Pre University Examination (2017-2018)
B.Sc.-I (CBZ)
Paper I- Cell Biology, Genetics and Plant Breeding
Set B

Time: 3:00 Hours **Max. Marks: 33**

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1. Answer the following (not more than 20 marks) **½ mark each**

(a) "Cri du chat syndrome" is the example of which type of chromosomal aberration?

Answer: Cri du chat syndrome - also known as 5p- syndrome and cat cry syndrome - is a rare genetic condition that is caused by the deletion (a missing piece) of genetic material on the small arm (the p arm) of chromosome 5. The cause of this rarechromosomal deletion is unknown.

(b) Write the function of chloroplast.

Answer: Chloroplast is responsible for enabling photosynthesis to occur so that plants can convert sunlight into chemical energy.

(c) Write the name of famous plant breeder.

Answer: Dr. B P Pal, T S Venkatraman, M S Swaminathan, Pushkarnath, N G P Rao, Ramdhan Singh etc.

(d) Define Karyotheca.

Answer: The double-layered membrane surrounding the nucleus of a eukaryotic cell, separating the nucleoplasm from the cytoplasm.

(e) Give one example of Amitosis.

Answer: Asexual reproduction in acellular organisms like bacteria and protozoans and also a method of multiplication or growth in foetal membranes of some vertebrates.

(f) Who performed the "Bacterialconjugation experiment"?

Answer: Griffth, 1928 and Avery 1944.

(g) Give one example of vegetatively propagated plant.

Answer: *Polypodium, Iris,* couch grass and neetles (Rhizome), strawberry (stolon), *Bryophuyllum* (any part), *Ulmus* and Rose (buds and sukers), Onion, tulip (bulb), Potatoes, Dahlia (tubers), sweet potatoes (roots).

(h) What is Nucleoid?

Answer: The **nucleoid** (meaning nucleus-like) is an irregularly shaped region within the cell of a prokaryote that contains all or most of the genetic material, called genophore. In contrast to the nucleus of a eukaryotic cell, it is not surrounded by a nuclear membrane.

(i) Define Allelomarph.

Answer: A Pair or series of alternative forms of a gene that can occupy the same locus on a particular chromosome and that control the same character.

(j) Credit for green revolution goes to which scientist?

Answer: M S Swaminathan.

(k) Who discovered Central dogma.

Answer: Francis Crick in 1958.

(l) Who discovered polytene chromosome?

Answer: Polytene chromosomes were originally observed in the larval salivary glands of Chironomus midges by Balbiani in 1881.

(m) Which cell organelle can be considered as circulatory system of the cell?

Answer: Golgi complex and Cytoplasm.

(n) Name the two double membranous cell organelle.

Answer: Mitochondria, Chloroplasts, Endoplasmic Reticulum, Golgi Body, and Nucleus.

(o) Write name of two cell organelles in which Plasma genes are found.

Answer: Mitochondria and Chloroplast.

(p) Give full name of "IARI".

Answer: The Indian Agricultural Research Institute.

(q) Who gave term "Protoplasm"?

Answer: J. E. Purkinje in the year 1839 coined the term 'protoplasm' for the fluid substance of the cell.

(r) If the parents are I^AI^O (father) and I^OI^O (mother), give the blood groups of their children.

Answer: Aand O.

Unit I

2. Write short notes on following-

(i) Ultrastructure and function of Golgi complex. **1½ + 1½**

Answer: Structure of Golgi Complex:

The electron microscopic studies have revealed that this organelle consists of series of compactly grouped smooth contoured membrane limited vesicles of variable shapes and dimensions and variable number of small vacuoles.

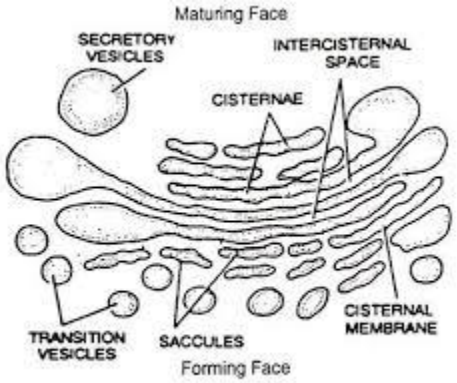


Figure 5.3: Ultrastructure of Golgi complex.

They are selectively stained with Neutral red stain and differ from mitochondria in staining property because they do not take Janus green stain (special stain for mitochondria). When the cytoplasm is centrifuged the mitochondria settle down first and golgi bodies afterwards.

This indicates that the golgi bodies are lighter than the mitochondria. The presence of golgi bodies in plant cells has been denied by some early cytologists, but the electron micrographs in recent years have revealed that these bodies are of universal occurrence in both plant and animal cells.

The vesicles of golgi bodies are chiefly of two types:

1. Small and spherical vesicles.
2. Broad flattened vesicles in parallel or often in semi-circular array, the cisternae (Singular— cisterna).

The cisternae are characterized by their dilated edges. They are compactly arranged in parallel fashion. The stack of flattened cisternae or saccules is known as ‘dictyosome’. The dictyosome has a polarity; its convex side forming the outer faces and concave side forming the inner face. The cisternae on the outer face are very flat and thin whereas those on the inner face or concave side are comparatively much dilated and thick.

The cisternae on the outer face react only with silver salt and osmic acid while those on the inner face do not react with silver salt and osmic acid. Thus the outer and inner faces are accordingly known as osmic or argentophilic and non-osmic or argentophobic.

The number of vesicles per dictyosome varies presumably because of different functional stages of golgi complex. The unit membrane of these cisternae is about 35 å thick, smooth surfaced, and not associated with ribosome granules.

On its outer surface the dictyosome is often bounded by canaliculae or cisternae of endoplasmic reticulum. Numerous spherical vesicles found in the vicinity of dictyosome are budded off by the cisternae at their ends. Palade (1956-58) has shown that the golgi bodies originate from smooth surfaced endoplasmic reticulum.

The smaller vesicles are aggregated around, the stacks of cisternae. These are also bounded by membranes. The central space of vesicle is very clear but frequently it becomes condensed and appears as small granule.

Functions of golgi apparatus:

- **Secretion:** It has been established that the cells that perform secretory functions have well developed golgi apparatus. The secretion may be in the form of lipids, enzymes, hormones, etc.
- **Cell wall formation in plants :** In plants, dictyosomes are known to synthesize pectin and some carbohydrates necessary for the formation of the cell walls.
- **Mucilage and gums:** Mucilage and gums secreted in the plant cells are due to the action of golgi apparatus (indirectly).
- **Acrosomeformation:** During spermato-genesis, golgi apparatus forms the acrosome.
- **Lysosome formation:** It has been established that secretory vesicles or primary lysosomes are produced from the sacs of the golgi apparatus.
- **Membrane transformation:** Golgi bodies are also involved in the transformation of one type of membrane into another type.
- **Presence of enzymes:** Several enzymes like glycosyl transferase, triaminopryophosphatase have been localised in golgi bodies.
- **Storage, condensation and packaging of the materials:** The golgi bodies are involved in storage, condensation, packaging and transfer of materials. The packaging in a golgi body involves wrapping of a membrane around a particular secretion and discharging it through the plasma membrane

(ii) Models of Plasma membrane. **3**

Answer: (i) Danielli and Davson Model: Harvey and Coley (1931) and Danielli and Harvey (1935) studied surface tension of cell membrane and on the basis of their observation they pointed out the existence of protein molecules adsorbed on the surface of lipid droplets which reduce the surface tension of droplets.

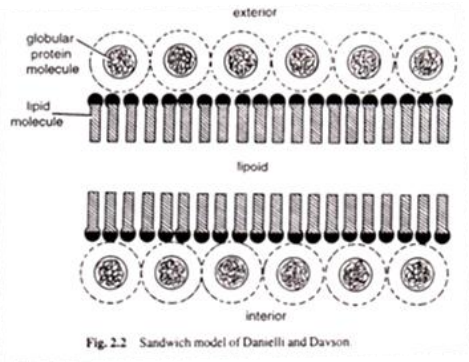


Fig. 2.2 Sandwich model of Danielli and Davson

According to bimolecular model of Danielli and Davson, plasma membrane consists of two layers of phospholipid molecules (a bimolecular leaflet) in which phospholipid molecules are arranged in such a way that hydrophilic heads of the phospholipid molecules face outside and hydrophobic non-polar lipid chains are associated in the inner region of leaflet.

The hypothesis also suggested that the polar ends of lipid molecules are associated with monomolecular layer of globular proteins. The plasma membrane would thus consist of a double layer of phospholipid molecules sandwiched between two essentially continuous layers of protein.

(ii) Unit Membrane Model:

In 1950 J. David Robertson studied the cell membranes from electron micrographs of sectioned material. The preparations involved usual fixing in solutions of osmium tetraoxide and potassium permanganate ($KMnO_4$), and dehydrating in solvents such as acetone before sectioning.

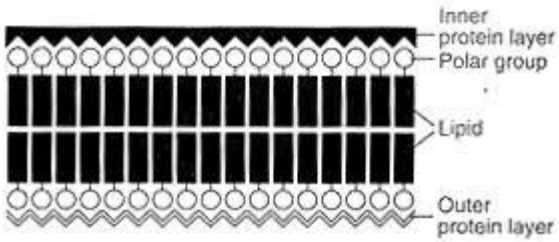


Fig. 2.36: The unit membrane of Robertson

This conclusion led Robertson in 1953 to propose unit membrane hypothesis according to which all biological membranes show generalised unit membrane construction. The unit membrane model visualises cell membrane as a trilaminar and indicates structure consisting of two dark osmiophilic layers separated by a light osmiophilic layer.The physical appearance of this trilaminar model has led to the term unit membrane. The unit membrane concept implies a trilaminar appearance with a bimolecular lipid layer between two protein layers. Each dense osmiophilic band is made up of protein (20 Å) and the polar groups of phospholipids (5 A) and is thus 25 Å thick.The clear Osmiophilic zone 35 A in thickness is a bimolecular layer of lipids without the polar groups. In other words, the unit membrane is 75 Å thick with a 35 Å thick phospholipid layer between two 20 Å thick protein layers. The plasma membrane surrounding the cell is thicker at the free surfaces of the cell than where it is in contact with other cells.In unit membrane model the protein layers are assymetrical. On the outer surface it is mucoprotein while on the inner surface it is non-mucoid protein.

Fluid Mosaic Model:

The fluid mosaic model of cell membrane was proposed in 1972 by S.J. Singer and G.L. Nicolson. According to this model, the cell membranes have been visualised as mosaics of lipids and proteins. The lipids are thought to be arranged primarily in a bilayer in which peripheral and integral proteins are embedded to varying degrees.Immunological experiments have indicated the attachment of antibodies to surface-exposed integral proteins such as glycophorine.This suggests that membrane proteins are not fixed within the lipid layer but are free to move laterally like icebergs floating in a sea of lipids. This picture has inspired Singer and Nicolson to coin fluid mosaic model.

If this analogy of icebergs floating in a sea of lipids is valid then it should be possible to freeze proteins by solidifying the lipid sea in which they float, his is indeed, possible when the phase transition occurs from liquid to solid. At this point the mobility of proteins in the membrane will be checked.Singer and Nicolson considered the lipoprotein association to be hydrophobic and fluidity of the membrane results due to hydrophobic interaction. It should be noted that phospholipids and many intrinsic proteins are amphipatic molecules, i.e., both hydrophilic and hydrophobic groups occur within the same molecule.The globular proteins of the membrane are of two different types: extrinsic (peripheral protein) and intrinsic (integral proteins).Because of rapid movement of lipid and protein molecules, the fluid mosaic model is different from the static picture of the membrane in Danielli and Davson model. The proteins of the membrane are concerned with the enzymatic activities, transport of molecules and with receptor function. The lipid bilayer acts as the permeability barrier.

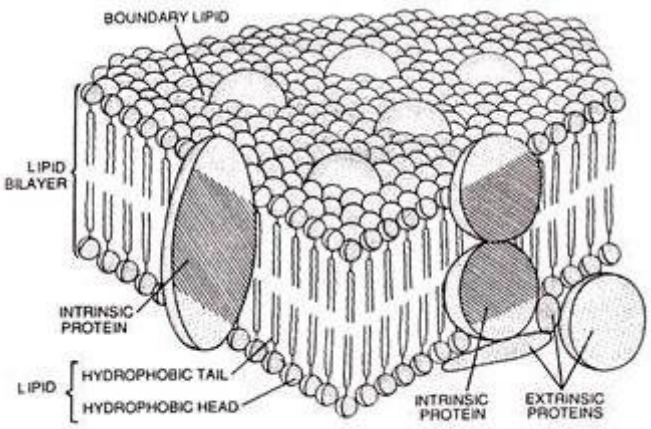


Fig 2.5 Fluid mosaic model of cell membrane.

The fluidity of lipid is supported by many indirect studies based on x-ray diffraction, differential thermal analysis and electron spin resonance (ESR) techniques.

OR

What are chromosomal aberration? Describe deletion and duplication with suitable diagram. 6

Answer: The arrangement and presence of many genes on a single chromosome provides a change in genetic information not only through change in chromosome number but also by a change in chromosome structure. The change in chromosome is due to alteration in genetic material through loss, gain or rearrangement of a particular segment. Such changes are called chromosomal aberrations. The modification brings about chromosomal mutations. Chromosomal mutations are very rare in nature but can be created artificially by 'X' rays, atomic radiation and chemicals, etc.

The structural changes in chromosomes are due to breaks in chromosome, or in its cell division subunit, i.e., chromatid. Each break produces 2 ends which may then follow three different paths.

(a) They may reunite, leading to eventual loss of that chromosomal segment which does not contain the centromere.

(b) Immediate reunion or reconstitution of the same broken ends may occur, leading to reconstitution of the original structure.

(c) One or both ends of one particular break may join those produced by a different break causing an exchange, or non reconstitutional union.

Mc Clintock (1941) studied in Zea Mays that chromosome breaks and duplication follows. A dicentric chromatid is found. During anaphase spindle fibres are attached to the two centromeres resulting in the formation of bridge from one pole to other. The bridge breaks causing deficiency or duplication.

Chromosomal aberrations are of 4 major types:

(a) Deletion (b) duplication (c) inversion and (d) translocation.

(A) Deletion or Deficiency:

Deletion or deficiency as the name suggests there is a loss of segment of chromosome. After break the part without centromere is lost. On the other hand the part attached to the centromere acts as deficient chromosome. Bridges (1917) for the first time observed deficiency in the Bar locus of *Drosophila*. Two types of deletions are found:

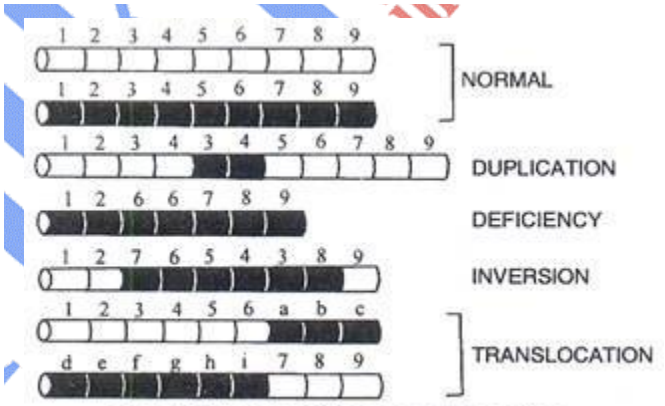


Fig. 43.2. Types of Chromosomal aberrations.

1. Terminal deletion:A single break near the end of the chromosome. Described in maize but otherwise not common.

2. Interstitial deletion: Chromosome breaks and reunites but the part is lost from in between.

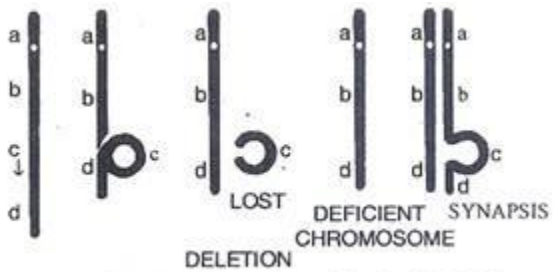


Fig. 43.3. Various steps involved in Deletion

Deletions are detected at the time of homologous pairing. If a part of chromosome is missing then the other chromosome also has to omit it in the form of bulging in order to make synapse. e.g., if a chromosome has 1, 2, 3, 4, genes. The part 2 is missing from one chromosome leaving, 1, 3, 4. The other homologous chromosome at the time of synapse bulge out or form loop at position 2.

If the missing segment is of physiological importance the individual will not survive. If dominant gene ‘A’ is missing the recessive allele ‘a’ may express itself. It is called pseudo

dominance.In corn the deficiency is restricted to pollen sterility. The male haploid gemetophyte shows deficiency while female of it may receive metabolites from maternal tissue supplementing the deficiency. The omitted segment forms buckles.

Deficiency in E. coli is also noted. The deletion points that the DNA is single stranded and looks like collapsed loop or brush.

(B) Duplication:

Here a segment of chromosome is repeated twice, i.e., duplicated. Duplication was discovered in Drosophila 'X' chromosome for the first time carrying wild type allele for vermilion (v^+) and has been transposed to an 'X' chromosome carrying the mutant vermilion allele (v), Bridges found that due to the fact that 'X' chromosome was carrying allele v and v^+both it was wild type instead of vermilion. Equal properties of v and v^+ produced wild type effect. Such 'duplication females' when crossed with nonduplicated vermilion males all female progeny was vermilion and all male progeny, i.e., y was wild type. (Fig.43.6.)

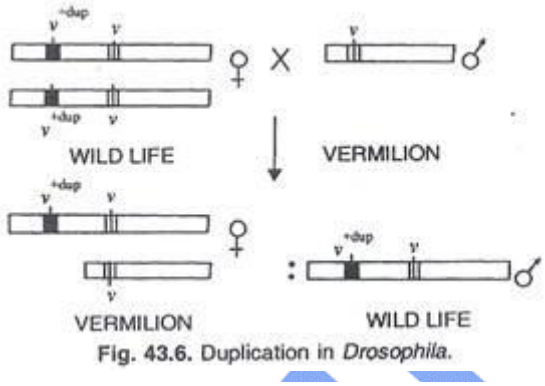


Fig. 43.6. Duplication in *Drosophila*.

Types of duplication:

1. Tandem duplication: When the duplicating segment is near the centromeres e.g., the sequence on chromosome isabcdefghithe centromere is present between e and f the segment d e is repeated immediately after its normal position.

2. Reverse tandem: When the segment is reversed in duplication, e.g., it is d e segment that is duplicated it will be duplicated as d e e d instead of d e d e.

3. Displaced tandem: The segment is repeated somewhere away from its original location but on the same arm (homobrachial displacement) or on the other arm (heterobrachial displacement).

4. Transposition: When the segment is duplicated on the non homologous chromosome it is called transposition.

5. Extra chromosomal: Duplication involves centromere it is called extra chromosomal. In salivary gland chromosome duplications are common either as buckling in the duplication heterozygote or as cross pairing between sections of different chromosomes.

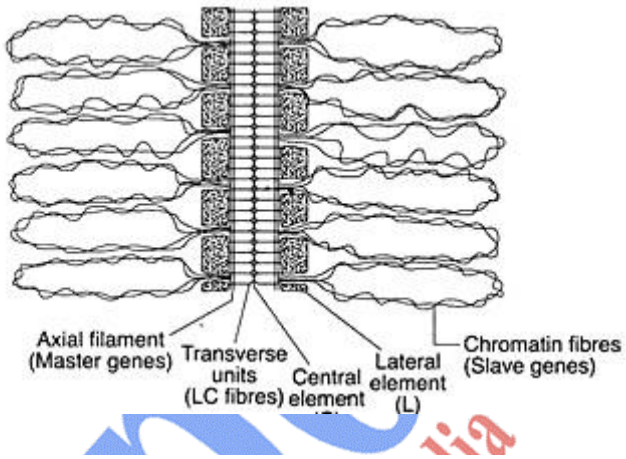
Unit II

3. Write short notes on following-

(i) Synaptonemal complex. **3**

Answer: A protein structure that forms between two homologous chromosomesduring meiosis and that is thought to mediate chromosome pairing, synapsis, and recombination. The synaptonemal complex is a tripartite structure consisting of two parallel lateral regions and a central element.

In cross section it can be observed that the synaptonemal complex is flattened ribbon like structure. Under electron microscope the synaptonemal complex appears consisting of parallel dense strands lies in a single plane that are curved and are twisted along its axis. These are flanked by chromatin.



The distance between the homologous chromosomes is considerable in molecular forms, more: than 200 nm of the three dense lines – the central element is of variable prominence, whereas the two lateral arms are very dense. The central element may also appear as a long tripartite bar with ladder like transverse connections.

The lateral arms vary in width in various species. They are formed of electron dense coarse granules or fibres. These arms are joined to the adjacent chromosomes by fine fibrils. The lateral elements show sub-divisions in two longitudinal components.

Series of lateral loops of chromatin arise from lateral elements. These loops fuse in the middle line to form central element. The synaptonemal complex is attached at both ends through its lateral elements to the inner surface of the nuclear membrane.

Function:

1. Maintenance of synapsis in fixed state for an extended period for crossing over to occur.
2. To provide a structural frame work within which exchange of segment take place.
3. To segregate recombination DNA from the rest of other chromosomal DNA.

(ii) Mitochondrial DNA and Chloroplast DNA. **1½ + 1½**

Answer: Mitochondrial DNA is a double stranded circular molecule, which is inherited from the mother in all multi-cellular organisms, though some recent evidence suggests that in rare instances mitochondria may also be inherited via a paternal route. There are about 2 to 10 transcripts of the mt-DNA in each mitochondrion. Compared to chromosomes, it is relatively smaller, and contains the genes in a limited number.

The size of mitochondrial genomes varies greatly among different organisms, with the largest found among plants, including that of the plant Arabidopsis, with a genome of 200 kbp in size and 57 protein-encoding genes. The smallest mtDNA genomes include that of the protist Plasmodium falciparum, which has a genome of only 6 kbp and just 2 protein- encoding genomes. Humans and other animals have a mitochondrial genome size of 17 kbp and 13 protein genes. Mitochondrial DNA consists of 5-10 rings of DNA and appears to carry 16,569 base pairs with 37 genes (13 proteins, 22 t-RNAs and two r-RNA) which are concerned with the production of proteins involved in respiration. Out of the 37 genes, 13 are responsible for making enzymes, involved in oxidative phosphorylation, a process that uses oxygen and sugar to produce adenosine tri-phosphate (Fig. 4.56). The other 14 genes are responsible for making molecules, called transfer RNA (t-RNA) and ribosomal RNA (r-RNA).

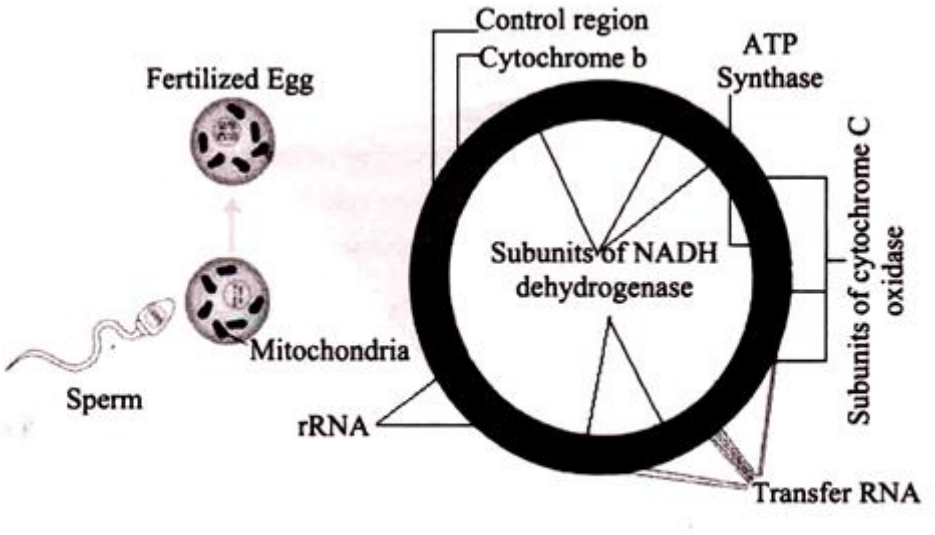


Figure 4.56: Mitochondrial DNA

Chloroplast DNA is comparatively large, circular in nature, commonly denoted as ctDNA. The presence of DNA in chloroplast was first identified in 1962. The size of chloroplast DNA is usually 140 kb in higher plants and less than 190 kb in lower eukaryotic plants. However, the size of the ctDNA is generally between 120 and 155 kb. There are many copies of circular DNA in chloroplast, i.e., between 20 and 100 copies per chloroplast in higher plants.In higher plants, chloroplast DNA exists as double-stranded circular molecule. Chloroplast contains one type of chromosome and assumes polyploid status. In chloroplasts of maize and pea, DNA replication begins at two sites about 7000 base pairs apart and proceeds

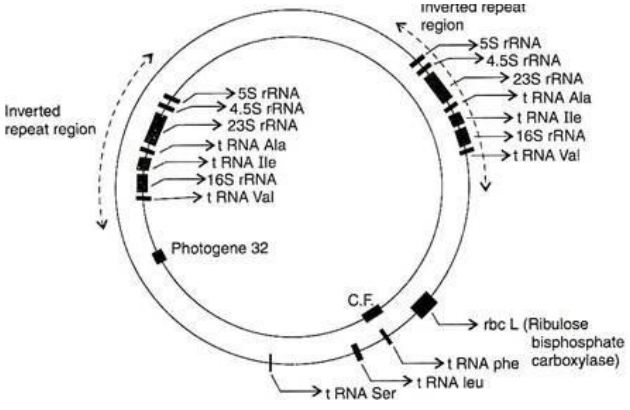


Fig. 5.1 Restriction endonuclease map of maize plastid chromosome

in both the directions.

Chloroplasts contain introns. They fall into two classes. One of the intron classes is located in tRNA genes and another class in protein coding region. Several photosynthetic related genes that encode proteins are located in thylakoid membrane.

Several evidences confirmed that chloroplast DNA contains 45 genes coding for RNA and 27 genes coding for proteins. These proteins are mainly involved in chloroplast gene expression. The genes coding for proteins of the thylakoid membrane and another 10 gene products are committed for electron transport process.

A restriction map for maize chloroplast DNA (139 kb) reveals that plastome contains unique 22,000 base pair inverted repeated sequence, containing the rRNA genes (Fig. 5.1). Some other plastome with similar repeats contains two copies of rRNA genes.

OR

What is meiosis? Give a detailed account and significance with suitable diagram. 6

Answer: Every sexually reproducing organism is characterized by another type of cell division occurring in the germinal line, where the chromosome number undergoes reduction. This division occurs in the male and female organs of flowers in plants and gonads in animals. In meiosis, single interphase is followed by two nuclear divisions — Meiosis-I and Meiosis-ll. Meiosis I is reductional division and Meiosis-II is equational division.

Meiosis-I: The first meiotic division consists of four stages-Prophase I, Metaphase I, Anaphase I and Telophase I.

1. Prophase I: Meiosis I has a long drawn out prophase which is divided into five sub-phases, namely, leptotene, zygotene, pachytene, diplotene and diakinesis.

Leptotene: In the prophase of meiosis, leptotene is the first stage where the chromosomes appear as very long narrow thread. It is preceded by 'S' phase in interphase, where DNA replication takes place. The leptotene threads appear apparently single though being double in nature. In this stage the nucleolus is very distinct and the entire nucleusappear to be convoluted in nature.

Zygotene: In zygotene, two homologous chromosomes, one being derived from the female and the other from the male parent, remain paired with each other throughout the chromosome length in every gene locus. The process of synapsis where homologous chromo-somes come together, characterizes the phase.Under electron microscope, the synaptonemal complex can be observed. The formation of synaptomal complex is an evidence of homologous pairing at homologous segments.

Pachytene: Homologous chromosomes which form the bivalents can be clearly observed in pachytene due to contraction of chromosome segments. During this phase, interchange of fragments between paternal and maternal sets of chromosomes occurs through a process known as crossing ever. The breakage and reunion of segments are achieved during this phase and two chromosomes originating thereby contain interchanged segments. Because of crossing over and interchange of segments between homologous chromosomes, chiasmata or cross-shaped structure is observed which is the visible sign of cross over.

Diplotene: During this phase, the chiasmata of each bivalent undergoes terminalization, that is, the movement of two homologous chromosomes to the two ends. The number of chromosome bivalents can be fully studied including those which are almost terminalized.

Due to chromosome contraction, they are very distinct as visible bivalent structure.

Diakinesis: Next phase is diakinesis, where the chiasmata are almost fully terminalized and the two chromosomes remain together by their extreme terminal chiasma.

2. Metaphase-I: The end of diakinesis marks the end of prophase and the beginning of first meiotic metaphase. This phase is characterized by the disappearance of nuclear membrane and nucleolus. The spindle structure is formed just like mitosis and the spindle fibres are almost identical both in its structure and function with those of mitosis.

The bivalents arrange themselves at the equator. The chromosomes point towards opposite direction of the poles and the chiasmata lie on the equatorial region. During this stage, the bivalents undergo maximum shortening and condensation.

3. Anaphase-I: In the succeeding anaphase, i.e. Anaphase I, the homologous centromeres move towards opposite direction of the pole. The centromere of each chromosome remains intact. The chromosome being separated, there are no chiasmata at this stage.

4. Telophase-I: Anaphase i is followed by succeeding telophase I in which each set of chromosomes reaches to the two different poles. As two chromosomes of a bivalent go to two different poles, each daughter nucleus contains half the number of chromosomes. For example, in Oryza sativa the somatic chromosome number is 2n = 24 and the daughter nucleus after first meiotic division contains 12 chromosomes.

Meiosis-II:

The first division of meiosis is followed by the second division cycle of the same stages namely – Prophase-II, Metaphase-II, Anaphase-II and Telophase-II as in mitosis (Fig. 5.3C). After the first reductional meiotic division, also termed as heterotypic division, the diads are formed, containing daughter nuclei with half the number of chromosomes than the parent cell, and enter into the homotypic division.

Prophase-II: The chromosomes condense and are composed of two chromatids – one parental and the other recombinant.

Metaphase-II: each chromosome arranges itself at the equator. The typical mitotic separation of two chromatids follows in **anaphase-ll**.

Thus, after **telophase-II**, the tetrads originating out of diads result in four cells (gametes/spores) containing haploid or half the number of chromosomes.

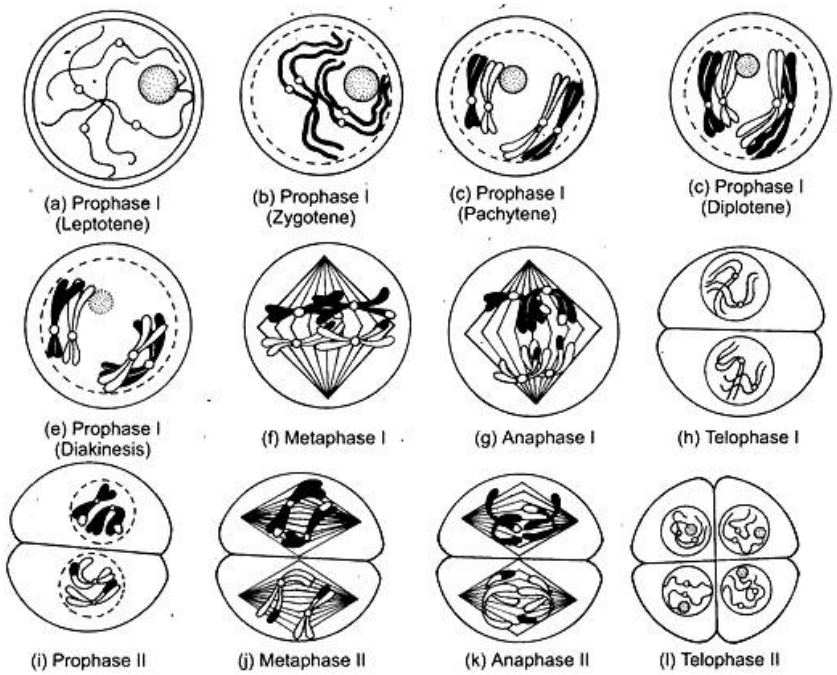


Fig. 5.3A: Different stages of Meiosis (diagrammatic)

Mitotic division occurs in the nuclei of the haploid spores in plants which ultimately give rise to gametes containing only one set of chromosomes or haploid ones. When the two male and female gametes unite, each being haploid, the zygote is formed with a diploid set of chromosomes.Throughout the organization of the body, equational division is the rule followed by reductional separation during the formation of germ cells.

Significance of Meiosis I and Meiosis II:

1. The meiosis is a logical and necessary part in the life cycle of sexually reproducing organisms, since it leads to the formation of gametes or sex cells, capable of engaging in fertilization. These gametes are haploid cells having only one member of each homologous pair.

2. The meiosis is concomitant of doubling of chromosome number due to gametic fusion. The gametes formed as a result of meiosis are haploid and the zygote formed by their fusion is diploid. Thus it is the only means for restoring the chromosome number, characteristic of the species.

3. Meiosis provides for new combinations of genetic material. During crossing over, the hereditary factors from male and female parents get mixed due to breakage and exchange of

chromatids in pachytene. Thus the gametes produced are not all alike but with variable combination of genes.

4. The random segregation of paternal and maternal chromosomes and the new alignments of genes in them resulting from crossing over, ensure genetic variations in the population. This inherited variability leads to the evolution of organisms.

Unit III

4. Write short notes on following-

(i) Mass selection. **3**

Answer: Mass selection

In mass selection, seeds are collected from (usually a few dozen to a few hundred) desirable appearing individuals in a population, and the next generation is sown from the stock of mixed seed. This procedure, sometimes referred to as phenotypic selection, is based on how each individual looks. Mass selection has been used widely to improve old "land" varieties, varieties that have been passed down from one generation of farmers to the next over long periods.

(a) Similar and superior phenotypes are selected (200-2000 plants).

(b) The seeds are harvested from individual plant separately.

(c) The harvested seeds from individual plant are sown in rows.

(d) The inferior or segregating progenies are rejected.

(e) The seeds from the remaining selected plants are harvested together.

(f) The composite seeds are used for preliminary yield trials along with standard checks.

(g) Multilocation co-ordinated yield trials are performed.

(h) Superior phenotypes are released as new varieties.

(i) Seeds are multiplied and distributed.

An alternative approach that has no doubt been practiced for thousands of years is simply to eliminate undesirable types by destroying them in the field. The results are similar whether superior plants are saved or inferior plants are eliminated: seeds of the better plants become the planting stock for the next season.

A modern refinement of mass selection is to harvest the best plants separately and to grow and compare their progenies. The poorer progenies are destroyed and the seeds of the remainder are harvested. It should be noted that selection is now based not solely on the appearance of the parent plants but also on the appearance and performance of their progeny. Progeny selection is usually more effective than phenotypic selection when dealing with quantitative characters of low heritability. It should be noted, however, that progeny testing requires an extra generation; hence gain per cycle of

selection must be double that of simple phenotypic selection to achieve the same rate of gain per unit time.Mass selection, with or without progeny test, is perhaps the simplest and least expensive of plant-breeding procedures. It finds wide use in the breeding of certain forage species, which are not important enough economically to justify more detailed attention.

Application of Mass Selection:

i) Improvement of Local or Deshi Varieties: The local varieties are mixtures of several genotypes, which would be inferior and low yielding, such plants will be eliminated through mass selection and local variety would be improved without adversely affecting its adaptability and stability.

ii) Purification of Existing Pure Line Varieties: Pure lines tend to become variable with time due to mechanical mixtures, natural hybridization, mutation etc. therefore, it is necessary that the purity of pure line varieties be maintained through regular mass selection.

Advantages of Mass Selection:

1. Variety developed through mass selection is more widely adapted than pure lines because of large no. of plants are selected.
2. It is easiest, simplest and quickest method of plant breeding because there is no controlled pollination, no progeny testing and prolonged yield trials
3.The breeder can developed more time to another program as it is less demanding method.

Disadvantages of Mass Selection:

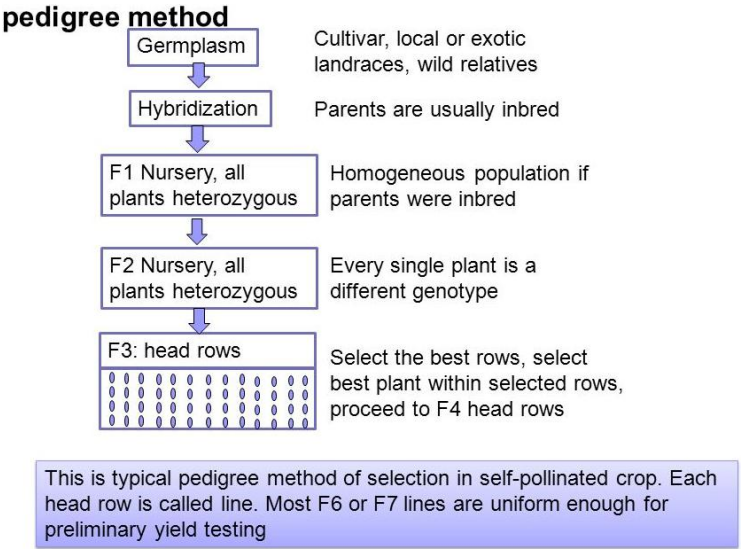
1. The varieties developed by this method show variation and are not uniform as pure lines.
2. In the absence of progeny test, it is not possible to determine whether the selected plats are homozygous for specific characters. Similarly, whether phenotypic superiority of selected plants is due to environment of the genotype can't be determined.
3. The varieties developed by mass selection are more difficult to identify than pure lines in seed certification program.
4. It is not useful for improvement in quantitative characters, such as yield because phenotypic and environmental effects can't be separated out.
5. Improvement is short lived, since the variety produced is a mixture of different genotypes, hence, required to be repeated every year in cross-pollinated crops.

(ii) Pedigree method. **3** **Answer:**

In Pedigree method, a detailed record of the relationship between the selected plants and their progenies is maintained as a result of this each progeny in every generation can be traced back to the F2 plant from which it originated, such record is known as pedigree record or pedigree. The pedigree may be defined as a description of the ancestors of an individual and

it generally goes back to some distant ancestors. Thus, it describes the parents grandparents, great grandparents so on of an individual.

Maintenance of Pedigree Record:



Pedigree record may be kept in several ways, but it should be simple and accurate. Generally, each cross is given a number. The first two digits of this number refer to the year in which the cross was made, and the remaining digits denote the serial number of the cross in that year.

For example, the number 7911, denotes the cross number 11 of the year 79. In the segregating generation one of the two systems of designation may be followed.

Application of Pedigree Method:

1) Selection of desirable plants from the segregating population in self- pollinated crops.

2) This method is commonly used to correct some specific weaknesses of an established variety (Combination breeding).

3) It is also used in the selection of new superior recombinant type's i.e Transgressive breeding.

4) This method is suitable for improving specific characteristics such as disease resistant, plant height, maturity etc.

Advantages of Pedigree Method

- Excellent method for improvement of easily observable, high heritability characters.
- As pedigree record is maintained, information regarding inheritance pattern of characters can be obtained as and when required.
- Each plant can be traced back to its parent plant.
- Only those progeny lines which contain plants with desired characters are selected for next generation. So there is scope for plant breeder's skills.
- Progeny tests are done, thus it is based on genotypic value rather than phenotypic value.
- Increased breeding efficiency by early identification of superior heterogeneous populations
- Scope for transgressive segregation to occur for the characters like yield.

- New variety development takes short period as compared to bulk method.

Disadvantages of Pedigree Method

- Costly
- Labor intensive.
- Requires skilled person as selection is practiced
- Pedigree record maintenance is time consuming.
- Selection for yield or other characters in F_2 and F_3 is ineffective.
- One important to note is genetic variation available for selection gets decreased in later generations due to the individual plant selection carried out earlier.

OR

What is epistasis? Explain dominant and recessive epistasis. 6

Answer: It is the phenomenon by which one gene does not allow alleles of another locus to express. Genes can either mask each other so that one is considered "dominant" or they can combine to produce a new trait. It is the conditional relationship between two genes that can determine a single phenotype of some traits.

Types of epistasis:

1. Dominant epistasis (12:3:1 ratio): When a dominant allele at one locus can mask the expression of both alleles (dominant and recessive) at another locus, it is known as dominant epistasis. In other words, the expression of one dominant or recessive allele is masked by another dominant gene. This is also referred to as simple epistasis.An example of dominant epistasis is found for fruit colour in summer squash. There are three types of fruit colours in this cucumber, viz., white, yellow and green. White colour is controlled by dominant gene W and yellow colour by dominant gene G. White is dominant over both yellow and green. Here W is dominant to w and epistatic to alleles G and g. Hence it will mask the expression of G/g alleles. Hence in F_2, plants with W-G-(9/16) and W-gg

Parents: White Fruit WWgg × Yellow Fruit wwGG

F_1: WwGg White Fruit

F_2:

	WG	Wg	wG	wg
WG	WWGG [W]	WWGg [W]	WwGG [W]	WwGg [W]
Wg	WWGg [W]	WWgg [W]	WwGg [W]	Wwgg [W]
wG	WwGG [W]	WwGg [W]	wwGG [Y]	wwGg [Y]
wg	WwGg [W]	Wwgg [W]	wwGg [Y]	wwgg [G]

W = White Fruit, Y = Yellow fruit, G = Green Fruit

Fig. 8.3. Dominant epistasis for fruit colour in Summer squash. The normal dihybrid modified to 12 : 3 : 1 in F_2 generation.

(3/16) genotypes will produce white fruits; plants with wwG-(3/16) will produce yellow fruits and those with wwgg (1/16) genotype will produce green fruits.

The green fruits are produced in recessive condition (wwgg). A cross between plants having white and yellow fruits produced F_1 with white fruits. Inter-mating of F_1 plants produced plants with white, yellow and green coloured fruits in F_2 in 12 : 3 : 1 ratio (Fig. 8.3). Thus the normal dihybrid ratio 9 : 3 : 3 : 1 is modified to 12:3: 1 ratio in F_2 generation. Similar type of gene interaction has been reported for skin colour in mice and seed coat colour in barley.

2. Recessive epistasis (9:3:4): When recessive alleles at one locus mask the expression of both (dominant and recessive) alleles at another locus, it is known as recessive epistasis. This type of gene interaction is also known as supplementary epistasis. A good example of such gene interaction is found for grain colour in maize. There are three colours of grain in maize, viz., purple, red and white. The purple colour develops in the presence of two dominant genes (R and P), red colour in the presence of a dominant gene R, and white in homozygous recessive condition (rrpp).

Parents: Purple Grains PPRR × White Grains pprr

F_1: PpRr Purple Grains

F_2:

	PR	Pr	pR	pr
PR	PPRR [P]	PPRr [P]	PpRr [P]	PpRr [P]
Pr	PPRr [P]	PPrr [W]	PpRr [P]	Pprr [W]
pR	PpRR [P]	PpRr [P]	ppRR [R]	ppRr [R]
pr	PpRr [P]	Pprr [W]	ppRr [R]	pprr [W]

P = Purple, R = Red, and W = White grains

Fig. 8.2. Recessive epistasis for grain colour in maize. The normal dihybrid segregation ratio of 9 : 3 : 3 : 1 is modified to 9 : 3 : 4 in F_2.

A cross between purple (RRPP) and white (rrpp) grain colour strains of maize produced plants with purple colour in F_1. Inter-mating of these F_1 plants produced progeny with purple, red and white grains in F_2 in the ratio of 9 : 3 : 4 (Fig. 8.2).

Here allele r is recessive to R, but epistatic to alleles P and p. In F_2, all plants with R-P-(9/16) will have purple grains and those with R-pp genotypes (3/16) have red grain colour. The epistatic allele r in homozygous condition will produce plants with white grains from rrP-(3/16) and rrpp (1/16) genotypes.

Thus the normal segregation ratio of 9 : 3 : 3 : 1 is modified to 9 : 3 : 4 in F_2 generation. Such type of gene interaction is also found for coat colour in mice, bulb colour in onion and for certain characters in many other organisms.

Unit IV

4. Write short notes on following-

(i) Role of mutation in plant breeding. **3**

Answer: Mutation in plant breeding improving the crop quality. Plant mutation can be artificially affected by mutagenic agents and its utilization for production of traditional to new superior variety is called plant mutation breeding. In India mutation breeding started in 1935 at Bose institute, Calcutta and established at IARI New Delhi in 1959. Role of mutation are as follows:

1. **Mutation breeding in Rice (*Oryzae sativa*) 2n=24:** some chemical mutagens used in rice to produce polyploidy varieties and diploids produce high yield and resistance verities through hybridization. P-500.28 mutated variety obtained from T-1145 at Bose institute, Calcutta. Jagannath variety produced from T.141.

2. Mutation breeding in Wheat (*Triticum aestivum*) 2n=42: chemical mutagen and eradication being used to produce resistance wheat varieties NP836 from NP799 using gamma ray at IARI New Delhi.

3. Mutation breeding in Cotton (*Gossypium*) 2n=52: cotton variety produced by X-ray treatment. Indore-2 was produced by Malwa Upland-4. L.SS Burry-0394, 320-F and H-14 another improved cotton varieties produced by mutation breeding.

4. Mutation breeding in Potato (*Solanum tuberosum*) 2n=48: production of early harvesting varieties and high yielding varieties introduced from mutation breeding.

5. Mutation breeding in Sugarcane (*Saccharum officinarum*) 2n=80: chemical mutagen and eradication used to mutation in sugarcane. Nodal buds of sugarcane are exposed to the radiation in mutant buds and tillers selected f1 and f2 generation through artificial crosses and field. Co-213, Co-602, Co-612, H.M-661 varieties is higher quality of sugarcane produced by mutation breeding.

(ii) Famous Indian plant breeder. **1½ + 1½**

Answer: Famous indian plant breeder:

1. M. S. Swaminathan: Monkombu Sambasivan Swaminathan, (born August 7, 1925, Kumbakonam, Tamil Nadu, India), Indian geneticist and international administrator, renowned for his leading role in India's "Green Revolution," a program under which high-yield varieties of wheat and rice seedlings were planted in the fields of poor farmers. Swaminathan, the son of a surgeon, was educated in India and at the University of Cambridge (Ph.D., 1952) as a geneticist.

During the next two decades he held a number of research and administrative positions (mostly in the Indian civil service). While working in those positions, he helped introduce Mexican semidwarf wheat plants to Indian fields and helped to bring about greater acceptance of modern farming methods. From 1972 to 1979 he was director general of the Indian Council of Agricultural Research, and he was principal secretary of the Indian ministry of agriculture and irrigation from 1979 to 1980. He served as director general of the International Rice Research Institute (1982–88) and as president of the International Union for Conservation of Nature and Natural Resources (1984–90).

2. B. P. Pal: Benjamin Peary "B.P." Pal (1906-1989) was a prominent Indian plant breeder who was a major figure in the Green Revolution. Pal received his PhD in plant genetics at Cambridge in the UK, first studying under Rowland Biffen and later under Frank Leonard Engeldow.

Upon receiving his PhD in 1933, Pal returned to India and assumed a position as an Economic Botanist at the Indian Agricultural Research Institute (IARI) at Pusa. Four years later, in 1937, he became the head of the division of botany at IARI. In the 1960's, Pal was one of the leading figures involved in bringing Norman Borlaug's high yielding Mexican varieties of wheat to India. (For more, see the article on Wheat Breeding in the Green Revolution.) Pal was appointed as the director of the Indian Council for Agricultural Research (ICAR) by Minister of Food and Agriculture C. Subramaniam in 1965, a position he held until his retirement in 1972.

3. T. S. Venkatraman: He was responsible for the spectacular achievement in evolving improved varieties and thereby stabilizing sugarcane industry in the country as it stands today and the worldwide recognition of the Coimbatore Institute. He transferred thick stem and high sugar contents from tropical noble cane (*Saccharum officinarum*) to north Indian canes (*Saccharum berberi*). This process is known as Noblization of sugarcane.

4. N. G. P. Rao: Dr. Neelamraju Ganga Prasada Rao is famously known as “Father of Hybrid Sorghum”. He is also famous for his basic and applied research in breeding and agronomy of several dryland crop. Due to his efforts sorghum hybrids, CSH1, CSH5 and CSH9 became very popular and were cultivated in over 8 to 10 million hectares. He was also well recognised for his contributions in dryland crops, particularly long staple desi cotton, castor, pigeonpea and also novel cropping systems. He also had held various positions such as Consultant to the Food and Agricultural Organization (FAO), All-India Coordinated

Sorghum Improvement Project, Project Coordinator (Sorghum), IARI, ICRISAT's Regional Sorghum Breeder for West Africa.

5. V. Santhanam: Dr.Vaidhyanathaswamy Santhanam (born 31 July 1925) is an Indian cotton scientist and former FAO of United Nations long term resident expert for Cotton and Project leader in Myanmar. He had served as a short term consultant to Vietnam as well.He is Chairman of the Expert Review team of the Southern India Mills Cotton Development and Research Association for November 2009 – March 2010. He is an author/co-author of over 110 publications including books and book chapters on cotton. Dr.Santhanam was born on 31 July 1925 at Tiruvarur in Tamil Nadu. He graduated from the Agricultural College, Coimbatore in the year 1946. He earned the Masters and Doctorate degrees by research in Plant Breeding and Genetics, from the Madras University.

Starting his professional career at the Cotton Breeding station of the same college, he had an illustrious professional career as a cotton research scientist with the Indian Council of Agricultural Research (ICAR).He was the first National Coordinator for the All India Coordinated Cotton Improvement Project under ICAR (1967–75). During his tenure, he had established a solid foundation for cooperative research among all the cotton growing states of India. In recognition of the work done by the cotton group headed by him, ICAR conferred the council's very first award for team research to them in 1975.

Dr.Santhanam served the Food and Agriculture Organisation in 1975 to 1983 as longtime resident expert on Cotton and Project Team Leader in Myanmar. He served them as short term consultant (Senior Advisor) in Myanmar and Vietnam during 1984 to 1987.

OR

Write an essay on green revolution. **6**

Answer: In the mid- and late-20th century a revolution occurred that dramatically changed the field of agriculture, and this revolution was known as the Green Revolution.

The **Green Revolution** was a period when the productivity of global agriculture increased drastically as a result of new advances. During this time period, new chemical fertilizers and synthetic herbicides and pesticides were created. The chemical fertilizers made it possible to supply crops with extra nutrients and, therefore, increase yield. The newly developed synthetic herbicides and pesticides controlled weeds, deterred or kill insects, and prevented diseases, which also resulted in higher productivity.

In addition to the chemical advances utilized during this time period, high-yield crops were also developed and introduced. **High-yield crops** are crops that are specifically designed to

produce more overall yield. A method known as multiple cropping was also implemented during the Green Revolution and lead to higher productivity. **Multiple cropping** is when a field is used to grow two or more crops throughout the year, so that the field constantly has something growing on it. These new farming techniques and advances in agricultural technology were utilized by farmers all over the world, and when combined, intensified the results of the Green Revolution.

Impact of Green Revolution

The green revolution resulted quantitative and qualitative development in the agriculture in India. The quantitative improvement occurs as a result of steep increase in the production of agriculture output. The qualitative improvement resulted into adoption of modernized technology in the agriculture. The impact of green revolution can be discussed as follows:

1. Spectacular increase in agriculture production

The dependence on food imports is eliminated with the increase in agriculture production. The country becomes self-sufficient in foodgrains. In fact India was the second largest importer in 1966 and it imported no foodgrain in subsequent decades except during late 80's and early 90's mainly due to failure of monsoons or untimely rains or floods in different regions. However, it may be noted that in recent years annual growth in the food grain production is losing its momentum.

2. Improvement in productivity

The tremendous increase in agriculture production occurred as a result of improvements in productivity. The productivity was quite low in the pre-green revolution period. The substantial increase in the productivity occurred in wheat and rice in the earlier periods but later on it spread to other crops also.

3. Increase in Employment

Green revolution generated employment opportunities into diverse activities which were created as a result of multiple cropping and mechanization of farming. It helped to stimulate non-farm economy that generated newer employment in various services such as milling, marketing, warehousing etc.

4. Food grain Price Stability

The adoption of new agricultural technology has led to the increased production and marketable surplus of crops especially food grains that have resulted into price stability of food items.

5. Strengthening of forward and backward linkages with industry

The increase in agriculture production has strengthened the forward linkage of agriculture sector with industry in the sense of supplying inputs to the industry. The backward linkage with the industry has also received a boost as agricultural modernization created larger demand for inputs produced by industry.

Problems with Green Revolution

The new agriculture strategy has resulted into increased productivity and returns for farmers. This has resulted in decline in rural poverty to an extent. However, the revolution resulted into increased income, wide interpersonal and regional inequality and inequitable asset distribution. The major problems associated with green revolution are as follows:

(1) Increase in personal inequalities in rural areas

The income inequality between rich and poor increases **due** to:

(i) The owners of large farms were the main adopters' of new technology because of their better access to irrigation water, fertilizers, seeds and credit. In other words, given the need for complex agricultural techniques and inputs, the green revolution benefits the large farmers. The small farmers lagged behind the larger farmer as small farmers had to depend upon traditional production method. Since the rich farmers were already better equipped, the green revolution accentuate the income inequalities between rich and poor.

(ii) Green revolution resulted into lower product price and higher input prices which also encouraged landlords to increase rents or force tenants to evict the land.

(iii) The mechanization pushed down the wages of and employment opportunities for unskilled labor in the rural areas thereby further widening the income disparities.

(2) Increased Regional disparities

Green revolution spread only in irrigated and high-potential rain fed areas. The villages or regions without the access of sufficient water were left out that widened the regional disparities between adopters and non-adopters. Since, the HYV seeds technically can be applied only in land with assured water supply and availability of other inputs like chemicals, fertilizers etc. The application of the new technology in the dry-land areas is simply ruled out. The states like Punjab, Haryana, Western UP etc. having good irrigation and other infrastructure facilities were able to derive the benefits of green revolution and achieve faster economic development while other states have recorded slow growth in agriculture production.

(3) Environmental Damage

Excessive and inappropriate use of fertilizers and pesticides has polluted waterway, killed beneficial insects and wild life. It has caused over-use of soil and rapidly depleted its

nutrients. The rampant irrigation practices have led to eventually soil degradation. Groundwater practices have fallen dramatically. Further, heavy dependence on few major crops has led to loss of biodiversity of farmers. These problems were aggravated due to absence of training to use modern technology and vast illiteracy leading to excessive use of chemicals.

(4) Restrictive Crop Coverage

The new agriculture strategy involving use of HYV seeds was initially limited to wheat, maize and bajra. The other major crop i.e. rice responded much later. The progress of developing and application of HYV seeds in other crops especially commercial crops like oilseeds, jute etc has been very slow. In fact, in certain period a decline in the output of commercial crops is witnessed because of diversion of area under commercial crop to food crop production. The basic factor for non-spread of green revolution to many crops was that in the early 1960's the severe shortage in food grains existed and imports were resorted to overcame the shortage. Government initiated green revolution to increase food grain productivity and non-food grain crops were not covered. The substantial rise in one or two food grain crop cannot make big difference in the total agricultural production. Thus new technology contributed insignificantly in raising the overall agricultural production due to limited crop coverage. So it is important that the revolutionary efforts should be made in all major crops.

It can be concluded that green revolution is a major achievement for India which has given it a food-security. It has involved the adaptation of scientific practices in the agriculture to improve its production and productivity. It has provided benefits to poor in the form of lower food prices, increased migration opportunities and greater employment in the rural non-farm economy. However, the inequalities between region and individuals that adopted green revolution and those who failed to adopt has worsened. Further, green revolution has led to many negative environmental impacts. The policy makers and scientists are urged to develop and encourage the new technologies that are environmentally and socially sustainable.

Role of Technology in Indian Agriculture

The important reason of low agricultural productivity in India is the unsatisfactory spread of new technological practices, including cultivation of HYV seeds. The adoption of new technology mainly the cultivation of HYV seeds requires intensive use of fertilizers and pesticides under adequate and often assured water supply. The use of HYV seeds involves higher yield risk as compared to the traditional seeds in the absence of proper irrigation facilities. The inadequate irrigation facilities in most part of the country explain the limited

regional spread of modern technology. Nearly 64 percent of total cultivated area is rainfed. Further, the irrigated area is generally used for growing rice and wheat while other crops are grown mostly in the rainfed and unirrigated area. In this scenario the technological development in terms of adoption of HYV seeds with chemical and fertilizers is only limited to few regions having irrigation coverage and that too for wheat and rice. Thus the adoption of new technology requires **the development of irrigation facilities** at first place so as to increase its regional and crop spread.

Another, factor that inhibits the dissemination of modern technology is the small and marginal land holdings and**slow progress of tenancy reforms**. The lack of ownership rights on land provide no incentive to adopt improved technology as the production is shared with the land owners and cost of adoption of new technology will be borne by the tenant cultivators. Thus institutional reforms in terms of land reforms have to be strengthened to improve adoption of modern technology.

The use of new technology improves the agriculture productivity. However, it also adds to the instability in the output growth. The application of new technology raises the response of output to water. Thus if applied under the rainfed conditions then the instability in output will be greater. However, the increase in output would be stable if applied under assured irrigated conditions. This requires effective public distribution system to stabilize prices during uncertain conditions.

Thus both institutional and technological changes have played important role in agriculture growth in India. The technological changes by themselves could not bring revolutionary productivity growth in the agriculture without the institutional and infrastructural changes. The new technology cannot be used if the agrarian system suffers from gross inequalities of land ownership and cultivation is in the hands of landless cultivators. Thus land reforms are required to abolish intermediaries and to undertake the reorganization of land holding. Further, modern technique also requires higher amount of investments.