-term exposure to sound levels higher than 85 dB can induce hearing loss. Repeated exposure to 105dB cause -hearing loss, (NIHL-noise induced hearing loss)

Non Auditory effects

Exposure to constant or high levels of noise, can damage human health in several ways along with effect on hearing, **Children** living in areas with high levels of noise pollution may suffer from stress, impairments in memory.

Old age people suffer from high BP, problem in communication, hearing loss etc.

1. **Psychological effects:** Noise can cause anxiety, depression, fatigue, and stress in humans and animals.
2. **Sleep disorders:** It is almost impossible to sleep when the surrounding noise exceeds 45 dB. Lack of sleep can further affect our behavior, making us aggressive and irritable.
3. **Memory:** A high level of noise is harmful to memory. It reduces our ability to focus and makes it difficult to study in the case of children.
4. **Physical effects:** Noise pollution causes people to develop high blood pressure and headaches. When exposed to loud sources of noise pollution making a loud noise for a long period, can cause a heart attack.



According to a study in Europe there was also a 34 percent increase in heart attacks, strokes, and other major heart-related disorders for every 5-decibel rise in the average 24-hour noise level.

Noise pollution control is important in the workplace and in the community.

CONTROL OF NOISE POLLUTION

Following steps can be taken to control or minimize noise pollution :

- **Reduction of Noise at source** Control the noise emanating from your radio and television.

  Use automobile horn only in case of emergency.

- **Ban on Crackers** -Do not burn fire crackers as they are noisy and pollute air.

  Proper oiling of machinery-Get all machinery and engines properly tuned and serviced at regular intervals

- **Use of sound absorbing materials,silencers**-Use of sound proof cabins and sound-absorbing materials in the walls.

- **Growing more trees-**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.

Standards and Application

Below are the noise standards as prescribed by WHO for various indoor and outdoor activities.

1. Inside homes – 30 to 35 dB
2. Inside school classrooms – 35 dB
3. Outdoor playgrounds – 55 dB
4. Inside hospitals – 30 dB
5. Around industrial and commercial areas – 70 dB
6. Festivals, ceremonies, entertainment events – 100 dB
7. Listening to music through headphones – 85 dB

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 the outside. 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 Sunlight energy reflected from earth remains trapped in the atmosphere by the greenhouse gases causing global warming on earth.

Causes of global warming

Carbon dioxide (CO2),

Chlorofluorocarbons (CFCs),

Methane (CH4) and

Nitrous oxides (N2O) are the main greenhouse gases that cause global warming.

An increased greenhouse gases— trap more sunlight ——

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. Increasing greenhouse gas emissions act like a blanket on the Earth, they trap the sun's heat, and does not allow it to go out and rise earths temperature. This leads to global warming and climate change. However, human activities have increased emissions of greenhouse gases into the atmosphere beyond what the Earth can support, resulting in climate change.

GLOBAL WARMING

More Greenhouse Gases = Warmer Earth

Global warming, also known as climate change, is the phenomenon involving **rise in the average earth's temperature observed over the century**. Earth is experiencing continual rise in the average temperatures. ,which has huge impact.

Global warming is responsible for many climatic and atmospheric changes experienced by the earth today. Around the world, there has been increase in average temperatures by 0.75 degree Celsius over the past 100 years

Causes-

1.Carbon dioxide (CO_2) 2.Methane (CH_4)

3.Nitrous oxides 4.Chlorofluorocarbons (CFCs)

5. water wapour, 6. Ozone

The quantity of greenhouse gases is increasing as burning of fossil fuels, (coal, petrol, gas), releasing the gases and other air pollutants into the atmosphere. This can cause Earth's atmosphere to trap extra heat., causing temperatures to rise.

Effects - global warming leads to increase in atmospheric temperature of the oceans, Earth surface. This result in water shortage, extreme weather conditions.

An increase in the atmospheric temperature will cause sea level to rise by 1 to 2 mm per year.

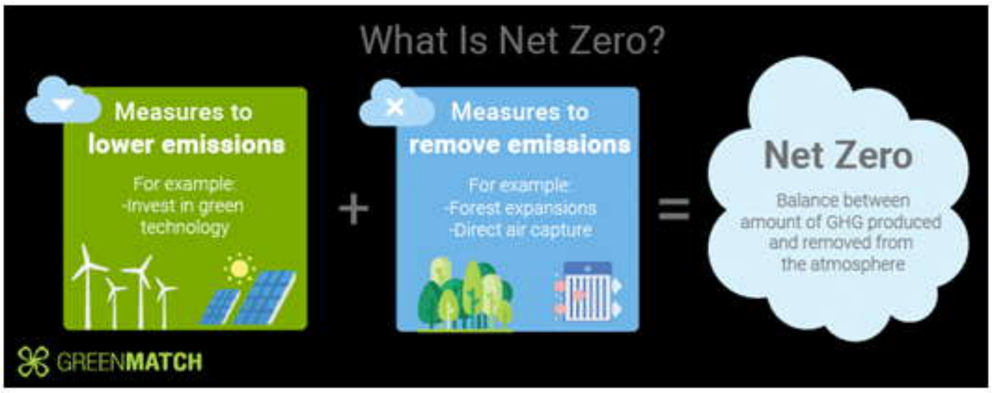
Temperature near ocean surface would Increase and cause glaciers and polar ice sheets to melt faster. This would flood the low lying coastal areas and a number of islands.

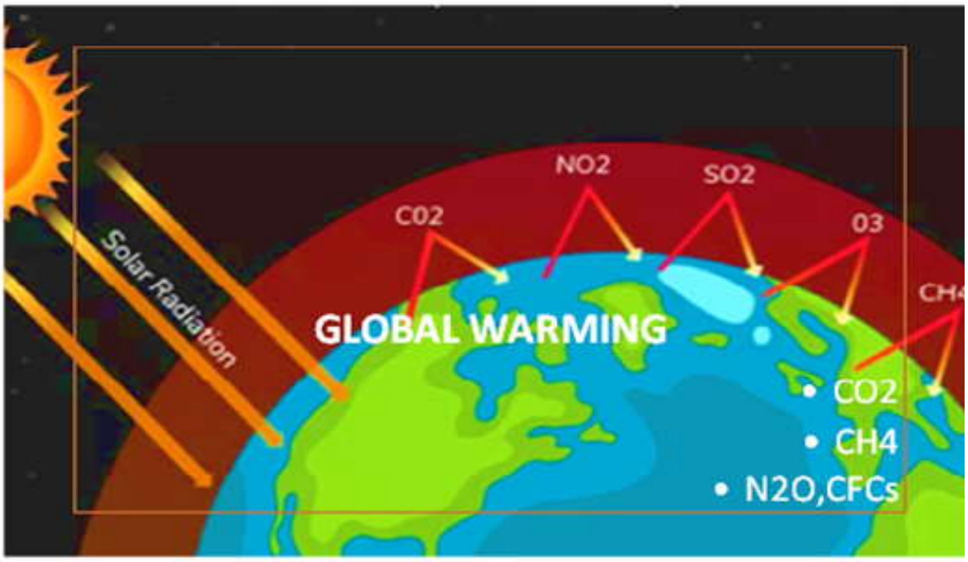
Global warming will produce severe heat waves during summers causingheat related illness and death.

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.

NET ZERO means cutting greenhouse gas emissions to as close to zero as possible UN initiative, Currently, the Earth is already about 1.1°C warmer than it was in the late 1800s, and emissions continue to rise. To keep global warming to no more than 1.5°C – as called for in the Paris Agreement – emissions need to be reduced by 45% by 2030 and reach net zero by 2050





INTEXT QUESITONS

1. Which of the following is (are) the anticipated effect(s) of Global warming?
   (A) Rising sea levels
   (B) Changing precipitation
   (C) Expansion of deserts
   (D) All of the above

Acid Rains

Acid rains- are form of precipitation with high nitric and sulfuric acids It can also occur in the form of snow, fog, and tiny bits of dry material that settle to Earth.

Normal rainfall is silightly acidic with pH 5.2, But acid rain has10times more acid content with pH 4.2-4.4. **Acid rain** occurs when Sulphur dioxide (SO_2) and oxides of Nitrogen (NOx) are emitted from rotting vegetation,Volcanoes, industries, vehicles-into the atmosphere, and are absorbed by water droplets in clouds and form . sulphuric and nitric acids . The droplets then fall to earth as rain, snow or mist

SOURCES (SO2 ;NOx)- SO2 – from thermal power plants, ore smelting, Oxides of Nitrogen (NOx) Emitted from -the combustion of fuels in vehicles, furnaces, industrial and electrical-utility boilers and engines, and other equipment.

Effects of Acid rains- Acid rain affects nearly everything. Plants, soil, trees, buildings and even statues can be transformed by the precipitation.

FORESTS	**Damage to plants/Forests**-Acid rains-. Impedes the growth of forests &damage. In extreme cases trees or whole forest can die. • Acid rains are highly injurious to plants. It damages foliage and weaken trees. It makes trees more susceptible to stresses like cold temperature, drought, Acid Rain depletes minerals from the soil and reduces growth of the plant. It causes death of young shoots, leaves turn yellow and fall off. whole plant may die.
SOIL	**A. Damage to the soil**-increase the acidity of the soil, and nutrients get washed away,soil fertility decreases. It can release toxic chemicals such as aluminium and mercury into the soil.
Fish	**B. Damage to aquatic ecosystem**:causes acidification of lakes and streams and damage to fish and other aquatic animals. Acidity releases aluminium into the water. aluminium hydroxide clog the gills of fishes. At pH lower than 5 most fish eggs do not hatch and can kill adult fish. it is disastrous for animals and creatures.
Building	C. Damages to buildings- acid rain damage marble buildings, statues, and sculptures etc.

Prevention of acid rain

Reducing the emission of SO_2, NOx at source by

1. Regulating the emissions coming from vehicles and buildings – This can be done by

a) Restricting the use of fossil fuels and

b) Using clean fuels / more renewable energy sources such as solar and wind power.

c) Placing scrubbers at industrial chimneys to stop the SO_2, NO_2 release in to the atmosphere. Using treated coal in power plants.

d) Energy conservation

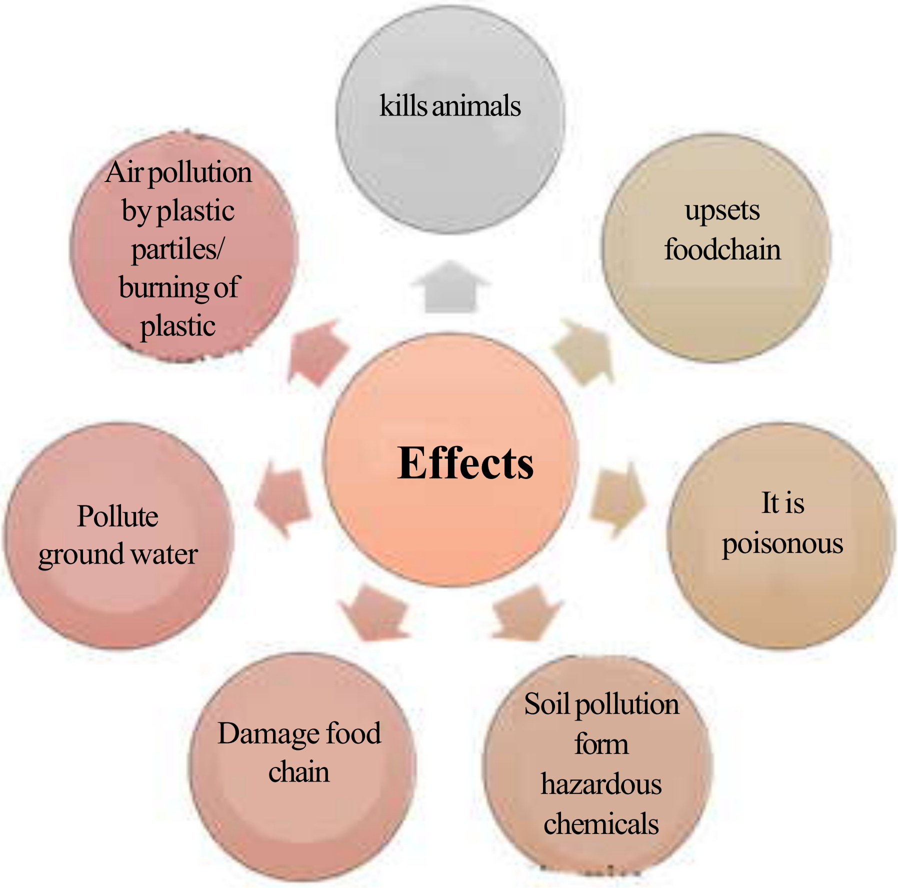
2. Adding lime to waterbodies to neutralise acidity.

PLASTIC POLLUTION

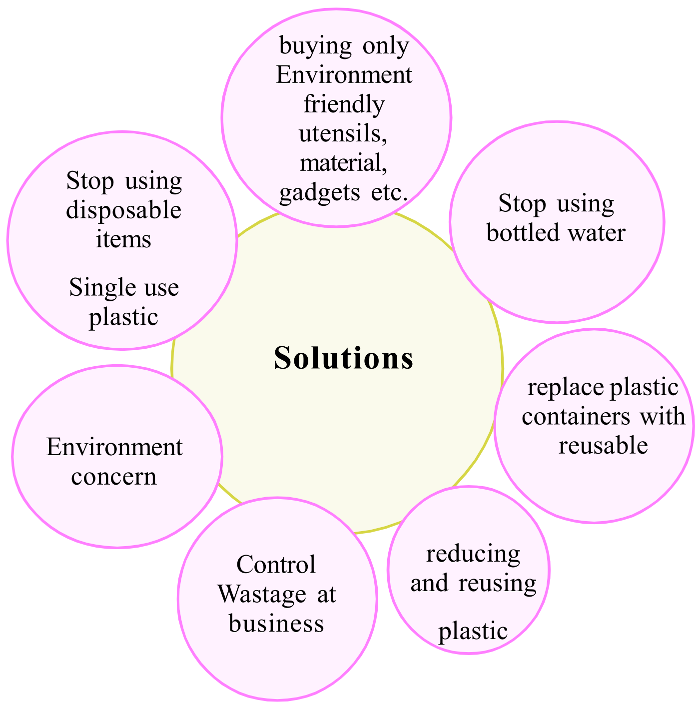
It is the accumulation of plastic products which has adverse effects on environment, wildlife and human beings.

If you look around in home, office, shops etc. plastic is omnipresent. Plastic crisis is increasing at alarming rate with increased usage of disposable /single use plastics (Plastic glasses, plates, covers, straws, bags etc.)

Plastic is widely used as it is inexpensive and durable. Thousands of products we use in our daily life are made up of plastic such as containers, playing kits, bottles, furniture, mats. Plastic is used everywhere in industry, in packaging, electronics, mobile phones, etc. Tonnes of plastic waste dumped into landfills and oceans every year.



Effects
kills animals
upsets foodchain
It is poisonous
Soil pollution form hazardous chemicals
Damage food chain
Pollute ground water
Air pollution by plastic partiles/ burning of plastic



Solutions
buying only Environment friendly utensils, material, gadgets etc.
Stop using bottled water
replace plastic containers with reusable
reducing and reusing plastic
Control Wastage at business
Environment concern
Stop using disposable items
Single use plastic

EFFECTS

As plastic is non -biodegradable it will not decompose &remains as waste in soil release toxic chemicals into the soil.

- Using water, food in plastics - cause serious health problems.
- Many animals on land and in oceans die because of Plastic covers, nets - and enter in to water for hundreds of years.

FACTS

1. Microplastics in bottled water and consuming food packed in plastics – toxic
2. Using tooth pastes, cosmetics with plastic microbeads – harm our health and all other animals which consume microplastic or beads and covers thinking as food.
3. Plastic fishing nets, covers – marine animals tortoise/fishes etc. get entangled in these nets and killed.

   Microplastics enter into fish and into human as they consume fish.
4. Birds, cattle (cow), killed by eating plastic covers or microplastic.
5. Highly toxic chemicals are released when plastics are burnt. We should avoid this.

CONTROL

Stopping single use plastics, using reusable items.

Adopting RRR Method

Reduce- using plastic

Reuse- plastic-covers / bottles for crafts other usable items

Making crafts other usable items with covers, bottles, cans etc.

Ex. Ropes can be made using plastic covers

Recycle -Burning plastics release toxic chemicals.,so avoid recycling.

Instead Reduce and reuse only are meant for controlling plastic pollution

Plastic production should be minimized.

INTEXT QUESTIONS

1. Name any two biodegradable pollutants.
   ____
2. Name any two non biodegradable pollutants
   ____
3. Mention adverse effects of noise pollution.
   ____
4. What is acid rain?
   ____

INTEXT QUESTIONS

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) ______________________

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.
- Soil pollution may be caused due to pesticides, radioactive wastes, domestic wastes etc.
- Noise is unwanted sound which may cause deafness, lack of concentration, high blood pressure and nervous disorders.
- Soil pollution includes addition of substances that reduce the fertility of the soil.
- Waste can he classified into biodegradable (e.g. cow dung, vegetable peels, paper, wood etc.) and non-biodegradable (e.g. aluminium cans, glass bottles, plastics, DDT etc.).
- Recycling of wastes such as cow dung, paper, sewage and rice husk, into useful products help in conservation of resources.
- Ozone provides a protective layer against harmful ultra-violet rays coming from the sun. Excessive use of chemical, such as CFCs used in spray cans, gas used in refrigerators and air conditioners, lead to thinning of the ozone layer.
- Accumulation of high concentration of carbon dioxide has led to the phenomenon of global warming (green house effect), and has resulted in increased earth's temperature.

TERMINALEXERCISES

1. Which of the following are biodegradable materials? Aluminium, wood, fruit peels, DDT, paper, glass, dung.
2. Which gaseous pollutant has the ability to absorb infra-red radiations?

3. A ship carrying oil from the gulf region collides with hug rocks and get damaged. It this just news or has some serious consequences? Give your opinion in one sentence.

4. To set up a new industry, a large forest area had to be cut. List four ways in which the environment in that area may be affected.

5. List any three ways in which noise from various sources can affect the wellbeing of a person. Suggest few methods to control noise pollution.

6. What does 'Global warming' mean ? Name the gas responsible for this phenomenon and why should it be considered an environmental problem.

7. How would you classify the waste generated at home? What is the difference between the different groups? How would you manage this waste so that it cause least pollution.

8. List any two effects of plastic pollution.

24 HUMAN DISEASES

In the previous lesson you have learnt about the diseases caused 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 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
- Know about sexually transmitted diseases
- List the causative agents, symptoms, prevention and control of syphilis, gonorrhea and AIDS
- Drug abuse and its prevention

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

The diseases may be classified into two broad categories

Classification of human diseases

Diseases

- Congenital diseases (Present since birth)
- Acquired diseases (Develop after birth)
    - Communicable diseases (Spread from infected person person to healthy)
    - Non-communicable diseases (do not spread from one person to another)
        - **Degenerative diseases** (caused due to malfunctioning of vital body organ)
        - **Deficiency diseases** (caused due to lack of nutrients in diet)
        - **Allergies (caused due to** hypersensitivity of the body to certain foreign substances)
        - **Cancer (caused due to** uncontrolled growth of cells and tissues)
        - **Other diseases (caused due to** various physical agents or any other reason)

A. Congenital disease

The disease which is present from birth (e.g. hole in the heart in infants). They are caused by some genetic abnormality or metabolic disorder or malfunctioning of an organ.

B. Acquired disease

The disease which may occur after birth during one's lifetime.

Acquired diseases may generally be classified into :

(i) Communicable diseases (Infectious diseases) : The diseases which can be transmitted from an infected person to a healthy person. Ex. measles.

(ii) Non-communicable diseases: These diseases do not spread from an affected person to a healthy individual

Non-communicable diseases classified into

(a) Degenerative diseases : The diseases caused by the malfunction of some vital organs of the body. Ex. heart failure.

(b) Deficiency diseases : These are caused due to nutritional deficiency such as that of minerals or vitamins in the diet. Ex. Anaemia (Beri- beri (vitamin B1).

(c) Allergies: caused due to hypersensitivity of the body to certain foreign substances

(d) Cancer : This is an abnormal, uncontrolled, unregulated and unwanted growth of cells. Ex. breast cancer.

(e) Other diseases: caused due to various physical agents or any other reason

Ex. Hearing Impairment

Table: Differences between communicable and non-communicable diseases

Communicable diseases	Non-communicable diseases
Caused by some biological agents or pathogens, such as viruses, bacteria, protozoan, helminths (worms) etc.	Caused due to some specific factor, such as malfunctioning of some vital organ, deficiency of nutrients, etc.
Spread from one person to another through contact, water, air, food, etc	Do not spread from one person to another by contact
The concern of society as these are related to community health.	The concern of the individual only.

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 .

(iii) **Contact with soil:** The soil contaminated with disease-causing viruses, bacteria, worms etc.

(iv) **Animal bite** : Viruses of rabies are introduced through the wound caused by the dog bite through saliva.

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) **Vectors (Houseflies, Mosquitoes, and Cockroaches)**. Houseflies carry the causative organisms of cholera on their legs and mouth parts from the faeces and sputum of infected persons to food and contaminate them. When this contaminated food is taken by a healthy person, he gets the infection. Similarly, mosquitoes carry dengue virus and malarial parasites.

(ii) **Air-borne :** The pathogens may reach humans through air and dust. The epidemic typhus spreads by inhalation of dried faeces of infected fly.

(iii) **Object borne (Fonite borne)** : Many diseases are transmitted through the use of contaminated articles, such as clothes, utensils, toys, door handles, taps, syringes and surgical instruments, etc.

(iv) **Water borne** : If potable water (drinking water) is contaminated with pathogens of diseases such as cholera, diarhhoea, hepatitis or jaundice, it reaches a healthy person upon consuming such water.

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 clothing's.

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).

Reservoir : An organism which harbours pathogen in large numbers and does not suffer itself.

Epidemic Disease : Spreading of a disease among a large number of people in the same place for some time Ex. plague.

Endemic Disease : A disease which is regularly found among a particular group of people Ex.. goiter

Pandemic : A disease which is found all over the world Ex.. AIDS.

Interferon : Type of proteins produced by infected cells of the body when attacked by a virus, which prevents 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 deceased and helps in identification.

A disease is an abnormal condition that affects the body of an organism. Any undesirable change occurring in the normal structure or functioning of a tissue or an organ of human body is referred to as disease. It may be caused by external factors (Infectious disease) or it may be caused by internal dysfunctions, (Autoimmune disease). Some diseases also caused by microorganisms. In this unit you learn some aspects concerning good health, onset of diseases, prevention and cure of the diseases.

Balanced diet is important for maintaining good health. If balanced diet is not taken, people suffer from malnutrition. This is one of the causes for ill-health. But in human beings health is also upset or spoiled due to lack of clean water, clean air, and hygienic food. Besides these, poverty, illiteracy and over population are also the major factors that cause ill-health and diseases.

The diseases are classified into many types These are 1. Infectious diseases, 2. Congenital diseases, 3. Dreadful diseases and 4. Epidemic diseases

1. Infectious diseases

These are also called as communicative diseases. These are passed from one person to another in different ways and through different media such as water, air, food, clothes etc. These are caused by microorganisms and worms. Some of the common infectious diseases are cold, cough and diarrhoea etc.

The infectious diseases are caused by microorganisms are as follows

1. **Bacteria:** Cholera, Leprosy, Plague and Tuberculosis

2. **Viruses:** Chiken Pox, , Measles, Mumps, Rabies

3. **Protozoa:** Malaria, Amoebic dysentery, Sleeping sickness, Leishmaniasis

4. **Fungi:** Skin-diseases, Ring worm diseases, Onychomycosis , Candidiasis

5. **Worms:** Filaria, Cysticercosis, Ascariasis and Taeniasis

S.No.& Pathogen	Disease	Causative Agent	Symptoms
1. Bacteria	Cholera	*Vibrio cholerae*	Watery diarrhea, vomiting
	Leprosy	*Mycobacterium leprae*	Discolour of skin, pain less ulcers on the soles of feet
	Plague	*Yersinia pestis*	Skin sores, High fever.
	Tuberculosis	*Mycobacterium tuberculosis*	chronic cough, chest pains, high fever
2.Viruses	Chiken Pox,	*Varicella virus*	Skin rashes, skin bumps, fever
	Measles	*Para mixo virus*	rashes on skin, runny nose
	Mumps	*Para mixo virus (rubiola virus)*	Swollen parotid glands, pain in testicles
	Rabies	*Rhabdo virus*	Hydro phobia, nausea, vomiting
3.Protozoa	Malaria	*Plasmodium sp.,*	Shivering , cold fever
	Amoebic dysentery	*Entamobea histolytica*	Blood motions, loose feces
	Trypanosomiasis	*Trypanosome brucuei*	Sleeping sickness, Malaise
	Leishmaniasis	*Leishmania sps.,*	Skin problems, Reduced hepatite
4.Fungi	Aspergillosis	*aspergillus*	Shortness of breath, coughing up blood.
	Ring worm diseases	*Trichophyton rubrum*	Patche with rised scaly, pustular lesions, Skin diseases
	Onychomycosis	*Tinea unguium*	Discolored, Smelly
	Candidiasis	*Candida albicans*	Loss of taste, Redness of mouth
5.Worms	Filaria	*Uchararia banchrofty*	Elephant foot , Bulging of lymph glands
	Fascioliasis	*Faschiola sps., (Liver fluke)*	Swollen liver, Shortness of breath
	Ascariasis	*Ascaris sp.,*	Abdominal pain, Anorexia
	Taeniasis	*Tanea solium*	Diarrhea,

2. Congenital diseases

A number of diseases are acquired at birth. Such diseases are passed on from one generation to another in some members (congenital defects). **Sir Archibald Garrod** was bold enough to say that such inherited disorders are due to defective metabolism. However we now know that not all inherited disorders are due to detective metabolism.

A number of genetic disorders are also caused due to missing enzymes. Therefore, therapy with the missing enzymes offers great promise in the case of number of disorders. This is known as enzyme therapy..

Disease	Cause	Effect
1. Down's syndrome	Abnormal chromosome number	Mental retardation
2. Haemophilia	Defective blood clotting Mechanism	Continuous bleeding
3. Sickle cell anemia	Change in the shape of RBC i.e. to sickle shape	Anemia
4. Thalasemia	Abnormal haemoglobin	Anemia
5. Phenylketonuria (PKU)	Defective conversion of phenylalanine to tyrosine	Mental retardation
6. Albinism	Conversion of tyrosine to Dopa is defective	Milk white skin, gray eyes light sensitive
7. Gout	Abnormal production of uric acid	Arthritis
8. Gaucher's disease	Cerebrosides accumulation	Enlarged spleen, enlarged liver, neurological manifestations
9. Talactosemia	Impaired metabolism of galactose	Cataract, mental retardation, enlarged liver
10. Glycogen storage	Defect in glycogen breakdown	Heart diseases, muscle weakness, mental retardation

3. Dreadful Diseases

AIDS, Cancer and very recently SARS are considered as dreadful diseases. The diseases like cancer and AIDS have been known for a few decades while the disease SARS has been identified only recently i.e. about one decade ago.

SARS (Severe acute respiratory syndrome): It is a communicable viral disease caused by a new strain of corona virus. It is a mysterious silent killer. This SARS virus was officially declared the causative agent on 16th April 2003 by WHO.

SARS mostly spread through close contact with an infected person (droplet transmission) when that person sneezes and cough droplets escape into air. Themost common symptoms in patient progressing to SARS include fever, malaise, chills, headache, myalgia, dizziness, cough, sore throat and running nose etc. In some cases there is rapid deterioration with low oxygen saturation and acute respiratory distress requiring ventilator support. It is capable of causing death in as many as 10 per cent of cases.

CANCER: Cancer may be regarded as a group of diseases characterized by an

(i) Abnormal growth of cells

(ii) Ability to invade adjacent tissues and even distant organs, and

(iii) The eventual death of the affected patient if the tumour has progressed beyond that stage when it can be successfully removed. Cancer can occur at any site or tissue of the body and may involve any type of cells. The factors include tobacco, alcohol, dietary, occupational exposures, viruses, parasites, life styles (customs and habits), radiation, air and water pollution, pesticides etc. act as causative agents to cancer.

4. Epidemic Diseases

Epidemic means "upon or above" and occurs when new cases of a certain disease, in a given human population, and during a given period, substantially exceed what is expected based on recent experience. Epidemics of infectious disease are generally caused by a change in the ecology of the host population (e.g. increased stress or increase in the density of the vector species), a genetic change in the parasite population or the introduction of a new parasite to a host population (by movement of parasites or hosts).An epidemic may be restricted to one location; however, if it spreads to other countries or continents and affects a substantial number of people, it may be termed a pandemic. The epidemic diseases are whooping-cough, measles, influenza, and recent epidemics like Dengue, Swine flu and Chikungunya.

Dengue:

Dengue fever is an infectious disease carried by mosquitoes and can be caused by any one of four types of dengue virus: DEN-1, DEN-2, DEN-3, and DEN-4.This disease used to be called "break -bone" fever because it sometimes causes severe joint and muscle pain that feels like bones arc breaking.

Dengue fever symptoms of typical uncomplicated (classic) dengue usually start with fever within 4 to 7 days after mosquito bite. These symptoms include: high fever, (up to 105°F), severe headache, retro-orbital (behind the eye) pain, severe joint and muscle pain, nausea and vomiting, and rash. The rash may appear over most of the body 3 to 4 days after the fever begins, and then subsides after 1 to 2 days. There may be a second rash a few days later.

Symptoms of dengue hemorrhagic fever include all of the symptoms of classic dengue plus bleeding from the nose, gums, or under the skin, causing purplish bruises, which results from damage to blood vessels. This form of dengue disease can cause death.

Swine flu:

Swine flue has been creating a terror effect all round the globe and has been declared epidemic in most parts of the world. In India day-by-day the graph of infected persons has been claimed to go up so, it is important to take into consideration about this disease as it may prove deadly one. Swine influenza, also called pig influenza, swine flu, hog flu and pig flu,is an infection caused by any one of several types of swine influenza viruses. Swine influenza virus (SIV) or swine- origin influenza virus (S-OIV) is any strain of the influenza family of viruses that is endemic in pigs. As of 2009, the known SIV strains include influenza C and the subtypes of influenza A known as H1N1,H1N2, H2N1, H3N1, H3N2, and H2N3.

The main route of transmission is through direct contact between infected and uninfected animals. These close contacts are particularly common during animal transport. The direct transfer of the virus probably occurs either by pigs touching noses, or through dried mucus. Airborne transmission through the aerosols produced by pigs, coughing or sneezing is also an important means of infection. People who work with poultry and swine, especially those with intense exposures, are at increased risk of zoonotic infection with influenza virus endemic in these animals, and constitute a population of human hosts in which zoonosis and reassortment can co-occur. Vaccination of these workers against influenza and surveillance for new influenza strains may therefore be an important public health measure.

Chikungunya :

Chikungunya occurrence was first detected in human blood samples in 1952-53 from Tanzania, Africa. This disease was reported in India for the first time in Calcutta in 1963. Chikungunya virus is transmitted by two mosquitoes, *Aedes albopictus* and *Aedes egypti* from the infected to a normal person. The disease is also locally named as Joint Pain disorder. This mosquito is an oracious day time feeder and bites people only during day. Symptoms are expressed after an incubation period of 1-12 days after mosquito bite which include fever, headache, joint pain, arthritis affecting multiple joints, swelling of joints, rash, conjunctival infection, photophobia, chills, nausea, vomiting, bleeding or hemorrhage.

Sexually Transmitted Diseases

Spread of sexually transmitted diseases (STD's) is still a major problem and a severe threat to healthy society. Diseases or Infections which are transmitted through sexual intercourse (contact) are collectively called sexually transmitted diseases (STDs) . STDs also known as venereal diseases (VD) or Reproductive tract infection (RTI). Untreated STDs in women may lead to complications, which include pelvic inflammatory diseases (PID) , abortions, ectopic pregnancies, infertility, cancer of the reproductive tract etc . But there is no reason to panic because prevention is possible by following the simple principles mentioned below.

i. Avoid Sex with unknown partners/multiple partners.

ii. Always use condoms during coitus.

iii. Consulting qualified doctor for early detection of STDs and get complete treatment if diagnosed.

Most common STDs and their causative organisms

Bacterial agents	Disease	Main Symptoms
1. *Neisseria gonorrhoeae*	Gonorrhoea(or) Haemorhagic fever	pustules on Gonococcemia fingers (or) joints, buring sensation and discharge from female
2. *Chlamydia trachomatis*	Cervicitis	Cervix inflammation in female
3. *Treponema pallidum*	Syphyllis	Ulcerations on rectum & genitalica
4. *Haemophilus ducreyi*	Chancroid	Painful pus Filled ulcer on genitalia
5. *Mucoplasma horninis*	Urethritis	Infection to urinary tract
6. *Ureaplama urealyticum*	Urethritis	Infection to urinary tract
7. *Calymmotobacterium*	Granutoma inguinate	Ulcerated papules on skin, Granulomatis around genitalia
8. *Shigella spp*	Shigellosis	Bacillary dysentry

Viral agents	Disease	Main Symptom
1. Human(alpha)herpes	Herpes genitalis	Fever and genital (sorness virus) 1 (or) 2 (herpessimplex virus)
2. Human (beta) herpes	Herpes	Inflammations (herpesvirus 5) (formerly cytomegalovirus)
3. Hepatitis virus	B strain	Hepatitis Jaundice, dark urine
4. Human papilloma Virus	Papillioma	Genital warts disease
5. Molluscum	Contagiosm Keratitis	Umbilicated papules
6. Human immune Virus (HIV)	AIDS	Loss of immunity

Protozoan agents	Disease	Main symptoms
Entamoeba histolytica	Vulvovaginits	Inflammation of vulva and vagina
Giardia lamblia	Giardiasis	Diarrhoea
Trichomonas sps	Vaginalis, Trichomoniasis	Discharge of green mucus from vagina

Fungal agents	Disease	Main symptoms
Candida albicens	Vaginilis	Erythmatous exudative lesions of mucus

AIDS

The AIDS (Acquired Immune Deficiency Syndrome) disease was first reported in United States in 1981. The disease is caused by infection with **human immunodeficiency virus (HIV),** a lentivirus (lenti = slow) within the family Retroviridae. Two serotypes of HIV have been identified: HIV-1 and HIV-2. HIV is a spherical, enveloped, RNA virus, measuring 90-120 nm in diameter.

Transmission of AIDS

- Sexual contact.
- Transfusion of infected blood and blood products.
- Sharing of needles and syringes, particularly in intravenous drug addicts.
- Mother to unborn child

Symptoms of AIDS

Fever for long periods (more than a month), weight loss upto 10% of the total body weight, diarrhea for long periods (more than a month). Serological tests for anti-HIV are screening tests – ELISA, Dot blot assays and confirmatory Tests- Western blot test, PCR

Occupational diseases

Asbestosis

Asbestosis is a chronic (long-term) lung condition caused by prolonged exposure to asbestos. Asbestos is a general term for a group of minerals made of microscopic fibres. In the past, it was widely used in construction of houses, buildings and apartments etc. Asbestosis is caused by breathing in asbestos fibers. People working in certain trades are more likely to have been exposed to asbestos in the past.

Symptoms

Shortness of breath., Persistent dry cough., Chest tightness or chest pain., Weight loss from loss of appetite., A dry, crackling sound in the lungs while breathing in wider and rounder than normal fingertips and toes (clubbing)

Treatment & prevention

There is no treatment that can reverse the damage done by asbestos, but certain steps can help slow down progression of the disease and relieve symptoms. Avoiding further exposure to asbestos and other irritants like cigarette smoke will help to slow down the disease from progressing.

Silicosis

Silicosis is a long term lung disease. It caused by inhaling amount of crystalline silica dust and it is naturally found in certain types of stone, rock, sand and clay. Those are working with these material can create a very fine dust that can be easily inhaled.

Symptoms

Silicosis usually appear after many years of exposure. In early stages symptoms are mild and include cough, sputum and progressive shortness of breath. As the scarring continues to worsen, the first real signs of a problem may be an abnormal chest pain and ray and a slowly developing cough.

Treatment & prevention

There is no specific treatment for silicosis. Removing the source of silica exposure is important to prevent the disease from getting worse. Supportive treatment includes cough medicine , bronchodilators and oxygen if needed. Antibiotics are prescribed for respiratory infections as need.

Fig: A lobe of lung effected with Silicosis

Asthma

Asthma is a chronic lung disease affecting people of all ages. It is caused by inflammation and muscle tightening around the airways, which makes it harder to breathe. The common asthma is caused by allergens, air pollution and other airborne irritants, The respiratory infections, weather conditions, strong emotions, and certain medicines also cause asthma. Therefore asthma triggers vary from person to person.

Symptoms

Symptoms can include coughing, wheezing, shortness of breath and chest tightness. These symptoms can be mild or severe and can come and go over time

Treatment and prevention

There is no cure for asthma currently. But treatment can help in control of symptoms and Inhalers are good medicine to treat.

Pneumoconiosis

The pneumoconiosis is a group of lung disease caused by the lung's reaction towards inhalation of certain dusts.

The main cause of the pneumoconiosis is work-place exposure. Environmental exposures have rarely been related to these diseases. Pulmonary reactions to mineral dust Silica and asbestosis are highly fibrogenic and is therefore very likely to cause pneumoconiosis

Symptoms

In early stages, the most common symptoms are cough, shortness of breath and chest tightness. Sometime the coughing may bring up black sputum (mucus). These symptoms may initially occur after strenuous activity, but as the disease progresses, they may become present at rest as well

Treatment and prevention

Medication and breathing exercises may be prescribed to open airways and decrease inflammation. In most cases, pulmonary rehabilitation, an exercise program designed to help patients with chronic lung conditions, is recommended to improve quality of life

Fig: Pneumoconiosis effected lungs

2. Diseases caused by pesticide exposure

- DDT,
- Endosulphan
- Malathion

DDT

What is DDT ?

DDT (dichloro diphenyl trichloroethane) is a synthetic insecticides and initially used with great effect to combat malaria, typus and the other insect born diseases.

DDT Effects

DDT and its metabolites are readily absorbed onto sediments and soil which can act both as sinks and as long-term sources of exposure.

Diseases caused by DDT

Higher doses of DDT exposure may cause effects on the nervous system, endocrine system, kidney, liver and immune system.

Endosulfan

What is Endosulfan?

Endosulfan is an organochlorine insecticide and acaricide. It causes acute toxicity, bioaccumulation and acts as an endocrine disruptor.

Endosulfan effects

High exposure to endosulfan sulphate may cause head ach, giddiness, blurred vision, nausea, vomiting, diarrhea and muscle weakness. Sever poisoning may cause convulsion and coma. Endosulfan is a pesticide that was widely sprayed in Kerala's Kasaragod district from the mid 70s until 2011 to protect cashew, cotton, tea, paddy crops from whiteflies.

Malathion

What is Malathion?

Malathion is an organophosphate insecticide that is commonly used to control mosquitoes and a variety of insects that attack fruits, vegetables, landscaping plants and shrubs.

Malathion effects

It can cause nausea, vomiting , stomach cramps and diarrahea as well as confusion blurred vision, sweating , muscle twitching , irregular heart beating, convulsion and death. Symptoms occur when, malathion inhaled, swallowed or absorbed through skin.

Non pesticide management solution (NPM)

Non pesticide management provides a set of natural alternatives to chemical pesticides. It is an alternative model of agriculture which largely depends on replacing external inputs with locally available resources. It utilizes formers knowledge and skills apart from traditional pest management practices with good understanding of the biology of insects and diseases. The core of NPM strategy is use of the Neem tree. Neem seeds powder along with water is sprayed on to the crops. The good point about neem is that it does not directly kill insects but instead act as a repellent protecting the crop from damage. Neem is less expensive than chemical insecticides and it also has the advantage of not killing predatory insects.

3. Diseases caused by heavy metal exposure

- Mercury (Hg),

- Arsenic (As),
- Lead (Pb), and Cadmium (Cd)

Mercury

Mercury is chemical element with symbol Hg and atomic number 80. It is also known as quick Silver and formerly named hydragyrum.

Effects of Mercury

The inorganic salts of mercury are corrosive to the skin, eyes and gastrointestinal tract, and may induce kidney toxicity if ingested. Neurological and behavioural disorders may be observed after inhalation, ingestion or dermal exposure of different mercury compounds.

Arsenic

What is Arsenic ?

Arsenic is a chemical element with the symbol As and atomic number 33. Arsenic occurs in many minerals, usually in combination with sulfur and metals, but also as a pure elemental crystal.

Effects of Arsenic

A small molecule that can easily get into cells, can cause cell injury and death by multiple mechanisms. In addition, arsine gas may interact directly with red cell membranes. Long-term exposure to arsenic from drinking-water and food can cause cancer and skin lesions. It has also been associated with cardiovascular disease and diabetes. In utero and early childhood exposure has been linked to negative impacts on cognitive development and increased deaths in young adults.

Lead

What is Lead ?

Lead is a chemical element with the symbol ' Pb' and atomic number 82. It is a heavy metal that is denser than most common materials. Lead is soft and malleable, and also has a relatively low melting point.

Effects of Lead

Lead exposure causes anemia, hypertension, renal impairment, immunotoxicity and toxicity to the reproductive organs. The neurological and behavioral effects of lead are believed to be irreversible abdomen and joints pains, constipation, learning disability or slow growth fatigue, hyperactivity, baby colic, insomnia and memory loss.

INTEXT QUESTIONS

1. What are infectious diseases?

   ____

2. What are the congenital diseases?

   ____

3. What are the dreadful diseases?

   ____

4. Define Epidemic diseases?

   ____

5. What is good health? How diseases are caused? How diseases are classified?

   ____

6. Write a note on cancer?

   ____

25

BIOTECHNOLOGY

The global population is increasing rapidly. Biotechnology meets the high productivity demands of food and other challenges of human life.

Biotechnology is a multidisciplinary subject, based on the principles of molecular genetics, microbiology and biochemistry. For the first time Carl Ericay (1919) used the term biotechnology. It has come from two words namely bio (meaning biology) and technology (technological applications).

Objectives:

- To know the recombinant DNA technology
- Appreciate the importance of biotechnology in human life
- Define genetic engineering and mention its utility
- To know about gene clonning

It is defined as the industrial applications of living organisms and their biological process such as biochemistry, microbiology, genetic engineering etc…In order to make best use of the microorganisms for the benefit of mankind.

Genetic engineering:

Over the centuries man has been trying to alter the genetic makeup of organisms by conventional breeding methods. All these methods are trial and error process, which suffer from certain drawbacks, for instance, it is not possible to transfer the foreign genes between unrelated organisms through traditional breeding methods. Similarly, a desired prokaryotic gene can't be transferred to an eukaryotic cell or vice versa. Moreover, the conventional breeding programmes are time consuming in the development of new strains. The use of recombinant DNA technology facilitates in overcoming some of these problems.

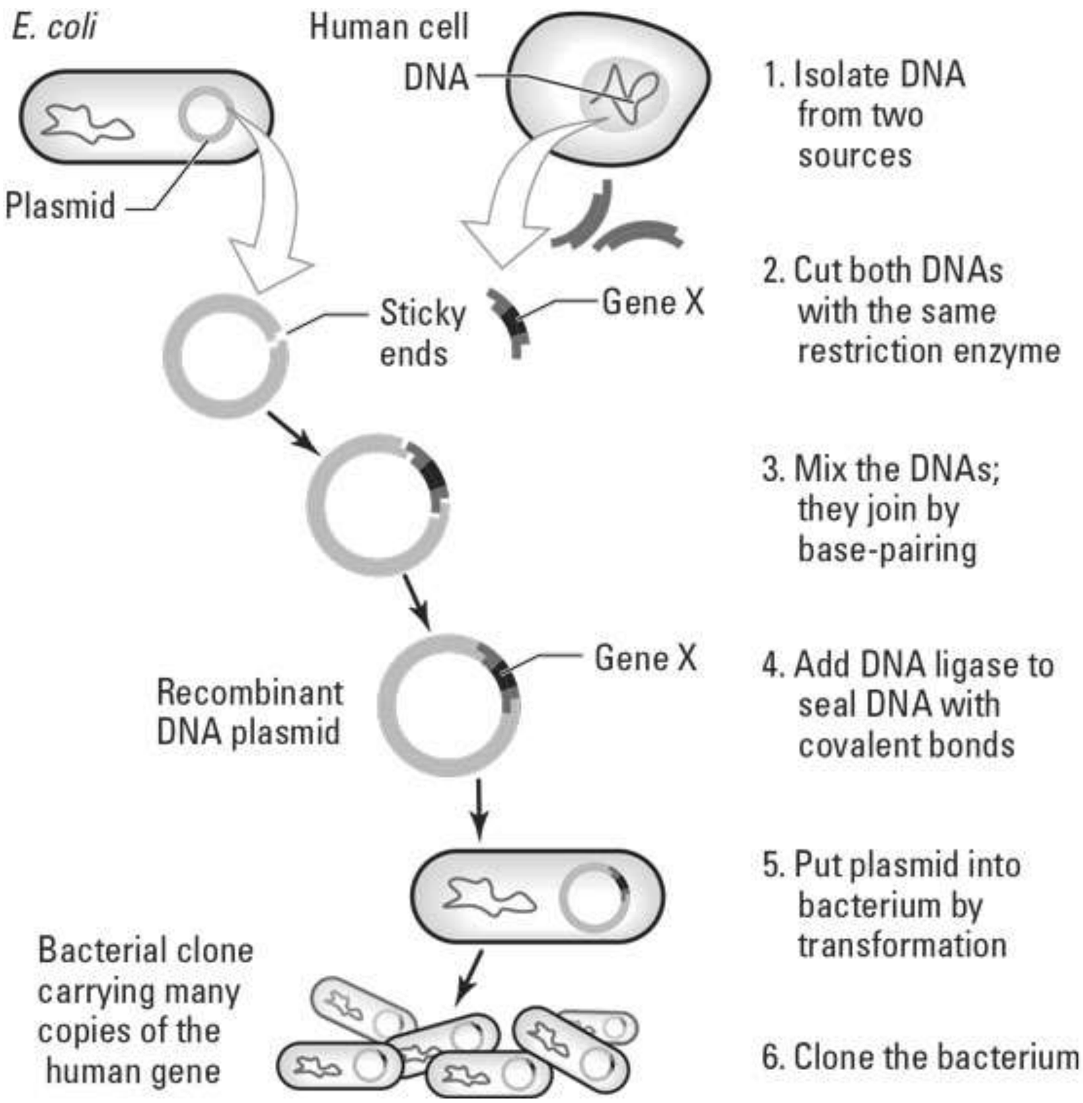
r-DNA Technology

Recombinant DNA technology comprises altering genetic material outside an organism to obtain enhanced and desired characteristics in living organisms or their products.

This technology involves the insertion of DNA fragments having a desirable gene sequence from a variety of sources via appropriate vector. Using this technology we can get multiple copies of a particular gene. This technique is called gene cloning.

The important steps in r-DNA technology as follows:

1. Isolation of a desired gene.
2. Insertion of the isolated gene into a suitable vector.
3. Introduction of recombinant vector into a host.
4. Selection of the transformed host cells.
5. Isolation and purification of the desired product.



Applications of r- DNA technology

1. Pest resistant plant varieties can be produced through r-DNA technology.
2. Drought tolerant plants can be produced by using r-DNA technology.
3. By using this technology plants with high nutritive value can be produced.
4. Genes useful for nitrogen fixation are called "Nif genes" This technology helps to introduced Nif genes into plants.
5. Human insulin is produced by transformed yeast cells having r-DNA that contain insulin gene.
6. Somatotropin hormone which promotes growth in humans is produced from E.coli cells.
7. The protein produced by transformed *pseudomonas phorascens* since inhibits the insect growth.
8. A new strain of colon bacillus is prepared which produce Alpha interferons that inhibit the growth of viruses.
9. Microorganisms which release methane rapidly in biogas plants have been grown.
10. Different types of vaccines are produced by r-DNA technology.

INTEXT QUESTIONS

1. Define genetic engineering.

   ____

2. What is a clone?

   ____

3. What do you mean by the term recombinant DNA?

   ____

WHAT YOU HAVE LEARNT

- Biotechnology is the application of scientific knowledge by industries that produce biological products like food supplements, enzymes, drugs etc
- Tools of r-DNA technology are cell culture, restriction enzymes, plasmids, ligase and host bacteria.

- Recombinant DNA (r-DNA) technology resulted from the discovery of
  - (i) Plasmids and
  - (ii) restriction enzymes.
- Genetically engineered organisms carrying foreign genes are called transgenics.
- Genetic engineering is defined as construction and use of DNA molecules engineered by recombinant DNA technology.
- Recombinant DNA technology may be used to obtain commercially important proteins such as insulin, clotting factors, monoclonal antibodies, enzymes, antibodies and vaccines, etc.

TERMINAL EXERCISES

1. Define biotechnology.
2. Enumerate in a sequence the steps in recombinant DNA technology.
3. Describe the uses of genetic engineering.

ANSWERS TO INTEXT QUESTIONS

1. Causing genetic change by artificially manipulating DNA is genetic engineering.
2. Clone is a group of genetically identical cells. Such cells are descendants of a single cells
3. Two or many molecules of DNA from two different species were combined and are inserted into a host organism to produce new genetic combinations.

EMERGING AREAS OF BIOTECHNOLOGY

1. Genomics: Genomics is a rapidly emerging area of research. It will revolutionalise our understanding of biology. It is the study of how genes and genetic information are organised within the genes and concerned with the structure, function, evolution and mapping of genomes.

Almost every cell in a person's body contains a complete copy of the genome.

Genomics has been described either as functional or as structural genomics.

Functional genomics involves a study of the functions of all specific gene sequences and their expression in time and space in an organism.

Structural genomics involves study of the structure of all proteins encoded in a fully sequenced genome. Plant genomics is a part of this larger field.

2. Protemics: The term proteome was coined to refer to the total protein complement expressed by the genome within a cell.

It includes investigation of biological process by the systematic analysis of a large number of expressed proteins for specific properties such as their identity, activity and their molecular interactions.

3. Metabolomics: Metabolomics or metabolite profiling is the large scale study of small molecules commonly known as metabolites within cells, biofluids, tissues and organisms is the study of total content of metabolites present in a biological sample under given genetic, nutritional or environmental conditions.

26 IMMUNOBIOLOGY

Immunology is the science that is concerned with immune response of an organism to foreign challenges. **Edward Jenner** is the **father of Immunology**. The word immunity derived from Latin word is "**Immunis,**" which means **"Exempt**".

We all are affected with a large number of infectious agents, which cause diseases. but our body is able to protect by itself from most of them. The ability of an individual to fight against the disease causing microorganisms is called **Immunity.**

The array of cells, tissues proteins and organs which carry out this activity (fighting with foreign substances) constitute the **Immune system.**

Objectives

After completing this lesson, you will be able to:

- Explain the concept of "self " and "non -self".
- To understand the lines of defence in the body.
- Describe the types of defence mechanisms in the body.
- 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.

Jenner, the father of immunology

Edward Jenner(1749-1823) is considered as the father of modern immunology. He demonstrated that the inoculation of cowpox crusts afforded protection to humans against smallpox. He observed that milk maids who recovered from cowpox never contracted the 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 as the 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-selfcomponents 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.

DEFENCE MECHANISMS IN THE BODY

There are four defence mechanisms in our body:

- Immunity to defend the body from infections
- Metabolic defence to metabolize and detoxify foreign chemicals.
- Stoppage of bleeding(homeostasis) and thus preventing blood loss.
- Resistance to stress mainly through the release of hormones

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 tumor.

Thus immunological defence serves three main functions:

- Defence against microorganisms.
- Recognition and destruction of mutant cells(surveillance).
- Removal of damaged or non functional cells to maintain normal state(homeostasis).

Lines of defence in the body

Lines of immunity/defence

i) **First line of defence:** Skin, mucus membrane, lysozyme of tears saliva, tears. etc.

ii) **Second line of defence** : Macrophages, natural killer cells,antimicrobial substances, inflammation, fever.

iii) **Third line of defence :** Lymphocytes(T-cells,B- cells),Antibodies.

Whenever pathogens try to penetrate the body of an organism, skin and mucus membrane fight against infectious pathogens and prevent their entry, This is called the " First line of defence".

If the skin is damaged, microorganisms enter the deeper part of an organism. The macrophages, NK cells , antimicrobial substances etc, fight against the infectious agents and prevent their entry this is called second line of defence. Even if this line is crossed by micro-organisms. Lymphocytes antibodies fight against them this is called third line of defence. When all of these three lines of defence fail to kill the micro-organisms it causes the disease.

INTEXT QUESTIONS

1. Who is considered as the father of immunobiology?

   ____

2. What are the three main functions of immunological defence?

   (1) __________________________________

   (2) __________________________________

   (3) __________________________________

3. Define immunology.

   ____

4. Give two example for second line of defence.

   ____

5. Define the 'disease'.

   ____

IMMUNE SYSTEM

By now, you are aware that immunity to infection is one of the most important factors facilitating the 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 :

1) Central lymphoid organs or primary lymphoid tissue.

Example : Thymus and bone marrow

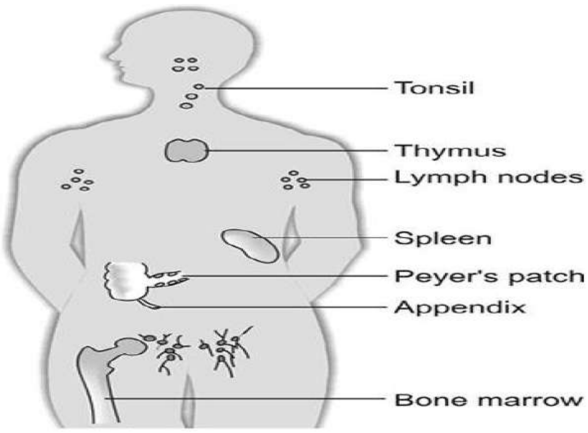


Fig: Major Lymphoid organs and tissues

2) **Peripheral lymphoid organs or secondary lymphoid tissues**:

Examples : spleen, payers's patches, tonsils, lymph nodes and mucosa-associated lymphoid tissue (MALT), which is associated withthe respiratory system, urogenital and alimentary canal

2. Cells of Immune system

(i) Lymphocytes (Lymphoid cells)

All these are initially derived from the hemopoietic (blood cell producing) stem cells of bone narrow.

Stem cells mean undifferentiated cells which can undergo unlimited division and can give rise to one or several different cell types. Bone marrow stem cells are 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 1012 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 makers.

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 hindgut 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

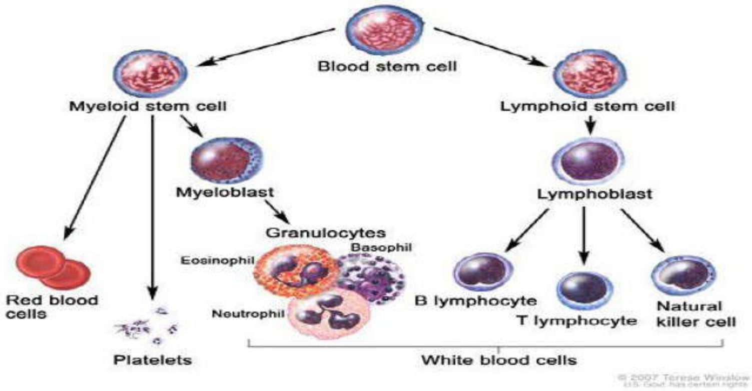


Fig: Origin of B and T CELLS

Characteristics of B-cells

- B cells display immunoglobulin as an integral protein of their cell membranes
- This surface immunoglobulin (antibody)acts as the receptor for antigen specific to it.
- B-cells are responsible for the production of antibodies. Activated B-cells transform into plasma cells. You will learn about 'antigen' and 'antibody' in the next section of this lesson.

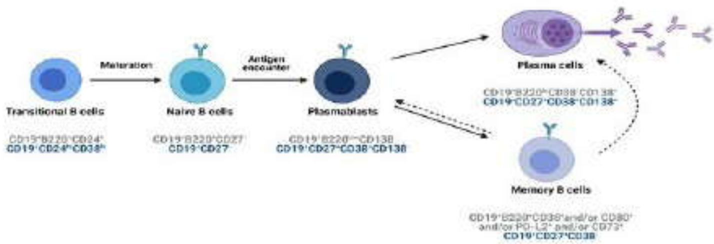


Fig : B- cell differentiation and antibody production

Plasma cells produce thousands of antibody molecules per second before they die in a day or two.

Some of the B-cells do not differentiate into plasma cells but rather become 'memory cells', which produce antibodies in the event of encountaring antigen re-appearing again in future.

B) T-Cells (T-lymphocytes)

In contrast to B-cells ,other lymphocytes leave bone marrow in a 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

- Regulate immune response.
- Mediate cell-mediated immune (CMI) response.
- Induce B-cells to produce antibody.

T-cells are functionally classified into three categories (TH, TC,Ts)

1) Helper T-cells (TH) : Promote response of B-cells resulting in antibody production (activate other T- cells).
2) Cytotoxic T-cells (TC): Kill virally infected cells and tumour cells
3) Suppressor T-cells (TS): Suppress helper T-cells and may also be B-cells to limit/ regulate activitity of the latter.

Thus we see that T-cells mediate two general types of immunological functions **effector** and **regulatory.**

Structurally, 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

1. Name the two Categories of immune cell

   (1) ____________________

   (2) ____________________

   (3) ____________________

ANTIGEN AND ANTIBODY

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

Definition and Properties of an antigen

An antigen is a 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 'antigenicdeterminant'.

Requirements for becoming an antigen

- Substance should be foreign to the host.
- Molecular weight of molecule should be 10000 Dalton or more.
- It should possess chemical complexity.

TYPES OF IMMUNOGLOBULINS : There are five major classes of antibodies distinguished by the amino acid sequences in the heavy chains. These classes are designated as IgA, IgG, IgM, IgE, IgD (**Ig** = immunoglobulin).

TYPES OF IMMUNE RESPONSES

Broadly, immune responses can be classified into two categories : Non-specific immune responses and Specific immune responses.

- 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 the 'complement'. There are two non-specific types of immune responses

- Specific immune responses (adaptive immune responses) depend upon the immunological recognition of the substance or cells to be attacked. Specific immune responses are again two types :

    a) Cell mediated immune responses : Mediated by the cytotoxic T-cells and natural killer cells. These constitute major defense 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 extra cellular fluid.

The above two differ from each other as shown in below Table. Both cell mediated and antibody mediated immune responses are facilitated by helper T-cells and inhibited by suppressor T-cells

Table

Table : Difference between cell-mediated and humoral (antibody mediated) immune responses

Cell-mediated immune responses	Humoral immune responses
1. Killing of intracellular organisms	1. Antibodies specifically combine with antigen which stimulate their production.
2. Destruction of tumor 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. Combination of antigen with antibody may also cause lysis of cellular antigens present on the red blood cells or bacteria.

INTEXT QUESTIONS

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?

   ____

TYPES OF IMMUNITY

There are two main types of immunity : (1) Natural or innate (i.e. genetic, from birth) and (2) Acquired (i.e. developed during life time).

A) NATURAL OR INNATE IMMUNITY

A healthy individual protects 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:

- Physical barriers (preventing entry of germs)
- Phagocytic cells and (Dealing with germs which enter)
- Soluble components (Complement)

PHYSICAL BARRIERS

It is the first line of defence. It means preventing the entry of pathogens into the body.

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 urinogenital tract have an exterior epithelial cell layer covered by a protective mucous lining. In the respiratory tract, cilia covering 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.).

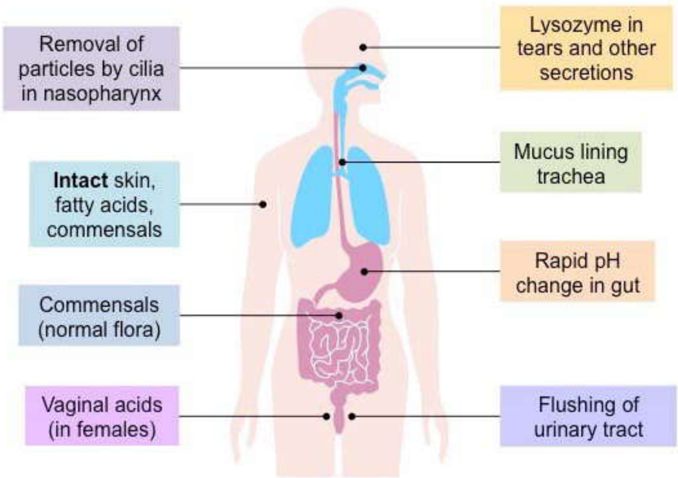


Fig: Natural physical barriers to infections

If the germs somehow enter the body by evading 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 the complement system which are described below.

Phagocytic Cells

When the micro-organisms or foreign particles such as colloidal carbon enters 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 of microorganisms is assigned to two major types of cells named as microphages and macrophages.
- Microphages are the polymorph nuclear 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 the ‘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 C3.Complement component may also act as opson-in (e.g. C36). Opson is that 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.

1) 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.

2) Other diseases such as common cold,influenza, bacillary dysentery and pneumococcal pneumonia confer immunity for a shorter period, sometimes only for a few weeks.

(ii) Passively acquired immunity

It may be developed in the following ways :

- Transfer of antibodies (e.g. IgG) from mother into foetus across the placenta.
- Breast fed children also receive antibodies from the mother's milk.
- Pooled human immunoglobulin is also given to patients with a congenital inability to make antibody globulin.

ACTIVE IMMUNIZATION (VACCINATION)

People have 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 to introduce attenuated germs into the body. The body then generate specific population of memory cells. These memory cells can rapidly increase in number of the renewed contact with the same antigen and more antibodies can be produced to provide protection against infection.

Types of Vaccine

Three main types of vaccines are available :

- Killed organisms as vaccines : Examples : typhoid, cholera , pertussis (whooping cough), rabies and poliomyelitis.
- Live attenuated (weakened) organisms as vaccines; Examples : BCG, rubella, measles and polio.
- Attenuation mimics the natural behavior of the organism without causing disease. The actively multiplying organism provides a sustained antigen supply.
- Toxoid vaccines : Examples : diptheria and tetanus.

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

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 diptheria and tetanus toxoids and for pertussis Bordotella pertussis, the whooping cough organism.
- MMR vaccine =Attenuated strain of measles, mumps and rubella).

Another class of vaccines termed as polysaccharide vaccines are available comprising vaccines for influenza, meningitis and pneumonia. In these vaccines the relevant immunogenic portions of the organism are used.

Vaccines of future : against Malaria, Leprosy, Anthrax, AIDS

INTEXT QUESTIONS

1. Mention two physical barriers of the body.

   ____

2. Macrophages are found in the large number in the following organs :

   (1) ______________________________

   (2) ______________________________

   (3) ______________________________

3. Give two examples of each of the following

   (i) Killed organism vaccine______________________

   (ii) Live attenuated organism vaccine______________________

   (iii) Toxoid vaccine______________________

WHAT YOU HAVE LEARN

i) There are various types of defence mechanisms in our body. Immunity defends us against infections.

ii) Immune system is a complex network of cells, tissues and soluble factors working in close coordination.

iii) Thymus and bone marrow are the central or primary lymphoid organs.

iv) Lymphocytes which are the major cells performing immune functions are of two main types Blymphocytes and T-lymphocytes.

v) B-cells are transformed into plasms cells which produce antibodies.

vi) Foreign molecule which triggers an immune response is called antigen.

vii) Antibodies (immunoglobulins) are of five types, of which 1gG is found in the highest concentration.

viii) There are two main types of immune responses – specific and non-specific.

ix) Specific immune responses can be either cell-mediated or antibody (humoral)-mediated.

x) There are two types of immunity – natural or innate and acquired.

xi) Vaccination is a type of actively acquired immunity.

xii) 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 of antibody production.
5) List main functions of T-cells.
6) Draw a schematic diagram of the structure of an antibody.
7) What are the main physical barriers of the body?
8) Describe important feature of phagocytic cells.
9) Give one main difference 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

27 APPLIED BIOLOGY

1. CROP IMPROVEMENT/PLANT BREEDING
2. HORTICULTURE, MUSHROOM CULTURE AND HYDROPONICS
3. PLANT TISSUE CULTURE
4. AGRICULTURE, FORESTRY AND MEDICINAL PLANTS
5. FISHERIES AND AQUA CULTURE

1. CROP IMPROVEMENT/ PLANT BREEDING

Man is directly or indirectly dependent on plants for food, clothing, medicine etc. Ever since the dawn of civilization, man has been creating and cultivating new types of plants and enjoying their fruits. To meet the needs of the ever-increasing population there is a need to develop superior crops. The process of bringing wild species under human management is called as "Domestication". Slowly man started selection of plants that cater to his needs. Migration of human being from one place to another brought about the movement of his cultivated plant species. Plant breeding as a branch of botany developed after the rediscover of Mendel's principles in 1900. Plant breeding is the applied branch of Botany which deals with the improvement of agricultural crops

Plant breeding or Crop improvement is the improvement in the heredity of crop plant and production of new crop varieties which are far better than original / existing one in all aspects.It is a applied science which needs thorough knowledge of other branches of botany such as genetics, cytology, plant taxonomy, plant pathology, entomology, biochemistry, plant physiology, agronomy, statistics, etc.

Plant bleeding or crop improvement is "An applied branch of botany that deals with the improvement of crops and production of new crop varieties which are for superior to the existing types in all characters"

Objectives

At the end of this unit, student should be clear of the importance of plant breeding

- To evolve a variety with desirable characters. Eg. high yield, good quality, disease resistance, drought tolerance, etc.
- Understand and differentiate between the conventional and the modern plant breeding methods
- To produce useful variations by introducing recombination of characters.
- To produce and utilize hybrid vigour.

- Incorporation of cropping seasons (creating short term or long term varieties depending on the need).
- Making crop rotation easier.

Methods of Plant breeding

Different types of plant breeding methods depend on the reproduction and pollination mechanisms of crop plant. There are mainly 5 types of plant breeding methods:

A. Introduction

B. Selection

C. Hybridization

D. Mutation breeding

E. Polyploidy breeding

A. Introduction

Plant breeding involves the introduction of high-yielding varieties from their natural habitats into new locations. It is a very easy and quick method of breeding. A plant introduced into a new location must adapt to the new environment. Acclimatization is the adaptation of the introduced plant to the new environment. One precaution must take when the plant parts must be thoroughly tested in quarantine.

Advantages:

- No scientific knowledge is necessary and only some amount of skill is required.
- The new varieties can be directly used in agriculture and horticulture.
- The pollen and seeds serve as germplasm banks for crop improvement.

Germplasm refers to the seeds, pollen, or plant parts having all possible alleles for all the genes in a given crop.

Ex: Some of the important varieties introduced into India through Introduction

CROP	Variety	Imported from which country
Paddy	IR-8	Phillipines
Wheat	Sonara 63, Sonara 64	Mexico
Oats	kent	Australia

B. Selection

Selection is the oldest system of plant breeding. It is also the basis for the rest of the plant breeding systems. Selection may be natural or artificial. Nature itself can choose suitable species as per climatic conditions. Artificial selection means selection by man. Using the differences between species, man tries to develop them by selecting those with desirable characteristics.

Selection is done in 3 ways namely

i. Mass selection

ii. Pure line selection

iii. Clonal selection

i. Mass selection

Mass selection is one of the oldest methods of crop improvement. In this method, individual plants are selected on the basis of phenotype from a mixed population, their seeds are bulked and used to grow the next generation.It is more commonly used in the improvement of cross pollinated crops than in self pollinated species. Heterozygosity and variability are the two basic points for mass selection.

Advantages:

- It is easiest method of selection. It is an art than a science
- This method is applicable to local or wild crop varieties of cross pollinated plants

Ex: TMV-1, TMV-2 in Groundnut and Dharvar American, Dodahattilocal, Combodia type in cotton

ii. Pure line selection

It is a method in which new variety is developed by selection of single best plant progeny among traditional varieties or land races. A pure line breeding method is normally used for self-pollinated crops. Pure line varieties are homozygous as they are genetically similar and true breeding. Every year superior strains are selected from each row, seeds are collected separately and grown in individual separate rows in the coming year. By repeating the process for about 10 years, a new variety is produced.

Advantages:

- It is the only method to improve the local varieties of self pollinated plants .
- The progeny developed by this method are phenotypically and genotypically uniform.

Ex: Rice CO 4,6,10,14 varieties, RSB-17 in Groundnut

iii. Clonal selection

A group of plants obtained vegetatively from a single plant is known as' **clone'** and the method of developing varieties from the clone is known as clonal selection. All the plants in a clone or phenotypically and genotypically similar. Many vegetative parts such as setts (Sugarcane), cuttings (Rose), tubers (Potato), bulbs (onion), suckers (banana), etc., are the units of clonal selection. Selection is effective when it is between clones but not within a clone, because all the individuals with a clone have same genotype.The best proved ones are given names, multiplied, recommended and distributed to farmers.

Advantages:

- The traits of progeny are stable for any number of generations.

Ex: Potato: Kurfi red and Kurfi safed varieties.

Mango: Mandapa Pedda Neelam

C. Hybridization

Hybridization is the most important method of plant breeding. Hybridization can be defend as the method of producing new crop varieties by crossing two genetically different parents. The plant breeder always aims to incorporate as many desirable qualities from various varieties into a single variety. To evolve a variety with desirable characters, Eg. High yield, good quality, disease resistance, drought tolerance, etc. In hybridization genetic recombination occurs. The genetic variability is enhanced and hence utilized for crop improvement.

Hybridization Procedure

I. Selection of Parents

Select homozygous plants with desirable characters as parents. Parents to be grown in isolation & self pollinated for several generations to bring homozygosity in desirable traits.

II. Emasculation

Most of the crop plants develop bisexual flowers. Removal of anthers from bisexual flowers of female parents, when flowers are in bud condition is called "Emasculation". It prevents self pollination. Different methods are employed for removal of stamens in hybridization. Foreceps and scissor method, cold, heat and alcohol methods are also used based on size of flower.

III. Bagging

After emasculation, female flower is enclosed in a bag of ideal sizes, made of plastic, cellophane or paper to prevent unwanted cross pollination.

IV. Artificial cross pollination

It is defined as artificial cross pollination between genetically unlike parents. Viable pollen is collected from desired male plant & transferred on to the stigma of the desired emasculated female parent. New genetic recombination can be created by hybridization. Many hybrids exhibit hybrid vigour or heterosis.

Heterosis refers to the superiority of F_1 hybrids over their parents in one or more characteristics. The word hybrid vigour is a synonym for heterosis. G. H. Shull coined the term heterosis in 1914.

Based on the nature & relationship of plants to be crossed, hybridization can be –

Inter-varietal – Cross between plants of two different varieties of same species

Intra-varietal – Cross between two plants of different genotypes but same variety.

Intra-specific hybridization. Cross between two plants of same species. Eg. Hybrid Maize.

Inter-specific – Cross between two species of genus - Eg. Wheat, Cotton, Tobacco

Inter-generic – Cross between two different genera. Eg. Sugarcane X Bamboo, Wheat X Rye, Radish X Cabbage.

D. Mutation breeding

Mutation is a sudden heritable change in a characteristic of an organism. Hugo devries used the term 'mutation 'and identified in Oenothera plant. Introduction of desirable mutations in plants and their utilization for the production of new superior varieties is called Mutation breeding. Muller and Stadler laid the foundation for mutation breeding. Among several methods of plant breeding, mutation breeding has shown remarkable success in crop improvement at a much faster rate than traditional breeding.

Types of Mutations (Based on Origin)

i. Spontaneous Mutations

These mutations arise automatically with very low frequency in nature. They caused due to action of natural aspects like temperature fluctuations, electric currents etc.

Ex: Oenothera *gigas* & Oenothera *nanella*

ii. Induced Mutations

An induced mutation is the type of mutation that occurs once an organism's DNA is exposed to a mutagen. Mutagens can be physical or chemical agents.

Ex: Physical Mutagens- X-rays, γ -rays, α - rays and U.V.rays

Chemical Mutagens-Formaldehyde, Nitrous acid, EMS, MMS

Malic hydrazide, and Colchicine

Ex: IR-8 Rice, Aruna variety of Castor, Sweedish variety of Barley

E. Polyploidy Breeding

The utilisation of polyploid condition for the improvement of crops is called as Polyploidy Breeding. Any plant having more than two sets of chromosomes are termed as "polyploids". Some plants are triploids(3x), tetraploids (4x), hexaploids(6x) and so on.

Methods of producing artificial polyploids

a. Cold treatment of zygote

b. Applications of chemicals like colchicine, coumarin, acenaphthene, etc. to floral and vegetative buds

c. x-ray treatment

Ex: Banana-Triploid (3x), Commercial Wheat variety –(*Triticum aestivum*) Hexaploid(6x)

INTEXT QUESTIONS

1. List out major plant breeding methods?

2. What is hybridization and describe the procedure of hybridization.

3. What is mutation breeding? Discuss its types.

4. Waht is heterosis?who coined that word?

5. What is germplasm?

6. What is clone?

7. What are mutagens? Give two examples.

8. What is emasculation? Mention its importance.

9. Write short notes on Pure line selection.

10. Explain briefly on polyploidy breeding.

2. Horticulture, Mushroom Culture and Hydroponics

Advances in agricultural practices have led to introduction of many new methods in raising different kinds of plants. Horticulture, Mushroom culture and Hydroponics are few of these techniques which increase the commercial value of flowers, mushrooms and other plant products. In this lesson you will learn about these methods.

Objectives

- Identify different types of ornamental plants.
- Classify ornamental plants into different categories.
- Explain the difference between flowering and foliage shrubs and the methods of raising them
- Classify different types of trees, climbers and bulbous plants with few examples.
- Mention the ways by which indoor plants helps to decorate our homes and the techniques of growing them.
- List some facts about designing a home garden.
- List the steps of Mushroom Culture.
- Define hydroponics, explain its methods and its limitations.

Horticulture

Horticulture is the study of different types of ornamental plants and their cultivation. Horticulture deals with propagating, growing and marketing of flowers, seeds, seedlings, bulbs, nursery operations, protection of plants, storage and handling.

Ornamental plants

Ornamental plants are primarily grown for decorative purpose. Whcih include both flowering and nonflowering Plants.

Types of ornamental plants

Ornamental plants

- Trees
- Shrubs
- Climbers
- Bulbous plants

Trees:

Trees are perennial hardy plants with a single straight stem (trunk) bearing crown of leaves on their top. They are grown in gardens, parks and on the roadside to provide shade and beauty. Trees when planted on both sides of the road they are called Avenue trees.

Examples of ornamental trees: Gul mohar, Silk cotton, Bottle brush

Shrubs:

Shrubs are perennial. Shrubs may bear either flowers or foliage. Flowering shrubs are grown for their beautiful flowers. Examples: Jasmine, Rose, Hibiscus

Foliage (leafy) shrubs have color or alternative leaves. Examples: Mehndi, Crotons, Acalypha.

Climbers:

Climbers are weak stemmed plants. They climb around the support. They consist of special structures for climbing like Tendrils, thorns, hooks etc. They add beauty to the garden due to attractive foliage or flowers. Examples:

Bulbous plants:

Bulbous plants include modified underground stem like corm, tubers. On growing they produce attractive colored flowers. Examples: Lilies, Dahlia, Canna, Gladiolus,

Bulbous ornamental plants are also grown for their attractive leaves Example: Colocasia, Monstera and Ferns.

Indoor plants

Indoor plants are grown in living room of the house for decoration purpose.

Types of Indoor plants

1. **Foliage plants:**

   These plants consist of green leaves or different colored leaves (variegated leaves) in different shapes.

   Examples: Asparagus, Tradescantia.

2. **Ferns:**

   Ferns are attractive, nonflowering and shade loving.

   Examples: Maiden hair fern, silver fern.

3. **Palms:**

   Palms with single stem or large leaves suitable for growing in large room or halls.

   Examples: Warf palm, Pygmy Date palm.

4. **Cacti and succulents:**

   These plants consist of a thick freshy leaves or stem, which store water.

   Examples: Opuntia, Euphorbia, Bryophyllum.

5. **Bonsai:**

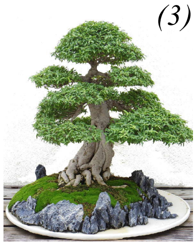
   Bonsai are dwarf adult plants grow in shallow plants which add beauty to drawing room.

(1)

(2)

(3)

Fig: (4)



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INTEXT QUESTIONS

1. What are different types of indoor plants?

2. Why are plants grown indoors?

3. What is Terrarium?

Terrariums

Terrariums are set up in glass cases like Aquarium, and using different plants. They add beauty and variety to the internal decor.

Home Garden

A garden in a home add to its beauty. A home garden should have variety of plants. Home garden should be properly maintained with the hedges trimmed, Lawn properly mowed and the flower beds regularly weeded. In home garden seasonal vegetables can also be grown for every day usage.

Mushroom culture

Mushrooms are fleshy fungus belonging to kingdom fungi. They first appear as white tiny balls consisting of a short stem and a cap which opens like an umbrella later.

Fig A Typical Mushroom

Edible and cultivable Mushrooms

1. White button mushroom (*Agaricus bisporus*)
2. Paddy straw mushroom (*Volvariella volvacea*)
3. Oyster mushroom (*Pleurotus ostreauts*)
4. Shiitake mushroom (*Lentinus edodes*)
5. Winter mushroom (*Flammillina velutipes*)

Importance of Mushrooms:

1. Mushrooms are considered as vegetable meat as they are source of quality proteins and are rich in vitamins and minerals. Mushrooms contain 20-33% proteins and good source of vitamin C, vitamin B and vitamin D (upon UV exposure) and minerals like potassium (K), phosphorous(P) and sodium (Na).

2. Mushrooms contain high fiber which helps in disease Heart and Cancer prevention.

3. Mushrooms contain low carbohydrates. Hence safe for diabetes.

4. Mushrroms contain antioxidants like vitamin C and choline hence regulate the immunity.

5. Mushrooms have a huge market with export potential.

6. Mushrooms grow independent of sunlight without fertile land.

Types of Mushrooms grown in India

In India, 3 types of mushrooms are commonly grown for commercial use. They are

1. **White Button mushroom**
2. **Paddy straw mushroom**
3. **Oyster mushroom**

Mushrooms can be grown in different climatic conditions prevailing such as

1. White button mushroom: Mid November to mid-March
2. Paddy straw mushroom: February to mid-November
3. Oyster mushroom: September to November

Method of cultivation of White button mushroom (*Agaricus bisporous*)

The optimum temperature for vegetative growth i.e.; spread of the mycelium is 22-25^{0}C and for reproductive stage is 14-18^{0}C.

Steps involved in mushroom cultivation

1. **Composting**
2. **Spawning**
3. **Casing**
4. **Cropping and Harvesting**
5. **Preservation**

Composting:

Compost is prepared by mixing wheat or paddy straw, Chicken manure with a number of organic and inorganic fertilizers. The compost is kept at high temperature (50^{0}C centigrade) for 1 week and then mushrooms are cultivated on it.

Spawning:

Mushroom seed is called spawn. Which is a vegetative mycelium. Inoculation of the spawn in to the compost is called spawning.

Casing:

Covering the compost with a thin layer of soil is called casing. Casing supports provides humidity, prevents drying of the compost, regulates temperature and helps in better growth of the spawn.

Cropping and Harvesting:

Mushrooms are grown seasonally under control environmental conditions. proper temperature and humidity is to be maintained for growth of mushrooms and to prevent growth of pests and diseases. It takes 7-8 days to come to the button stage. Mushrooms are harvested after 3 weeks of casing.

Preservation:

Mushrooms are perishable. Hence carefully are preserved during storage, marketing and processing. Mushrooms are preserved to increase the shelf life by Vaccum cooling, by giving Gamma radiation and storing at 15^0 C, Freeze drying in brine solution, Citric acid, Ascorbic and, Dehydration and by canning.

INTEXT QUESTIONS

1. Mention three advantages of Mushroom Cultivation

   ____

2. Name any three mushroom species commonly found in India

   ____

3. How can we be preserve cultivated mushrooms for a longer time?

   ____

4. List the main steps involved in Mushroom cultivation

   ____

HYDROPONICS

Hydroponics is a technique for growing plants in a nutrient solution (water with certain fertilizers)

Hydroponics involves growing plants in containers filled with water or with coarse sand and gravel to which nutrients are added.

Containers are made of glass, metals or plastic.

Method of growing plants through hydroponics. They are

1. **Water culture**:

   Plants are suspended with roots submerged in water that contains plant nutrients. Roots absorb water and nutrients and do not perform anchoring function. Air must be regularly supplied for proper growth.

Composition of Water Culture

It contains the following.

1. 3.4 kg - Potassium nitrate
2. 0.65 kg – Ammonium sulphate
3. 2.65 kg – Magnesium sulphate
4. 1.05 kg – Monocalcium phosphate
5. 3.0 kg – calcium sulphate

2. **Aggregate culture**: Plants are grown without soil. The roots absorb water and nutrients but perform anchoring function. Roots are placed in substrate material like coarse sand, gravel or peat.

IMPORTANCE OF HYDROPONICS

Hydroponics is a scientific method of studying the Plant nutritional requirements. By different composition of nutrients, we can find of suitable of nutrients for successful growth of the plant.

It can be used for commercial crop production.

It is used in large scale cultivation of flowers and vegetables.

It is effective alternative method of growing plants where soil is not available like ships, in desserts and in covered arctic areas

INTEXT QUESTIONS

1. Define hydroponics

   ___

2. State the two methods of growing plants without soil

   ___

3. Why does air have to be constantly pumped into the nutrient solution? Give reasons for your answer

   ___

4. What will happen, when plants grown in a nutrient solution?

   ___

Synopsis

- Horticulture is the study of different types of ornamental plants and their cultivation.
- There are different types of ornamental plants like seasonal annuals, flowering, and foliage shrubs, ornamental trees, climbers, bulbous and indoor plants.
- Seasonal annuals are grouped according to the season of their growth and flowering into summer, winter and rainy season.
- Ornamental shrubs and are useful to decorate our homes.
- Indoor plants.
- A home garden adds beauty to the house. It has to be carefully designed.
- The five species of mushrooms cultivated in India are 1. white button mushroom, 2. paddy straw mushroom, 3. oyster mushroom, 4. shitake mushroom, and 5. wintermushroom,
- The main steps in mushroom cultivation are composting, spawning, casing, cropping, and harvesting.
- Hydroponics is the method of growing plants without soil.

- Two methods of growing plants without soil are 1. water culture and 2. aggregate culture.
- The nutrient solution contains nitrates, sulphates, phosphates of potassium, magnesium, calcium, manganese and Iron dissolved in water.
- Air has to be constantly pumped into the solution.
- Hydroponics is used for commercial production of crops, vegetables and flowers in places where Fertile soil is not available.

TERMINAL EXCERCISES

1. What is meant by horticulture?
2. Define Hydroponics.
3. List the different techniques used to propagate indoor plants.
4. Which important points would you bear in mind while designing a home garden?
5. What are the advantages of Mushroom Cultivation?
6. Mention are the methods used to increase the shelf life of mushrooms?
7. Explain the terms "compositing" and "spawning".
8. Give the composition of basic nutrient solution used in hydroponics.
9. Distinguish between:
   (i) Water culture and aggregate culture
   (ii) Seasonal plants and perennial plants
   (iii) Ferns and palms
   (iv) Casing and spawning
11. List three varieties of mushroom found in India.
12. Give two examples of different types of ornamental plants.
13. Describe the various steps invalved in mushroom culture
14. Explain the importance of hydroponics.

3. PLANT TISSUECULTURE

Information gained regarding the plant growth a differentiation made it possible to culture Individual plant cells, tissues and organs invitro 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 is the 'cellular totipotency'.

Objectives

After completing this lesson, you will be able to:

- To know the r-DNA technology
- Explain the term 'cellular totipotency' and prove the formation of complete plant in the favorable 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 regenaration.

Technique of tissue culture

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 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 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 regulations Auxins (Indole acetic acid- 1AA; 2,4 - Dichlorophenoxy acetic acid – 2, 4 -D), Gibberellins, Cytokinins are used. The culture medium is poured in glass vessels (rimless culture tubes, flasks or bottles) and closed tightly with the non- absorbent cotton plugs which allow the exchange of gases.s

2. Sterilization of the culture medium

The culture medium is rich in nutrients and therefore attracts the growth of microorganisms there by 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 121^0C 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 full fledged plant or organs invitro is called explant.

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

The explants taken from garden or polted 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 and aseptic environment.

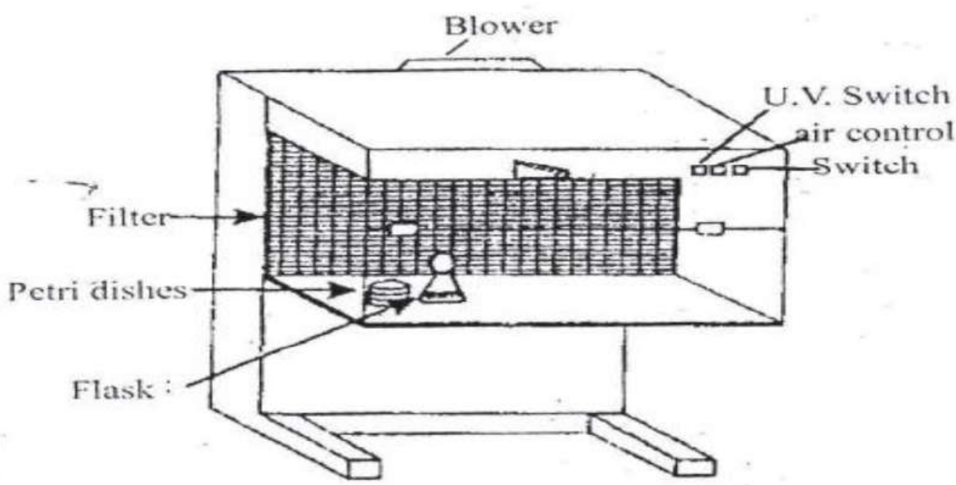


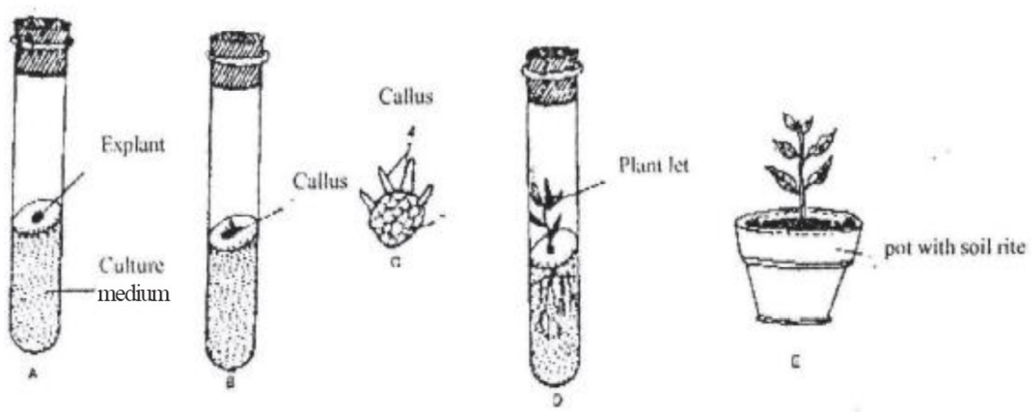
Fig : Laminar airflow used for aseptic manipulation of cultured tissue

5. Inoculation for growth

The culture vessels with inoculated explants are incubated under controlled conditions of temperatures, 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 'organo- genesis'.
- 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.

Procedure of Tissue culture

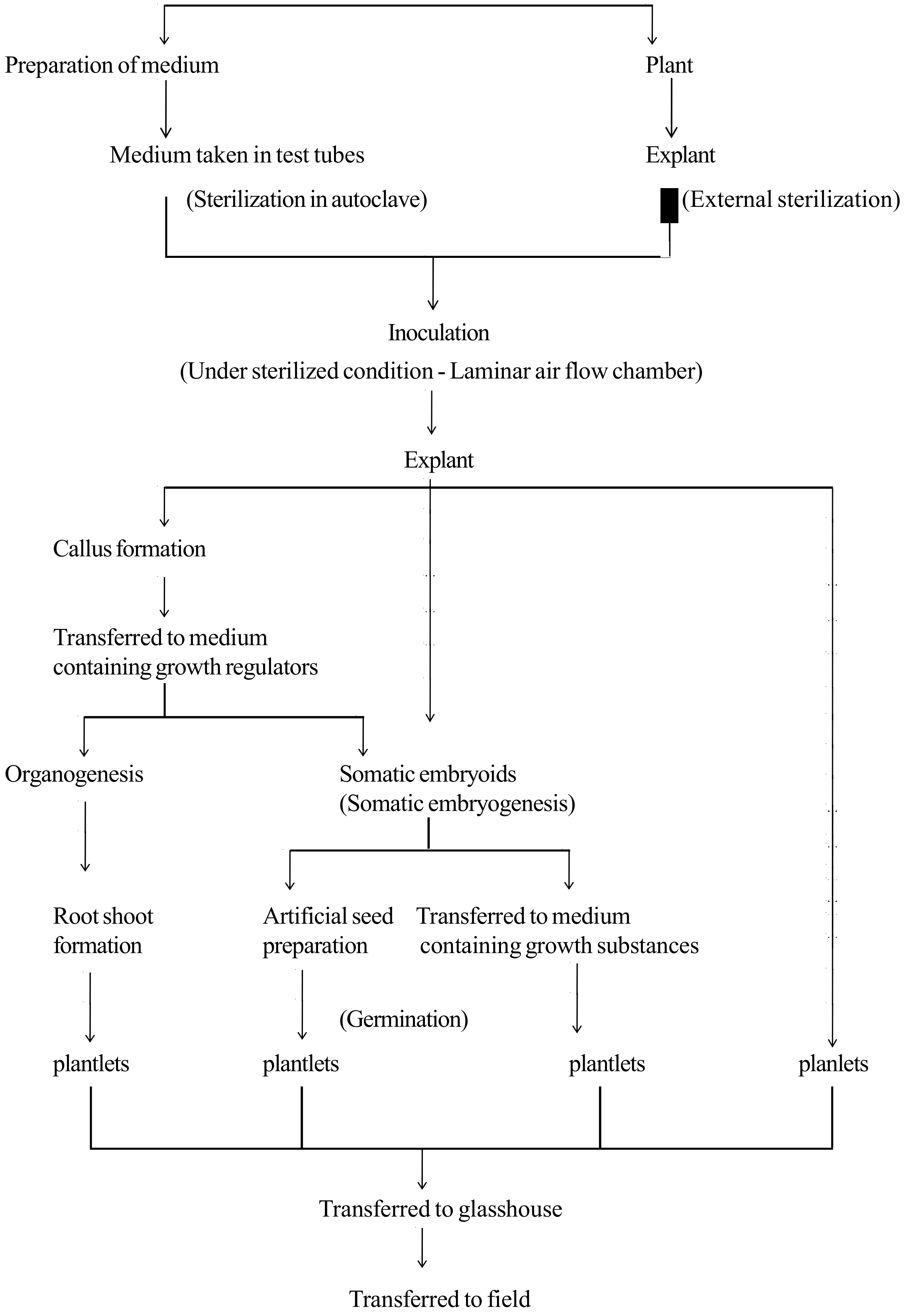


6. Acclimatization of plantlets and transfer to pots

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 to 2 weeks. The polythene bag is gently remined 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

INTEXT QUESTIONS

1. What is meant by totipotency?

____

2. Define basal medium.

____

3. The mostly used medium is?

____

4. Define explant.

____

5. Define rhizogenesis and caulogenesis.

____

6. What is meant by inoculation?

____

7. Define somatic embryos.

____

8. What are synthesis 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.

Glossary

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

4. AGRICULTURE, FORESTRY AND MEDICINAL PLANTS

Agriculture plays an important role in providing basic necessities of mankind in three ways-food, clothes and shelter. In addition to agriculture, we draw many essentials for our living from nature. Forests play a very important role in providing useful products for man e.g. rubber, supporting wildlife, e.g., such as tiger and improving the environment. Medicinal plants many of them obtained from forests, provide important drugs, which are used for treating a large number of diseases. In this lesson, you will learn about agriculture, forestry and medicinal plants.

Objectives

- State the major role of agriculture.
- Classify the crops and their importance.
- Define the green revolution.
- Define the forestry.
- Different types of forests.
- Medicinal plants and their uses.

ROLE OF AGRICULTURE

Food and clothing are the basic needs of man. Whatever we eat in our daily life, most of them we get from plants. The clothes we wear are also made from plants, e.g. cotton is plant product. Plants provide most of the basic necessities of life to human beings. These include (1) Food (cereals, fruits, oil seeds etc.) (2) Fibres for making clothes (cotton, jute, etc.) (3) Beverages (tea, coffee,etc.) (4) Forests (timber, rubber, etc.). Herbivores consume plants as their food. Plants can of two types i.e. cultivated and wild plants.

Cultivated and Wild Plants:

Plants which are specially grown by humans are called cultivated plants Ex. wheat, rice. The plants that grow by themselves in nature are called wild plants e.g. bathua, cholai etc.

CLASSIFICATION OF CROPS:

Crops are grown regularly in large numbers in fields for food or for obtaining other products. Crops are classified in a number of ways as follows:

(i) According to use, crops may be classified into food crops and Commercial crops.

Food Crops	Commercial crops
1. They are grown to provide food and may be stored for a long period Ex. wheat, rice, vegetables.	1. Plants or plant which can be sold and money can be earned out of it. Ex. tea, jute ,cashew nut, rubber, sugarcane.

The most widely used general classification of crops are:

1. **Cereal crops**

   Cereals are used as food not only in India but all over the world. They are rich in carbohydrates and grown for food. It includes wheat, rice, maize, bajra, barley, rye, oat, sorghum(jowar), ragi, etc. These are consumed by animals as well as by human.

2. **Pulse Crops:**

   It includes all the types of pulses we use as a food, these are also called leguminous plants. They are rich sources of protein e.g. sweet peas, gram, pigeon pea, soya bean, beans, ground nut, lentil etc.

3. **Fruit Crops:**

(i) Fruits are rich in vitamins, minerals and carbohydrates. Fruits provide vitamins, minerals and variety to our diet. Some fruits are also rich source of sugar e.g. grape, banana and mango.

(ii) Fruits are consumed fresh or in the form of juice, jam etc. examples- mango, apple, banana, oranges, pomegranate etc.

(iii) Fruit trees are usually perennial tress, which bear fruits once a year. Many fruit crops are grown in India examples- chickoo, mango, apple, orange etc.

4. **Vegetables Crops:**

Vegetables provide minerals, proteins and carbohydrates. A large number of vegetables are grown in our country. Some important ones are e.g. Potato, Tomato, Pea, Cauliflower, Brinjal, Gourds etc.

5. **Stem Crops:**

Oils are an important part if our food. They are a rich source of energy. Seeds of some crops yield oil on being pressed in machines. The remainder becomes the seed cake to be used as cattle feed. Some of the oil yielding crops are groundnut, cottonseed, coconut, mustard and sunflower.

9. **Fibre Crops:**

The two most important fibre crops of our country are cotton and jute. They supply the raw materials for our textile and jute industries.

Green Revolution

In 1952, the yield of wheat and rice was 654kg and 800kg per hectare respectively. This yield was insufficient to fulfill the demand. Therefore our Government and Agriculture Scientists paid a special attention towards the improvement of agriculture. By doing so, the production of cereal crops increased tremendously and we became self-sufficient. The various steps taken to achieve this goal have been collectively termed as green revolution.

Green Revolution: Spectacular increase in the yield of crops, particularly cereals, the application of modern techniques in agriculture is called **Green Revolution**.

The factors which help to bring about the green revolution are:

1. Introduction of high yielding varieties of crops.
2. Multiple cropping, better irrigation and sufficient supply of fertilizers.
3. Use of crop protection measures against diseases and pest.
4. Transfer of the technology of scientific farming from research farms to village farmers.
5. Organized transport arrangements to reach the produce from the fields to market.

1. Medicinal Plants

1. Tulsi

1. The Botanical name of the plant is *Ocimum Sanctum.*
2. It belongs to the family Lamiaceae (Labiatae).
3. The leaves are used as expectorant, stomachi, anti-catrrtia and aromatic.
4. The decoction of the leaves is used to cure malaria, gastic diseases of children and liver disorders.
5. The leaf juice is also used to check vomiting and as an antihelminthic.
6. Many people wear Tulsi beads, which is said to have certain physical and medicinal properties

2. Peppermint

The botanical name is *Menthe piperita*

Peppermint isperennial herb belonging to the family Lamiaceae, sometimes regarded as 'the world's oldest medicine', with archaeological evidence placing its use at least as far back as ten thousand years ago. Peppermint are naturally high in manganese, vitamin A and vitamin C. Crushed leaves rubbed on the skin help soothe and relax the muscles. Infused peppermint leaves are used to:

- Reduce irritable bower syndrome
- Against upset stomachs
- Inhibit bacterial growth
- Treat fevers
- Flatulence
- Spastic colon

3. Ashwangandha

The botanical name is *Withania somnifera*

Ashwagandha, a perennial shrub, is also known as Indian ginseng or winter cherry, and belongs to the family Solanaceae. The benefits of ashwagandha are many; in addition to promoting fertility, aiding in wound care, and boosting the immune system, some other benefits are:

- Diuretic, Sleep aid
- Anti-epileptic
- Anti-tumor, Pain relief
- Eye health
- Heart tonic
- Lowers cholesterol & Regulates blood sugar
- Reduces depression and anxiety, Combats stress
- Fights cognitive decline due to brain cell degeneration

4. Tippateega

1. The botanical name is *Tinospora cordifolia.*
2. It belongs to the family Menispermacae.
3. It is a common climbing shrub found through out tropical India.
4. The fresh plant is antiperiodic alterative, Tonic, Hepatic, Stimulant and diacritic.
5. The plant is commonly used in rheumatism, urinary diseases, syphilis, skin diseases, piles, Bronchitis, Jaundice.

5. Karakaya

1. The botanical name of karaka is *Terminalia chebula*.
2. It belongs to the family comretaceae.
3. It is large deciduous tree, commonly found in North India also found in Maharastra.

4. The dried fruit forms the chebulic or black myrobalan of commerce (Tanning material).
5. With iron salt is employed in making country ink, and mixed with ferruginuous mud, it makes a black paste employed by barness and shoemakers as well as by dyers.

6. Aloe vera (Kalabanda):

1. The Botanical name of the plant is *Aloe vera*.
2. It belongs to family Liliaceae.
3. The succulent shrub is a native of west Indies.
4. The leaves are used for external application on inflamed painful part of body as palastry.
5. The leaf juice is orally administered to control fever and inflation in urine.
6. The root juice mixed with turmeric and apply to reduce the Burning Sensation feet palm.
7. The juice mixed with sandal powder and turmeric and used as a cosmetic.

7. Turmeric

1. Botanical name of the plant is *Curcuma longa*.
2. It belongs to the family Zingiberaceae.
3. The plant is a perennial herb.
4. The crop is grown in warm and moist regions.
5. Small pieces of rhizome with a bud are sown 3 inches deep into soil in the months between April to August.
6. The attractive yellow colour and delicate flavour has been most preferred as an essential ingredient of curry powder and masalas.
7. It is also used to flavour and colour butter, cheese, pickles and other food stuffs.
8. It is used as cosmetic and Antiseptic against internal external injuries.

8. Sarpagandha:

1. Botanica name is *Rauvolfia serpentina*.

2. It belongs to the family Apocynaceae.

3. The roots of plant are used to control hypertension and neuro psychiatric.
4. It lowers the blood pressure and sedative influence.
5. The drug is also reported to be useful in certain gyanecological conditions like menstrual, moliminia, frigidity and women complaining of menopausal syndrome

9. Amla (Indian Gooseberry):

1. The Botanical name is *Phyllanthus emblica.*
2. It belongs to the family Evphorliaeae.
3. It is a medium sized dicidious tree, found in mixed deciduous forest of Indian.
4. It is often cultivated in gardens and homeyards.
5. The fruit, bark and leaves are rich is tannin.
6. The dried powder of fruit is mixed with sugar or honey for oral administration to control bleeding during menstrual cycle in woman.
7. The fruit also controls fever, stomachic and Jaundice.
8. Now-a-days it is mixed in hair oil to improve colouration.

FOREST:

A forest is a large area of land with a lot of vegetation but dominated by various types trees. These trees are usvally of different species and are of different age. Wild animals may or may not be present

Forestry is the science of study of forest

Types of forests

The different kinds of forests are:

1. Coniferous forest:

Tress with needle-like leaves with persistent foliage and bearing reproductive organs. Found in cold or temperate cold climates

Ex: Pine, Cedrus (Deodar) etc.

2. Deciduous forest:

Most of the trees in such forests drop their leaves in winter andnew leaves grow in springs.There are found in temperate warm and temperate cold climates

Ex: Oak, beach,hickory, chestnuts, cypress.

3. Tropical rain forest:

Trees with broad-leaves, deciduous or evergreen.Such, forest occur in warm climate. Zones of the world with high rainfall. Trees are covered with epiphytes and the soil in which humus large number of animals inhabit such forests.

Ex: vines, Creepers, lianas and orchids.

Importance of forest

Forest plays an important role in various ways.

1. Forest as an Ecosystem:

If you walk through a forest you may find various insects, birds, animals and wild beasts. There are different kinds of organisms living in close association with each other, feeding on others and being themselves eaten by some others. The ants, termites and bacteria break down the dead wood, the fallen leaves and the excreta of animals, into simpler compounds, which become a part of soil. The ultimate source of energy is the solar energy, which is trapped by the green leaves. This chain of getting food and energy goes on and on. Such a community of organisms along with its environment is called an ecosystem. Thus, forest is an ecosystem.

2. Forests Improve the Environment in many ways

(a) Forests release oxygen

Plants in forests take in large quantities of carbondioxide and improve the quality of air by releasing oxygen into the atmosphere during the process of photosynthesis.

(b) Forests prevent soil erosion

i) Roots hold the soil particles together preventing them from being washed away.

ii) Leaves and branches take much of the force of the falling rain thus checking the loosening of top soil.

iii) Trunks reduce the force of flowering waters, thus checking soil erosion as well as preventing floods.

(c) The forests trees hold sufficient moisture in their root system.

3. Forests Support Wild Life

The wild animals are nature's great beautifies and even more than that they maintain proper balance in their ecosystem through food chains. Many forests in our country have been specially reserved for preserving wild life.

4. Forests supports Sericulture and Lac Culture

Sericulture is the breeding and management of insects for the production of silk. Its commercial use is in the polishing wooden furniture. The other common use is in sealing parcels, packets and envelope. Lac culture is the scientific management of lac insects. To obtain a high amount of quality from the forest. Lac is harvested by cutting the tree branches that hold sticklac. It is used in various dyes like ink, paints, and varnishes.

Forests maintains the proper balance of atmospheric gases and stabilizes the climatic conditions. They provide hundred kinds of usable materials. They are indeed a nation's wealth. Forestry is a science in itself. Overall the forests are not only vital for the sustenance of life on earth but also provide a lot of usable materials.

5. FISHERIES AND AQUACULTURE

In the world, India is amongst the top three producers of rice, wheat, liquid milk, poultry products, fruits, vegetables, coconut, tea, spices, marine and fresh water products including fish and shrimp. Fishes are rich in protein, vitamins and mineral salts and are also known as valuable protective food. Fish forms an important item of the diet in many areas of the world. The development of fisheries is therefore, one of the most promising industry. In this lesson, you will learn about many varieties of fish, their collection, rearing, breeding and their economic importance.

Objectives

After completing this lesson, you will be able to:

- Define the term fisheries.
- List some important fresh and marine fish found in India.
- List the economic importance of fish, some molluscs and sea weeds.
- Mention the effect of environmental pollution on fish
- Describe fishing technology and equipments used for fishing
- Define fish migration and fish diseases.
- Define aquaculture.

FISHERIES

India has a coastline of about 8,129 km, 5 million km of continental shelf and 2.02 million of exclusive economic zone. India is a major marine fish producer and ranks seventh in the world.

Areas where fish are reared commercially, are known as artificial fisheries.

The fishes are bred, reared and later harvested. The fishery may be a natural water body or an artificial one. A variety of fish may be reared together. In addition to fish, aquatic crustaceans and molluscs are included in fisheries. In India the economically most important crustacean fisheries are those of prawns shrimps and crabs. Among molluscs, edible oysters and pearl oysters are also of economic importance.

Common Edible Fish

Depending on the nature of water in which fish is reared, fisheries are divided into three categories:

1. **Fresh Water Fisheries or inland Fisheries :** They include fish found in rivers, irrigation canals, reservoirs, lakes, tanks and ponds. Rohu, Catla, Mystus,Gourami, and Gambusia are some of the best varieties of fresh water fish.

2. **Estuarine or Brackish Water Fisheries:** They operate in estuaries (where river water and sea water get mixed), delta channels, backwaters, lagoons and coastal lakes. Estuarine fish are more common in Bengal and Kerala. The tidal water collects the fish in the enclosures. The main varieties are Pearl spot, Milkfish and Mullet.

3. **Marine Fisheries**: These deal with fishing operations along seacoasts. The Indian subcontinent approximately has a 5600 kms long coastline. About 80% of India's marine fish are supplied by the west coast and the remaining 20% by the east coast. The premier varieties are mackerels, sardines, sharks, and catfish.

COMMON INDIAN EDIBLE FISHES

	Fish	Occurrence
Fresh water fish (inland fish)	*Carp (Herbivorous Fishes)* *(i) Catla Catla* *(ii) Labeo rohita* *(iii) Cirhinous mrigla*	Throughout India in its Northern, Eastern and Southern parts
Cat fishes (Carnivorous)	*(iv) Mystus* *(v) Hilsa* *(vi) Bombay duck*	Throughout India: Entire Indian coast Maharashtra coast Maharashtra coast
Estuarine or Brackish water fish	*(i) Mullet* *(ii) Pearl Spot*	Lagoons and coastal areas Coastal lakes of Bengal and Kerala
Marine Fish	*(i) Pomfrets* *(ii) Salmon t* *(iii) Sardines*	Indo-pacific coast Eastern and Western coast Southern and Western coast

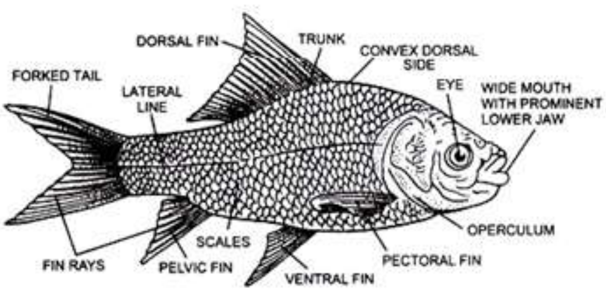


Fig : Catla Catla

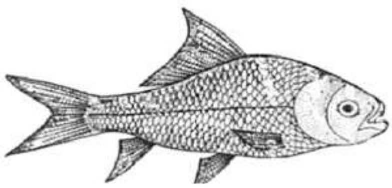


Fig : Catla Catla

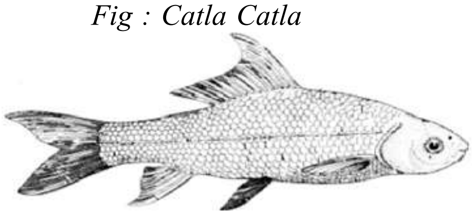


Fig : Labeo rohita

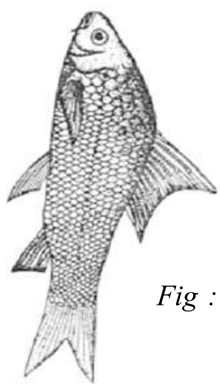


Fig : Cirrhina mrigala

There are several other aquatic resources such as molluscs, echinoderms and seaweeds. Some of which have been exploited for aquaculture. These are as follows :

Culture of Molluscs

Molluscs comprising oysters, clams, mussels, squids, cuttlefish, octopus etc. form important resources of food. The edible oyster (*Crassostrea* species), Mussels (*Perna* species), Clams (*Meretrin* species, *Arca* species, *Donax* species, *Circa gibba*, *Solen* species, *cardium* species), Cuttle fish (*Sepia* species), Squid (*Loligo* species) and Octopus are all utlized as food resource. Pearl osysters, the sacred ehank, *Turbo*, *Trochus* and window pane oysters (*Placenta placenta*) are all of commercial importance.

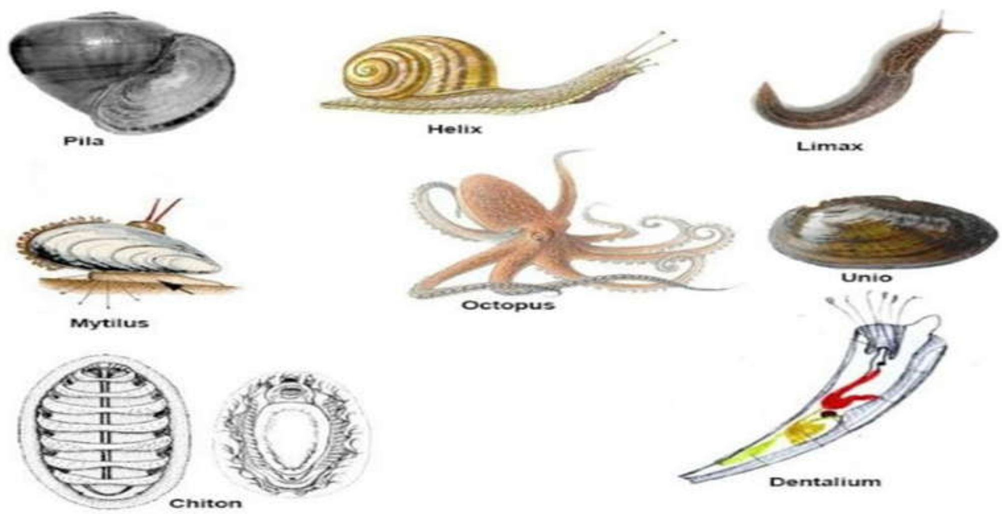


Fig : Common Molluscs

Sea Weeds

Sea weeds are also an importance marine resource and are found along the rocky intertidal and sub-tidal regions of the coast of India. The Sunderbans, the Chilka lake, the deltas of Godavari and Krishna, the rocky shore of Vishakhapatnam, Mahabalipuram, Gulf of Mannar, Gujarat coasts and Lakshadeep, Andaman and Nicobar islands are rich in sea weeds. Seeweeds are used for human consumption as cattle and poultryfeed, as manure and for industrial purpose as a source of agaragar and algin. Species of *Gelidiella* and *Gracilaria* (the red sea weeds) are source for manufacture of agar-agar. The brown sea weeds like *Sargassum*, *Turbinaria Dictyota* contains alginic acid. *Ulva*, *Entromorphas*, *Caulerpa*, *Porphyra* are varieties used in human food.

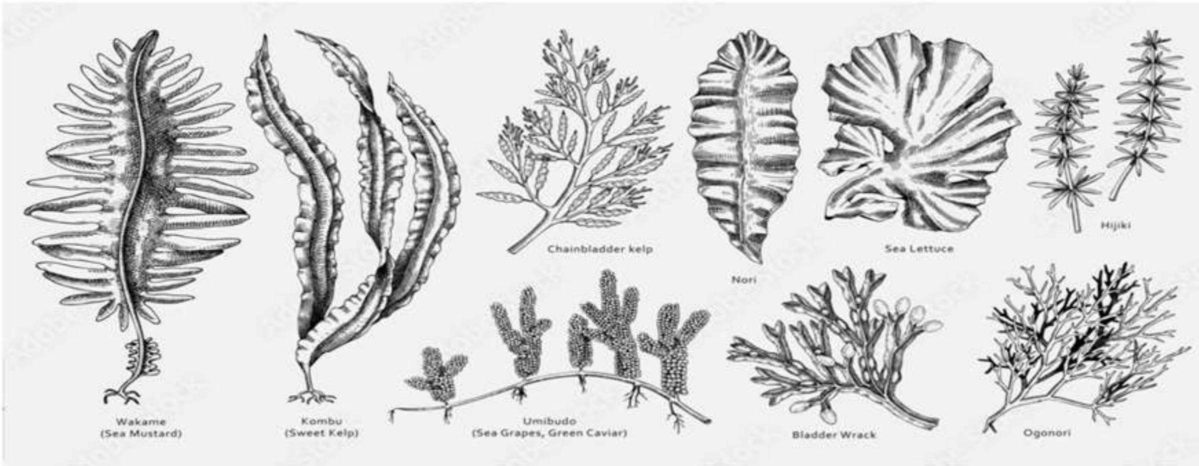


Fig : Common Sea Weeds

IN TEXT QUESTIONS

1. Name two fresh water fishes.

   ____

2. In which part of India is pearl spot found.

   ____

3. Define the term fisheries.

   ____

4. Give two examples of marine fish.

   ____

5. Name two common edible fish commonly consumed in India.

   ____

Economic Important of Fish

Fish is a valuable source of food that is rich in proteins. Fish proteins are easily digestible. Apart from being a good source of food, Fish also have the following uses:

1. **Medicinal use** – fish liver oil is a natural source of vitamin A and Vitamin D.
2. **Industrial use** – Body oils of sardines, herrings and salmons are used for the manufacture of edible oils and margarine. This oil is used in soap, paint, and varnish

industries.

3. **Feed for farm animals** – Fish meal (dried fish) provides proteins to farm animals.

4. **Agricultural use** – As organic manure in the fields.

5. **Adhesive** – Skins and bones are also used in making high quality glues and adhesives.

6. **Shark skin**- Shark skin is also used in the manufacture of handbags, wallets, shoes etc. after tanning. Hide (leather) is also used to make parchment sheets.

Aquaculture as an Occupation

Aquaculture is an occupation of many living near rivers and the sea and most aquaculture jobs are located in coastal community.

Aquaculture involves the rearing and management of useful aquatic plant and animal resources such as fish and shell fish, (prawn, molluscs, crabs etc.) It is also known as fish farming and accounts for about ten percent of the world's commercial fish harvest. China leads all countries in aquaculture production. Fish farms range from simple ponds or flooded rice fields to highly engineered hatcheries in which the environment is monitored and kept under control. Environment control eliminates harmful environmental conditions and helps fish flourish and grow fast. Fish are provided with proper nutrients as per a regulated plan and are protected from the harmful animals that prey on them. Aquaculture is utilised for culturing pearls on a commercial scale as well as in:

(i) Rebuilding of salmon and trout stocks that have been severely reduced.

(ii) Raising fishes for consumption as food such as carp, cat fish, gourami, milk fish, salmon, tilapia etc.

Practice of aquaculture also includes **Pisciculture** and **Pond culture** (fish cultivation in large water bodies).

(i) Pisciculture (Fish Farming)

Is concerned with the production of fish in lakes, rivers, large ponds, canals and is called fresh water or inland fisheries. In Pisciculture young fishes are reared in nursery ponds, transferred to lakes or rivers and finally harvested as fish for table food.

(ii) Pond culture (Kitchen Fisheries)

This involves culturing fish in small ponds. This practice is quite common in Bengal. Proper management is carried on till fish attains full size. They are also protected from diseases.

INTEXT QUESTONS

1. At the present times, which country leads in fish production.

   ____

2. What does aqua cultrue include other than culturing fish?

   ____

3. What is meant by pisciculture?

   ____

4. Give one difference between pisciculture and pond culture.

   ____

5. Why is regulation of the environment in which fish are nearest important?

   ____

Effect of Changing Environment on Aquaculture

Fish population is adversely affected by a number of environmental factors. These are as follows.

Water Pollution

The problem of water pollution mainly affects marine water fish. A variety of insecticides, pesticides, industrial effluents and domestic sewage find their way into many rivers and pose a serious problem for fisheries. The magnitude of pollution varies with the size of the river, the flow of water etc. Let us take few examples.

(i) The paper mills located on the bank of a river in Orissa consume nearly 270 million liters of water per day. This heavy withdrawal of water together with the discharge of high toxic effluents causes considerable harm to the fisheries for a stretch of nearly 24 km downstream.

(ii) The effluents from Sindhri fertilizer factory have been found to have adverse effects on fish and prawn. Vast investigations in respect of effluents of paper pulp-textile industries, tannery manufacturing units, sugar distillery, coal, etc. have shown adverse effects on fisheries while sewage used as a fertilizer for fish farm has been found to cause extreme damage to fish culture.

(iii) Thermal pollution caused by the discharge of hot water used for cooling reactors and generators can be a serious problem in tropical waters where the normal temperature itself is high and further increase would be lethal to the fish which are already living in the higher ranges of temperature tolerance. At present, a potential source of pollution is the atomic reactor wastes. Consequences of water pollution are given below.

- Many of favorite fishes like the Bombay Duck have almost disappeared from the Kalu river near Mumbai. This has been due to the release of a number of toxic wastes from the chemical industries into the river.
- Excessive use of chemical fertilizers may lead to the phenomenon of **Eutrophication** (enrichment of the water body with nutrients). This results in **algal bloom**, (excessive growth of algae which use up available oxygen) followed by oxygen depletion in water and ultimately the death of fish.
- Thermal (heat) pollution from various heavy industries causes fish mortality.
- Ultra violet radiations affect fish eggs that become non-viable, that is, they fail to develop.
- Leakage of petroleum from ships and off-shore oil wells forms an oil slick on the surface of the water and thus fishes are unable to breathe due to non-availability of dissolved Oxygen in the water.

Fishing Technology

Fish constitutes the most important part of the diet of many people. Fishing has been carried out since ages and human beings have developed various gadgets and technologies for catching all varieties of fish from all regions and masses of water, at all depths as well as in large quantities to take care of the ever increasing population and demands. Today it constitutes one of the largest traded food items.

Organized fishing is practiced with the help of equipment specially designed for easy capture of fish. Equipment differs according to the nature of water bodies, and the characteristics of the fish species to be captured.

Principal equipment for fishing includes

1. Sea fishing gears

The various equipment used in fishing are called fishing gears. Most of the large scale fishing is done at sea. Sea fishing gears are of the following types.

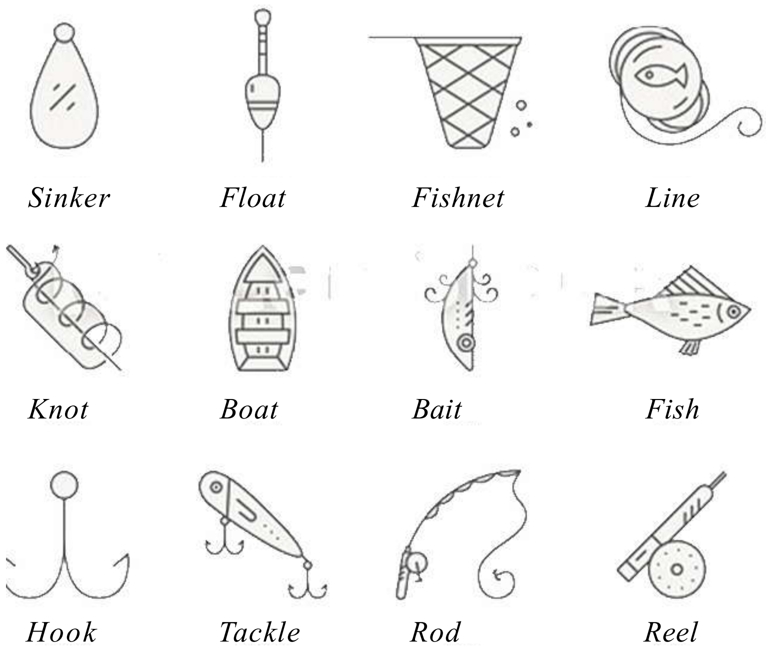
Nets: The main gears are made of cotton yarn hemp or other special man-made fibres. Nets are fixed in the tidal region during the low tide. High tide brings the fish along with water flow into the net

2. Seines

These are very large nets for active fishing. The net encircles a large part of water believed to contain a lot of fish. A Seine is used in running water. Depending upon the nature of water body, different types of Seines (Pure Seine, Shore Seine, etc) are used.

3. Hooks and Lines

Metallic hooks of various sizes and designs are provided with a bait to catch different types of fish. The line is a wire, which carries the hook to various depths and distances from the fishing raft or boat.



FISH MIGRATION

A number of fish show a periodic movement form one dwelling place to another. This periodic movement is called **migration**. Fish migrate to other places for spawning (egg laying) or to avoid unfavourable climatic conditions. Many fish migrate from one part of the ocean to another at times. Marine fish like Hilsa swim up from sea to fresh water for spawning e.g. cel. Some fresh water fish migrate from lakes to sea for spawning. During winters in the cold part of the globe, water at the surface freezes. The fish migrate to the bottom and remain there till the end of the cold season.

INTEXT QUESTIONS

1. Mention two way by which gets polluted water.

   ____

2. What do you mean by thermal pollution?

   ____

3. What causes "algal bloom"?

   ____

4. How does UV radiation cause loss of fish?

   ____

5. What is "seine"?

   ____

Fish Diseases

Like other animals, fishes are also affected by various diseases. These diseases can be broadly classified under bacterial, viral, fungal, protozoan and those caused by large parasites like tapeworms and roundworms. Diseases like tuberculosis, eye infection, kidney diseases and various types of tumours – benign and malignant are reported from both freshwater as well as marine fish.

Furunculosis, a common disease of fresh water fish is caused by bacteria and can be treated with tetracyclines and the **vibrio infections** respond to sulphonamide therapy.

Tail rot, another common disease caused by bacteria can be controlled by administering a mixture of penicillin and streptomycin.

Food poisoning caused by fish and fishery products may be due to a variety of causes. Some fish and shellfish (prawns, shrimps etc.) possess poisons or biotoxins. These biotoxins are not destroyed by cooking and cause illness when fish containing them are eaten. Some people are allergic to fish, molluscs or crustaceans.

Some poisons affect the central nervous system, while others cause gastrointestinal and skin disorders. Food poisoning can also be caused by eating spoiled or rotting fish. Toxicprinciples in the flesh of such fish cause gastroenteritis. Bites and strings caused by varieties of fishes and invertebrates like jelly fish result in serious inflammatory conditions. Dermatitis can be caused by irritants found in the skin of fishes belonging to the tuna fish group.

WHAT YOU HAVE LEARNT

- The areas used for rearing, breeding and catching of fish constitute fisheries
- Fish and shell fish, that is, molluscs and crustaceans such as crab, prawn and shrimp are reared in fisheries.
- Mackerels, sardines, sharks and catfish are some marine edible fish.
- Fresh water edible fish include Rohu, Catla, Mystus, Gourami, and Gambusia.
- Estuarine fish such as pearl spot, milk fish and mullet are found in back water lagoons (areas where sea water comes and cover a part of land).
- Fish are a good and cheap source of animals proteins, and Vitamins A and D.
- Aquaculture involves rearing and management of useful aquatic plants and animals.
- Aquaculture or fish farming provides controlled environment, protection and nutrients to the fish.
- Aquaculture includes Pisciculture and Pond culture.
- Fish are used for animal feed, agricultural manure, making of adhesives, soaps, paints and varnishes.
- Environment changes adversely affect the fish population.
- Water pollution due to chemicals released from industry and agriculture, fertilizers, release of hot water, UV rays and oil spills cause fish mortality and affect fish production.

INTEXT QUESTIONS

1. Classify different fish on the basis of their natural habitat. Also mention two examples of each.
2. List any four uses of fish for mankind.
3. Define aquaculture mentioning its importance.
4. Discuss briefly the effect of changing environment on fish population.
5. What is meant by migration? Why do fish migrate?
6. What can happen if rotton fish is consumed?