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class 12

Biology

SHORT NOTES 2025-2026



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NOTE - कुछ लोगों ने ये नोट्स शेयर किये थे या इन्हें गलत तरीके से बेचा था तो उनके खिलाफ कानून कार्यवाही की जा रही है इसलिए आप अपने नोट्स किसी से भी शेयर न करें।

Class XII (2025 - 2026)

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INDEX

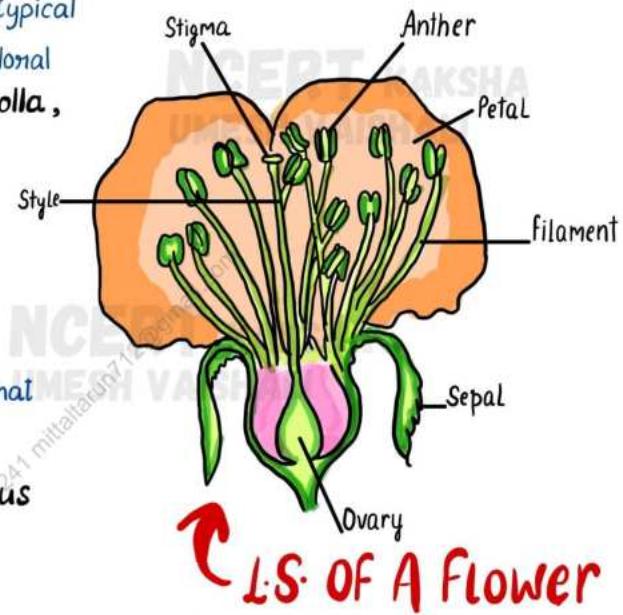
UNITS	COURSE STRUCTURE	PG. No.	MARKS
UNITS - I	Reproduction	1 - 19	
	Chapten 1 : Sexual Reproduction in Flowering Plants	1 - 7	
	Chapten 2 : Human Reproduction	8 - 16	16
	Chapten 3 : Reproductive Health	17 - 19	
UNITS - II	Genetics and Evolution	20 - 41	
	Chapten 4 : Principles of Inhenitance and Vaniation	20 - 25	20
	Chapten 5 : Molecular Basis of Inhenitance	26 - 36	
	Chapten 6 : Evolution	37 - 41	
UNITS - III	Biology and Human Welfare	42 - 51	
	Chapten 7 : Human Health and Diseases	42 - 47	12
	Chapten 8 : Microbes in Human Welfare	48 - 51	
UNITS - IV	Biotechnology	52 - 62	
	Chapten 9 : Biotechnology : Principles and Processes	52 - 56	12
	Chapten 10: Biotechnology and its Applications	57 - 62	
UNITS - V	Ecology and Environment	63 - 73	
	Chapten 11: Organisms and Populations	63 - 66	10
	Chapten 12: Ecosystem	67 - 70	
	Chapten 13: Biodiversity and Conservation	71 - 73	
TOTAL			70

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Sexual Reproduction in Flowering Plants

→ **FLOWER :-** Flower is a modified stem which functions as a reproductive organ and produces ova and/or pollen. A typical angiospermic flower consists of four whorls of floral appendages attached on the receptacle: **calyx**, **corolla**, **androecium** (male reproductive organ consisting of stamens) and **gynoecium** (composed of ovary, style and stigma).



NOTE :- Smallest flower occurs in *wolfia microscopia*, while the largest in that of *Rafflesia*.

NOTE :- National flower of India is *Lotus* (*Nelumbium*)

→ LIFE : CYCLE OF AN ANGIOSPERM (SEXUAL REPRODUCTION) :-

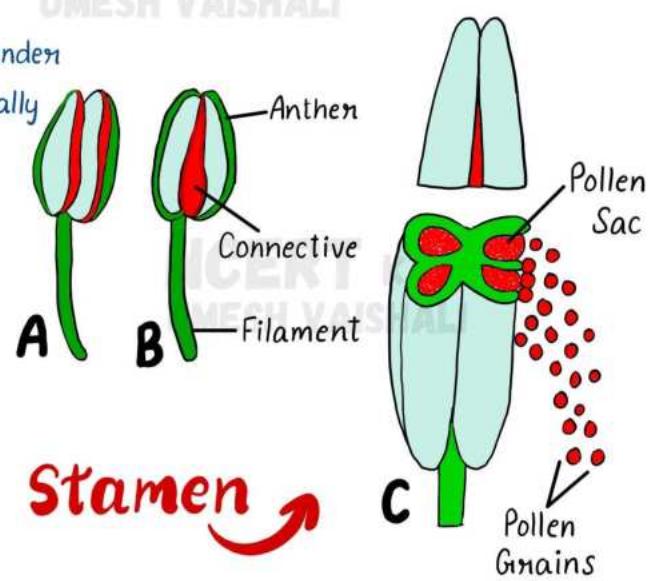
- PRE - FERTILISATION : STRUCTURES AND EVENTS :-

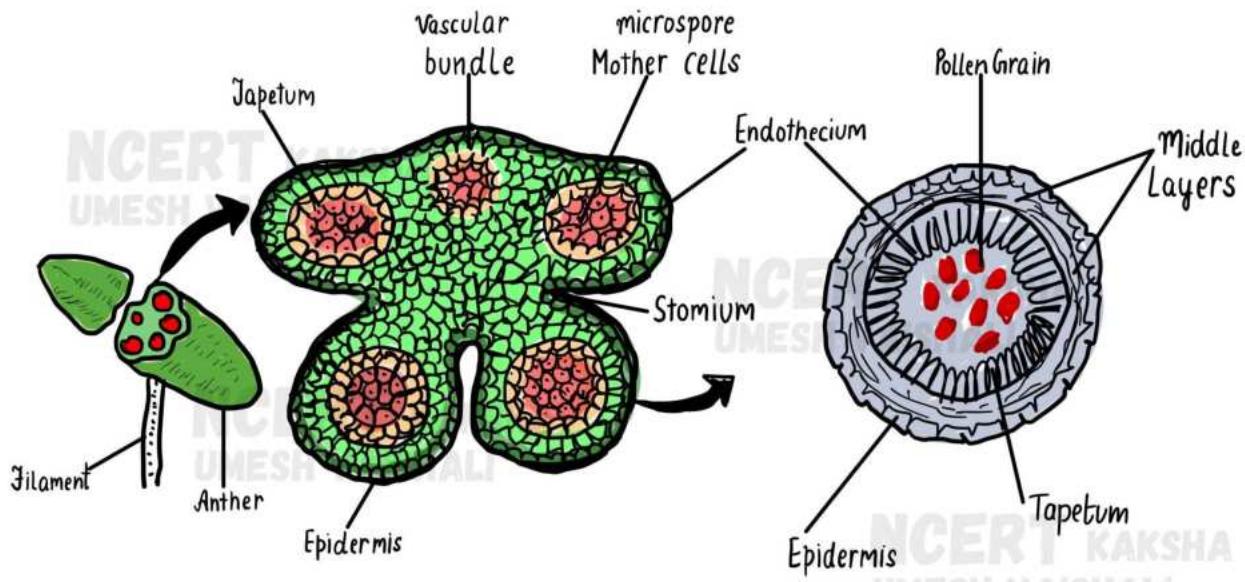
- Several structural and hormonal changes lead to formation and development of the floral primordium. Inflorescence is formed that bears floral buds and then flower.
- In flowers, male (androecium) and female (gynoecium) differentiate and develops in which male and female gametes are produced.

(a) **STAMEN :-** Stamen consists of long and slender stalk called filament and generally bilobed anthers. Each lobe contains two theca (dithecious).

(b) STRUCTURE OF ANTER :-

The anther is four - sided structure consisting of four microsporangia, two in each lobes.





(c) STRUCTURE OF MICROSPORANGIUM :-

- Microsporangium develop further and become pollen sacs which contain pollen grains.
- Microsporangium is generally surrounded by four layered walls - the epidermis, endothecium, middle layer and tapetum. Innermost layer tapetum nourishes the developing pollen grains.

(d) STRUCTURE OF MICROSPORE (POLLEN GRAINS) :-

The process of the formation and

differentiation of microspores (pollen grains) from microspore mother cells (MMC) by reductional division is called microsporogenesis.

The cells of sponogenous tissues undergo meiotic division to form microspore tetrads. As the anther mature and dehydrate, the microspore dissociate and develops into pollen grains.

NOTE:- MMC = Microspore Mother cells

→ DEVELOPMENT OF MALE GAMETOPHYTE :-

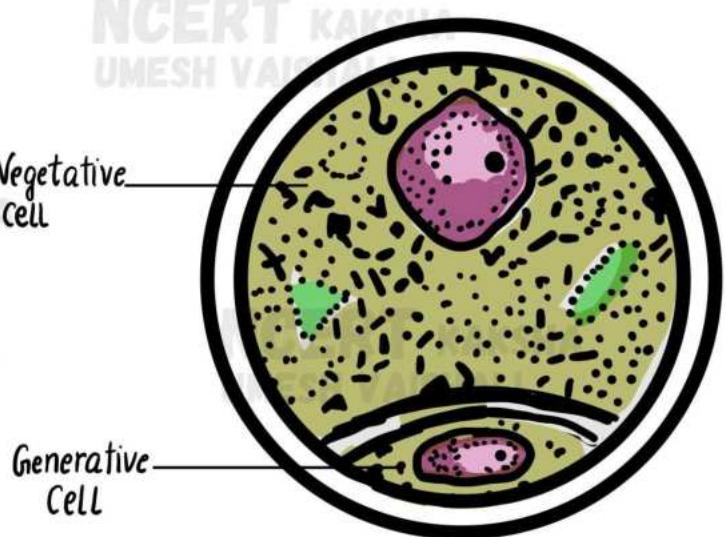
A Mature pollen consist of 2 cells with nucleus (Vegetative and Generative)

1) VEGETATIVE CELL

- Bigger
- Abundant food reserve
- Large irregular nucleus
- Responsible for the development of pollen grains

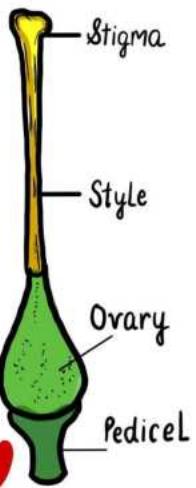
2) GENERATIVE CELL

- Small
- Involves in syngamy (fuse with an egg)
- Dense cytoplasm and nucleus



→ **THE PISTIL :-** Gynoecium may consist of single pistil (monocarpellary) or more than one pistil (polycarpellary) which may be fused (syncarpous) or free (apocarpous). e.g. Multicarpellary and syncarpous pistil - Papaver. Multicarpellary and apocarpous pistil - Michelia.

- Each pistil has three parts the **stigma**, **style** and **ovary**. Inside the ovary is ovarian cavity (locule). The placenta is located inside the ovarian cavity. Megasporangia (ovules) arises from placenta.

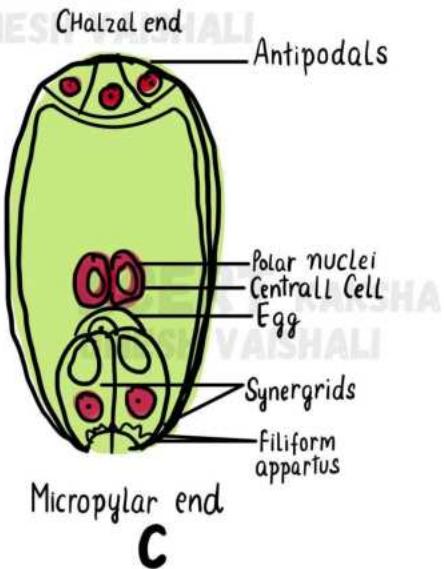
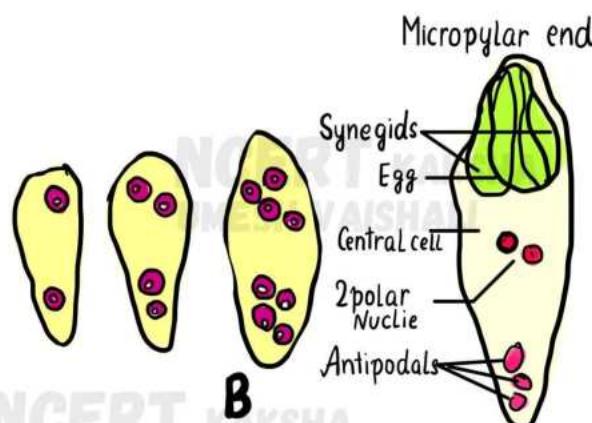
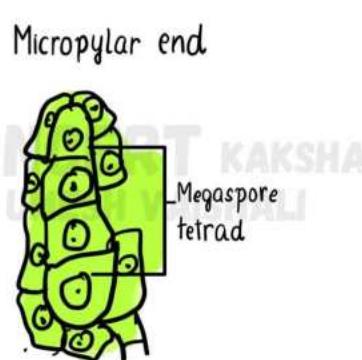
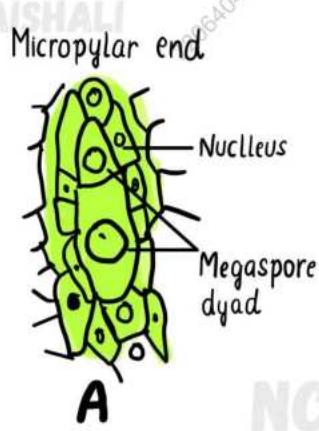
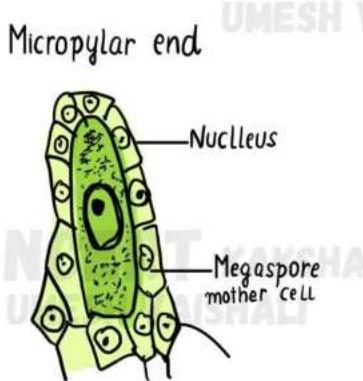


Pistil

→ DEVELOPMENT OF OVULE AND FEMALE GAMETOPHYTE :-

(a) MEGASPORANGIUM OVULE :-

- Ovule is a small structure attached to placenta.
- Funicle - stalk by which ovule is attached to placenta
- Hilum - junction between ovule and funicle
- Integuments - protective envelope
- Microspore - small opening at the tip of ovule into which pollen tube enters
- Chalaza - basal part of ovule
- Nucellus ($2n$) - mass of cells enclosed in integuments. Has abundant food reserve.



(b) MEGASPORANGIUM :- The process of formation of megasporangium from megasporangium mother cell by meiotic division is known as megasporogenesis. This process takes place in ovule. Ovule differentiates a single megasporangium (MMC) in the micropyl region of nucellus. MMC undergoes meiotic division that results into the production of four megasporangia.

- In most of the flowering plants three megasporangia degenerate. 1 megasporangium develops into female gametophyte (embryo sac).
- The nucleus of functional megasporangium divides mitotically to form two nuclei which move to opposite poles to form 2-nucleate embryo sac. Two more sequential mitotic divisions result in 8-nucleate embryo sac.

(c) DEVELOPMENT OF FEMALE GAMETOPHYTE :-

- Six of the eight nuclei surround by cell wall and remaining two nuclei (polar nuclei) are situated below the egg apparatus.
- Three cells are grouped at micropylar end to constitute **egg apparatus** and three cells at chalazal end forms **antipodal cells**. At maturity, embryosac is 8-nucleate and 7 celled.

→ **POLLINATION :-** The process of transfer of pollen grains from anther to stigma is called as pollination or pollination. Pollination is of two types -

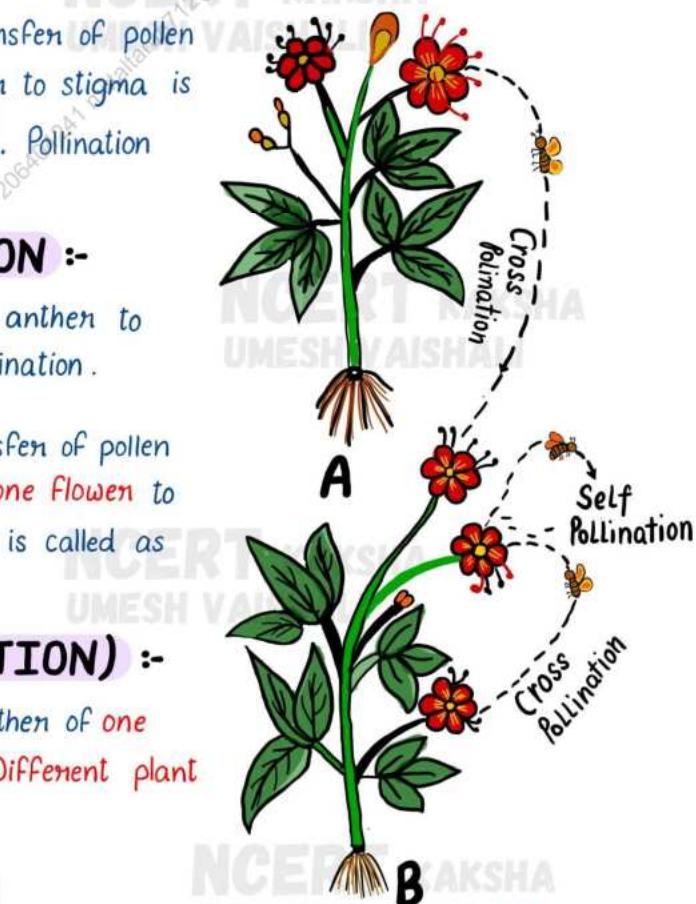
(a) AUTOGAMY SELF POLLINATION :-

The process of transfer of pollen grain from anther to stigma of **same flower** is called as self pollination.

(b) GEITONOGAMY :- The process of transfer of pollen grain of anther of **one flower** to stigma of **another flower** having same plant is called as Geitonogamy.

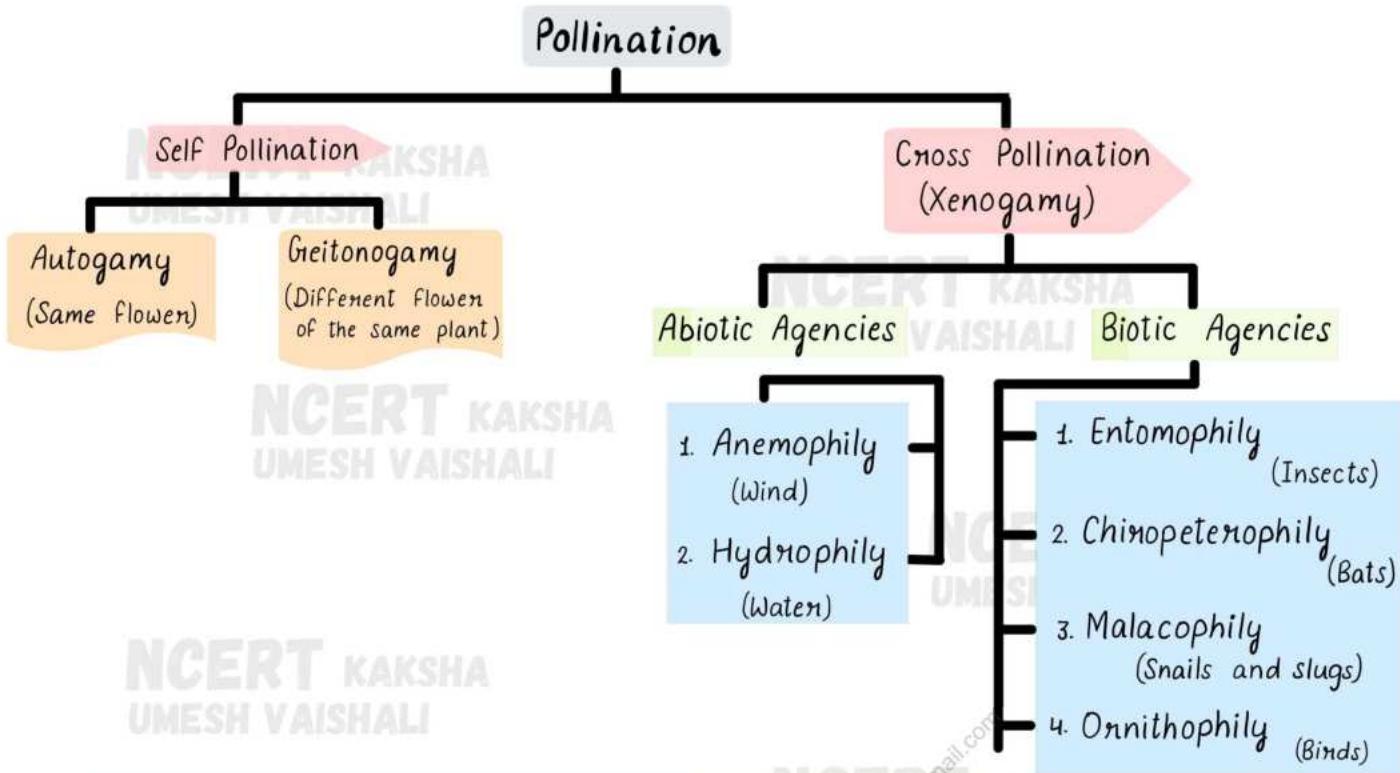
(c) XENOGAMY (CROSS POLLINATION) :-

The process of transfer of pollen grain of anther of **one flower** to stigma of **another flower** having **Different plant** is called as Xenogamy.



Learn Something
New Everyday

Pollination ↗



→ **OUT BREEDING DEVICES (CONTOIVONIES) :-** Many plants have mechanisms that

discourage or prevent self pollination. To promote cross pollination and increase genetic diversity. Thus plants have developed many devices to encourage cross pollination the examples of out breeding devices are as follows.

Unisexuality - In this case the plant bears either male female flowers it is also called as monoecius. If flower are unisexual self-pollination is not possible.

Dichogamy - When anthen and stigma mature at different times in a bisexual flowers as to prevent self pollination.

- 1) protandry
e.g. sunflower
- 2) pootogyny
e.g. Gloriosa

Prepotency - Pollen grains of other flowers germinate rapidly over the stigma than the same flower.
e.g. Apple.

Heterostyly (heteromorphy) - There are two or three types of flower in which stigma and anthen are placed at different. It is mechanical device to prevent self pollination in a bisexual flower. In plants natural physical barrier is present between two sex organs avoid contact of Pollen grain and stigma.

Self sterility (self incompatibility) - This is genetic mechanism due to which the germination of pollen on stigma of same flower is inhibited.

→ **DOUBLE FERTILISATION** :- After entering the one of the synergids, each pollen grain releases two male gametes. One

male gametes fuse with egg (**Syngamy**) and other male gametes fuse with two polar nuclei (**triple fusion**) to produce triploid **primary endosperm nucleus (PEN)**. Since two types of fusion takes place in an embryo sac the phenomenon is called **double fertilisation**. The PEN develops in

to the endosperm and zygote develops into embryo. Post fertilisation events include endosperm and embryo development, maturation of ovules into seeds and ovary into fruits.

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→ FORMATION :-

(a) **ENDOSPERM** :- The primary endosperm cell divides many time to forms triploid endosperm tissue having reserve food materials.

Three types of endosperm development →

- (i) nuclear type
- (ii) Cellular type
- (iii) Heliobial type

(b) **EMBRYO DEVELOPMENT** :- Embryo develops at the micropylar end of the embryo sac where the zygote is located.

Embryogeny - early stages of embryo development. The zygote gives rise to the proembryo and subsequently to the globular, heart-shaped and mature embryo.

Embryo consists of : ■ embryonal axis ■ cotyledons ■ plumule ■ radicle

→ **POLYEMBRYONY** :-
► Occurrence of more than one embryo in a seed
► Often associated with apomixes. Ex: Citrus, groundnut

→ POLLEN PISTIL INTERACTION :-

- 1) It is the interaction of pollen grains with sporophytic tissue (stigma).
- 2) It begins with pollination and ends with fertilization.
- 3) All the events from the deposition of pollen grain on stigma to the entry of pollen tube in the Ovule (synergid) one referred as pollen-pistil Interaction
- 4) Pollination does not guarantee the transfer of right type of pollen grain, after wrong type also land on stigma.
- 5) The pistil has the ability to recognize the species thus wrong type of pollen is discarded to the pollen-pistil is determined by special proteins. This process involves recognition followed by promotion or inhibition of pollen. It also plays important role in sexual reproduction & seed formation.
- 6) Due to pollen pistil interaction, intense competition develops even in the compatible pollen grain.

→ **INCOMPATIBILITY** :- Incompatibility is the inability of functional male and female gametes to affect fertilization in particular combinations.

Incompatibility is the integral part of pollen-pistil interaction. Incompatibility operates between species (interspecific) as well as within species (intraspecific).

→ **PARTHENOCARPY** :- The fruit is normally formed by stimulus of fertilization. Sometimes fruits may be formed without the act of fertilization. This is called parthenocarpy.

→ **PARTHENOGENESIS** :- Thus is a type of apogamy. In *Solanum nigrum* development of haploid egg into embryo has been observed. It leads to formation of haploid embryo and plant. This type of parthenogenesis is called **haploid parthenogenesis**.

→ **SEED** :- Fertilized and mature ovule develops into seed. seed consists of :

- cotyledon (s)
- embryonal axis
- Seed coat - double layered - formed by integuments.

- **Testa** (outer coat)

- **Tegmen** (inner coat)

- NOTE** :-
- **Micropyle** small opening on seed coat, it facilitates entry of H₂O & O₂ into seeds (for germination)
 - **Hilum** scar on seed coat
 - **Seed** Albuminous / Non- Albuminous
 - **Perisperm** remnants of nucellus that is persistent. Ex: Black pepper
 - **Dormancy** state of inactivity

→ **SIGNIFICANCE OF SEED AND FRUIT FORMATION** :- Fruits provide nourishment to the developing seeds

Fruits protect seeds in immature conditions. Seeds serve as important propagating organs of plant. Seeds and fruits developed devices for their dispersal and this help in the distribution of the species.

→ **PERICARP** :- The wall of ovary develops into wall of fruits called **pericarp**. In true fruits only ovary contributes in fruit formation by in false fruit thalamus also contributes in fruit formation.

→ **APOMIXIS** :- Form of asexual reproduction - mimics sexual reproduction - seed formed without fertilisation .

Formation of apomictic seeds :

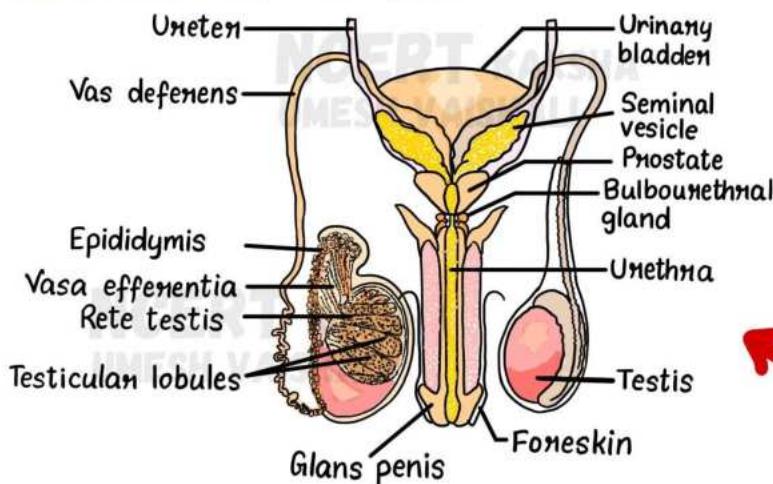
- diploid cell (formed without meiosis)-develop into embryo without fertilization .
- cells of nucellus (2n) surrounding embryo sac - protrude into embryo sac - develop into embryos. Ex. Citrus and Mango.

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Human Reproduction

→ THE MALE REPRODUCTIVE SYSTEM :- It consists of -

- Primary sex organs i.e. a pair of testes suspended in a scrotum.
- Secondary sex organs i.e. a pair of ducts each differentiated into rete testis, vasa efferentia, epididymis and vas deferens, ejaculatory duct and the associated glands
- External genitalia
 - The testes are situated outside the abdominal cavity in a pouch called **scrotum**, which help in maintaining the low temperature of testes necessary for spermatogenesis.
 - Each testes has about 250 testicular lobules and each lobule contain highly coiled **seminiferous tubules** in which sperms are produced. Each seminiferous tubules is lined by two types of cells, **spermatozoa** (male germ cell) and **septate cells**.
 - Leydig cells** or interstitial cells present around the seminiferous tubules synthesize and secrete androgen hormone.
 - Ejaculatory duct store and transport the sperm from testes to outside through urethra which originate from urinary bladder and extend through penis to its external opening **urethral meatus**.
 - The penis is male external genitalia. The enlarged end of penis is called the **glans penis** is covered by a loose fold of skin called **foneskin**.
 - Male accessory glands include paired **seminal vesicles**, **prostate** and **paired bulbourethral glands**. Secretion of these glands forms the seminal plasma which contains fructose, calcium and enzymes. The secretion of bulbourethral glands also helps in lubrication of the penis.



Male
Reproductive
System

→ THE FEMALE REPRODUCTIVE SYSTEM :-

- (a) The primary sex organ that is a pair of ovaries
- (b) Secondary sex organs - the duct system consisting of a pair of fallopian tube, a uterus, cervix and vagina.
- (c) External genitalia
- (d) Mammary glands

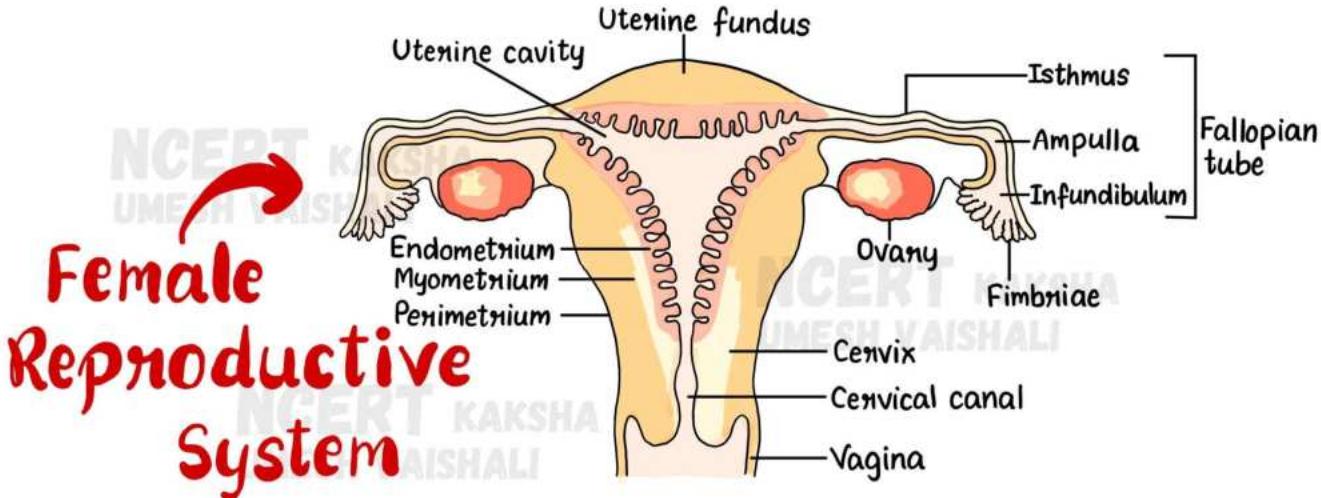
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- Ovaries are primary female sex organ that produce the female gamete and several steroid hormones. Each ovary is covered by thin epithelium which encloses the ovarian stroma, which is divided
- Fallopian tube extends from periphery of ovary to the uterus. The part closer to ovary is a funnel shaped structure called **infundibulum** having finger like projection called **fimbriae**.
- Infundibulum leads to **ampulla** and join with uterus with **isthmus**. Uterus is pear shaped structure also called womb.
- Uterus open vagina through a narrow cervix. The cavity of cervix (**cervical canal**) along with vagina forms the birth canal.
- The wall of uterus has three layers of tissue.

- I. Perimetrium - external membrane.
- II. Myometrium - middle thick layer of smooth muscles which exhibit strong contraction during delivery of baby.
- III. Endometrium - line the utrine wall and undergo cyclic changes during menstrual cycle.

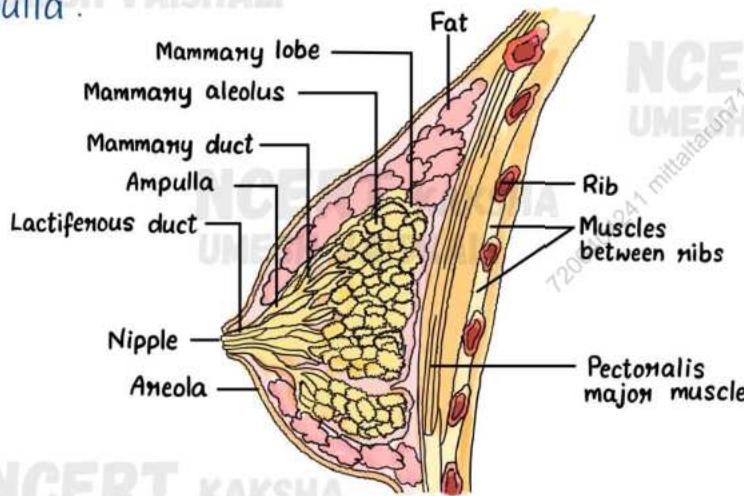
→ FEMALE EXTERNAL GENITALIA INCLUDES :-

- Mons pubis - cushion of fatty tissues covered by skin and pubic hair.
- Labia majora - fleshy fold that surround the vaginal opening.
- Labia minora - paired fold of tissue under labia majora.
- The opening of vagina is often partially covered by a membrane called **hymen**. The tiny finger like projection present at the upper junction of two labia minora above the urethral opening is called **clitoris**.



Female Reproductive System

→ **MAMMARY GLANDS** :- Mammary glands are paired structures that contain glandular tissues and variable fats. Each glandular tissue contains 15-20 mammary lobes containing alveoli that secrete milk. Mammary ducts join to form mammary ampulla.



Mammary Glands

→ **GAMETOGENESIS** :- The gametogenesis is the process of formation of gametes in sexually reproducing animals .

* Spermatogenesis

* Oogenesis

→ **SPERMATOGENESIS** :-

- The process of formation of the male gamete sperm from the germinal epithelium of testis called
- At the puberty hypothalamus begins secretion of gonadotropin releasing hormone (GnRH).
- It initiates the significant increase IN secretion of follicle stimulating hormone (FSH).
- spermatogenesis involves three phases .

* **MULTIPLICATION PHASE** :- The primordial germ cell (2n) of seminiferous tubules undergo repeated mitotic division to produce spermatogonia.

*** GROWTH PHASE :-** Some Spermatogonia stop dividing and grow in size to develop Spermatocytes due to accumulation of food.

*** MATURATION PHASE :-** It involves (meiosis) to formation of two haploid cell.

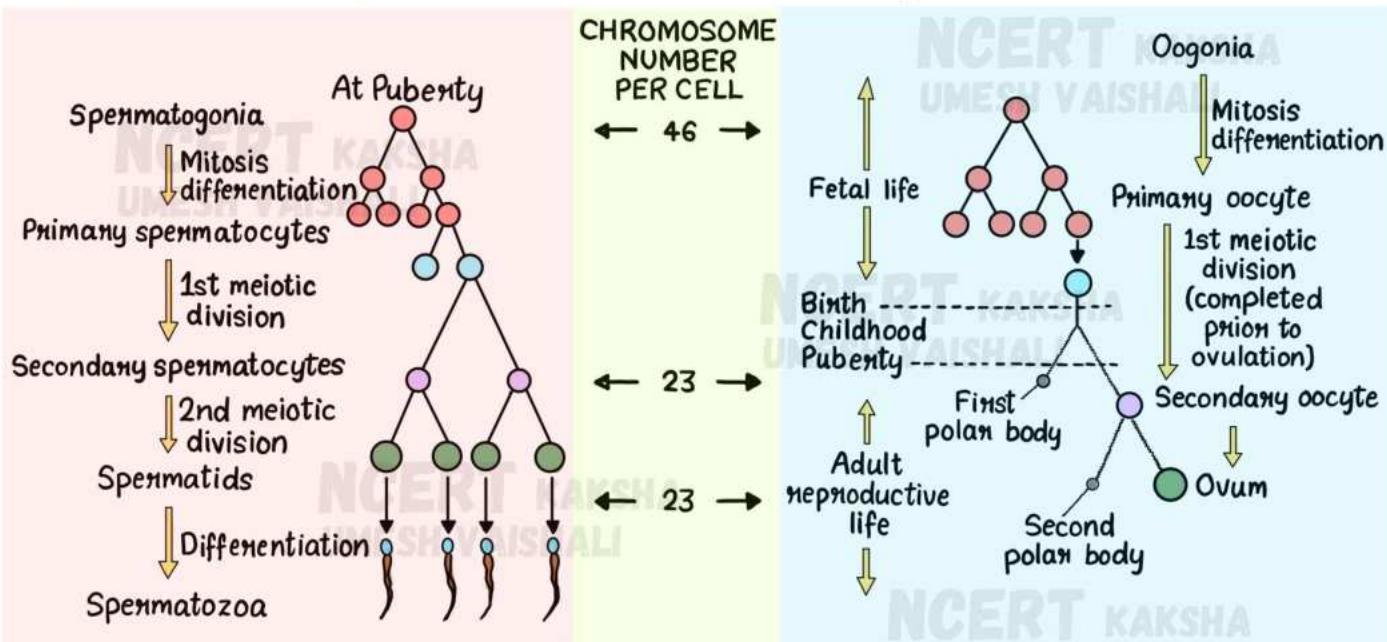
Secondary spermatocyte undergoes (**meiosis II**) to form four haploid spermatid transfer into function spermatozoa by **Spermiogenesis**.

→ OOGENESIS :- It is the process of formation of the haploid female gamete egg from germinal epithelium.

*** MULTIPLICATION PHASE :-** The primary germ cells ($2n$) of ovary undergoes repeated **Mitotic division** to form oogonia ($2n$).

*** GROWTH PHASE :-** Some of the oogonia stop division and begin to increase in size and form the primary oocytes ($2n$).

*** MATURATION :-** The diploid primary oocytes undergoes (**meiosis I**) to form 2 haploid daughter cells. But due to unequal division of cytoplasm one is large cell body called secondary oocyte another small cell called as **1st polar body**. Last phase usually complete in the fallopian tube at the time of fertilization large ovum (n) **2nd polar body**.



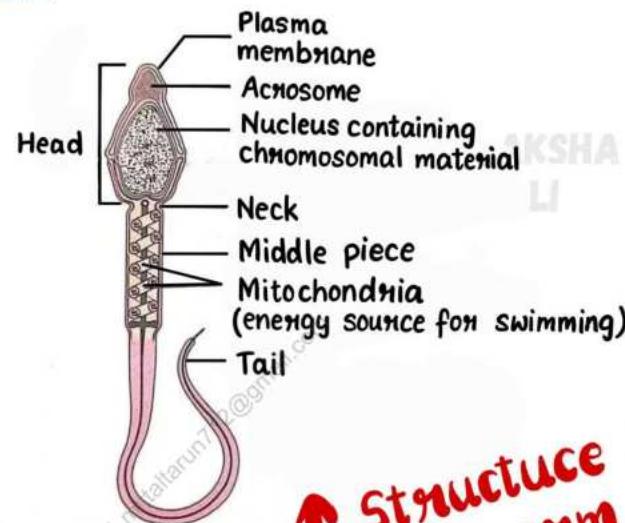
Schematic Representation of (a) Spermatogenesis (b) Oogenesis

→ **STRUCTURE OF SPERM** :- Sperm is the male gamete it is a motile, microscopic elongated cell. It divided into three parts.

* **HEAD** :- The sperm head to oval in shape contain haploid nucleus. There is cap like structure called acrosome contain hydrolytic enzyme like zona lysine & corona penetrating enzymes.

* **NECK** :- It is a very short region having two centriole i.e. proximal centriole & distal centriole.

* **MIDDLE PIECE** :- It has an axial filament surrounded by 10-74 spinal turns of mitochondria. It provide energy to sperm. It is long slender and tapering part. The part surrounded by plasma membrane is main piece & End piece without plasma membrane.



Structure of
a sperm

→ **MENSTRUAL CYCLE** :-

MENSTRUAL PHASE :-

- In a 28 days menstrual cycle, the menses take place on cycle days 3-5
- The production of LH from the anterior lobe of the pituitary gland is reduced.
- The withdrawal of this hormone causes degeneration of the corpus luteum and therefore progesterone production is reduced.
- Production of oestrogen is also reduced in this phase.
- The endometrium of uterus breaks down & menstruation begins.
- The cells of endometrium secretions, blood & unfertilised ovum constitutes the menstrual flow.

FOLLICULAR PHASE :-

- This phase usually includes cycle days 6-13 or 14 in a 28 days cycle.
- The follicle stimulating hormone (FSH) secreted by the anterior lobe of the pituitary gland stimulates the ovarian follicle to secrete oestrogens.
- Oestrogens stimulates the proliferation of the endometrium of the uterine wall.

- The endometrium becomes thicker by rapid cell multiplication and this is accompanied by an increase in uterine glands & blood vessels.

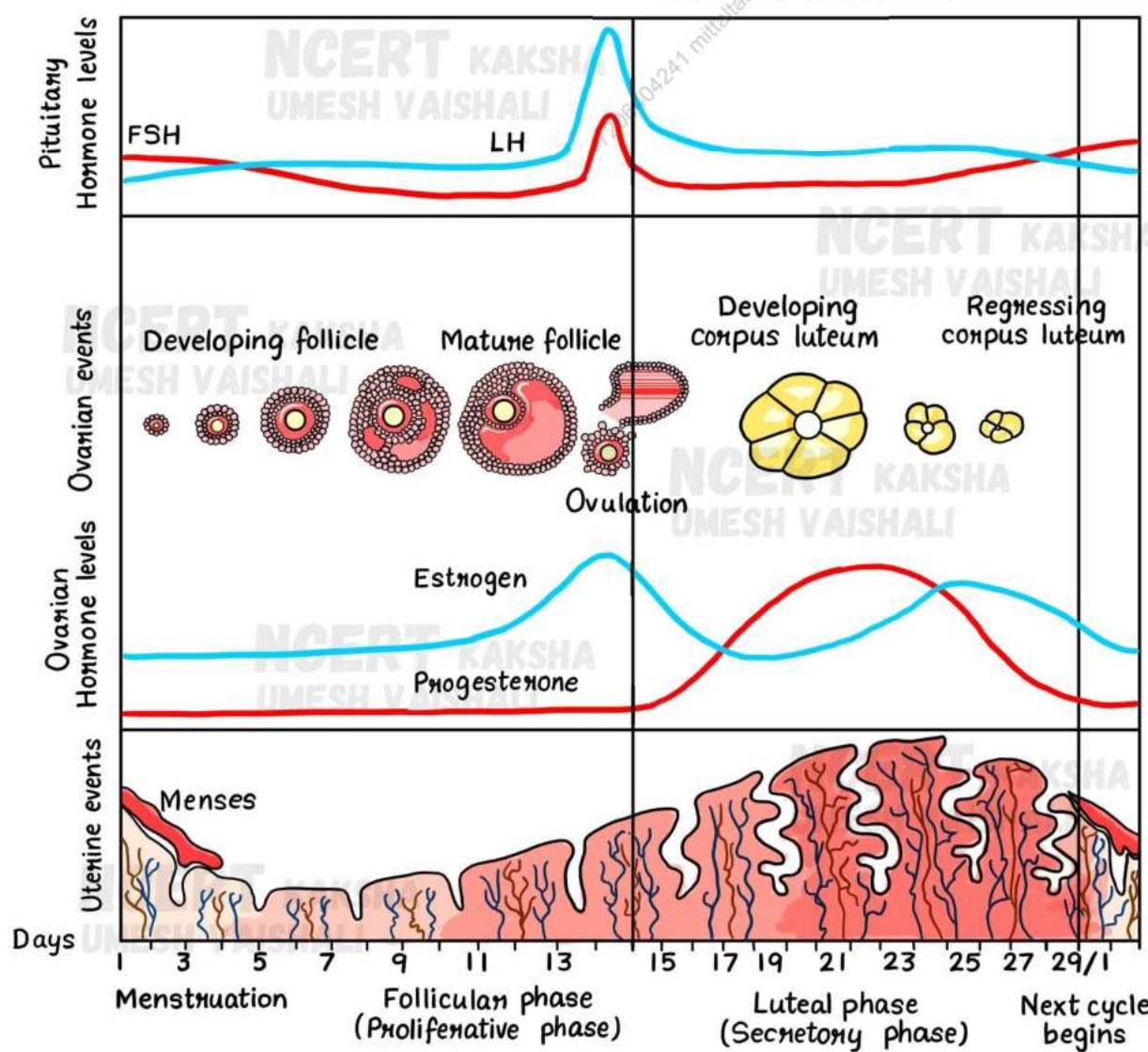
OVULATORY PHASE :-

- Both LH & FSH attain a peak level in the middle of cycle (about 14th day).
- Oestrogen concentration in blood increases.
- Rapid secretion of LH induces rupturing of graafian follicle and thereby the release of ovum.
- In fact LH causes ovulation.

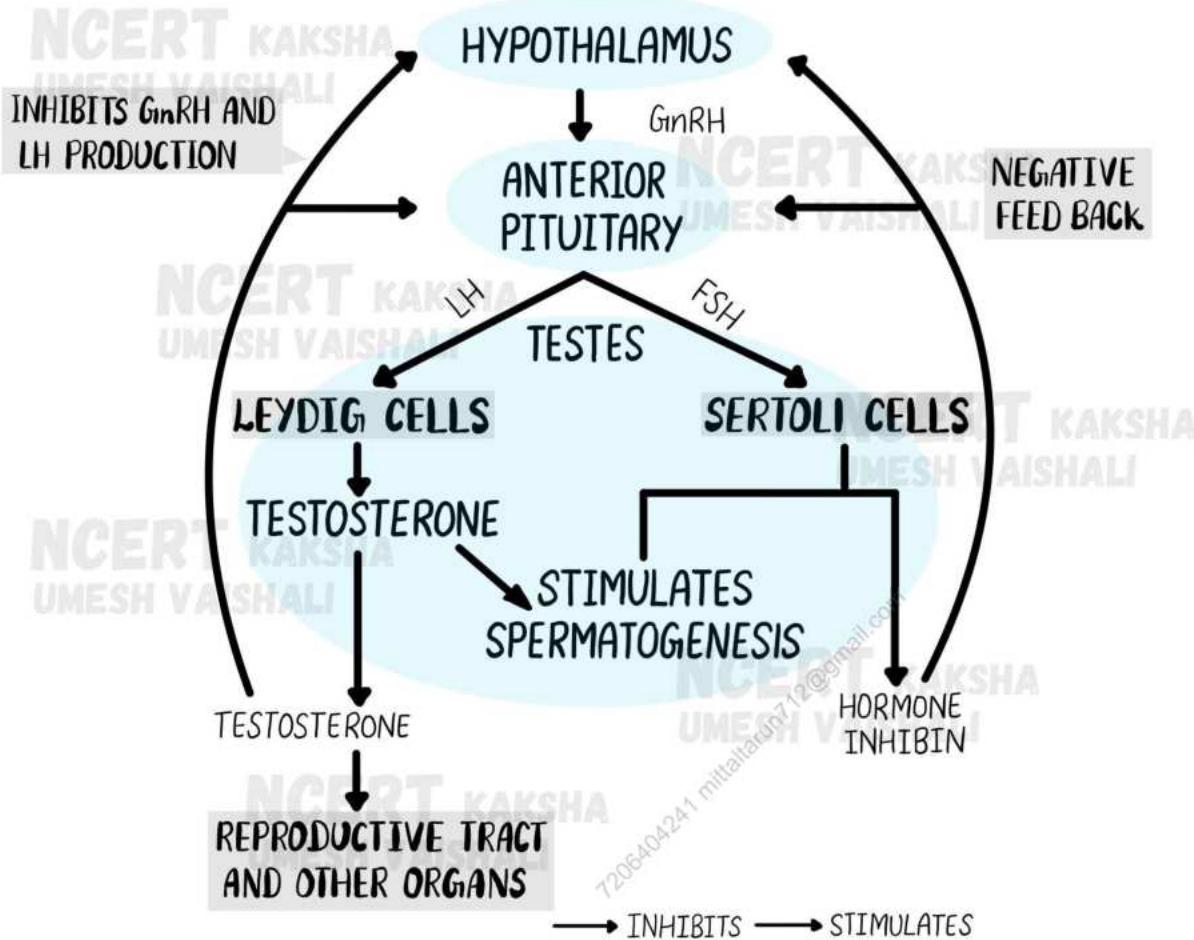
LUTEAL PHASE :-

- Includes cycle days 15 to 28.
- Corpus luteum secretes progesterone
- Endometrium thickens.
- Uterine glands become secretory.

Various events during menstrual cycle



HORMONAL CONTROL IN MALE REPRODUCTION



→ FERTILISATION AND IMPLANTATION :-

- During coitus, the semen is released into the vagina, passes through the cervix of the uterus and reaches the ampullary- isthmic junction of the fallopian tube.
- The ovum is also released into the junction for fertilisation to occur.
- The process of fusion of the sperm and the ovum is known as fertilisation.
- During fertilisation, the sperm induces changes in the **zona pellucida**, and blocks the entry of other sperms. This ensures that only one sperm fertilises an ovum.
- The enzymatic secretions of the acrosomes help the sperm enter the cytoplasm of the ovum.
- This causes the completion of meiotic division of the secondary oocyte, resulting in the formation of a haploid ovum (oovid) and a secondary polar body.
- Then the haploid sperm nucleus fuses with the haploid nucleus of the ovum to form a diploid **zygote**.

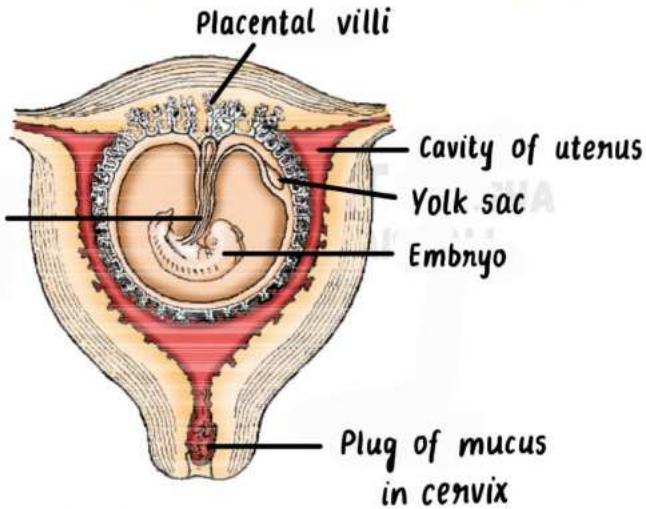
- Mitosis starts as the zygote moves through the isthmus of the oviduct (cleavage) and forms 2,4,8,16 daughter cells called **blastomeres**.
- The 8-16 cell embryo is called a **morula**, which continues to divide to form the **blastocyst**. The morula moves further into the uterus.
- The cells in the blastocyst are arranged into an outer **trophoblast** and an **inner cell mass**.
- The trophoblast gets attached to the uterine endometrium, and the process is called implantation. This leads to pregnancy.
- The inner cell mass gets differentiated to form the embryo.

→ **PREGNANCY AND EMBRYONIC DEVELOPMENT :-** The finger-like projections on trophoblast after implantation called is called **chorionic villi** that along with uterine wall forms functional unit between developing embryo and maternal body called **placenta**. Placenta is attached with fetus with an umbilical cord that transports food and oxygen to embryo.

- Hormones hCG (human chorionic gonadotropin), (human placental lactogen and relaxin) are produced in woman only during pregnancy by placenta.
- After implantation, the inner cell mass (embryo) differentiates into an outer layer called **ectoderm** and an inner layer called **endoderm**. A **mesoderm** soon appears between the ectoderm and the endoderm. These three layers give rise to all tissues (organs) in adults. It is important to note that the inner cell mass contains certain cells called stem cells which have the potency to give rise to all the tissues and organs.
- In human, after one month of pregnancy the embryo's heart is formed. By the end of 2nd month limbs and digits are formed. By the end of 12 months, major organs and external genital organs are well developed. The first movement of foetus is observed in 5 month. By the end of 24 weeks body is covered with fine hair, eye lids and eyeless are formed. At the end of 9 month fetus is fully developed.

The human
foetus within
the uterus

Umbilical cord with
its vessels



PARTURITION AND LACTATION :-

- Human pregnancy has the duration of 9 months. This called the **gestation period**.
 - At the end of this period, vigorous uterine contractions lead to the delivery of the foetus. This process is called **parturition**.
 - Parturition is a neuro-endocrine mechanism, and is started by the signals from the developed foetus and the placenta, which produce the **foetal ejection reflex**.
 - This causes the release of oxytocin from the pituitary, which causes stronger uterine contractions.
 - This lead to the expulsion of the baby along with the placenta.
 - During pregnancy, the mammary glands undergo differentiation, and milk is produced during the end of pregnancy.
 - The milk produced during the first few days of lactation is known as **colostrums**. It contains several antibodies that aid the newborn to develop resistance.

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Reproductive Health

→ Reproductive health :- According to WHO, reproductive health means total well-being in all aspects of reproduction i.e. physical, emotional, behavioral and social.

→ Reproductive health problem and strategies :-

- India was amongst the first countries in the world to initiate to the programme "family planning" initiated in 1951.
- Reproductive health in a society from a crucial part of general health.
- Improved programs covering wider reproduction-related areas are currently in operation under the popular name '**Reproductive and child health care (RCH) program**'.
- Health and education of young people and marriage and child bearing during more mature stages of life are important attributes to the reproductive health of a society

NOTE :- • WHO = World health organization

• RCH = Reproductive and child health care



launch in october 1997

→ Measures taken by Government :-

- Through the help of audio-visuals & print media.
- Even family members, close relations are involved in the awareness.
- Sex education was introduced in school to provide awareness.
- Proper information about reproductive organs, adolescence & related changes, safe & hygienic sexual practices, sexually transmitted diseases, AIDS etc.

→ Demography :- The scientific study of human population is called **demography**. while the persons involved in the scientific studies of human population are called **demographers**.

→ World human population since 1804 A.D. :-

Year	Population
1804 A.D.	1 billion
1927 A.D.	2 billion
1960 A.D.	3 billion
1965 A.D.	3.5 billion
April, 1974 A.D.	4 billion
11 July, 1987 A.D.	5 billion
12 Oct., 1999 A.D.	6 billion
31 Oct., 2011 A.D.	7.00 billion

→ **Population Explosion OR Population Holocaust** :- Such a high growth rate of human population is called "Population Explosion or population Holocaust".

- :-
- World's population day 11 July
 - U.P. has the largest population in India.
 - Sikkim has the smallest population in India.
 - According to 2011 census, India's population was 1210.2 million.
 - According to 2023 most popular country in the world -
1) India 2) China 3) United States
 - State with the highest literacy rate equal to Kerala.

→ **Determination of Human population growth rate** :-

$$\text{Annual growth rate (\%)} = \left(\frac{P_2 - P_1}{P_1 \times N} \right) \times 100$$

Where
 P_1 = Population size of previous census
 P_2 = Population size of present census
N = Number of years between the two census.

→ **Amniocentesis** :- It is a technique used to find out chromosomal abnormalities in developing embryo by using amniotic fluid.

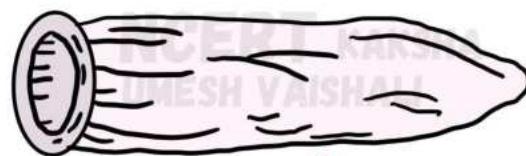
- It is also misused to check foetal sex determination based on the chromosomal pattern in the amniotic fluid surrounding the developing embryo.

→ **Birth Control measures** :- Birth Control measures involve usage of ideal contraceptives.

These measures include : **Mechanical barriers** (e.g. use of condoms, diaphragms, cervical caps vaults and Intra-uterine devices) which prevent meeting and fusion of gametes;

Natural method like periodic abstinence (especially risk period from 10th to 17th day of menstrual cycle), coitus interruptus and lactational amenorrhoea; **Physiological or oral contraceptives** (e.g. combined pills like Saheli and Mala-D which contain progesterone-estrogen combinations);

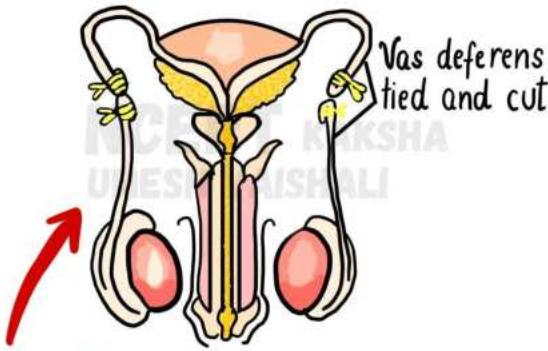
Surgical methods (e.g. vasectomy and castration in male; and tubectomy and tubal ligation in female).



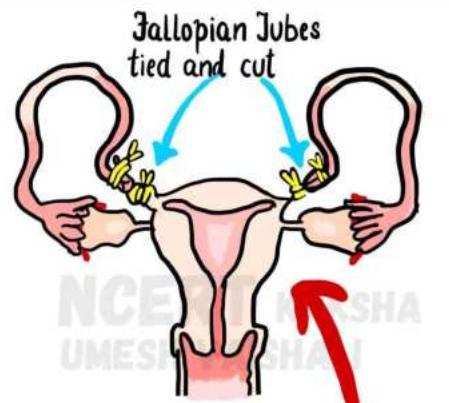
Condom
for Male



Condom
for female



Vasectomy



Tubectomy

- **Medical Termination of Pregnancy (MTP)** :- Medical Termination of Pregnancy was aimed to get rid of unwanted pregnancy or when foetus is suffering from some incurable congenital disorder or a threat to mother or foetus or both. Due to its misuse, it was legalised in 1971.
- **Sexually Transmitted Diseases (STDs)** :- Sexually Transmitted Diseases are those communicable diseases which are spread through unprotected sexual contact. Due to changing sexual behaviour and increasing antibiotic-resistant pathogens, these are increasing at high rate especially in the age-group of 15-24 years. These may be caused by bacteria (e.g. Syphilis, Gonorrhoea and chlamydia), or viruses (e.g. AIDS, Hepatitis - B, Genital warts, Genital herpes, etc) or Protozoans (e.g. Leucorrhoea) or yeast (e.g. vaginal candidiasis), etc. These can be prevented by avoiding multiple sexual contacts, use of condoms, etc. If untreated, these may lead to PID, still birth, infertility, etc.
- **Infertility** :- Infertility is inability to conceive even after two years of unprotected sexual co-habitation. It may be due to male or female causes which may be physical, congenital, pharmaceuticals, psychological, etc. The measures like test tube baby, GIFT, ICSI and Artificial insemination are available to treat infertility cases and are collectively called **Assisted Reproductive Technologies (ARTs)**. Test tube baby production involves in vitro fertilization (IVF) followed by Embryo Transfer (ET).

NOTE:-

- HPV = Human Papilloma Virus
- GIFT = Gamete Intra - Fallopian Transfer
- ICST = Intra - Cytoplasmic Sperm Injection
- AIH = Artificial Insemination Husband
- IUI = Intra - Uterine Insemination
- ZIFT = Zygote Intra - Fallopian Transfer
- ARTs = Assisted Reproductive activities

Principles of Inheritance and Variation

→ MENDEL'S LAWS OF INHERITANCE

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CHARACTER DOMINANT TRAIT RECESSIVE TRAIT

Seed shape	Round	Wrinkled
Seed colour	Yellow	Green
Flower colour	Violet	White
Pod shape	Full	Constricted
Pod colour	Green	Yellow
Flower position	Axial	Terminal
Stem height	Tall	Dwarf

Mendel's experiments involved four steps - selection, hybridization, selfing and calculations. Mendel experimented on pure breeding plant of Pea (*Pisum sativum*). He selected 14 contrasting traits for 7 characters in pea for his experiments. It is now known that these 7 characters are located on only 4 chromosomes of Pea plant. Mendel used hybridization technique to conduct his experiments. Hybridisation is the crossing of two different individuals to produce an off spring which will have characters of both parents. He crossed parents with contrasting traits. Firstly he made monohybrid cross (i.e. cross between parent that differ from each other in one character) followed by dihybrid cross and finally trihybrid cross. The F₁ hybrids were self crossed to give rise to F₂ - generation.

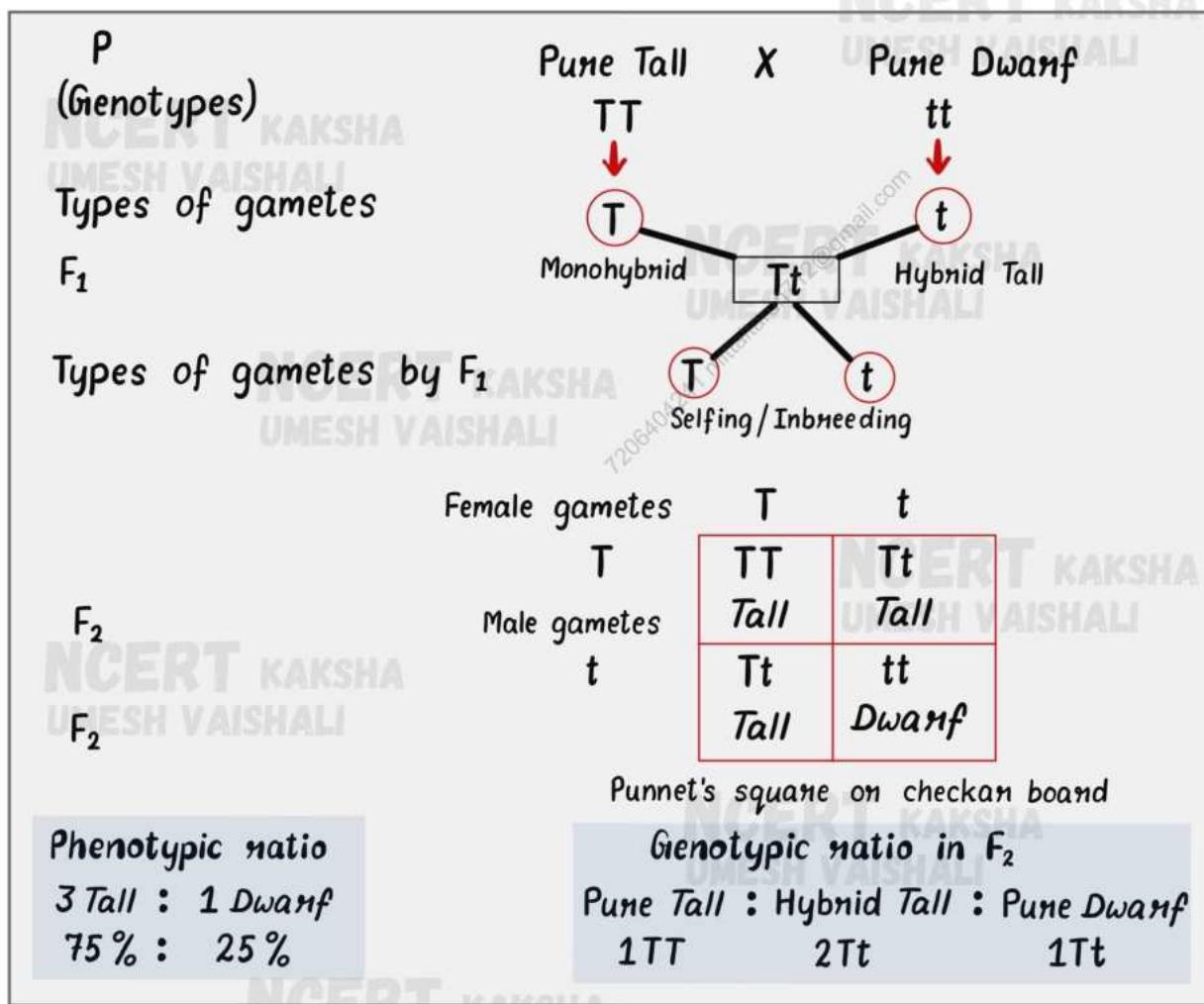
Seven pairs of contrasting trait in pea plant studied by Mendel

→ INHERITANCE OF ONE GENE (MONOHYBRID CROSS) :-

It is a cross involving

single pair of contrasting traits of a character. All the contrasting trait used by Mendel studied 7 characters on 7 pair of contrasting traits.

In a monohybrid cross, when a cross is made between pure tall and pure dwarf plant in F₁ generation, all plants will be tall. When F₁ plants are self-pollinated, then in F₂ generation both tall and dwarf plants are found in approx. Ratio of 3:1. F₂ ratio obtained in monohybrid cross by selfing of F₁ individuals. Phenotypic ratio is 3:1 (dominant : recessive) but genotypic ratio is 1:2:1 (pure dominant : hybrid dominant : recessive).



(a) **LAW OF DOMINANCE** :- "When two homozygous individuals with one or more sets of contrasting characters are crossed, the alleles (characters) that appear in F₁ are dominant and those which do not appear in F₁ are recessive"

(b) **LAW OF SEGREGATION (PURITY OF GAMETES)** :- The law of segregation states that when a pair of contrasting factors or allelomorphs or genes are brought together in a hybrid (heterozygote), these factors do not blend or mix-up but simply associate themselves and remain together and separate the time of gamete formation.

Incomplete Dominance

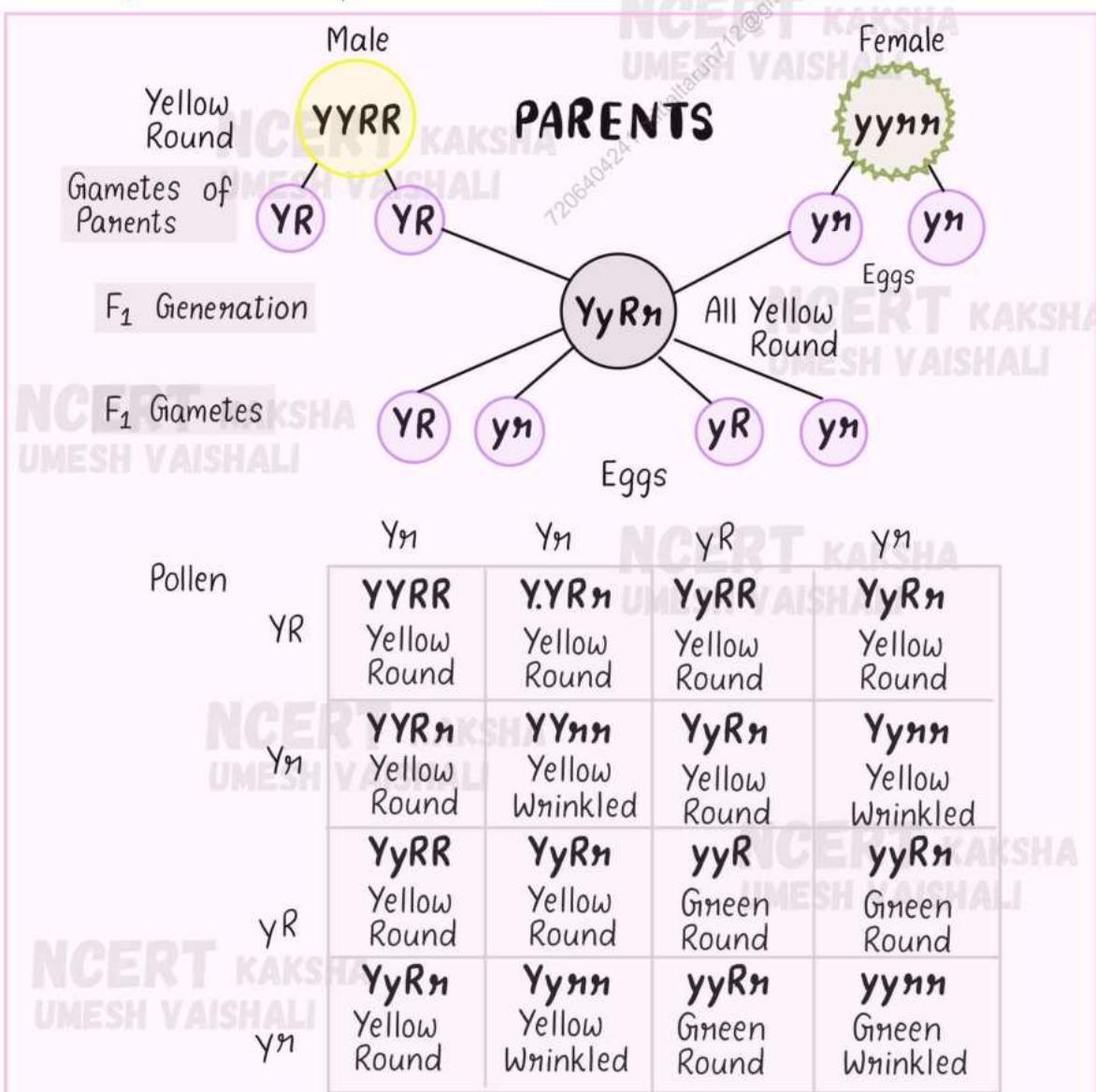
- Effect of one of the two alleles is more conspicuous.
- It produces a mixture of the expression of two alleles.
- The F1 does not resemble either of the parents.
E.g.: Flower colour in dog flower.

Co-Dominance

- Effect of both alleles are equally conspicuous.
- There is no mixing of the effect of the two alleles.
- The F1 resembles both the parents.
E.g.: ABO blood grouping in humans.

INHERITANCE OF TWO GENES :-

LAW OF INDEPENDENT ASSORTMENT :- The law states that "When hybrid possessing two (or more) pairs of contrasting factors (alleles) forms gametes, the factors in each pair segregate independently of the other pair".



CHROMOSOMAL THEORY OF INHERITANCE :- Chromosome as well as gene both occurs in pair

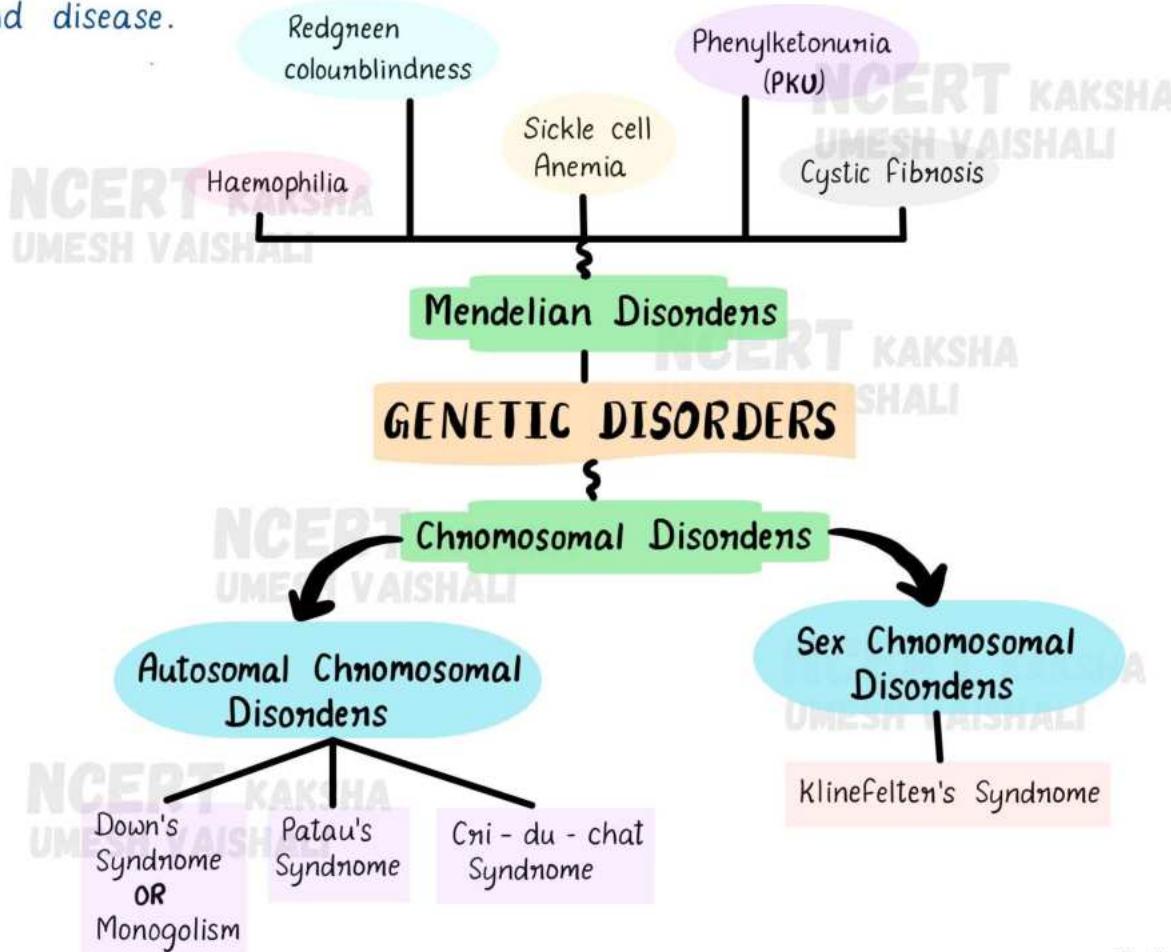
The two alleles of a gene pair are located on the same locus on homologous chromosomes. Sutton and Boveri argued that the pairing and separation of a pair of chromosomes would lead to segregation of pair of factors (gene) they carried. Sutton united the knowledge of chromosomal segregation with mendelian principles and called it the chromosomal theory of inheritance.

→ **MULTIPLE ALLELES** :- When more than two allelic form of wild type are located on the same locus in a given pair of chromosomes, they are known to compose the series of multiple alleles.

→ **PLEIOTROPY** :- Responsibility of a single gene for more than one phenotypic effect, often seemingly unrelated is known as pleiotropy.

→ **MUTATION** :- Mutation a phenomenon which results in alteration of DNA sequence and consequently results in the change in the genotype and phenotype of an organism. The mutations that arise due to change in single base pair of DNA are called **point mutation** e.g Sickle cell anaemia.

→ **PEDIGREE ANALYSIS** :- The analysis of traits in several of generation of a family is called the **pedigree analysis**. The inheritance of a particular trait is represented in family tree over several generations. It is used to trace the inheritance of particular trait, abnormality and disease.



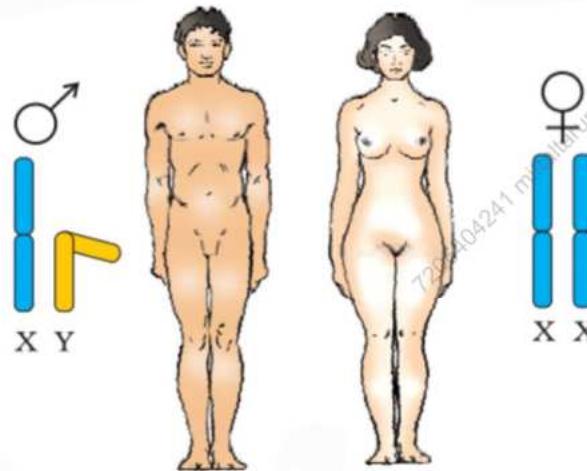
→ SEX DETERMINATION :-

1) IN HUMAN BEINGS :-

- The chromosomal mechanism of sex-determination is of **XX-YY** type.
- The human nucleus of each cell contains 46 chromosomes or 23 pairs of chromosomes. Of these 23 pairs are **autosomes**.
(Responsible for determination of body characters) and 1 pair is of **sex chromosomes**.
- (Responsible for determination of sex).
- In female two homomorphic sex chromosomes are **XX** & in male two heteromorphic sex chromosomes are **XY**. Thus the genotype of female and male is.

Female - 46 chromosomes = 44 Autosomes + XX (sex chromosomes)

Male - 46 chromosomes = 44 Autosomes + XY (sex chromosomes)

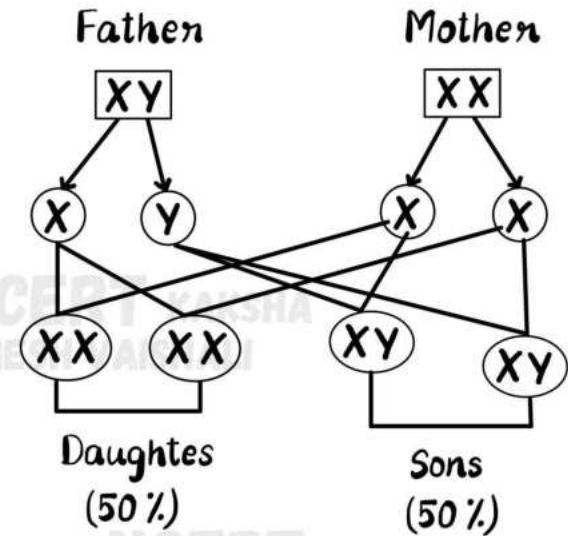


Sex Determination in humans

2) MECHANISM OF SEX DETERMINATION :-

- During gamete formation the diploid germ cells in the testes and ovaries undergo meiosis to produce haploid gametes (Sperm & eggs).
- The human male is heterogametic and produces two types of sperm - one type of sperm contains 22 autosomes and one X-chromosome and the other type of sperm contains 22 autosomes and one Y-chromosome.
- The human female is homogametic and produces only one type of eggs containing 22 autosomes and one X-chromosome.
- During fertilization if X-containing sperm fertilizes the egg having X-chromosome then resulting offspring with XX chromosome is a female.

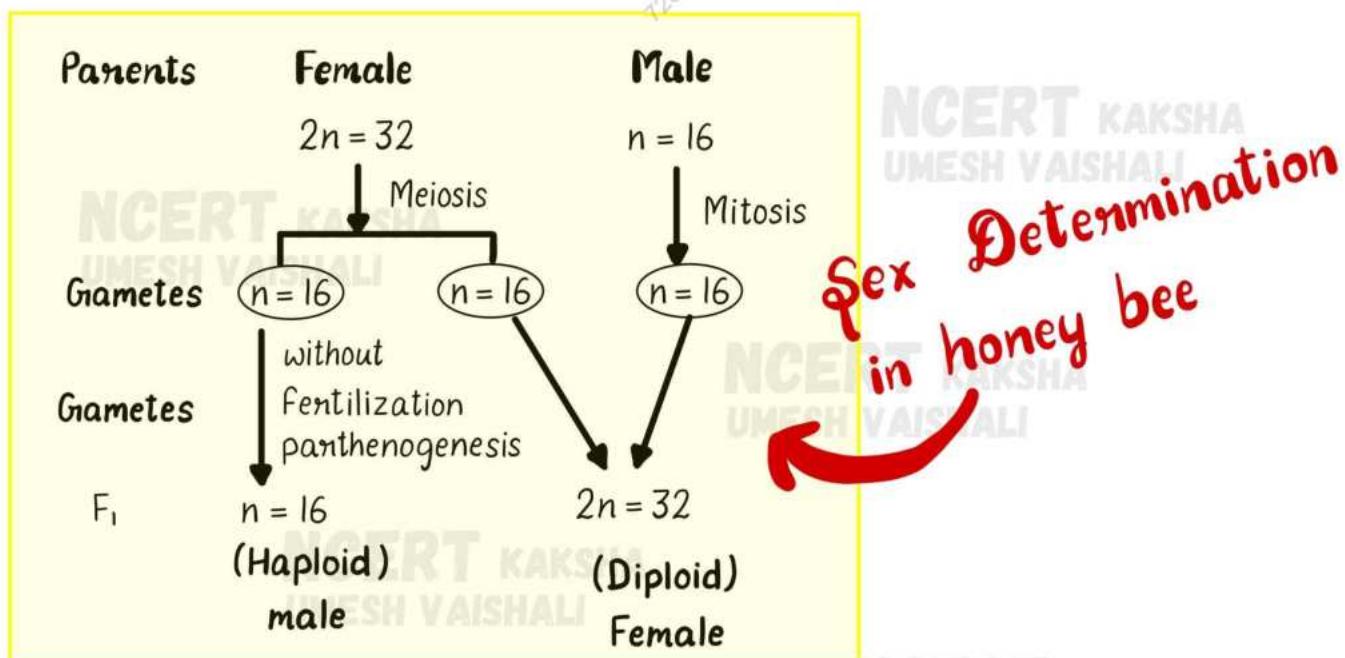
- IF Y-containing sperm fertilizes the egg having X-chromosome then resulting offspring with XY chromosome is a male.
- This indicates that the sex of the child depends on the types of sperm fertilizing the egg and thus the father is responsible for sex of the child and not the mother
- Chromosomal mechanism of sex determination is called heterogamety. It may be male heterogamety or female is heterogamety.



IN HONEY BEES :- In honey bees, chromosomal mechanism of sex determination is haplo-diploid type.

In this type, sex of individual is determined by the number of sets of chromosomes received. **Females** are **diploid** ($2n=32$) and **males** are **haploid** ($n=16$). Female produces haploid eggs ($n=16$) by meiosis & male produces haploid sperms ($n=16$) by meiosis.

If the egg is fertilized by sperm, the zygote develops into a diploid female ($2n=32$) (queen and workers) and unfertilised egg develops into haploid male ($n=16$) (Drone) by way of **parthenogenesis**.



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Molecular Basis of Inheritance

→ The DNA :-

Structure OF Polynucleotide Chain :-

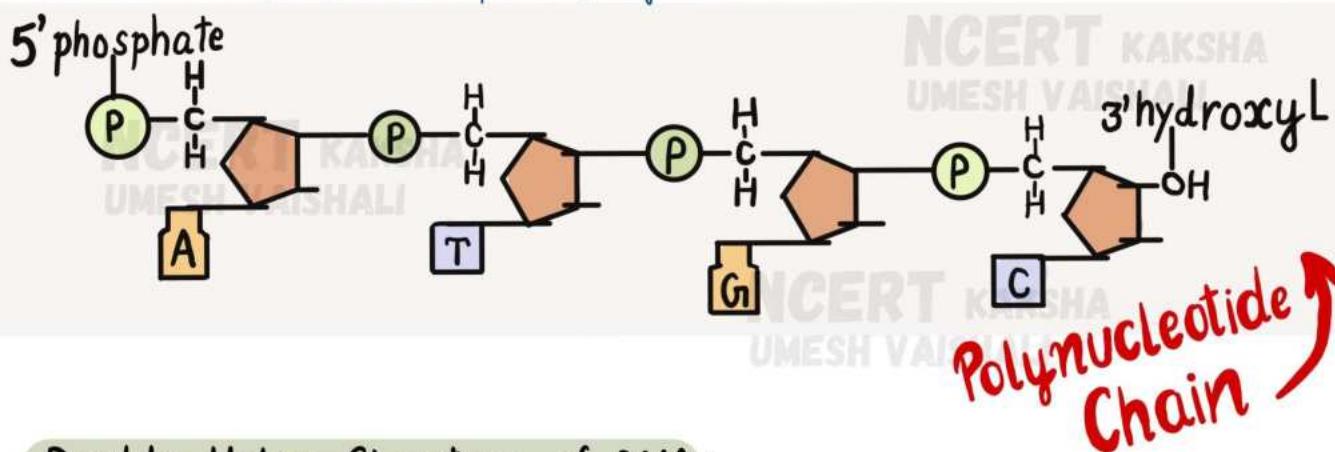
- A nucleotide has three components – a nitrogenous base, a pentose sugar (ribose in case of RNA, and deoxyribose for DNA), and a phosphate group. There are two types of nitrogenous bases – Purines (Adenine and Guanine), and pyrimidines (Cytosine, Uracil and Thymine).

Cytosine is common for both DNA and RNA and thymine is present in DNA.
Uracil is present in RNA at the place of thymine.

A Polynucleotide Chain

A nitrogenous base is linked to pentose sugar with N-glycosidic linkage to form a nucleoside. When phosphate group is linked 5'-OH of a nucleoside through phospho-ester linkage nucleotide is formed. Two nucleotides are linked through 3'-5' phosphodiester linkage to form dinucleotide. More nucleotide joins together to form polynucleotide.

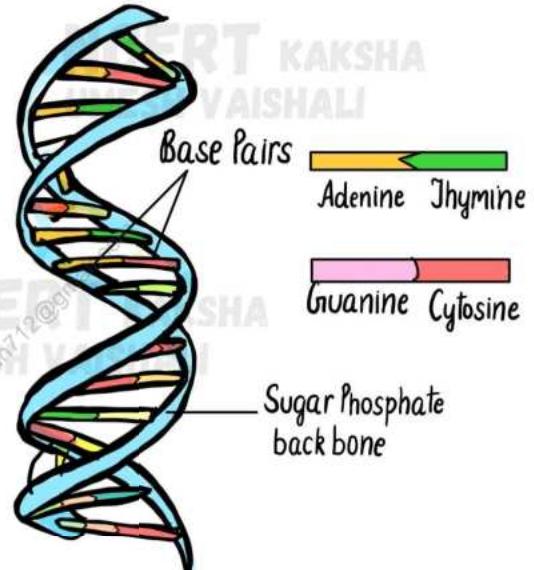
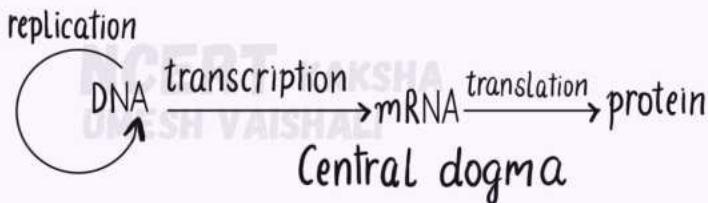
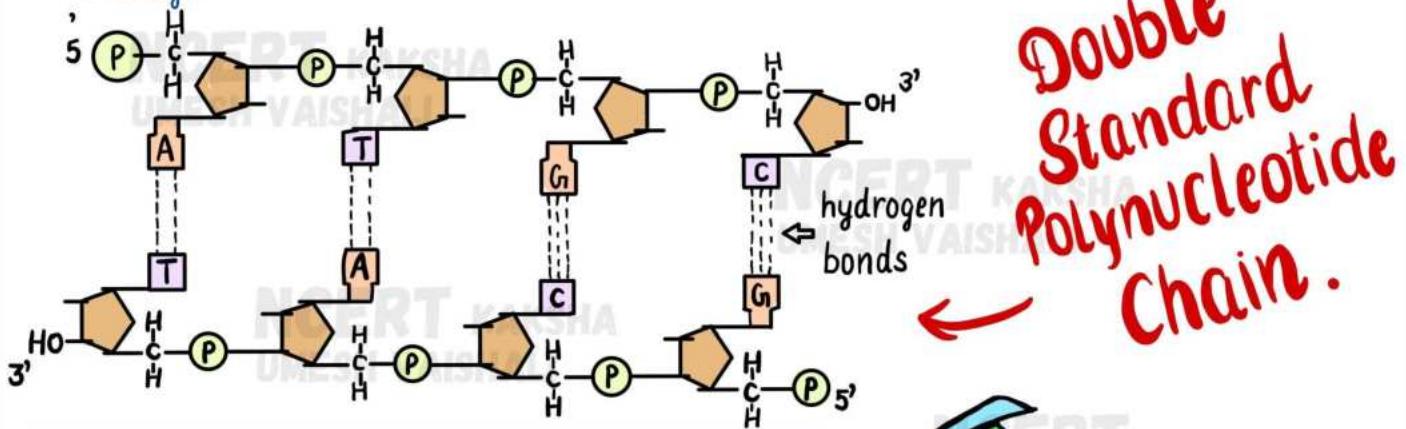
In RNA, nucleotide residue has additional -OH group present at 2'-position in ribose and uracil is found at the place of thymine.



Double Helix Structure of DNA :-

- DNA is made of two polynucleotide chains in which backbone is made up of sugar-phosphate and bases projected inside it.
- Two chains have anti-parallel polarity. One 5' to 3' and with 3' to 5'.
- The bases in two strands are paired through H-bonds. Adenine and Thymine forms double hydrogen bond and guanine and Cytosine forms triple hydrogen bonds.
- Two chains are coiled in right handed fashion. The pitch of helix is 3.4 nm and roughly 10 bp in each turn.

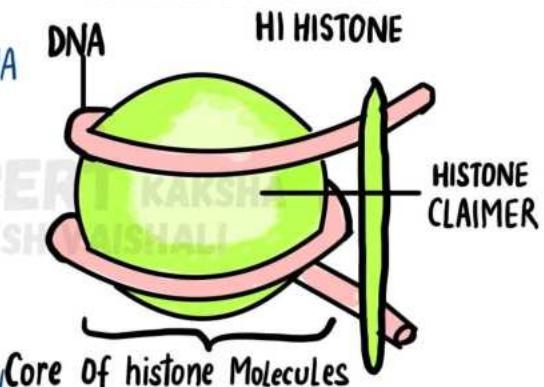
- The plane of one base pair stacks over the other in double helix to confer stability.



DNA double helix

Packaging OF DNA helix :-

- Distance between two consecutive base pairs in a DNA = $0.34\text{ nm} = 0.34 \times 10^{-9}\text{ m}$.
- Total number of base pairs in a human DNA = $6.6 \times 10^9\text{ bp}$.
- Total length of human DNA = $0.34 \times 10^{-9} \times 6.6 \times 10^9 = \sim 2.2\text{ m}$.
- 2.2 m is too large to be accommodated in the nucleus (10^{-6} m).
- Organisation of DNA in prokaryotes:
 - They do not have nucleus. DNA is scattered.
 - In certain regions called nucleoids, DNA (negatively charged) is organised in large loops and is held by some proteins (positively charged).
- Organisation of DNA in eukaryotes:
 - They have positively charged basic proteins called histones (positive and basic due to presence of positive and basic amino acid residues, lysine and arginine).
 - Histone octamer - Unit of eight molecules of histone.
 - DNA (negatively charged) winds around histone octamer (positively charged) to form



nucleosome.

- 1 nucleosome has approx. 200 bp of DNA.
- Nucleosomes in a chromatin resemble beads present on strings.
- Beads on string structure in chromatin are further packaged to form chromatin fibres, which further coil and condense to form chromosomes during metaphase.
- Non-histone chromosomal proteins - Additional set of proteins required for packaging of chromatin at higher level.

→ The Search for Genetic Material :-

Transforming Principles :-

- Griffith performed experiments with the bacteria *Streptococcus pneumoniae*. This bacterium has two strains S-strain and R-strain.

S strain bacteria	R Strain Bacteria
<ul style="list-style-type: none">• Produce smooth colonies on culture plate.• Have a polysaccharide coat.• Virulent (causes pneumonia)	<ul style="list-style-type: none">• Produce rough colonies on culture plate.• Do not have a polysaccharide coat.• Non-virulent (does not cause pneumonia).

Griffith Experiment :-

S strain (heat-killed) + R strain (Live) → Inject into mice → mice die

Griffith concluded that R strain bacteria have somehow transformed by heat killed S strain bacteria. Some transforming principles transferred from S strain to R strain and enabled the R strain to synthesise a smooth polysaccharide coat and become virulent. This must be due to the transfer of the genetic material.

→ Biochemical Characterisation of Transforming Principle :-

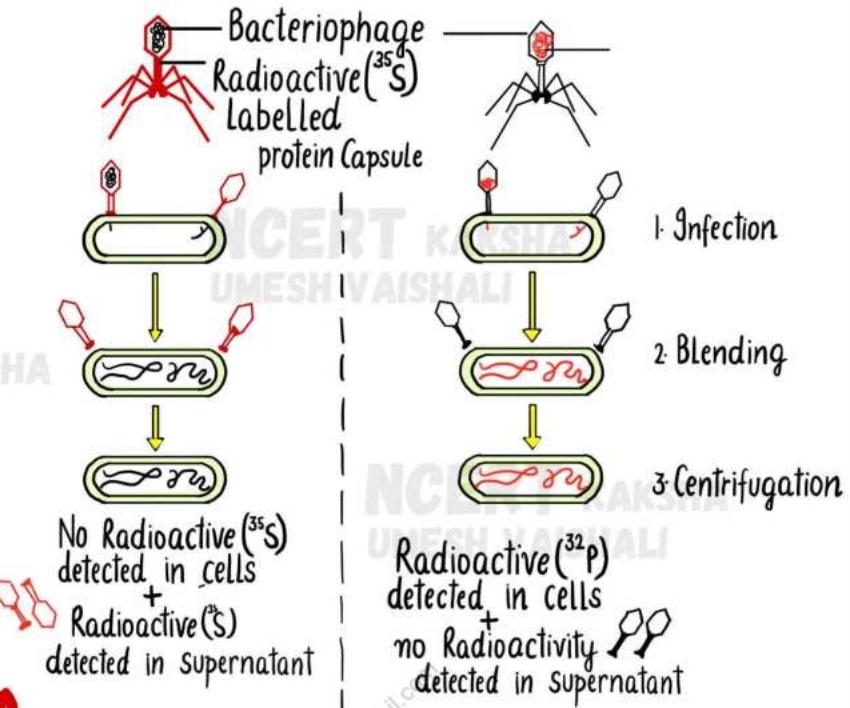
- **Oswald Avery, Colin Macleod and Maclyn McCarty** worked out to determine the biochemical nature of transforming principle of Griffith.
- They purified bio-chemicals (proteins, DNA, RNA, etc) from the heat killed S cells to see which ones could transform live R cells into S cells. They discovered that DNA alone from S bacteria caused R bacteria to become transformed. So, they concluded that DNA is the genetic material.

→ The Genetic material is DNA :-

- In one preparation, the protein part was made radioactive and in the other nucleic acid (DNA) was made radioactive. These two phage preparations were allowed to infect the culture of *E. coli*. Soon after infection, before lysis of cells, the *E. coli* cells were gently agitated in a blender, to loosen the adhering phage particles and the culture was centrifuged.

- The heavier infected bacterial cells pelleted to the bottom and the lighter viral particles were present in the supernatant. It was found that when bacteriophage containing radioactive DNA was used to infect E.coli, the pellet contained radioactivity.
- If bacteriophage containing radioactive protein coat was used to infect E.coli, the supernatant contained most of the radioactivity.

The Hershey Chase Experiment



Properties Of Genetic Material (DNA versus RNA)

Properties Of Genetic Material :-

- It should be able to generate its replica.
- It should chemically and structurally be stable.
- It should provide the scope for slow changes (mutation) that are required for evolution.
- It should be able to express itself in the form of 'Mendelian Characters'.

→ RNA World :-

RNA was the first genetic material. There is now enough evidence to suggest that essential life processes (such as metabolism, translation, splicing etc.) evolved around RNA. RNA used to act as a genetic material as well as a catalyst (there are some important biochemical reactions living systems that are catalysed by RNA catalysts and not by protein enzymes).

→ Replication :-

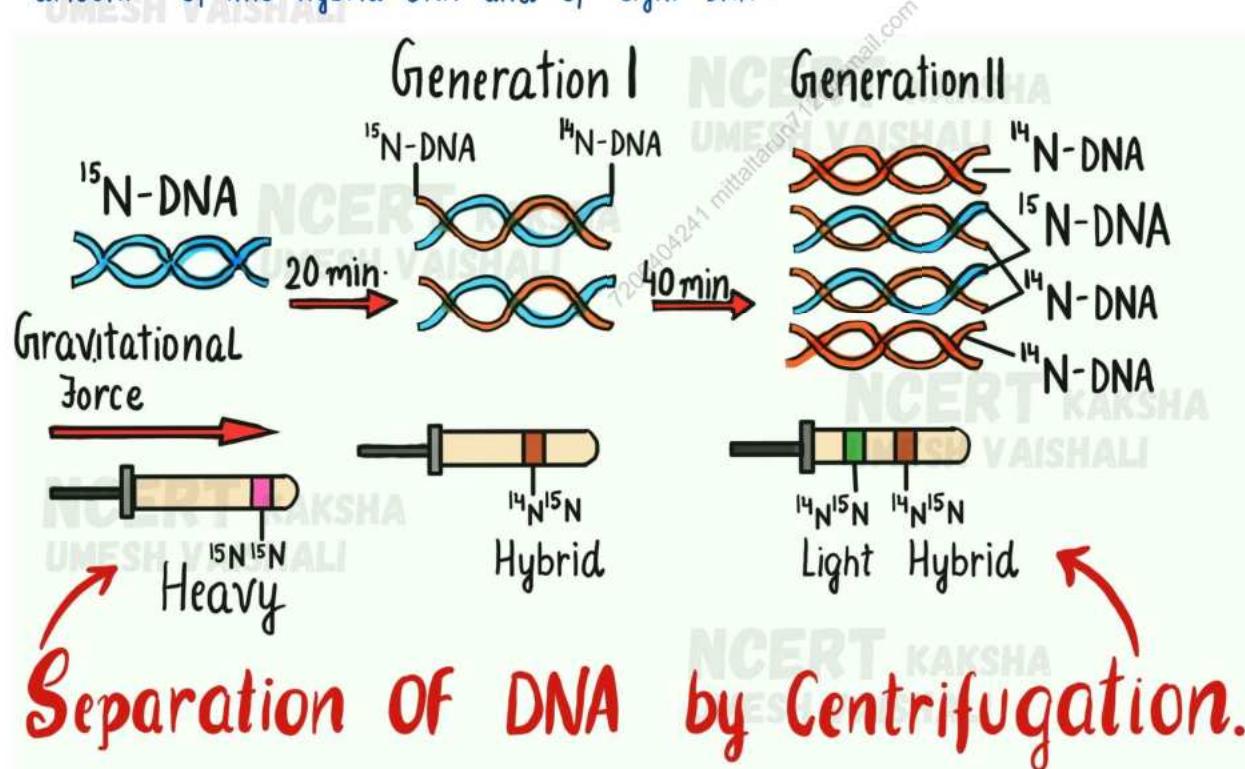
The experiment Proof :-

Matthew Meselson and Franklin Stahl performed the following experiment in 1958.

- They grew E.coli in a medium containing ¹⁵NH₄Cl (¹⁵N is the heavy isotope of nitrogen) as the only nitrogen source for many generations. The result was that ¹⁵N was incorporated into newly synthesised DNA (as well as other

nitrogen containing compounds). This heavy DNA molecule could be distinguished from the normal DNA by centrifugation in a cesium chloride (CsCl) density gradient. Please note that ^{15}N is not the radioactive isotope, and it can be separated from ^{14}N only based on densities.

- Then they transferred the cells into a medium with normal $^{14}\text{NH}_4\text{Cl}$ and took samples at various definite time intervals as the cells multiplied and extracted the DNA that remained as double-stranded helices. The various samples were separated independently on CsCl gradients to measure the densities of DNA.
- Thus, the DNA that was extracted from the culture one generation after the transfer from ^{15}N medium (that is after 20 minutes; $E. coli$ divides in 20 minutes) had a hybrid or intermediate density. DNA extracted from the culture after another generation [that is after 40 minutes. II generation] was composed of equal amount of this hybrid DNA and of 'Light' DNA.



The Machinery and the enzymes :-

- Replication occurs in S phase of cell cycle.
- Enzyme involved - DNA polymerase (DNA dependent DNA polymerase)
- Replication requires energy.
- Source of energy - Deoxyribonucleoside triphosphates (DNTPs).
- DNTPs have dual purpose - Act as substrates and provide energy also.
- Replication initiates at specific regions in DNA called origin of replication.
- DNA polymerase polymerises a large number of nucleotides in a

Very short time.

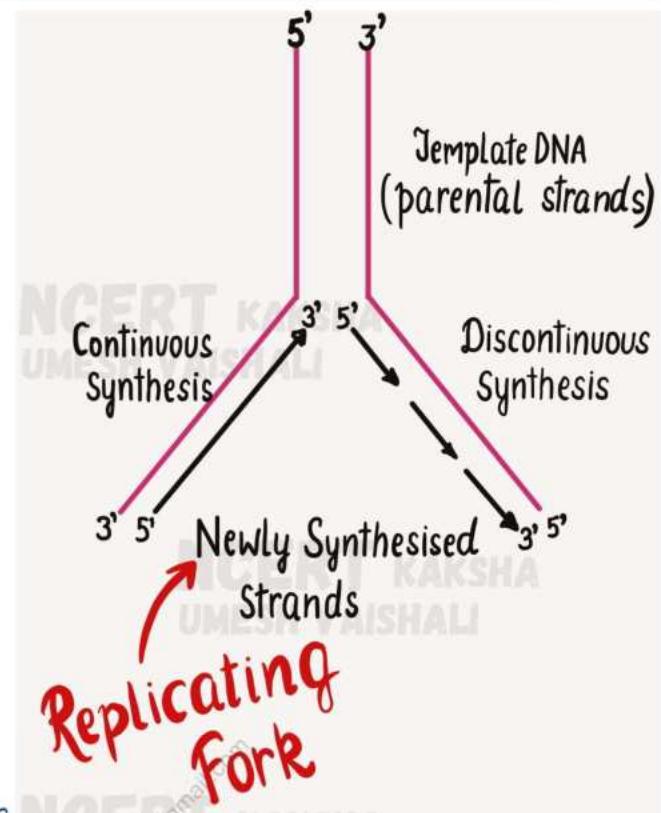
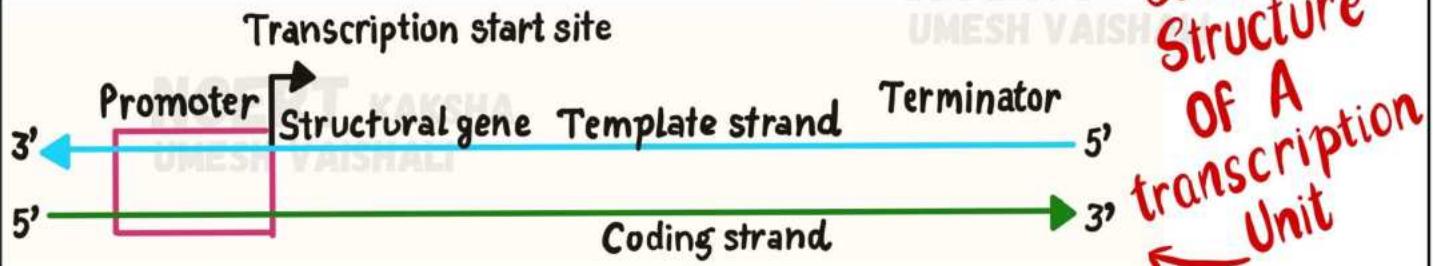
- During the course of replication, two parent strands do not completely open, but a small openings form in which replication occurs. This small openings forms a replication fork.
- DNA polymerase can polymerise only in one direction that is $5' \rightarrow 3'$.
- Therefore, replication occurs smoothly at $3'$ to $5'$ end of DNA. Continuous replication, but occurs discontinuously at $5'$ to $3'$ end).
- The discontinuous fragments so formed are joined by DNA ligase.

→ Transcription :-

- The process of copying of genetic information from one strand of DNA into a single stranded RNA called transcription.
- DNA is located in the nucleoid of prokaryotic cells in nucleus of Eukaryotic cell.
- DNA transcription takes place in nucleus and translation occurs in cytoplasm.
- DNA has promoter and terminator sites. Transcription start at promoter site and stop at terminator site.
- Transcription in both prokaryotic and Eukaryotic cell involves three stages :-
 - Initiation
 - Elongation
 - Termination

Transcriptional Unit :-

- A transcriptional unit has primarily three regions :-
 - Promoter - Marks the beginning of transcription; RNA polymerase binds here.
 - Structural gene - Part of the DNA that is actually transcribed.
 - Terminator - Marks the end of transcription.



Transcription unit And the Gene :-

Cistron is a segment of DNA coding for a polypeptide.

When a single structural gene in transcriptional unit is said to be **monocistronic**.

Where as long segment of DNA having set of various structural gene is referred as **polycistronic**.

Structural gene in Eukaryotes have interrupted non-coding sequence (**Introns**) and having coding sequence called (**exons**).

So that the Introns removed by following process and result in formation of hnRNA.

Types of RNA And The Process of Transcription:-

- Transcription has three steps-initiation, elongation and termination.

- Initiation :

- RNA polymerase binds with the promoter to initiate the process of transcription.
- Association with initiation factor (σ) alters the specificity of RNA polymerase to initiate the transcription.

- Elongation :

- RNA polymerase uses nucleotide triphosphate as substrate, and polymerisation occurs according to complementarity.

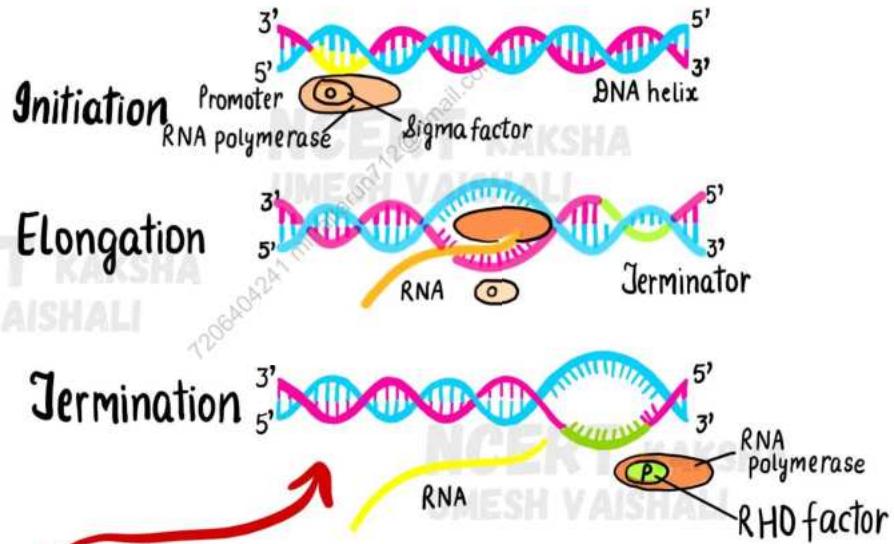
- Termination :

- Termination occurs when termination factor (P) alters the specificity of RNA polymerase to terminate the transcription.

- As the RNA polymerase proceeds to perform elongation, a short stretch of RNA remains bound to the enzyme. As the enzyme reaches the termination region, this nascent RNA falls off and terminated.

→ Genetic Code :-

- Genetic code is the relationship of amino acids sequence in a polypeptide and nucleotide/base sequence in mRNA. It directs the sequence



Process Of Transcription in Bacteria

of amino acids during synthesis of proteins.

- **George Gamow** suggested that genetic code should be combination of 3 nucleotides to code 20 amino acids.
- **H.G. Khorana** developed chemical method to synthesising RNA molecules with defined combination of bases.
- **Marshall Nirenberg's** cell free system for protein synthesis finally helped the code to be deciphered.

Salient features OF Genetic Code are:-

- The code is triplet. 61 codons code for amino acids and 3 codons do not code for any amino acids called stop codon (UAG, UGA and UAA).
- Codon is unambiguous and specific, code for one amino acid.
- The code is degenerate. Some amino acids are coded by more than one codon.
- The codon is read in mRNA in a contiguous fashion without any punctuation.
- The codon is nearly universal. AUG has dual functions. It codes for methionine and also act as initiator codon.

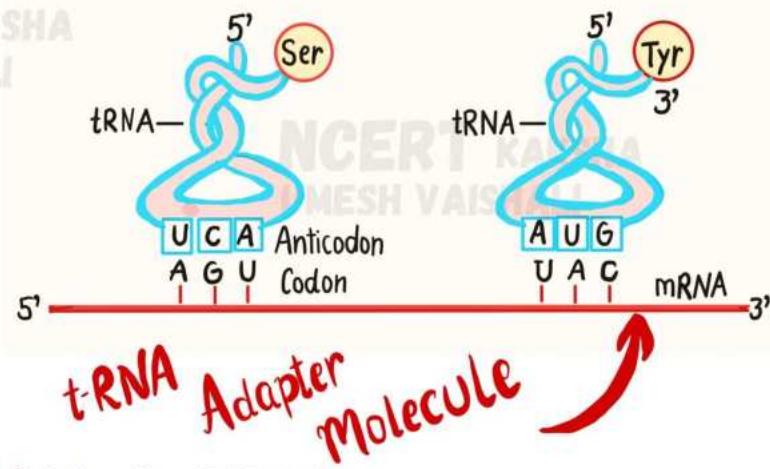
Mutations And Genetic code :-

A change of single base pair (point mutation) in the 6th position of Beta Globin chain of Haemoglobin results due to the change of amino acid residue glutamate to valine. These results into diseased condition called sickle cell anaemia.

Insertion and deletion of three or its multiple bases insert or delete one or multiple codons hence one or more amino acids and reading frame remain unaltered from that point onwards. Such mutations are called frame-shift insertion or deletion mutations.

t-RNA - the adapter Molecule :-

The t-RNA called as adapter molecules. It has an anticodon loop that has bases complementary to code present on mRNA and also has amino acid acceptor to which amino acid binds. t-RNA is specific for each amino acids.



The secondary structure of t-RNA is depicted as clover-leaf. In actual structure, t-RNA is a compact molecule which looks like inverted L.

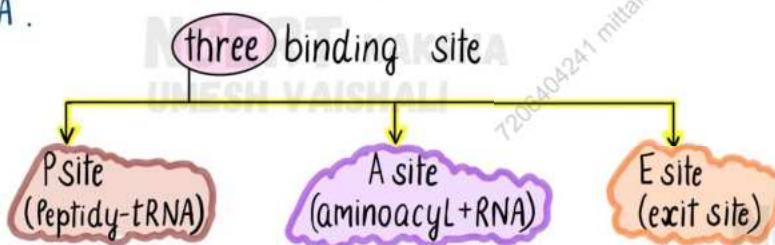
→ Translation :-

- Translation is the process in which translating the sequence of m-RNA to sequence of Amino Acid.
- Process of translation requires amino acids mRNA, tRNA, Ribosomes, ATP, Mg^{++} ions enzymes.
- About 20 different types of amino acids are known to form proteins.
- RNA serve as intermediate molecules between DNA and Protein.

DNA $\xrightarrow{\text{transcription}}$ mRNA $\xrightarrow{\text{translation}}$ Polypeptide.

- Ribosome serve as site for protein synthesis
Ribosome consist of two subunit $\begin{cases} \text{Large} \\ \text{Small} \end{cases}$

- These occur separately to cytoplasm only during protein synthesis
these two subunit get associated together.
- A ribosome has one binding site for m-RNA and three binding site for t-RNA.



Regulation OF Gene Expression:-

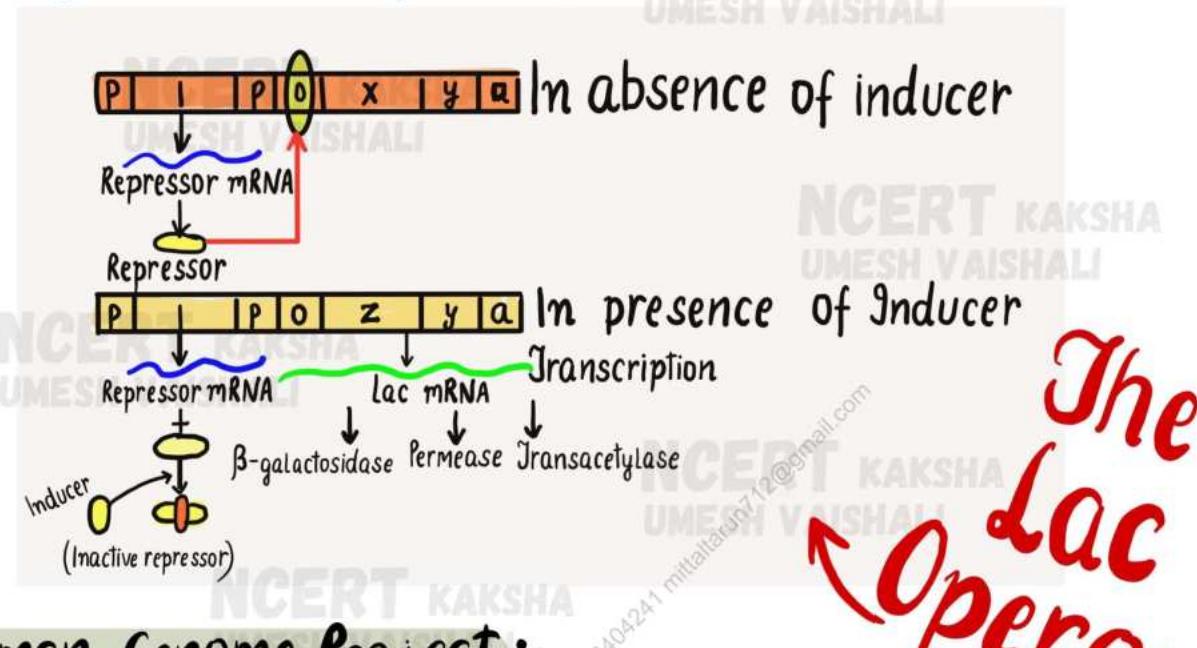
All the genes are not needed constantly. The genes needed only sometimes are called regulatory genes and are made to function only when required and remain non-functional at other times. Such regulated genes, therefore required to be switched 'on' or 'off' when a particular function is to begin or stop.

The Lac Operon :-

Lac operon consists of one regulatory gene (*i*) and three structural genes (*y, z* and *a*). Gene *i* code for the repressor of the Lac operon. The *z* gene code for beta-galactosidase, that is responsible for hydrolysis of disaccharide, lactose into monomeric units, galactose and glucose. Gene *y* code for permease, which increases permeability of the cell. Gene *a* encode for transacetylase.

Lactose is the substrate for enzyme beta-galactosidase and it regulates switching on and off of the operon, so it is called inducer.

- Regulation of LAC operon by repressor is referred as negative regulation. Operation of Lac operon is also under the control of positive regulation.
- Human Genome Project was launched in 1990 to find out the complete DNA sequence of human genome using genetic engineering technique and bioinformatics to isolate and clone the DNA segment for determining DNA segment for determining DNA sequence.



The Lac Operon

Human Genome Project:

- The human genome project (HGP) was initiated in 1990. This project was co-ordinate by the US department of energy and national institute of health.
- This project had a 15 year plan but completed in 13 years (1990 to 2003).
- In the HGP, 26 countries participated.
- By human genome project we identify and map originally **80,000 - 100,000 genes**. In human beings scientist have indicated that the actual no. of the human gene may be **20,000 to 25,000**.
- The complete sequence of human genome has been described as the "**blue print of humanity**".

Goals Of HGP:

- Identify all the approximately 20,000 - 25,000 genes in human DNA.
- Determine the sequences of the 3 billion chemical base pairs that make up human DNA.
- Store this information in databases;
- Improve tools for data analysis;

- Transfer related technologies to other sectors, such as industries;
- Address the ethical, legal and social issues (ELSI) that may arise from the project.

Salient features of Human Genome :-

- The human genome contains 3164.7 million bp.
- The average gene consists of 3000 bases, but sizes vary greatly, with the largest known human gene being dystrophin at 2.4 million bases.
- The total number of genes is estimated at 30,000 - much lower than previous estimates of 80,000 to 1,40,000 genes. Almost all (99.9 percent) nucleotide bases are exactly the same in all people.
- The functions are unknown for over 50 percent of the discovered genes.
- Less than 2 percent of the genome codes for proteins.
- Repeated sequences make up very large portion of the human genome.
- Chromosome 1 has most genes (2968) and the Y has the fewest (231).
- Scientists have identified about 1.4 million locations where single base DNA differences (**SNPs - Single nucleotide polymorphism** pronounced as snips) occur in humans. This information promises to revolutionise the processes of finding chromosomal locations for disease-associated sequences and tracing human history.

→ DNA Fingerprinting :-

- DNA fingerprinting is a very quick way to compare the DNA sequence of any two individuals. It includes identifying differences in some specific region in DNA sequence called as repetitive DNA because in this region, a small stretch of DNA is repeated many times.
- Depending upon the base composition, length of segment and number of repetitive units satellite DNA is classified into many categories.
- Polymorphism in DNA sequence is the basis for genetic mapping of human genome as well as fingerprinting.
- The technique of fingerprinting was initially developed by Alec Jeffreys. He used a satellite DNA as probe to so high polymorphism was called Variable Number of Tendon Repeats (VNTR).

UNIT-II (GENETICS AND EVOLUTION)

CHAPTER - 6

Evolution

→ ORIGIN OF LIFE :-

- ★ The origin of life is considered unique events in the history of universe. Huge cluster of galaxies comprises the universe. Galaxies contain stars and clouds of dust and smoke.
- ★ Big Bang Theory attempts to explain the origin of universe. According to this theory, a huge explosion occurs that forms the different galaxies.
- ★ In solar system of milky way galaxies, earth has been supposed to be formed about 4.5 billion years ago. There was no atmosphere in early earth. Water vapour, methane, carbon dioxide and ammonia released from molten mass covered the earth surface.
- ★ UV rays from sun splits the water into hydrogen and oxygen. Life appeared 500 million years after the formation of earth.

→ THEORIES OF REGARDING THE ORIGIN OF LIFE AN EARTH :-

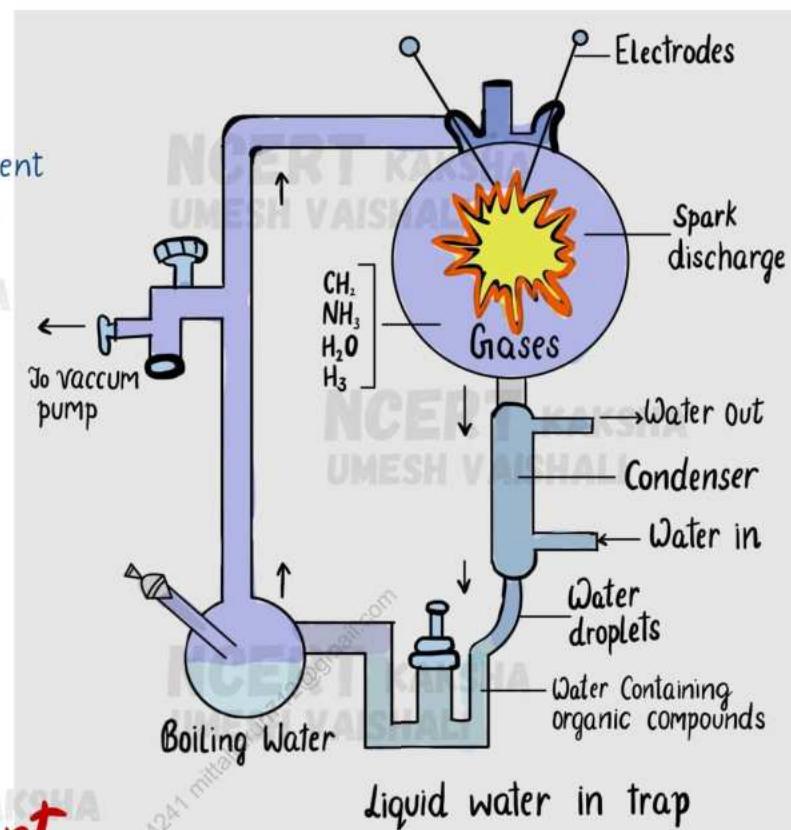
- Some scientist believes that life comes from other planets. Early Greek thinker thoughts that unit of life is called sponges transferred from other planets.
- According to other theory, life comes out of dead and decaying matters like straw and mud. This theory is called theory of spontaneous origin.
- Louis Pasteur experimentally proved that life arises only from pre-existing life. Spontaneous theory of origin of life is dismissed after that.
- Oparin and Haldane proposed that the first form of life could have come from pre-existing non-living organic molecules like RNA and protein etc. The formation of life preceded by chemical evolution. At that time condition on earth were - high temperature, volcanic eruption, reducing atmosphere containing CH_4 and NH_3 .

→ MILLER EXPERIMENT OF ORIGIN OF LIFE :-

- ÷ S.L. Miller in 1953, conducted an experiment to show the origin of life on earth in the physical environment similar to condition prevails at that time.

- Millen created similar condition of temperature and pressure in laboratory scale. He created electric discharge in a flask containing CH_4 , H_2 and NH_3 and water vapour at 800°C.
- He observed formation of amino acids in flask after 15 days of electric discharge. Similar experiment by other scientist found formation of sugars, nitrogen bases, pigment and fats.
- Analysis of meteorite content also reveals similar compounds that reveal that similar process are occurring elsewhere in the space. This experimental evidence about the origin of life is called chemical evolution of life.

Miller Experiment



→ EVIDENCES OF EVOLUTION :-

PALEONTOLOGICAL EVIDENCE :-

Different aged rock sediments contain fossils of different life forms that probably died during the formation of particular sediment. Fossils are remains of hard part of life-forms found in rocks. The study showed that different from varied over time and certain life forms are restricted geological time span. Hence, new forms of life have arisen at different times in history of earth.

HOMOLOGOUS ORGANS :-

those organs that perform different function but have similar origin and structure are called homologous organs. For example human, cheetah, bat and whales share similarities in pattern of bones of forelimbs although these forelimbs perform different functions in these animals. In these animal similar structure developed along different directions due to adaptation of different needs. This is called divergent evolution.

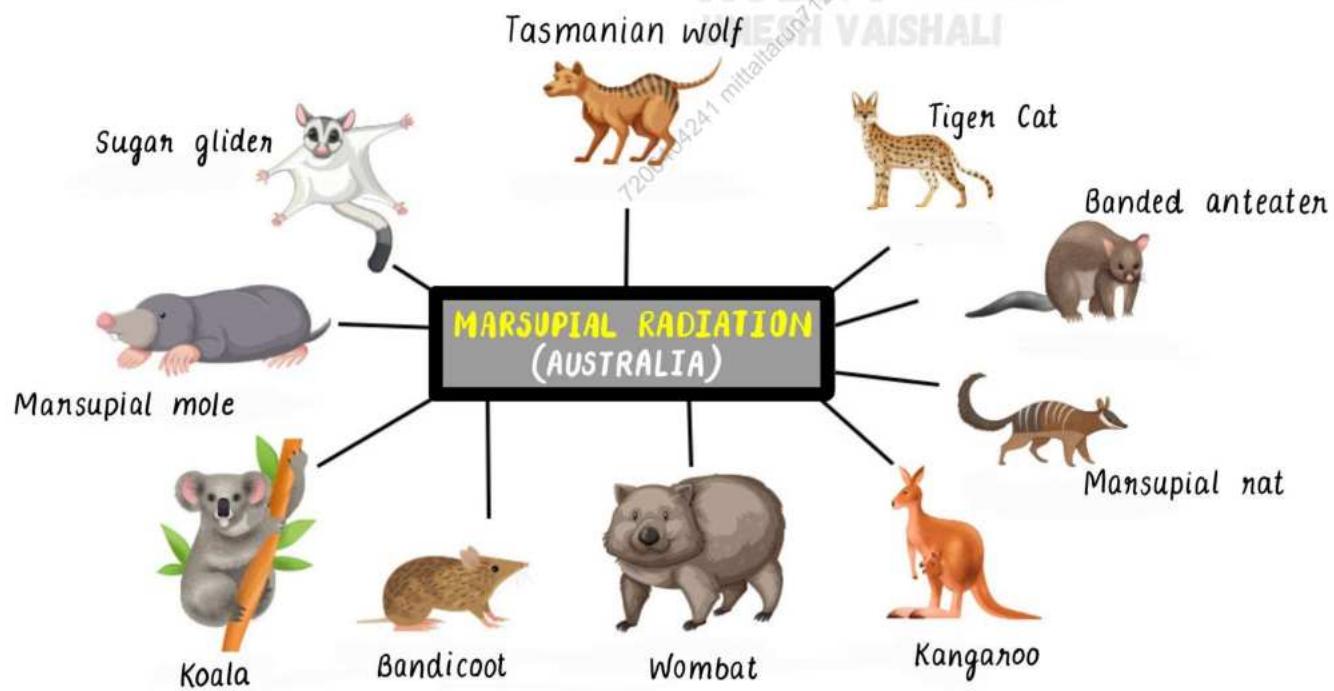
→ NATURAL SELECTION :-

Natural selection operates through differential reproduction and comparative reproductive success. Natural selection is of 3 types: **Stabilizing**, **Directional** and **Disruptive**

→ **SPECIATION** :- Speciation is the origin of new species. It may be gradual or abrupt. Gradual speciation is either **allopatric** (in different geographical areas) or **sympatric**. Abrupt speciation occurs either by mutations or hybridization followed by polyploidy.

→ **ANTHROPOLOGY** :- Anthropology is study of human evolution. It includes early human ancestors (like *Parapithecus*, *Dryopithecus* and *Ramapithecus*) and human types (like *Australopithecus*, *Homo habilis*, *H. erectus*, neandertal man, cro-magnon man and modern man. It included a number of morphological changes.

→ **ADAPTIVE RADIATION** :- Adaptive radiation show that different members of the same ancestral type are evolved along different lines in different habitats of the same area so are proofs of **divergent evolution**. These have been observed in Darwin's finches on Galapagos islands, marsupials in Australia and also found in eutherians on the basis of modification of limb structure and type of locomotion.



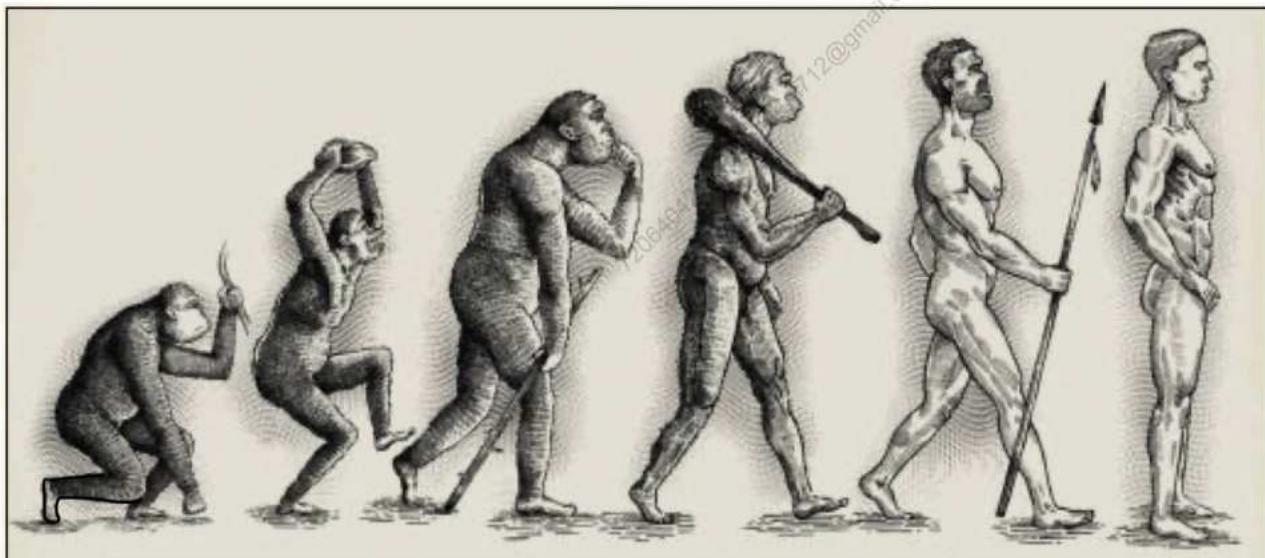
Adaptive Radiation of Marsupials of Australia

→ **BIOLOGICAL EVOLUTION** :- The nature for fittest and fitness is based on characteristics which are inherited. Some organisms are better adapted to survive in otherwise hostile environment. Fitness is the end result of the ability to adopt and get selected by nature.

animal. This process began in **Palaeocene** epoch. During this period, dwindling forests forced arboreal mammals to adapt to life on land. This descent must have been the driving force.

In the following chart it can be seen that we are most closely related to **gibbons**, **chimpanzees** and **gorillas**. The major evolutionary trends in transition from ape to man are considered further.

Special characteristics have been acquired by man in the course of evolution. Major changes that took place in evolution of man include increase in size and complexity of brain and enhanced intelligence, increase in cranial capacity, bipedal locomotion, opposable thumb, erect posture, shortening of forelimbs and lengthening of hind limbs, development of chin, broadening of pelvic girdle, development of lumbar curvature, social and cultural development (articulated speech, art, development of tools, etc).



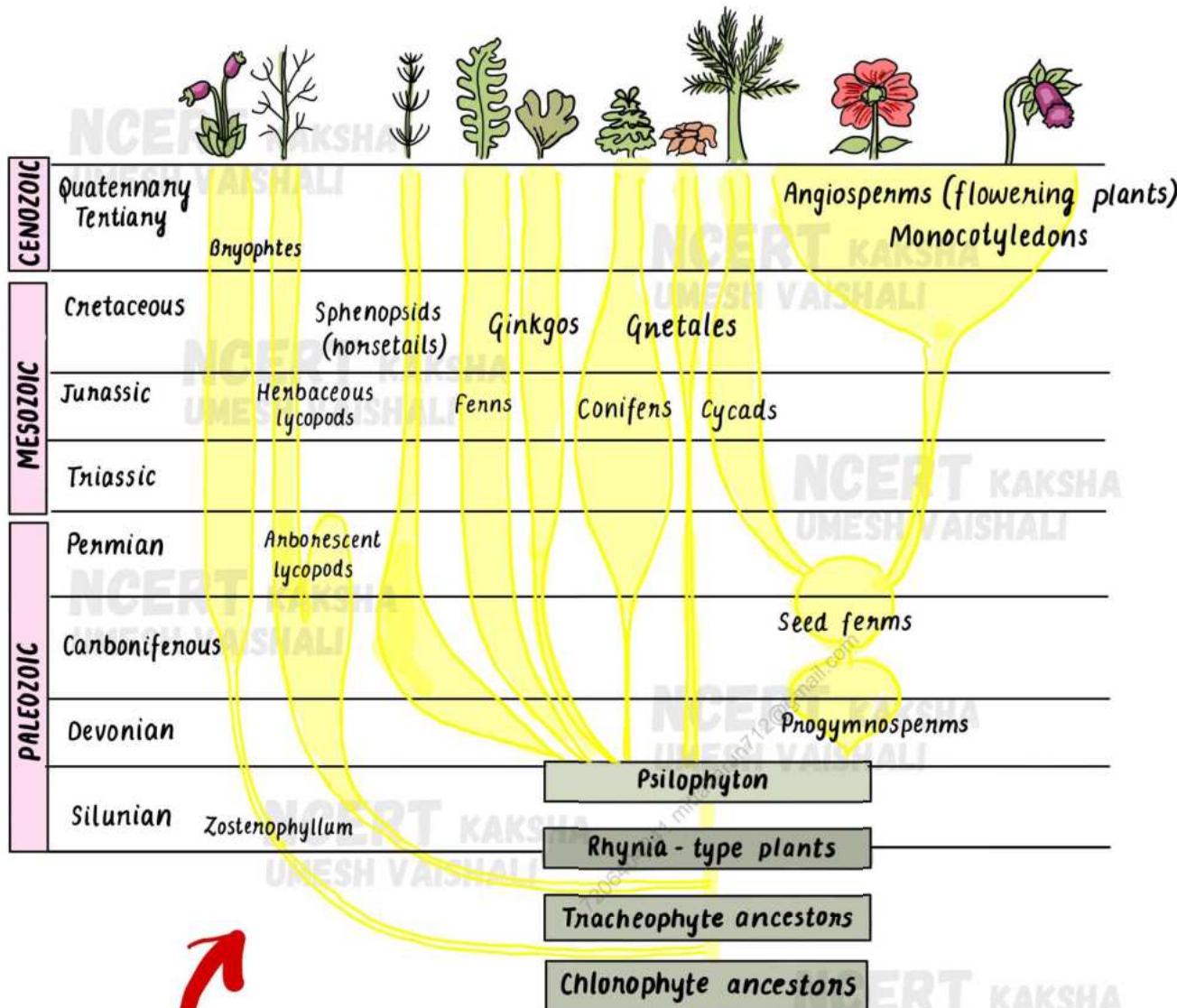
C Stages of Human Evolution

Cranial capacity of human begins increased over a period of time and large size of frontal lobe helped in development of high forehead.

Increase in intelligence necessitated physical development so that body and brain could be used effectively and productively.

Freedom of forelimbs from locomotory function and opposable thumb led to better utilization of hands for holding objects effectively and development of motor skills etc. Bipedal locomotion, upright posture coupled with stereoscopic vision helped man to move around safely on land.

Evolutionary history of man was traced with the help of fossil remains found over a period of time.



Evolution of Plants

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Human Health and Disease

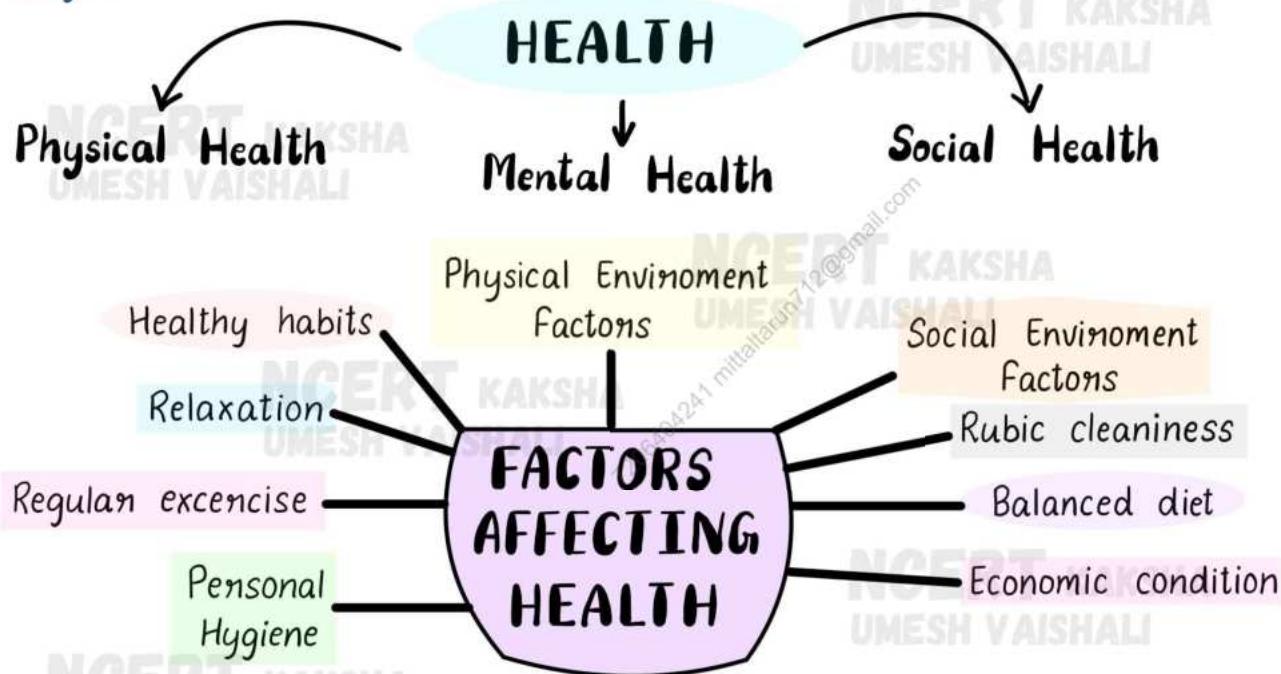
NOTE

World health organisation (WHO) [1948].

HEALTH :-

"Health is a state of complete physical, mental and social well being and not merely an "absence of disease" or "physical fitness".

Health is a state of body when all the organs and system are functioning properly and a perfect balance is maintained between the environment and the body".

**DISEASE :-**

Any condition which interferes with the normal functioning of the body and impairs the health is called disease.

NOTE

MALT	~ Mucosa associated lymphoid Tissue
AIDS	~ Acquired Immuno Deficiency Syndrome
HIV	~ Human Immuno Deficiency Syndrome
NACO	~ National AIDS control organisation
NGOs	~ Non-governmental organisation
CMI	~ Cell-mediated immunity

IMMUNITY :-

Immunity or disease resistance is the ability of an organism to resist the development of a disease. The study of immunity is called **immunology**, while the infected person with no disease is known as **immune**.

IMMUNITY

Inborn (Innate Immunity)

Acquired Immunity

- Active immunity
- Passive immunity

Inborn (Innate) Immunity	Acquired Immunity
<ul style="list-style-type: none"> ★ It is present from the birth. ★ It is inheritable immunity. ★ It is not acquired from the previous attack of disease. e.g., against distemper disease. 	<ul style="list-style-type: none"> ★ It is developed after the birth during one's own life. ★ It is not inheritable. ★ It is acquired in response to a disease or vaccine. e.g., against smallpox, polio, tetanus etc.

- **ALLERGY** :- Allergy is characterized by hypersensitivity of body of certain allergens. Histamine of mast cells induces allergy. Common types of allergy are : hay fever, asthma and anaphylactic shock.
- **AUTO IMMUNITY** :- If Autoimmunity, immune cells start killing certain body cells ("self"). Important autoimmune disease are : chronic anaemia, myasthenia gravis, chronic hepatitis, insulin - dependent diabetes, rheumatoid arthritis, etc.
- **IMMUNE SYSTEM IN THE BODY** :- The human immune system includes lymphoid organs, tissue, cells and soluble molecules like antibodies.

Lymphoid organs are the organs where origin and maturation and proliferation of lymphocytes occur. Primary lymphoid organs include bone marrow and thymus.

After maturation lymphocytes migrate to secondary lymphoid organ like spleen, lymph nodes, tonsils, peyer's patches of small intestine and appendix. They provide the sites for interaction lymphocyte with antigens.

There is lymphoid tissue also located within the lining of respiratory, digestive and urogenital tract called mucosal associated lymphoid tissue (MALT). It constitutes 50% of lymphoid tissues in human body.

→ COMMON DISEASE IN HUMANS :-

NAME OF DISEASE/ TEST	PATHOGEN EPIDEMIOLOG	CAUSAL ORGANISMS	SYMPTOMS	EFFECTS
Typhoid/ Widal test	direct and oral	Salmonella typhi	Sustained high fever, weakness, stomach pain,	
Pneumonia	Air borne OR droplet infection	Streptococcus pneumoniae and Haemophilus influenzae	Fever, chills, cough and headache.	Alveoli get filled with fluid leading to severe problems in respiration.
Common cold	Air borne OR droplet infection OR fomite borne	Rhinoviruses	Nasal congestion and discharge, sore throat, cough and headache.	Infect the nose and respiratory passage.
Malaria	By the bite of an infected mosquito	Plasmodium (P. vivax, P. malariae and P. falciparum)	The chill and high fever recurring 3 to 4 days	Parasite multiply within liver cells and then attack the RBCs.
Amoebiasis or Amoebic dysentery	direct and oral	Entamoeba histolytica	Constipation, abdominal pain, cramps, stool with mucous and blood clot.	Infect the large intestine.
Ascariasis	direct & oral	Ascaris (Helminthes)	Internal bleeding muscular pain, fever, anemia etc.	Healthy person get infected through water, vegetable etc.
Elephantiasis or filariasis	Indirect and inoculative	Wuchereria (W. bancrofti and W. malayi)	Inflammation in the lower limb and genital organs.	Lymphatic vessels of lower limbs get blocked.
Ring worms	Through contact with other persons OR from Trichophyton and soil OR fomite - borne	Microsporum, Trichophyton and Epidermophyton	Appearance of dry, scaly lesions on various part of body.	Infects the skin, nails and scalp.

→ AIDS :- (Acquired Immuno Deficiency Syndrome) was first reported in 1981. It is caused by HIV (human Immuno deficiency virus), a retrovirus.

Transmission of HIV occurs by -

- ★ Sexual contact with infect person
- ★ Transfusion of contaminated blood and blood products
- ★ Sharing infected needles as in intravenous drug abusers
- ★ Infected mother to her child through placenta.

AIDS/HIV does not spread by Physical contact, It spread only through body fluids. There is always time lag between infection and appearance of symptoms that may vary from 5-10 years.

Diagnostic test for AIDS is ELISA (enzyme-linked Immuno-sorbent assay). The treatment of this disease with anti-retroviral drug is partially effective and just prolonged the life but not prevents the death.

→ CANCER :- Cancer is one of the most dreaded diseases of human beings and is a major cause of death all over the world. Normal cells show a property called contact inhibition by virtue of which contact with other cells inhibit their uncontrolled growth. Cancer cells lost this property.

Cancerous cells continue to divide giving rise to masses of cells called tumors.

There are two kind so tumors - (a) Benign tumors
(b) Malignant tumors

→ CAUSES OF CANCER :- Cancerous neoplastic cell may be induced by physical, chemical and biological agents called carcinogens. Cancer causing viruses called oncogenic virus have gene called viral oncogenes. Several genes called cellular oncogenic (c-onc) or proto oncogenic have been identified in normal cells which, when activated under certain conditions, could lead to oncogenic transformation of the cells.

→ CANCER DETECTION AND DIAGNOSIS :- Cancer detection is based on biopsy and histopathological study of the tissues, blood and bone marrow test for increased cell counts. Radiography, CT (computer tomography), MRI (magnetic resonance imaging) are very useful to cancers of internal organs.

→ TREATMENT OF CANCER :-

- **Surgical** ~ cancerous tissues are surgically removed.
- **Radiotherapy** ~ tumor cells are irradiated lethally by radiation.
- **Chemotherapy** ~ drugs are used to kill cancerous cells, but shows side effects like hair loss, anemia, etc

► **Immunotherapy** ~ patients are given with alpha - interferon which activate their immune system and help in destroying the tumor.

DRUGS AND ALCOHOL ABUSE :- Commonly abused drugs include opioids, cannabinoids and coca alkaloids obtained from flowering plants and a few from fungi.

■ **OPIOIDS [HEROIN] -**

* **Source :** Acetylation of morphine extracted from the latex of poppy plants (*Papaver somniferum*)

* **Consumed by :** Snorting or injection

* **Properties :** White, bitter and odourless

* **Mode of action :** Binds to opioid receptors present in the CNS and GI tract

* **Effect :** It is a depressant; slows down body functions

■ **CANNABINOIDS -**

* **Source :** Inflorescences of the plant *Cannabis sativa*

* **Consumed by :** Inhalation or oral ingestion

* **Mode of action :** Binds to cannabinoid receptors present in the brain

* **Effect :** Affects the cardiovascular system

■ **COCAINE -**

* **Source :** Coca plant *Erythroxylum coca*, found in South America

* **Consumed by :** Snorting

* **Mode of action :** Interference with transfer of neurotransmitter, dopamine

* **Effect :** Stimulates the CNS, producing a sense of euphoria and increased energy, excessive dosages cause hallucination

→ **ADOLESCENCE AND DRUG ABUSE :-**

• Adolescence is the period during which the child becomes matured.

• It is between 12 - 18 years of age.

→ **CAUSES OF DRUG ABUSE :-**

* Curiosity * Excitement * Stress or pressure to excel in examination
* Adventure * Experimentation

→ **EFFECTS OF DRUG/ ALCOHOL ABUSE :-**

* Reckless behaviour * Violence
* Malicious mischief * Drop in academic performance
* Depression, isolation, aggressiveness, etc.

- **DEPENDENCE** :- Dependence is the tendency of the body to manifest a characteristic and unpleasant withdrawal syndrome if regular dose of drug/alcohol is abruptly discontinued that includes anxiety, shakiness, nausea and sweating.
- **PREVENTION** :- Prevention avoid undue peer pressure, education & counselling, seeking help from parents and peers, seeking professional and medical help etc.
- **ADDICTION** :- Addiction is physical and mental dependency of alcohol or tobacco on drugs. It causes many ill effects on individual's health, family and even society.

**SUCCESS is a
journey
not a
Destination**

**NCERT KAKSHA
UMESH VAISHALI**

Microbes in Human Welfare

→ **MICROBS** :- Microbes are microscopic organisms which perform all the metabolic activities like growth, metabolism, reproduction, etc. These include bacteria, cyanobacteria, mycoplasmas, a number of fungi like rust, smut, etc.; Protozoans, viruses, viroids and prions.

→ MICROBS IN HOUSEHOLD PRODUCTS :-

- ★ Microorganisms like Lactobacillus and others commonly called lactic acid bacteria (LAB) grow in milk and convert it to curd. The LAB produces acids that coagulate and partially digest the milk proteins. It also improves its nutritional quality by increasing vitamin B12. In our stomach too, the LAB play very beneficial role in checking disease causing microbes.
- ★ The dough is used for making food such as dosa and idli is fermented by bacteria. The Puffed-up appearance of dough is due to the production of CO₂ gas. The dough used for making bread is fermented using baker's yeast (*Saccharomyces cerevisiae*).
- ★ Cheese, is one of the oldest food items in which microbes were used. The large holes in 'Swiss cheese' are due to production of a large amount of CO₂ by a bacterium named *Propionibacterium shermanii*. The '**Roquefort cheese**' is ripened by growing a specific fungus on them for a particular flavour.

NOTE LAB = Lactic acid bacteria

→ MICROBS IN INDUSTRIAL PRODUCTS :-

- **FERMENTED BEVERAGES** - Fermented beverages (e.g. alcoholic drinks) are produced due to alcoholic fermentation of malt of cereals and fruits by brewing yeast (*Saccharomyces cerevisiae*).

Type of alcoholic drink depends upon the raw material used and type of processing.



■ ANTIBIOTICS - Antibiotic are antimicrobial chemicals produced by certain useful microbes. First antibiotic "Penicillin" was discovered by chance. Medicinal importance of antibiotics was given by chain and florey. More than 50% of antibiotics are obtained from members of genus *Streptomyces* (an actinomycete). Antibiotics are used in medicines, for food preservation, supplementary animal feed, etc.

■ CHEMICALS -

- ★ Aspergillus niger (fungus) - Citric acid
- ★ Acetobacter aceti (bacterium) - Acetic acid
- ★ Clostridium butylicum (bacterium) - Butyric acid
- ★ Lactobacillus (bacterium) - Lactic acid
- ★ Saccharomyces cerevisiae - Ethanol

■ ENZYMES -

- ★ Lipase - used in laundry detergents
- ★ Pectinase and protease - used in bottled juices
- ★ Streptokinase (*Streptococcus* bacterium) - used as clot buster (to remove clots)

■ BIOACTIVE MOLECULES -

- ★ Cyclosporin A (*Trichoderma polysporum* fungi) - used as immunosuppressive agent (for organ transplant patients).
- ★ Statins (*Monascus purpureus* yeast) - used as blood cholesterol lowering agents.

→ **MICROBS IN SEWAGE TREATMENT** :- Municipal waste water (sewage) contains large amount of organic matter and microbes which are pathogenic and cannot be discharge into natural water bodies like rivers and streams. Sewage is treated in sewage treatment plant to make it less polluting by using heterotrophic microbes naturally present in sewage. Sewage treatment is done in two stages -

In primary treatment, floating debris is removed by sequential filtration. Grit (soil and small pebbles) are removed by sedimentation.

Secondary treatment or biological treatment involves passing of primary effluents in large aeration tank to help the growth of aerobic microbes into flocs (masses of bacteria associated with fungal filament to form mess like structures). These microbes increase the consumption of organic wastes and decrease the BOD (biological oxygen demand) of the effluents.

BOD is the amount of oxygen that would be consumed if all the organic matter in one litre of water were oxidised by bacteria. It measures the amount of

organic matter present in the water. Greater the BOD of water more it is polluted.

- Once the BOD of sewage or waste water is reduced, the effluent is then passed into a settling tank where the bacterial 'flocs' are allowed to sediment. This sediment is called activated sludge. Sludge is passed into large tanks called anaerobic sludge digesters in which anaerobic bacteria digest the bacteria and fungi in the sludge and produce mixture of gas called biogas, which is a mixture of methane, hydrogen sulphide and carbon dioxide.
The effluents from the secondary treatment plant are released into water bodies.

→ **MICROBS IN PRODUCTION OF BIOGAS** :- Biogas is a mixture of gases produced by the microbial activity that can be used as fuel. Certain bacteria that grows anaerobically on cellulosic material produce large amount of methane along with CO₂ and H₂. These bacteria are collectively called methanogens (Methanobacterium).

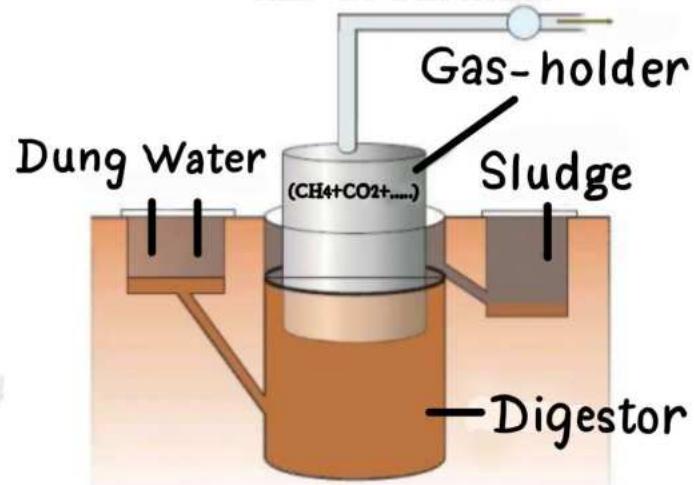
■ **BIOGAS PLANT** - The excreta of cattle (gobar) is rich in methanogens bacteria and is used for generation of biogas also called as gobar gas.

- The technology of biogas production was developed in India mainly due to the efforts of Indian Agricultural Research Institute (IARI) and Khadi and Village Industries Commission (KVIC).

Biogas plant consists of a concrete tank in which bio-wastes are collected and slurry of dung is fed.

A floating cover is placed over digester that moves upward when gas is produced. The gas produced is removed and supplied through an outlet pipe for consumption.

The spent slurry is removed through another outlet and used as fertilisers. Biogas plant is more often built in rural areas as large amount of cattle dung is available easily.



UMESH VAISHALI
Biogas Plant

NOTE

STP = Sewage Treatment Plant

BOD = Biochemical oxygen demand

IPM = Integrated Pest Management

→ **MICROBS AS BIOCONTROL AGENTS :-** Biocontrol agents are those microbes which are employed to control some harmful organisms like pathogens and pests. These include **bioherbicides** (to control weeds), control of cacti by cochineal insect, production of transgenic crop plants like tomato, tobacco etc... **Baculoviruses** (e.g. **Nucleopolyhedro Virus**) are species specific viruses acting as Biocontrol agents having insecticidal properties.

NOTE **IARI** = Indian Agricultural Research institute

KVIC = Khadi and Village Industries Commission

→ **MICROBS AS BIOFERTILIZERS :-** Biofertilizers are those micro-organisms which improve soil fertility and reduce agrochemical pollution. These include certain bacteria, cyanobacteria and mycorrhizae. Bacterial biofertilizers may be symbiotic (e.g. *Rhizobium leguminosarum*) anaerobic soil bacterium *Closteroidium*; aerobic soil bacterium *Azotobacter*; etc. In legumes, N_2 is fixed as NH_3 by nitrogenase enzyme in the presence of oxygen-scavenger **leghaemoglobin**. Cyanobacteria like *Anabaena*, *Nostoc*, *Aulosina*, etc have special N_2 -fixing cells called **heterocysts**. *Anabaena azollae* is found as an endophyte in the leaves of *Azolla pinnata*. Mycorrhizae are symbiotically associated fungal hyphae with the roots of higher plants like *Pinus*, Oaks, *Eucalyptus*, orchids, etc. Fungal hyphae derive shelter and nutrition from the roots while help in absorption of water and minerals, solubilize insoluble organic compounds, secrete growth-promoting substances, etc.



Biotechnology : Principles and Processes

→ **Biotechnology** :- "The integration of natural science and organisms, cells, parts thereof and molecular analogies for products and services is called biotechnology."

→ Principles of Biotechnology :-

- **Genetic Engineering** :- It includes techniques to alter the chemistry of genetic material (DNA and RNA) to introduce them into host organism and change the phenotype of host organism. It includes creation of **recombinant DNA**, use of **gene cloning** and **gene transfer**.
- **Bioprocess engineering** :- Maintenance of sterile (microbial contamination-free) ambience in chemical engineering processes to enable growth of only the desired microbe/eukaryotic cell in large quantities for the manufacture of biotechnological products like antibiotics, vaccines, enzymes etc.

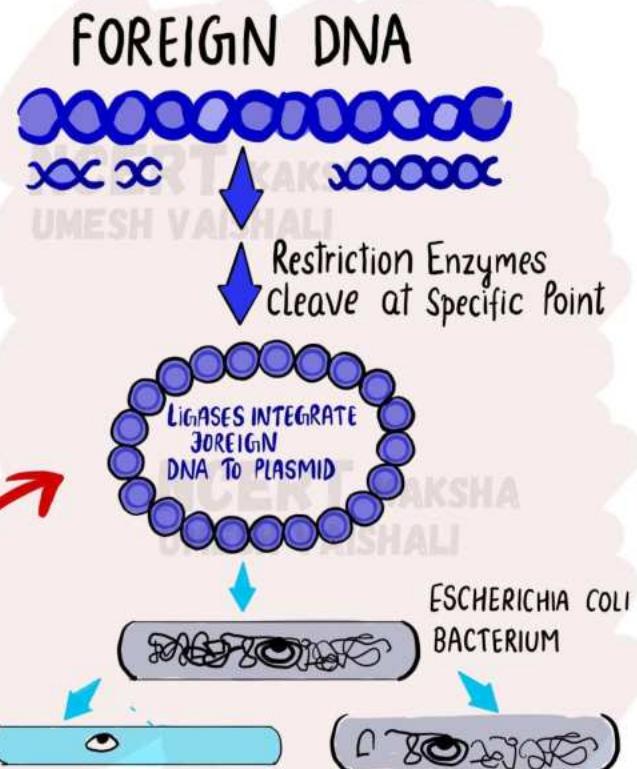
→ Tools Of Recombinant DNA Technology :-

(a) **Restriction Enzymes** :- Steward Linn and Werner Arber (1963) isolated two enzyme which restricted the growth of bacteriophage in bacterium *E.coli*. One of these enzymes added methyl groups to DNA and Second one cut DNA. The second enzyme was named as "**Restriction endonuclease**".

They are of two types .

- **Exonucleases** - They remove nucleotides from the ends of DNA.
- **Endonucleases** - They make cuts at specific positions within DNA.

*Production
of Recombinant
DNA*



S.No.	Restriction	Source	Sequence with recognition sites
1.	Eco RV	Escherichia coli	5'GAT [↓] ATC 3' 3'CTA [↑] TAG 5'
2.	AluI	Arthrobacter luteus	5'A-G [↓] C-T 3' 3'T-C [↑] G-A 5'
3.	Bam HI	Bacillus amyloliquefaciens	5'G [↓] G-A-T-C-C 3' 3'C-C-T-A-G [↑] G 5'
4.	Eco RI	Escherichia coli	5'G [↓] A-A-T-T-C 3' 3'C-T-T-A-A-G 5'
5.	Eco RII	Escherichia coli	5'C [↓] C-T-G [↑] G 3' 3'G-G-A-C-C 5'
6.	Pst I	Providencia stuartii	5'C-T-G-C-A-G 3' 3'G [↑] A-C-G-T [↓] C 5'
7.	Sall	Streptomyces albus	5'G [↓] T-C-G-A-C 3' 3'C-A-G-C-T [↑] G 5'

(b) Cloning Vehicles (Vectors) :- A vector is a DNA molecule which has the ability to replicate in an host cell and into which the DNA fragment to be cloned known as DNA insert is integrated for cloning.

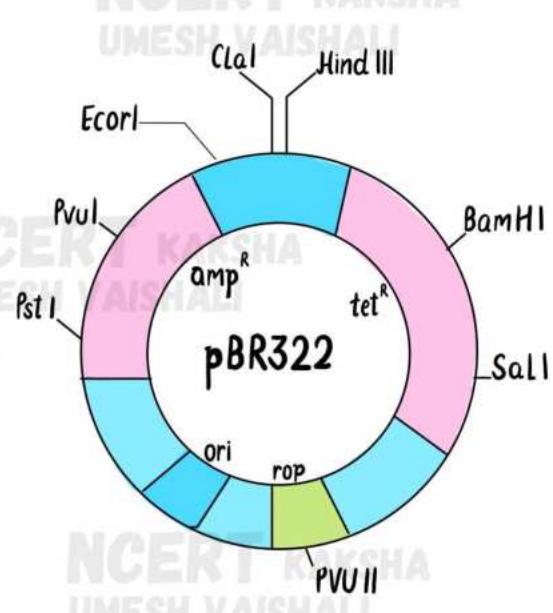
They are of five types :-

(i) Origin of Replication (ori) :-

- Replication starts from ori. Any fragment of DNA when linked to ori can be made to replicate.
- With the help of this, the genetic engineer may control copy number of the recombinant DNA. To recover a high number, suitable origin of replication must be chosen.

(ii) Selectable marker :-

- These genes help to select recombinants over non-recombinants.
- Antibiotic resistance genes such as amp^r (ampicillin resistant), tet^r (tetracycline resistant) serve as selectable markers usually.



(iii) Cloning sites :-

- These sites refer to the recognition sites for restriction enzymes (such as EcoRI, HindIII, PvuI, BamHI etc).
- These are the sites where restriction enzymes cut the DNA.
- Cloning process becomes completed when more than one recognition sites are present.
- Therefore, ligation is carried out only at the restriction sites present on the antibiotic resistance genes.

(iv) Cloning vectors for plants and animals :-

- Ti plasmid (tumour-including plasmid) refers to the plasmid of Agrobacterium tumefaciens.
- A tumefaciens is a plant pathogen. It produces tumours in the plants it infects.
- Ti plasmid can be modified into a cloning vector by removing the genes responsible for pathogenicity.
- Retrovirus - These are the viruses that infect animals. They produce cancers in animals.
- Retroviruses can be disarmed to be used as a cloning vector.

(v) Competent host :-

- Competent host refers to the bacterial cells that have the ability to take up the vector (containing Recombinant DNA).
- Methods to introduce recombinant DNA into competent host:
- Cells are treated with divalent cations (e.g. Ca^{2+}). Then, these cells are incubated with recombinant DNA on ice, followed by heat shock (at 42°), and then putting them back on ice. By this, bacteria are able to take up recombinant DNA.
- Microinjection - Recombinant DNA is directly injected into the nucleus of animal cell.
- Biolistics (Gene Gun) - Cells are bombarded with high velocity micro particles of gold or tungsten.
- Disarmed vector as in case of *A. tumefaciens* and retrovirus.

→ Process Of Recombinant DNA Technology:-

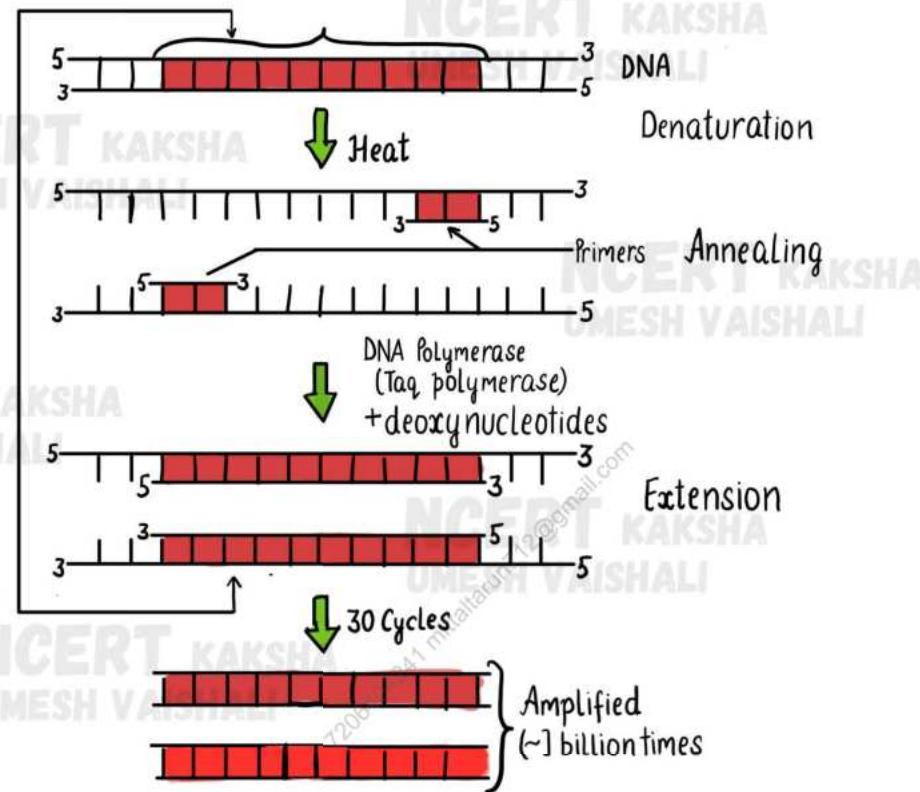
- Isolation of the Genetic Material - Genetic material is isolated from other macromolecules by using enzymes such as Lysozyme (bacteria), cellulase (plant cells), chitinase (fungus). DNA that separate out can be removed by spooling. The RNA can be removed by treatment with ribonuclease whereas proteins can be removed by treatment with protease.
- Cutting of DNA at specific location: It is performed by using restriction enzyme and Agarose gel electrophoresis to check the progression of a restriction enzyme digestion. After cutting sources of DNA as well as vector DNA with a

specific restriction enzyme to cut out 'gene of interest' from the source DNA.

- Amplification of interest using PCR - to get multiple copies of the DNA or gene of interest in vitro by using set of primers and enzyme DNA polymerase.

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Polymerase
Chain
Reaction



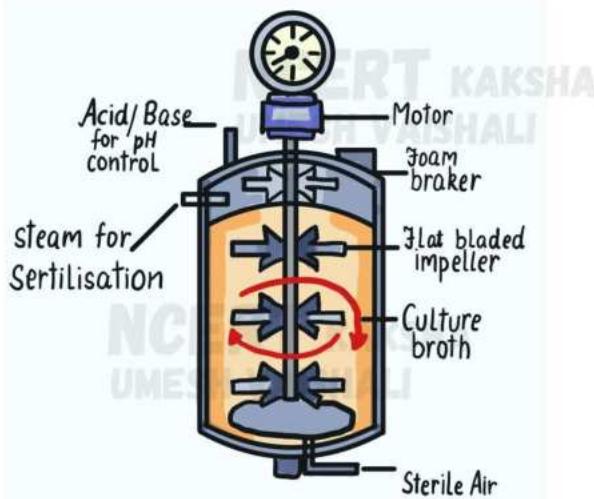
- Insertion OF Recombinant DNA into the host Cell/Organism - It includes making the recipient cells competent to receive, take up DNA present in its surrounding etc. The recombinant DNA bearing gene for resistance to an antibiotic is transferred into E. coli cells, the host cell become transformed into ampicillin-resistance cells.

- Obtaining the Foreign Gene Product =

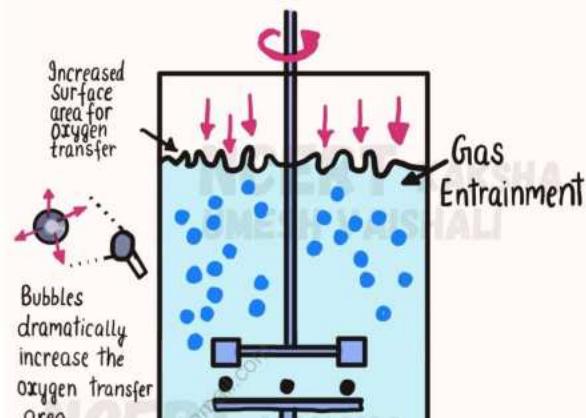
1. This is the stage for which the recombinant DNA was produced.
2. The cell containing recombinant DNA will produce a novel protein product.
3. For large scale production of the desirable product (antibiotics, vaccines, enzymes), optimum conditions are to be provided.
4. Continuous culture - Used culture media is drained from one side and fresh culture media is added from the other side.
5. Cells are kept throughout in their log phase.
6. Larger biomass is produced by this method leading to higher yield.
7. Bioreactors - Large vessels in which large volumes (100-1000 litres) of culture can be produced.

Optimal growth conditions for microbes are present (temperature, pH, substrate, salts, vitamins etc.)

8. A bioreactor has the following components - agitator system, oxygen delivery system, foam control system, temperature and pH control system, sampling ports.



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- Downstream Processing - It involves processes that make the product obtain ready for marketing. This process includes separation and purification called as downstream processing. Suitable preservatives are added to it and send for clinical trial in case of drugs before releasing to market for public use.

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Biotechnology and its Applications

→ BIOTECHNOLOGICAL APPLICATIONS IN AGRICULTURE :-

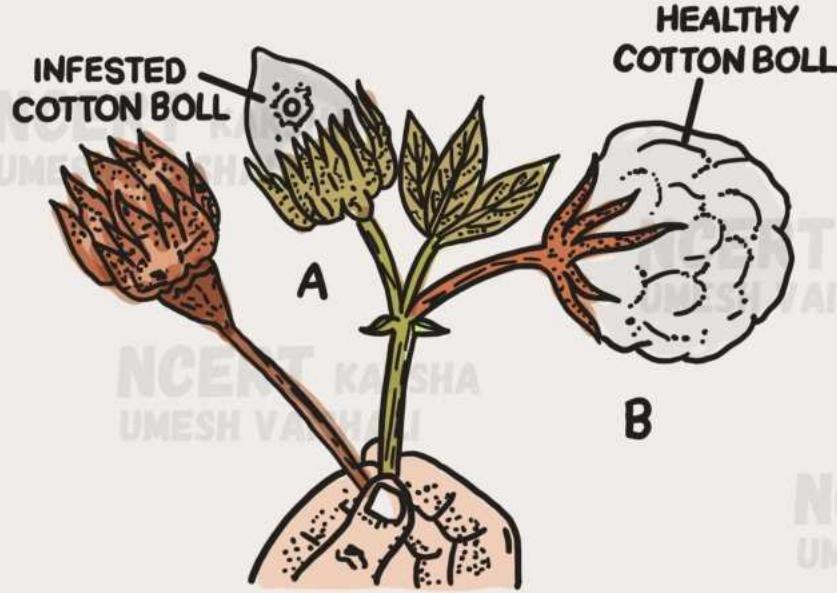
Food production can be increased by

- Agro - chemical based agriculture
- Organic agriculture
- Genetically engineered crop - based agriculture.

- Green revolution successfully increased the food production many folds by using better management practices and used of agrochemicals, fertilizers and pesticides. Further increase in production is not possible by using these methods. To overcomes this genetically modified crop is used.
- Plants, bacteria, fungi and animals whose genes have been altered by manipulation are called **Genetically Modified Organisms (GMO)**. GM plants have many applications-
- Mode crops more tolerant to abiotic stresses
- Reduced reliance on chemical pesticides
- Helped to reduce post harvest losses
- Increased efficiency of mineral usage by plants
- Enhanced nutritional value of food, e.g., Vitamin 'A' enriched rice.

→ BT COTTON :-

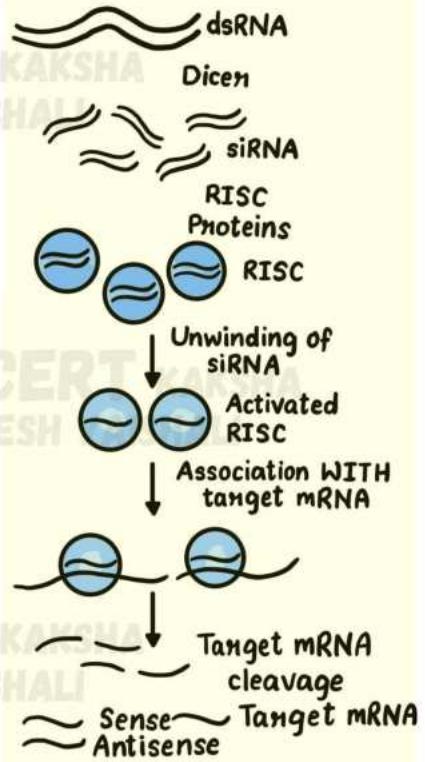
- Bacillus thuringiensis* is a bacterium that produces proteins to kill certain insects such as lepidopterans (caterpillars), coleopterans (beetles), and dipterans (flies/mosquitoes). *B. thuringiensis* produces a protein crystal containing a toxic protein (inactivated state).
- Inactivated toxin $\xrightarrow{\text{alkaline pH}}$ Activated toxin (gut of insect)
- Activated toxin binds to the epithelial cells in the midgut of insect and creates pores that cause lyses and swelling and eventually death of insects.
- This toxin is encoded by a gene called **Cry** in the bacterium. Genes encoded by *Cry IAc* and *Cry IIAb* control cotton bollworms and those encoded by *Cry IAb* control corn borers.
- Cry* genes are introduced into the cotton plants to produce Bt cotton, which is an insect resistant variety of cotton.



BT Cotton

→ PEST RESISTANT PLANTS :-

- Nematodes like *Meloidegyne incognita* infects the roots of tobacco plants and causes reduction in yield. The infestation of these nematodes can be prevented by the process of **RNA interference (RNAi)**. RNAi is present in all eukaryotic organisms as cellular defence by silencing of specific mRNA due to complementary dsRNA molecules that bind to and prevents translation of the mRNA.
- The source of complementary dsRNA may be from an infection by viruses having RNA genomes or mobile genetic elements that replicate through RNA intermediate.
- Nematode specific genes were introduced into host plant using *Agnobacterium* vectors. The parasite could not survive in a transgenic host expressing specific interfering RNA.

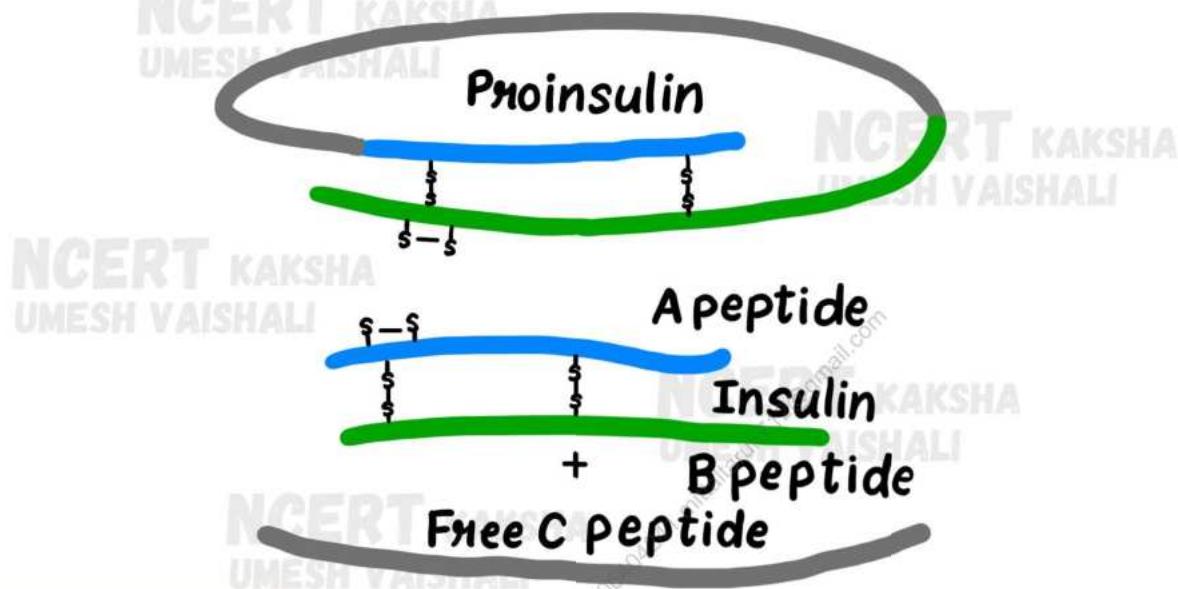


→ BIOTECHNOLOGICAL APPLICATIONS IN MEDICINE :-

(a) GENETICALLY ENGINEERED INSULIN :-

- Insulin is in great demand due to increase in number of patients with adult onset diabetes.
- Insulin extracted from animal source (example, slaughtered cattle and pigs) induce allergy in humans.

- Insulin as a pro-enzyme consists of 3 peptide chains - A, B and C.
- Pro-enzyme insulin removal of C peptide → Mature insulin.
- Mature insulin consists of only two peptide chains - A and B. Both these chain were separately isolated and introduced in plasmids of *E. coli* to produce insulin chains.
- Separately produced chains A and B were extract and combined by creating a disulphid bond to form mature human insulin.



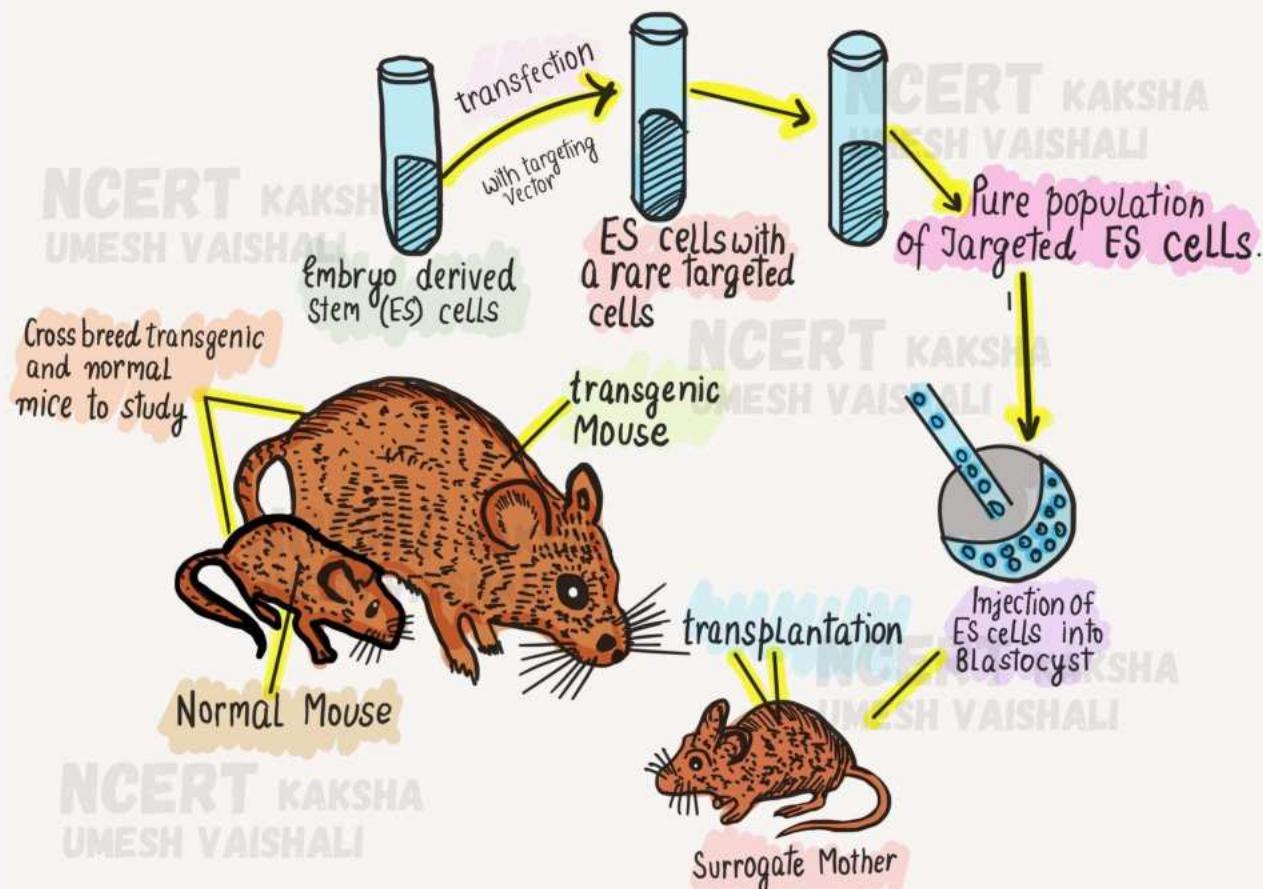
(b) GENE THERAPY :-

- Gene therapy is an attempt to deal with genetic or congenital disease.
- This aims at correction of a genetic defect by delivery of a normal gene into an individual or embryo to take over or compensate the function for a non-functional gene.
- The first disease to have a gene therapy is ADA (Adenosine deaminase) deficiency. In this, the gene coding for enzyme ADA gets deleted leading to deficiency of ADA and problems in immune system.
- ADA deficiency can also be treated with :
 - ↳ Bone marrow transplantation
 - ↳ Enzyme replacement therapy
- Gene therapy for ADA deficiency :
 - ↳ Lymphocytes isolated from patient's blood are cultured *in-vitro*.
 - ↳ Functional ADA cDNA are then introduced into the cultured lymphocytes.
 - ↳ These lymphocytes are returned back to the patient's body.
- Lymphocytes are not immortal. Therefore, repeated infusion of genetically engineered lymphocytes is required.
- Permanent cure - Introduction of gene isolated from bone marrow cells producing ADA into cells at early embryonic stages.

(c) MOLECULAR DIAGNOSIS :-

- Recombinant DNA technologies, PCR, ELISA (enzyme linked immuno sorbent assay) are some of the technologies of molecular diagnosis.
- Early diagnosis of bacteria and virus in body, when the concentration is extremely low, can be done by PCR since it amplifies the DNA several folds.
- PCR is used to detect HIV virus in suspected AIDS patients and mutations in genes in suspected cancer patients
- ELISA is based on antigen - antibody interactions. In the presence of an antigen, the antibody produced against it can be detected.
- Hybridisation with a radioactive probe - In this approach, gene is hybridized with a radioactive probe and autoradiography is used for detection. The regions where mutation is present in the gene will not appear in the photographic film since probe will not be able to bind with part.

→ **TRANSGENIC ANIMALS :-** The organisms (animals) which have had their DNA manipulated to possess and express an alien (foreign) gene are known as **transgenic animals**.



(i) NORMAL PHYSIOLOGY AND DEVELOPMENT :-

- Transgenic animals serve as models to study genetics, regulation and down regulation of genes, and their corresponding effects on physiology.
- They give information about the biological role of a particular factor in the body.

(ii) STUDY OF DISEASES :-

- They act as models to study genetic basis of diseases.
- These studies aid in finding possible treatment of diseases.
- Transgenic models exist of various human diseases such as cancer, cystic fibrosis, rheumatoid arthritis, Alzheimer's, etc.

→ BIOLOGICAL PRODUCTS :-

- Treatment of diseases often requires certain products that are expensive to make.
- Transgenic animals can be produced that have genes, coding for that particular product.
- Example - Human protein α -1- antitrypsin used to treat emphysema is isolated by this method.
- In 1997, first transgenic cow Rosie produced human protein-enriched milk, which contained α -lactalbumin and was nutritionally more suitable for human babies.

→ VACCINE SAFETY TESTS :-

- Transgenic mice are used to test vaccines for their safety before they are used for humans.
- Example - Transgenic mice are used to check polio vaccines.

→ CHEMICAL SAFETY TESTING :-

- Transgenic animals contain genes that make them more sensitive to toxic substances than non-transgenic.
- Toxicity testing in such animals helps us to obtain result in less time.

→ ETHICAL ISSUES :-

The Indian Government has set up organizations such as **GEAC (Genetic Engineering Approval Committee)**, which will make decisions regarding the validity of GM research and the safety of introducing GM-organisms for public services.

→ **BIOPATENT** :- A patent is the right granted by a government to an inventor to prevent others from making commercial use of his invention. Now, patents are granted for biological entities and for products derived from biological resources.

→ **BIOPIRACY** :-

- Use of bio-resources by MNCs and other organisations without proper authorisation from countries and people concerned without compensatory payment.
- Industrialized and developed nations are economically rich, but poor in biodiversity while opposite prevails for developing nations. Therefore developed countries exploit traditional knowledge and resources of poor countries for commercialisation.
- This is a matter of injustice since inadequate compensation and benefit sharing is given to poor countries in return. Therefore, steps should be taken by developing countries to prevent this exploitation.
- The Indian parliament has recently introduced second amendment of Indian patents bill to deal with these issues.

BELIEVE you can
AND
you **WILL**.....

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Organisms and Populations

→ Organism :-

- ★ It is the **smallest Level** of ecological hierarchy.
- ★ It is most distinct and easily observable unit.
- ★ It performs all the **life process** independently of those going on in other living organisms.
- ★ It always has **cellular nature**.
- ★ It is a **quantitative unit**.
- ★ The parts of the organism **cannot exist independently** of one another.

→ Populations :-

Population is defined as the total number of individuals of a species in a specific geographical area; can interbreed under natural conditions to produce fertile offsprings and functions as a unit of biotic community.

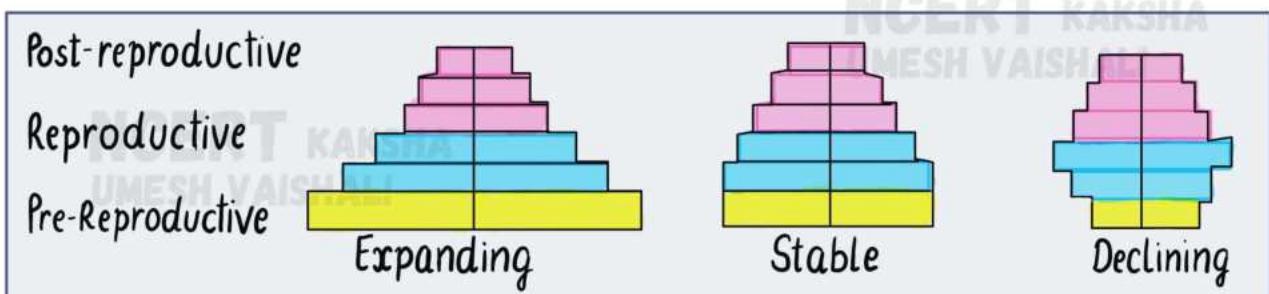
→ Population Attributes :-

A population has certain attributes that an individual organism does not such as an individual may have births and deaths, but a population has birth rates and death rates.

- ★ The birth and death rates are referred as per capita births or deaths respectively, which increases and decrease with respect to members of the population.
- ★ Sex ratio is another attributes of population. An individual may be male or female but population has sex ratio.
- ★ A population at given time composed of different individual of different ages. If the age distribution is plotted for the population, the resulting structure is called age pyramids. The shape of pyramids reflects the shape of growth status of population. Which may be

1. Expanding
2. Stable
3. Declining

Age Pyramids for Human Population



NOTE

Population density is the no. of individuals of a species per unit area or volume.

Population density (P.D.) can be calculated as:

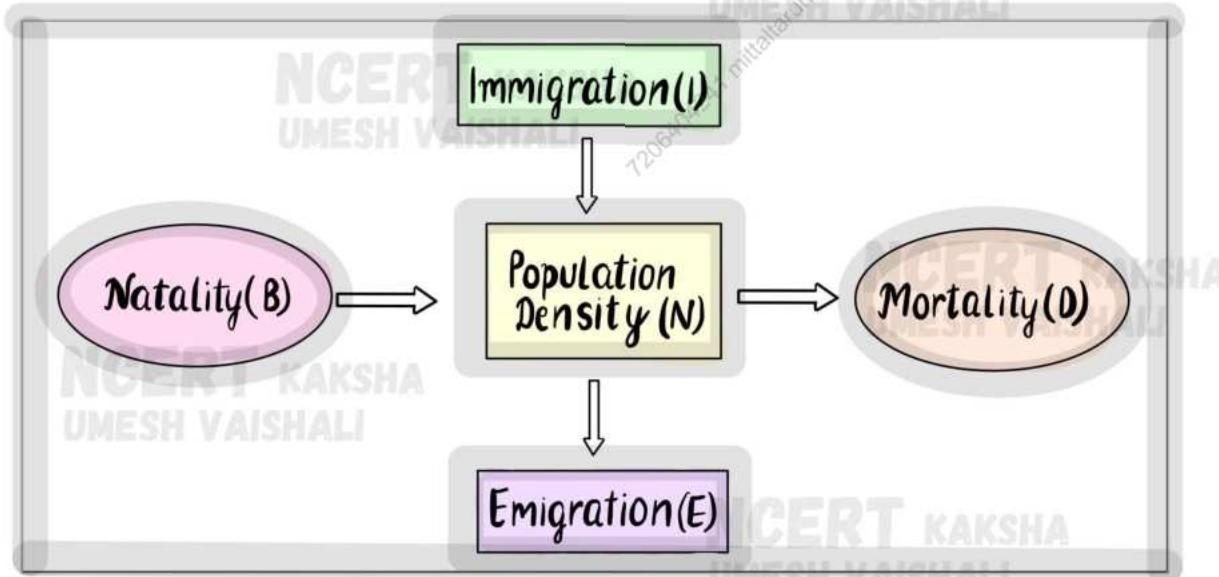
$$P.D. = \frac{N}{S}$$

Where N = number of individuals in a region.
 S = number of unit areas in a region.

→ Population Growth :

- ★ The size of a population is an ever-changing aspect since it depends upon availability of food, predation, weather conditions etc.
- ★ This gives us an idea whether a certain population is growing or declining.
- ★ If N is the population at time t , then its density at $t+1$ is :

$$N_{t+1} = N_t + [(B+I) - (D+E)]$$

**NOTE**

$$\text{Population size} = \frac{\text{B.P.}}{\text{E.R.}}$$

where B.P. = Biotic potential

E.R. = Environmental resistance

→ Growth Modals :

- (a) Exponential Growth – When the resources are unlimited, population tends to grow in an exponential pattern.

If the population size is N and the birth and death rates (not per capita) are b and d respectively, then increase or decrease in N at t (time period) is given by,

$$\frac{dN}{dt} = (b-d) \times N$$

where,

r - intrinsic rate of natural increase

N_t - Population density at time t

N_0 - Population density at time 0

r - intrinsic rate of natural increase.

e - Base of natural logarithms (2.71828).

If $(b-d) = r$, then

$$\frac{dN}{dt} = rN \quad \text{or, } N_t = N_0 e^{rt}$$

b) **Logistic Growth** :- When the resources are limited leading to competition between individuals and survival of the fittest, the population tends to grow in logistic manner.

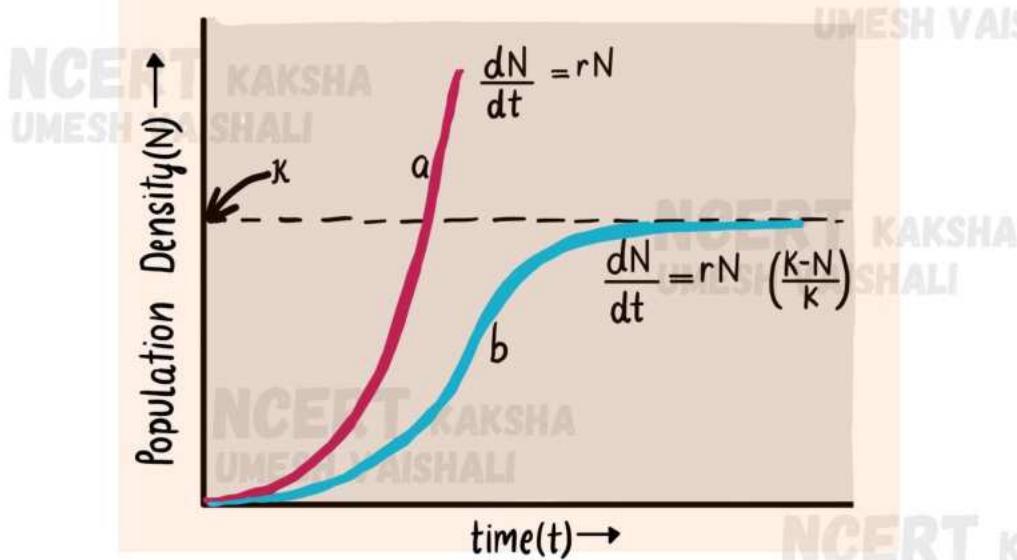
- In this kind of growth, there is an initial lag phase followed by acceleration or deceleration phases and finally asymptote, when it reaches its carrying capacity (K).
- When N in relation to t is plotted, it results in a sigmoid curve called the Verhulst-Pearl Logistic growth given by,

$$\frac{dN}{dt} = rN \left(\frac{K-N}{K} \right)$$

N - Population density at time t

r - Intrinsic rate of natural increase

K - Carrying Capacity.



→ Life History Variations :-

* Populations tend to increase their reproductive fitness in order to survive better. This is known as Darwinian fitness (high r value).

Some of the trends they follow in course of achieving this :

- ★ Some organisms breed only once in their lifetime. Example – Salmon, Bamboo.
- ★ Some breed many times. Example-Birds, Mammals.
- ★ Some produce a large number of small-sized offsprings. Example-Oyster.
- ★ Some produce a small number of large-sized offsprings. Example- Birds, Mammals.

→ Population Interactions :-

- ★ A natural habitat consists of many organisms living together and these organisms communicate and interact with each other. For example, plants depend on insects for pollination.
- ★ Interspecific interactions are interactions between two different species of organisms. They can be either beneficial or harmful to one or both partners.

Species A	Species B	Name of Interaction
+	+	Mutualism
-	-	Competition
+	-	Predation
+	-	Parasitism
+	0	Commensalism
-	0	Amensalism

- **Predation** :- It is a kind of direct food-relationship between two species of animals in which larger species, called predator, attacks, kills and feeds on the smaller species, called prey.
- **Competition** :- It is an antagonistic interaction in which two or more members of the same species (**intraspecific**) of the same trophic level compete for common resources like light, moisture, nutrients etc which are in short supply.
- **Parasitism** :- It is a type of antagonistic interspecific interaction in which smaller partner, called **parasite**, derives food and shelter from in or on the body of larger partner, called **host**.
- **Commensalism** :- It is the simplest kind of interspecific positive interaction in which smaller member, called **commensal**, is benefitted while the larger member, called **host**, is neither benefitted nor harmed. It is also called “**eating at the same table**”
- **Mutualism** :- It is a kind of positive interspecific interaction in which members of two different species favour the growth and survival of each other and their association is obligatory. So mutualism is a **functional association**.

UNIT-V (ECOLOGY)

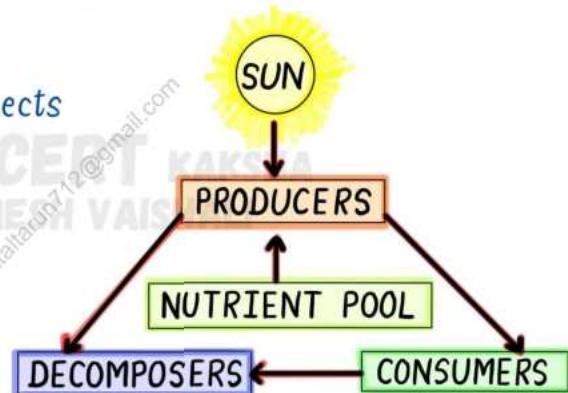
CHAPTER-12

Ecosystem

→ ECOSYSTEM, STRUCTURE AND FUNCTION :-

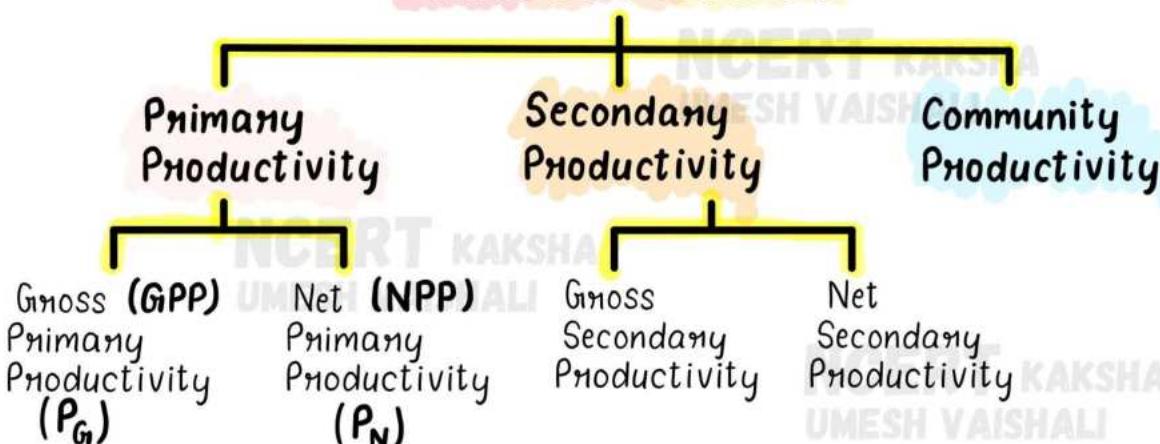
- **ECOSYSTEM** :- Ecosystem is an integrated system resulting from interaction of living and non-living factors of the environment.
- **STRUCTURE** :- An ecosystem is composed of the abiotic physico-chemical environment and biotic assemblage of plants, animals and microbes (Fig. 14.2). These components collectively form a natural, stable, self-sufficient and functional ecological unit, called ecosystem.
- **FUNCTION** :- The key functional aspects of the ecosystem are -

- 1) Productivity of an ecosystem.
- 2) Decomposition.
- 3) Energy flow of an ecosystem.
- 4) Nutrient cycling.



- **PRODUCTIVITY** :- The amount of food energy produced or obtained or stored by a particular trophic level per unit area in a unit time, or the rate of biomass production, is called productivity.

PRODUCTIVITY

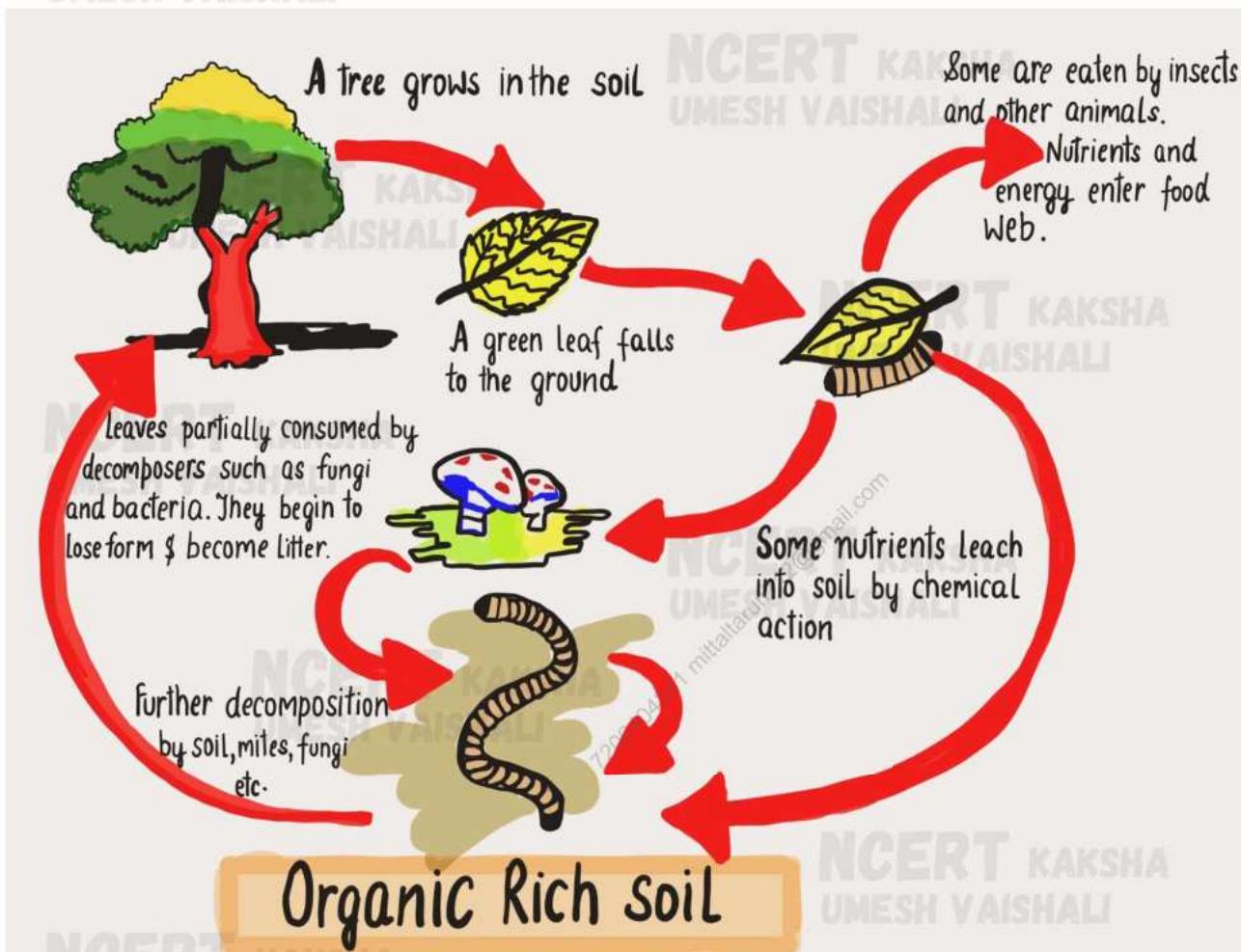


Net primary productivity = Gross primary productivity - Respiration rate

$$P_N = P_G - R$$

$$(NPP = GPP - R)$$

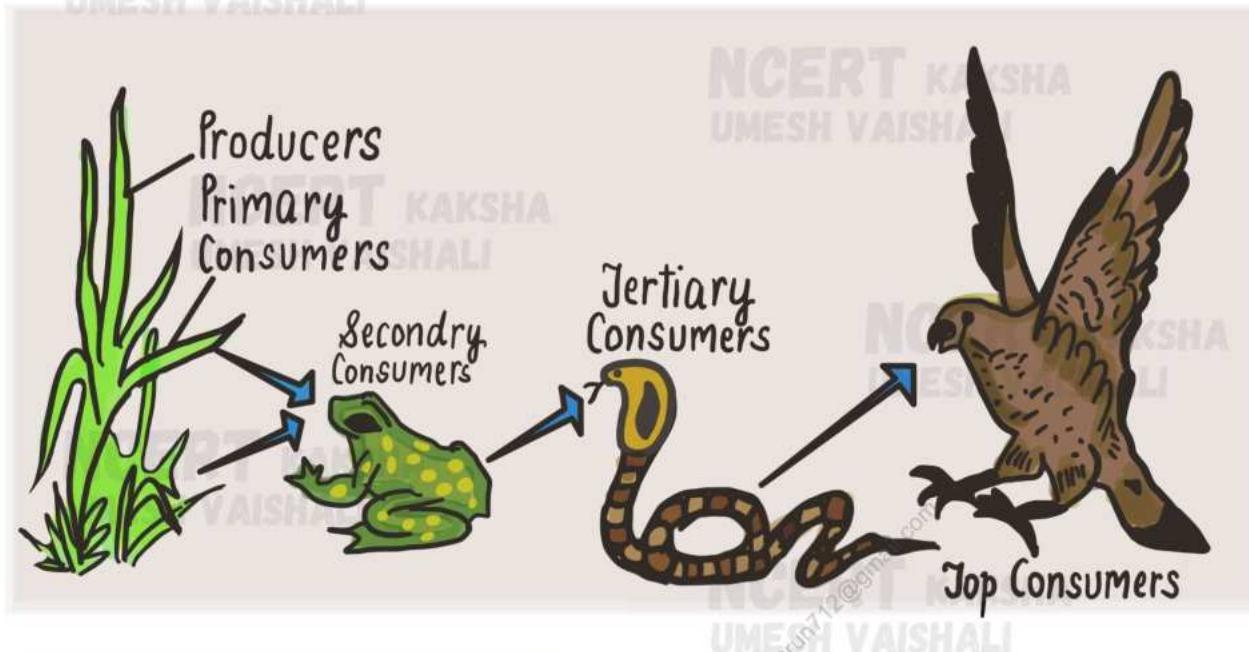
→ **DECOMPOSITION :-** Decomposition is the process by which complex organic compounds are broken into simpler and inorganic substances that can be utilized by the plants for their growth.



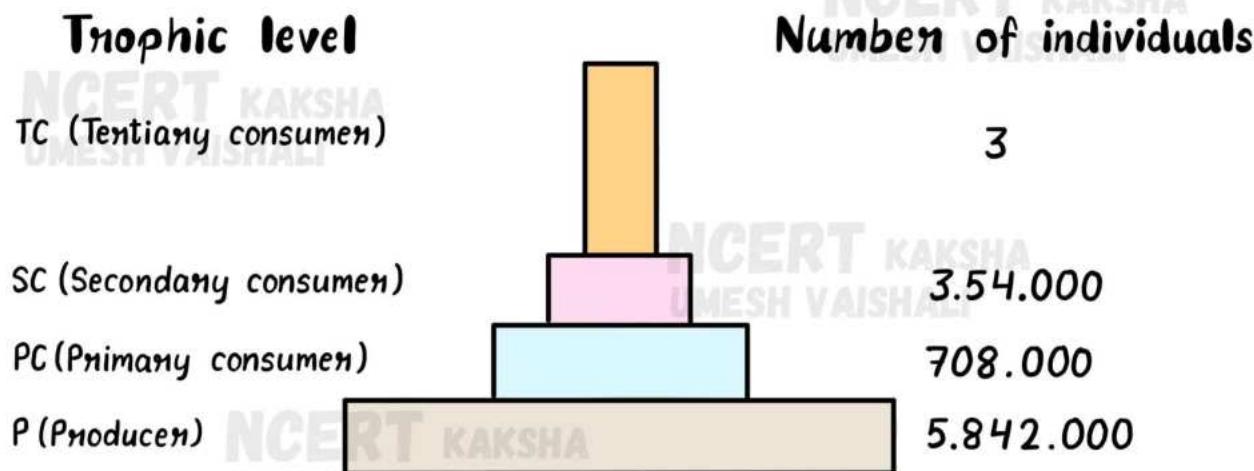
→ **ENERGY FLOW :-** Energy flow is the key function of ecosystem and is determined by two basic laws of thermodynamics. Energy conserving efficiency of producers is percentage of radiant energy trapped. On average, it is about 2-10 per cent of Photosynthetic Active Radiations (PAR) and the total biomass produced is called GPP. About 0.4 to 2% of PAR is utilized in respiration to provide energy for metabolic activities, while about 1.6 to 8 per cent of PAR is used in biosynthesis called NPP.

- **A FOOD CHAIN :-** A food chain is a series of trophic levels with repeated eating. There are two types of food chains : **Grazing food chains** (always start from the producers) and **Detritus food chains** (start from dead organic matter). A food chain is characterized by repeated eating and unidirectional flow of energy.

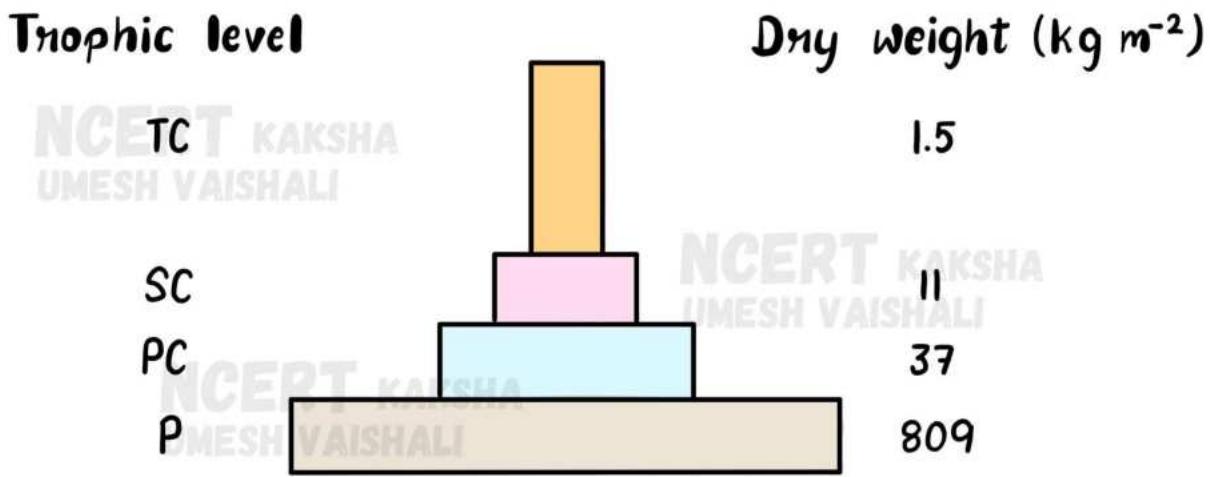
- **A FOOD WEB :-** A food web is a network formed by interlinking of a number of food chains. It provides alternative pathways of food availability and also prevents over population of any spp. in an ecosystem.



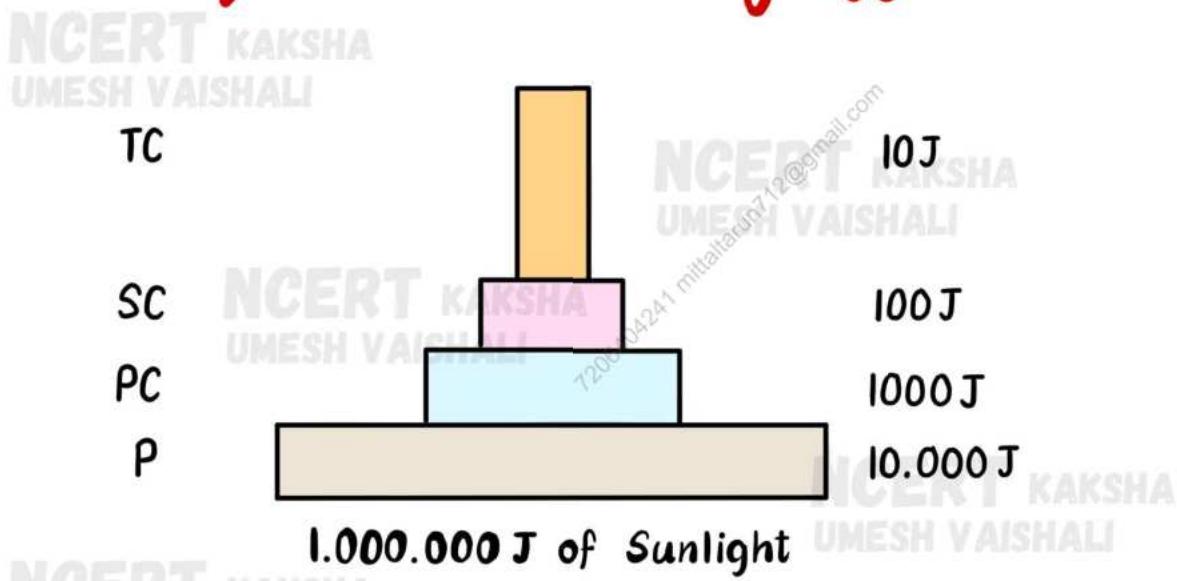
→ **ECOLOGICAL PYRAMIDS :-** An ecological pyramid is a pictorial representation of an ecological parameter, like number or biomass or accumulated energy at different trophic levels in a food chains in an ecosystem.



Pyramid of Numbers



Pyramid of Biogass



Pyramid of Energy

EVERY MORNING
is a new annival.....

Biodiversity and Conservation

→ Biodiversity:

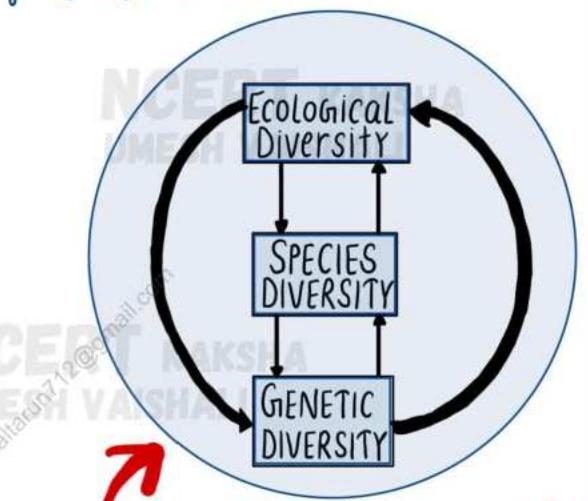
"The variability among living Organisms form all sources including, interalia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species , between species and of ecosystems." In short it refers to the whole variety of life on earth.

(i) **Genetic Diversity**: A single species might show high diversity at genetic level over its distributional range. The genetic variation shown by the medical plant *Rauwolfia vomitoria* growing in different Himalayan ranges might be in terms of the potency and concentration of the active chemical (*reserpine*) that the plant produces. India has more than 50,000 genetically different strains of rice, and 1,000 varieties of mango.

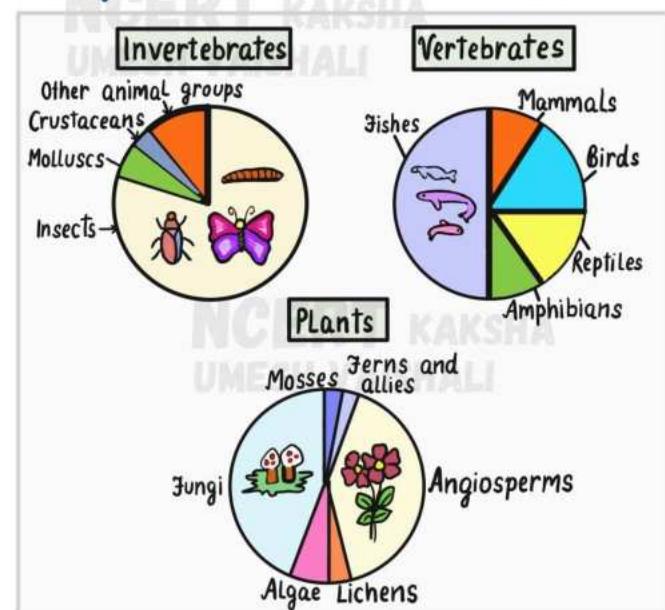
(ii) **Species diversity**: The diversity at the species level, for example, the Western ghats have a greater amphibian species diversity than the Eastern Ghats.

(iii) **Ecological diversity**: At the ecosystem level, India, for instance, with its deserts, rain forests, mangroves, coral reefs, wetlands, estuaries, and alpine meadows has a greater ecosystem diversity than a Scandinavian country like Norway.

Representing global biodiversity: proportionate number of species of major taxa of plants, invertebrates and vertebrates.



Interrelationship in biodiversity



Patterns Of Biodiversity:-

(i) **Latitudinal Gradients**—The plants and animals are not distributed evenly worldwide. The diversity of living forms decreases as we go from the equator towards the poles. A huge amount of plants and animals are concentrated in the tropical region because of the following reasons :-

- Tropical environment is less seasonal and almost constant and predictable as compared to temperate environment.
- Tropics receive the major part of the solar energy, which contributes to great productivity.
- Speciation is dependent upon time. Tropical areas have remained undisturbed for million of years unlike temperate regions, which have experienced frequent glaciations in the past.

(ii) **Species - Area Relationships**—Alexander von Humboldt observed that biodiversity increases with increase in explored area. This relationship can be given by,

$$\log S = \log C + Z \log A$$

Where,

S = Species richness

A = Area

Z = Slope of the Line (regression co-efficient)

C = Y-intercept

Value of Z is found to lie in the range of 0.1 to 0.2 for comparatively smaller areas such as countries while for very large areas such as entire continents the slope of the line is much steeper with Z value lying from 0.6 to 1.2.

→ The Importance of Species Diversity to the Ecosystem:-

The communities with more species are generally more stable than those with less species. A stable community should not show too much variation in productivity from year to year.

Rich biodiversity is essential for ecosystem health and imperative for the very survival of human race on this planet.

Loss Of Biodiversity :-

• **Habit Loss and fragmentation**—This is the major cause for loss of biodiversity. Habitat destruction is caused by human activities such as deforestation and increasing pollution, leading to the loss of many plants and animals.

- **Over-exploitation**— Humans due to their greed and increased exploitation of natural resources have contributed to the endangerment of commercially important species of plants and animals. Example—Species such as Steller's sea cow and passenger pigeon have been extinct due to over exploitation by Humans.
- **Alien-species invasion**— The unintentional or deliberate introduction of alien species. Example—Nile perch introduced in Lake Victoria led to the extinction of more than 200 species of cichlid fish in the lake.
- **Co-extinction**— When a plant or animal becomes extinct, another plant or animal which is dependent on it in an obligatory way also becomes extinct. Example—In case of plant-pollinator mutualism, the extinction of one partner will eventually lead to the extinction of other also.

→ Conservation Of Biodiversity:

It is the management of the biosphere in such a way that it may yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generations.

→ How do we conserve Diversity:

Diversity can be conserved by:

- **In-situ Conservation**— In order to conserve biodiversity better, some of the world's biodiversity hotspots (with high degree of biodiversity and endemism) have been identified and are protected. In India, biosphere reserves, Wildlife sanctuaries, and national parks are built for this purpose.
- **Ex-Situ conservation**— The threatened species of plants and animals are taken out of their habitats, and are kept in special settings as in zoological parks.

Nowadays, the gametes of endangered species can be preserved viable by methods such as cryopreservation and can be fertilized in-vitro followed by propagation through tissue culture methods. Similarly, seeds can be preserved in seed banks.