TAMIL NADU AGRICULTURAL UNIVERSITY

PBG 201

GENETICS AND CYTOGENETICS (2+1)

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GENETICS

GENETICS- is the science of inheritance and variation. The science of genetics deals with the principles that explain the similarities between parents and their progeny and the differences among individuals of a single species.

A mango seed sown in soil produces only a mango tree and not a guava tree. What is it, that is hidden in the mango seed, which makes it grow into another mango tree only.

Why should a human being give birth to a human being and not to any other organism.

Children resemble their parents is due to **Heredity** and they also differ from their parents to some extent in because of variation.

Heredity may be defined as the potential of an individual to transmit its characters to the offspring while variation are the differences that the individual acquires due to the interaction with the environment. The main aim of genetics is the study of Heredity and variation, while heredity tries to maintain uniformity, variation brings in plasticity.

The term genetics was first coined by Bateson in 1906.

SPONTANEOUS GENERATION- an organism originates from a preexisting organism of similar kind. Thus organisms do not arise or originate from non-living matter. But this was not universally accepted till the middle of 19^{th} century. Many biologists believed that some primitive organisms originated from non-living matter eg. decaying organic matter. Such origin of living organisms from non-living materials is known as spontaneous generation. Aristotle (384-322 B.C) the greatest biologists of early days, believe that not only plants but animals like fleas, mosquitoes and snails originated from decaying organic matter.

But later, Lois Pasteur proved that, organic matters decay due to the presence of microbes in them and that microbes do not originate spontaneous from the organic matter. (Pastern-Father of Microbiology).

EARLIER CONCEPTS OF HEREDITY- Earlier concepts of heredity made their beginning first with the discovery of sexuality in organisms, both plants and animals. The invention of the microscope gave a great impetus to probe into the world of microcosm

and get a visual knowledge about the link between one generation and the other bringing about heredity transmission of characters.

Reproductive organs in plants were reported for the first time by Grew in 1682. It was Camerations however who for the first time described sexual reproduction in plants. In 1717 Fairchild produced a hybrid having characters of both the parents. The hybrid was called 'Fairchild's mule'

PREFORMATION THEORY- the discovery of sexuality revealed the physical link between one generation and another, thus providing a physical basis for the transmission of heredity from parents to progeny.

The homun calus theory of Swammerdam suggested that the development of an organism is a simple enlargement of a minute but completely preformed individual. The preformed individual or homunculus could be present either in the sperm or in the ovum. Subsequent studies, later clearly showed that the Preformation was wrong, but the entire Preformation theory was nothing but a figment of imagination.

EPIGINESIS THEORY- Wolf (1738-1794) who opposed the Preformation concept, opined that, neither the egg nor the sperm had a preformed organism, but both of them have undifferentiated mass of living substance which developed into he organisms after fertilization. According to this theory called epigenesis new organs and tissues are formed denovo (from the mass of living substances in the gametes) due to vital forces.

PANGENESIS THEORY- Hippocrates (400 BC) believed that reproductive material is produced from all parts of the body so that all the characters are represented in the progeny.

Charles Darwin (1809-1882) was also a Votary for this type of inheritance. He modified the view of Hippocrates slightly and called it the theory of progenies. According to this all parts of the body produce invisible gemmules or pangenes which are carried into sex organs via blood stream. There the pangenes are assembled into gametes. During fertilization, pangenes of mother and father combine to produce the character of the offspring.

LAMARCKIAN THEORY - (J.B. Hamarck 1744-1829) of inheritance, often called inheritance of acquired characters opines that, any new character acquired during the life

time of an individual inherited. It will be seen from the above that Charles Darwin's pangene theory in nothing but a version of Lamarckian theory.

GERMPLASM THEORY OF WEISMANN- August Weinmann (1834-1914) disproved the pangene theory with his experiments on rats. He cut the tails of rats and observed the progeny for 22 generations. In every generation the rat progeny continued to have tails in spite of the fact that the parents were tailless. If the pangene theory were to the correct, the tailless parents could not have sent the tail pangenes to the gametes and consequently the progeny should have been tailless.

Weismann proposed his 'germplasm theory' which is essentially correct even today. According to his theory, the body of an organism can be divided into two somatoplasm and germplasm. Somatoplasm constitutes the vegetative body of the organism, while the germplasm constitutes the reproductive part. Somatoplasm develops newly in every individual and there is no continuity while the germplasm is continuous and links the generations. With the information present in germplasm, every individual develops its own somatoplasm. Hence any change or variation occurring in somatoplasm cannot the transmitted to the next generation, while those of germplasm can be inherited.

CELL

A Cell may be defined as the structural and functional unit of a living being. It is the minimal biological unit capable of maintaining and propagating itself.

A study of the structural and functional organization of different structures within a cell is known as '**Cytology**'.

Cytogenesis concerns with the study of various aspects of chromosomes and their effects on the development of characters of organisms. It is universally accepted that genes are located in chromosome. Cytogenetics originated as a result of bringing two different branches of biology namely cytology and genetics together.

HISTORY- the word '**Cell**' has been derived from the Latin word Cellula meaning a small compartment. The term was first used by Robert Hook (1665). Robert Hook who constructed the first compound microscope observed the sections of Cork and opined that they contain honeycomb like compartments. German biologists M.J. Schleiden and T.S. Schewann (1838) established the 'Cell theory' that all organisms are made up of cells.

One of the significant discoveries of the cell came from 'Robert Brown' (1830). He discovered the presence of a spherical body in the centre of every cell, which he named 'Nucleus'.

In 1835-37, Purkinje and Mohi independently discovered that protoplasm is an important constituent of every cell and it plays an important role in every cell activity including division.

Golgi (1838) discovered the golgi apparatus, Balbiam (181) discovered chromosomes in the salivary glands of chironomus. At amount the same time, Flemming (1882) studied cell division in detail and gave the name ' Mitosis'.

Endoplasmic reticulum was discovered by proter in 1945, while Benda gave the name mitochondria to organells originally discovered by Hemming. Lyzosomes were discovered in 1955 by de Duve.

The shape of cell may be variable like spherical, rectangular, flattened, oval, polygonal triangular come like column etc.,

There is a great rang eof variation among cells in size also. This small cell size can be encountered in coccus bacteria (0.2 to 0.5 m) while the largest size of the cell is seen in Ostrich egg (Marly 15 cm).

Gross morphology of the cell

A generalized plant cell has an outer most envelope called the 'Cell wall'. This is absent in animal cells. Internal to this in the plasma membrane. This encloses the nucleus and other cytoplasmic inclusions suspended in cytoplasm. The inclusions are Ribosomes, Lysosomes, Mitochondria, Plastids, Golgi complex, Endoplasmic reticulum, Vacrole and non-liging inclusions like ctystals, raphids etc.,

The primitive organisms like certain bacteria blue green algae, the nucleus is not properly organized hence such cells are called Prokaryotic, while in evolved organisms, the nucleus is organized. Such cells are called Eukaryotic. The following are some of the fundamental differences between eukaryotic and prokaryotic cells.

S. No.	Character	Prokaryotic	Eukaryotic cells
1	Nuclear membrane	Absent	Present
2	DNA	Naked ad circular	Combined with proteins
3	Chromosome	Single	Multiple
4	Nucleolus	Absent	Present
5	Coty regenells	Absent	Present
6	Chromplast	Absent	Present
7	Cell wall	Non-Cellulosic	Cellulosic
8	Flagella	No definite arrangement of firbrills.	9+2 fibrillar arrangement

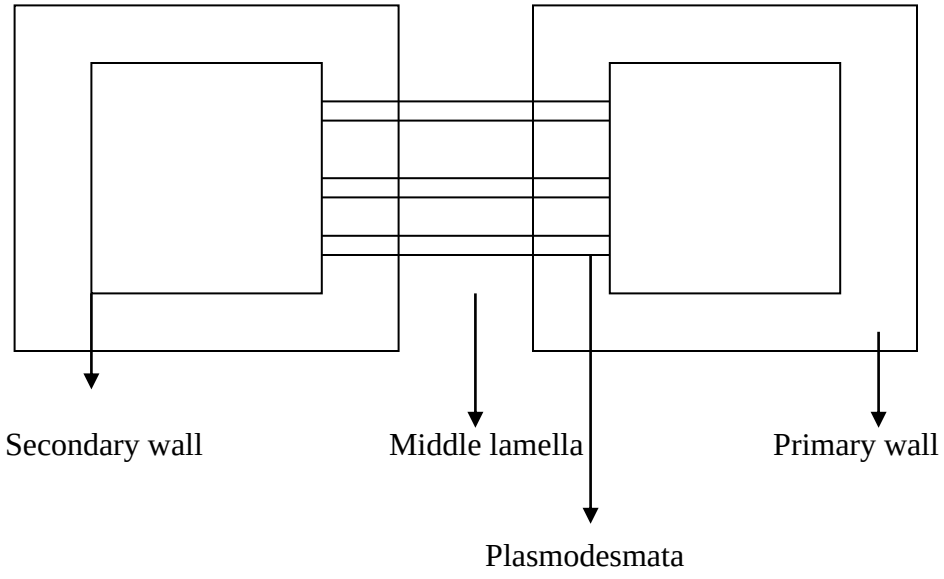
Studies with electron microscope have revealed various structures seen in an eukaryotic cell.

1. Cell wall
2. Plasma lemma
3. Endoplasmic reticular (E.R)
4. Ribosomes
5. Golgi bodies
6. Lysosomes
7. Sg herosomes
8. Chlroplasts
9. Mitochondria
10. Nucleus (Animal cell lack cell wall, chlnoplast while centrioles are not found in plant cell)

CELL WALL - Plant cells are surrounded by a non-living and rigid coat called a 'cell wall'. The main functions of a cell wall are to provide plant cells a definite shape and mechanical support and strength to tissue and organs. Cell wall has 3 distinct parts ;

1. Middle lamella
2. Primary cell wall
3. Secondary cell wall

Middle lamella - In plants, the wall of contiguous (immediate neighbour) cells are joined by middle lamella, which is composed mainly of pectin.



The pectin of middle lamella is most likely in the form of calcium (Ca^{++}) and Magnesium (Mg^{++}) salts. Adhesian of the walls of cotinguos cells in primarily dependant on the presence of Ca^{++} and Mg^{++} ions in themiddle lamella a removal of these ions results in the separation of cells from each other. Pectin is readily hydrolysed by the enzyme pectinase as well as by strong acids.

PRIMARY CELL WALL - is deposited after the formation of middle lamella and lies between midlle lamella and plasma lemma. It is main constituent are hemi cellulose (53%) and cellulose (30%). In addition it contains pectin (5%). Protein (5%) and lipid (7%).

SECONDARY CELL WALL - Is the last to be deposited and lies between cell wall and plasma lemma in a cell, it is the inner most laayer of wall. It is compsed of mainly of cellulose. The cellulose microfibrils are relatively more closely packed and they are arranged more or less parallel to each other. Several microfibrils associate to form a macrofibril, which is the structural unit of secondary cell wall.

PLASMA LEMMA (PLASMA MEMBRANE)

The membrane enclosing cytoplasm of a cell is known as plasma lemma or plasma membrane. It is composed of lipids and preoteins, the ratio between the two being quite variable among different cell types. Three distinct layers are seen under electron microscope, two or three are relatively dense and osmiphilic in nature; each of them is about 20^{o}A thich. The two osmaphilic layers are separated by a relatively light osmiphobic layer of about 35^{o}A thickness. The three layers together are known as 'Unit membrane'" this term coined by Robertson.

The chief function of plasma lemma in to regulate the movements of various molecules into and out of the cytoplasm. In addition to the passive movement of molecules, some ions are transported across plasma lemma by means of active transport.

CYTOPLASM

The substance, except nucelar, surrounded by the plasm lemma is known as 'Cytoplasm". Electron microscope reveal a member of membraneous and other structures in the cytoplasm; the portion of cytoplasm other than therse structure is known as 'hyaloplasm. Of the various structures preseent in the cytoplasm, mitochondria and plastids contain DNA; as a result they are autonomous to a limited degree. However, the remaining cytoplasmic structures do not contain DNA and they are specified exclusively by nuclear genes.

The cytoplasm may contain the following structues -endoplasmic reticulum (ER), ribosomes, Golgi bodies, Lysosomes, Sphersomes, Vacoles, certioles (in animals only), microtubrils, Mitochondira and plastids (in green plants only).

ENDOPLASMIC RETICULUM (E.R)

The cytoplasm contains an extensive network of membrane-enclosed space; these space along with the membranes enclosing them are known as E.R. It consists of 3 types of membrane-enclosed elements.

1. Vesicles of 25-500 in μ diameter
2. Tubules of 50-100 m μ diameter
3. 40-50 m μ thick cisterns of variable length and width.

The tubulus may or may not be extensivley branched, and the cisterns may or mmay not be connected with each other.

The ultastructure of E.R membrane in the same as that of a unit membrane, that is, it has two osmiophilic layers separated by an osmiopholic layers. E.R is grouped into two categories,

1. Smooth E.R.
2. Rough E.R.

In smooth E.R elements, both outer and inner surfaces are regular and smooth. In those cells where little or no protein synthesis takes place, only smooth ER is found. The rough ER elements, ther outer surfaces of membranes have a rough appearance due to the attachment of ribiosomes on the outer surface. Rough ER is mainly composed of cisterns (membrane-enclosed plate like elements) and is found in cells actively involved in protein synthesis. Smooth and rough E.R change into each other as per the needs of cells.

Functions of ER

i. it provides the structural base for protein (rough ER), lipid, phopholipid synthesis.
ii. it proivides channel for the transport of materials synthesized in association with ER to the various parts of cells and even outside the cells.
iii. it provides a controlled passage for the export of m.RNA moelecules from nucleus to rought ER.
iv. Several enzyme molecules are embedded in the membranes of E.R.

RIBOSOMES

These are dense granular nucleo protein strcutures occurring in cytoplasm, matrix of mitochondria and chlorplasts. In many instances ribosomes are attached to the ER. Observed first in plants cells in 1953 by Robinson and Brown, while studying bean roots. Ranging in diameter from 150 to 200A^{o}, they have RNA and protein in equal quantities.

Ribisomes are isolated by differential centrifugation depending on sedimentation co-efficient. The sedimentation coefficient is expressed in terms of Sved berg units. The 'S' units are related with the size and weight of the ribosome molecules.

TYPES

Two types of ribosomes have been identified based on the sedimentation co-efficient. If the organella is heavier, its sedimentation co-efficient is more. The two types are 70s ribosomes and 80s ribosomes.

Ribosomes may occur singly as isolated units when they are called 'monosomes'. When they occur in clusters or groups, they are called 'polyribosomes'. The poly ribosomes may have a sedimentation coefficient of 100s-600s. The number of ribosomes per cell varies, it may be 10,000 (bacterial cell) or up to 10 million (eukaryotic cell).

Ribosomes of chlorplasts and mitochondria have their own protein synthesis. They have a sedimentation co-efficient of 55s with two sub units 40s and 30s.

ULTRA STRUCTURE

Ribosomes are oblate or spheroidal structures having two sub units (a large and a small). The larger sub unit in dome like and the smaller subunit is placed above like a cap. The 70 s ribosome has two units 50 s and 30s.

FUNCTIONS

Ribosomes are the sites of protein synthesis. The polyribosomes serve as a plat form in the assembly of amino acids brought together by specific to RNA from cytoplasm.

GOLGI COMPLEX

Described first by Camilo Golgi in 1890. Golgi complex found in plant cell are often referred to as 'Dictyosomes". Each golgi body consists of following parts ;

1. Eisternae
2. Tubulus
3. Vesicles
4. Golgian vacuoler.

Functions

i. Absorbtion of compounds
ii. Sites of enzyme production
iii. Sites of hormonal produciton
iv. Sits of protein storage
v. Formation of plant cell wall-by synthezing pectin, hemicellulose and cellulose microfibrils. They also help in the formation of cell plate during mitosis.

PLASTIDS

These are living cytoplasmic inclusions found inmost of the plants. The plastids are of three categoties viz., chromoplasts, leucoplasts and chlroplasts.

Chromoplasts

They are pigmented plastids. The pigments are non-chlorophyllous like carotenes, xeithophyll fucoxalthin, phycoerythrin etc.,

Leucoplasts

They are colourless plastids. They lack pigments and are usually present in cells which do not receives direct light. Leucoplats may be seen in the storage leaves of onion. Leucoplats that store starch are called amyloplast, those that store oil are called elaioplasts and the ones storing proteins are called alemone plasts.

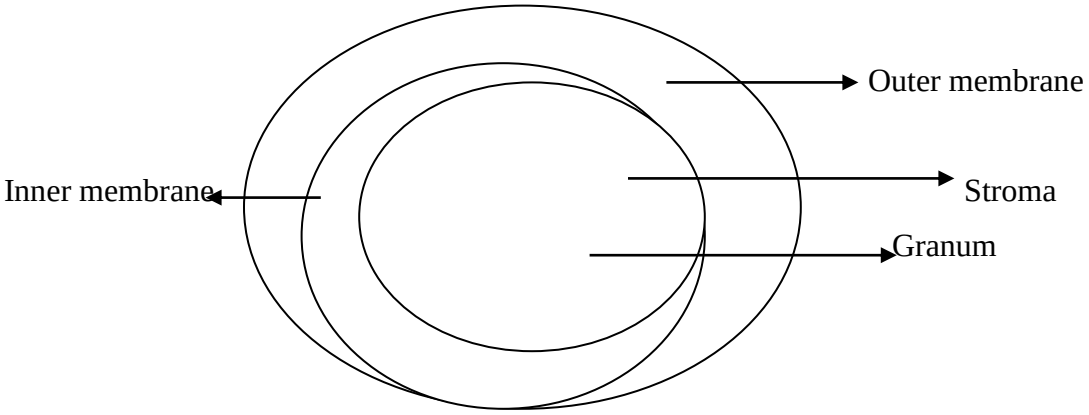
Chloroplast

These are by far, the commonest and the most plastids. As the primary sties for trapping and converting solar energy they are very vital for the existence of not only the green plants, bu for the whole living world.

Chloroplasts have varied shape and variied size. Chlorplast of polyploid cells are generally larger than in the diploid cells. They are uniformly distributed all over the cytoplasm, but in some instances they cluster towards the nucleus. The concentration of chlorplasts will also depend on light intensity.

Structure

It has a covering of two membrances with an inner membrane space. These membranes are smooth and there are no perforations or particles. The membrances are differentially permeable.



A section of chlorplasts reveals an intricate system of membranes enclosed in a granualr matrix. These membranes are called lamellae and the surrounding matrix-the stroma. In a sectional view, the lamellae can be seen packed and there stacks are called thylakoids. In higher plants, the thylakoids themselves form highly compact bundles called grana. Some thylakoids of granum extend into the stroma and maintain contact with other grama. These are called stroma thylakoid or stroma lamellae or inter grama.

Ribosomes and RNA have also been isolated from the chloroplasts indicating a mechinery for protein synthesis. Some of the important pigments present in chloroplast are chlorophylls, carotenoids, cytochromes etc.,

NUCLEUS

It is the most important organelle of the cell which regulates all its activities. It was discovered by Robert Brown (1831). Most of the cells are uninucleate. It has the following parts;

1. Nuclear membrane
2. Karyolymph (Nuclear sap)
3. Chromonemata
4. Nucleolous
5. Endosperms

NUCLEAR MEMBRANE

It helps in effective communication between nucleus and cytoplasm. The elements of E.R. contribute to the nuclear envleope during cell division. The nuclear membrane is a double membrane with a number of pores called 'Nucleopores'. The space between these two membranes is called 'perinucelar space' or cisterna.

KARYOLYMPH (NUCLEAR SAP)

It is proteinaceous, but also has nucleic acids, enzymes and minerals. It is quite probable that in plants the nuclear sap contributes to the spindle.

CHROMONEMATA

Enclosed in the karylymph and visible in the interphase nucleus are found a number of fibrillar structures constituting a network called chromonemata or chromatrin fibrils. Some coarsegranules are deposited on the chromatin net work. These are called chromocentres and constitute the points of condensation of chromosomes. During cell division the chromatin network brakes up into specific number of chromosomes. Two regions can be identified in the chromatin material. These are heterochromatic region and enchromatic region.

The heterochromatic region stains darkly and shows numerous bead like structure called 'Chromomeres'. The heterochromatic region has less DNA. This region is believed io the genetically and metabolically inert. The light staining region of the chromatin is

called the 'enchromatin region" This region contains more of DNA an is supposed to be genetically active.

NUCLEOLOUS

Nucleolous was first discovered by Fortana (1874). A speroidal body, situated either in the central or pheripheral position, the necleolous is supported to regulate the synthetic activity of the nucleus. Usually 2 or more chromosomes are associated with the nucleus (this can be seed during late prophase) and these are called nucleolar organisms as they play a role in re-appearance of the nucleolus after cell division. The number of neucleoli per nucleus varies from one to 2 or 3. Chemically the nucleolar is rich in RNA.

Functions

i. It is the active site of RNA synthesis
ii. It is the source of ribosomal RNA
iii. It produces precursors of ribosomes

ENDOSPERMS

These are granular structues present in the karyolymph and are smaller insize than the nucleolus.

CELL DIVISION

MITOSIS

All cells originate through division of pre-existing cells. Bodies of all multicellular organisms are derived from unicellular zygote through repeated divisions of zygote and the cells derived through its division. The division of chromosomes and cytoplasm of a cell into daughter cells is known as 'Cell division'. The cell that undergoes division is termed as 'parent cell', while the cells derived from the division of a parent cell are known as daughter cells.

Functions fo cell division

To produce two daughter cells, which are involved in the following;

i. Growth and development of somatic tissue of organims
ii. Regeneration of damaged tissues
iii. Produciton of new tissues
iv. Reproduction
v. Keeping the size of cells within a limited range.

Two types of cell division i. Mitosis ii. Meiosis

In addition, bacterial cells divide by fission (similar to mitosis). The various events occcuring in division may be grouped into

i. Karyo kenensis - Division of chromosomes
ii. Cytokinesis - Division of cytoplasm

MITOSIS

It was first used by Fleming in 1882. In plan ts, mitosis is confined to the meristamatic, tissues of root and shoot tips, young leaves flower buds and cambium.

On the basis fo chages in the morphology of necleus and the chroomosomes, the events in a mitotic cell division are grouped into five stages;

i. Interphase
ii. Prophase
iii. Metaphase
iv. Anaphase
v. Telophase.

In fact, cell division is a continuous process in which a cell gradually progressed from one stage to another. So one stage merges into the next one.

Interphase

In this stage of cell after the telophase of previous division and before oneset of prophase of the next one. During interphase, chromosomes are fully extented and uncoiled so that they do not takeup sufficient stain. Interphase in the longest stage. In a cell undegoing mitosis every 24 hours i.e. having a cell cycle of 24 hr., interphase may occupy upto 23 hours, while the division or mitotic phase may take up onluy 1 hour.

DNA replication occurs during the middle part of interphase. This provides the basis for classifying interphase into three substages.

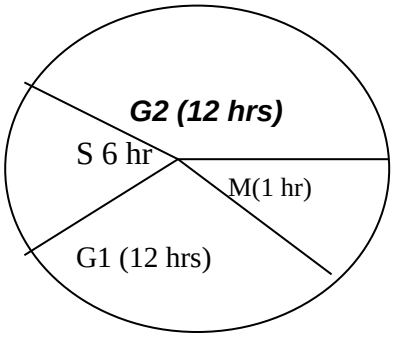
1. G1 (first gap)
2. S (Synthesis of DNA)
3. G2 (Second gap)

G1, G2 - Protein + RNA synthesis

S - DNA synthesis

M - Chromosome movement, division

Time taken in root tips fo vicia jaba.



PROPHASE

i. The appearance of define thread like strucures in nuclear is the most important event of prophase. In the beginning, chromosomes appear as a loose ball of thin wool. As prophase proceeds, chromosomes become increasingly shorter and thicker due to increased conelenstenin by mid prophase, the two chromatids of each chromosomes become visible. By the end of prophase all the chromosomes become considerably shorter and thicker.

ii. During prophase nucelolus and nuclear membrane remain present.

Chromosome condensation, that is decrease in length, with increased in thickness is mainly due to the coiling of chromosomes.

The two suiter chromatids of each chromosomes are coild inrelation to each otherl this is referred to as relational coiling. This relational coiling coiling is of two types.

i. Pleetominic coiling - The two suiter chromatids cannot separate from each other without the chromosomes being rotated. It is happening during prophase of mitosis.

ii. Paranimic coiling - Suiter chromatids are note twisted round each other, they are simply slipped into those of other they can easily separated without rotating the chromosomes. This type of coiling is found during meiotic prophase.

The relational coiling between sister chromatids goes on decreasing as the chromosomes become smaller, it disappears by late prophase.

METAPHASE

At the end of prophase four important events take place;

i. Disappearance of nucelolus

ii. Break down of nuclear envelope and distribution of its components into E.R

iii. Appearance of spindle apprartus.

iv. Arrangements of chromosomes on a single plane called 'equatorial plate'.

It is an imagigary plane and it does not represent any structural features of the cell. At meta phase, centromeres of all chromosomes lie on the equatorial plate, whiel their arms may extend outside this place.

The movement of chromosomes to an their orientation on the equatorial plate is termed metakinesis. The main features of metaphase are

i. Absenece of nucleolus

ii. Disappearance of nuclear membrane.

iii. Arrangement of chromosomes on the equatorial plate

iv. Shortest and thickest chromosomes (Condensation)

v. Coils are less in number and largest in diameter

vi. Presence of spindle appratus

vii. Absence of relation coiling between sister chromatids.

ANAPHASE

The two sister chromatids of each chromosomes separate and migrate towards the opposite poles of the cell. Anaphase begin when the centromeres of chromosomes appear to divide longitudinally so that the sister chromatids separate from each other and ends with the reachign of the chromosomes to opposite poles centromete in the first portion of each of the chromosomes to begin to move towards the poles.

Spindle fibres originate at two points located near the periphery of a cell and opposite to each other. These points are known as 'poles'

Chromosomes become somewhate more condensed as compared to those at metaphase, so that they appear relatively smaller in size.

TELOPHASE

Anaphase ends and Telaphase begins when sister chromatids of all the chromosomes of a cell reach the opposite poles. During telophase, the following events occur in the two groups of chromosomes collected at the opposite poles.

i. The chromosomes uncoil so that they become very long and thin and appeareed to be coiled into a loose ball of fine thread.

ii. Nucleus reappers

iii. Nucelar membrane is reorganised around each group of chromosomes.

iv. At the end of teophase, middle lamella appears at the equatorial plate of the cell.

The nuclear envelope dissociates into small elements which become part fo E.R. of the cell. During telophase, there elements reoriginate around the two groups of chromosomes and fuse to produce nucelar envelope around them.

In terms of duration, prophase in the longest stage of the division phase of cell cycle. In comparison anaphase is the shortest stage, while metaphase and telophase are considerably longer than anaphase.

CYTOKINESIS

It is complete by the end of Telophase. At the equatorial plate, elements of E.R. and products of golgi bodies organise and gives rise to cell plate and subsequently of cytoplasm begins in the centre of the cell and gradually extends outwards on each side in a plane, perpendicular to the axis of the spindle.

The two daughter cells produced by mitosis contain one nuclear eac; each nuclear has the same number of chromosomes as the parent cell. Each daughter cell enlarges in size till it becomes comparable to the parent cell.

MEIOSIS

Meiosis takes place during gamete formation and hence it is confined to reproductive cells only. As a consequence of meiosis, gamets contains only half (h) of the somatic chromosome number (2n). Therefore union between one male and one female gamete during fertilization restorers the chromosome number to the diploid (2n) state. Thus the chromosome number of a species remains constant from one generation to the next generation produced by sexual reproduction. In the absence of meiotic cell division, the chromosome num,ber of a species would be doubled in every generation, due to the fussion of male and female gametes, an impossible biological situation.

The nucleus of each cell undergoes two successive divisions referred to as the first and second meiotic division.

Pre-Meiotic Interphase

During 'S' phase of pre-meiotic interphase chromosomes replication takes place. But approximately 0.3% of the total DNA present in the nucleus does not replicate during the 'S' phase this DNA replicates during the zygotine substage of prophase I. A special stype of histone specific to cells preparing for meiosis is synthesized during S phase. This histone is not found in cells udnergoing mitosis, and it may be related to the entry of cells into meiosis.

FIRST MEIOTIC DIVISION

Significant events;

i. Pairing between homologous chromosomes.

ii. Crossing over between them during pachytene stage of prophase I

iii. Separation of homologus chromosomes and their migration to the opposite poles of a cell during Anaphase I. As a result, the two daughter nuclei produced by this division receive only half of the chromosomes present in somatic cells. For this reason, the first division is often referred as 'Reduction division'.

Prophase I - is divided into 5 sub stage viz.,

i. Leptotene
ii. Zygotene
iii. Pachytene
iv. Diplotene
v. Diakinesis

LEPTOTENE

i. There is a marked increased in the nuclear volume
ii. There is chromosome condensation so that they become visibile as fine threads like a loose ball of knitting wool. Each chromosome consists of two chromatids.

ZYGOTENE

It begings with the initiation of pairing between homologous chromosomes. The main events are as follows:

i. Paring between homologous chromosomes.
ii. Completion of replication of the remaining 0.3% DNA of each nucleus, this DNA synthesis is referred to as Z-DNA synthesis or Zygote DNA synthesis.
iii. Synthesis of a specific nucelear protein
iv. Development of the synaptenemal complex and
v. Progressive condensation of chromosomes.

Pairing of homologous chromosomes is often referred as 'Synapsis'.

Synapsis

i. May begin at both ends of a homologous pair and proceed towards its centre (or)
ii. It may begin at the centromere and progress towards the telomre (or)
iii. It may begin simultaneously at several places.

PACHYTENE

It begins when synapsis comes to an end and it ends when the homologous chromosomes begin to move away from each other. The main events are ;

i. Thre is a further condensation of chromosomes, so that chromosomes pairs become shorter and thicker.

ii. Chromosomes are easily recognisable during this stage and each invalent has four chromatids.

iii. The nucleolus is distinct and quite large.

iv. Crossing over between homologous chromosomes takes place during this stage.

DIPLOTENE

i. Homologous chromosomes of ech bivalent begin to move away from each other.

ii. The two homologous of each bivalent appear to be attached with each other at one or more points, these attachments are known as chiasma. It is believed that initially chiasma are located at the points of actual crossing over between homologous chromosomes.

iii. As diplotene progress, chiasmata, slowly move towards the ends of the homologous chromosomes; this movement is referred to as chiasma terminalization i.e. movement of chaisma towards terminal positions in the chrommosomes. Chiasma terminalization occurs mainly due to the movement of homologous chromosome away from each other.

iv. There is further condensation of chromosomes so that they become progressively shorter and thicker.

DIAKINESIS

i. Bivalents move away from each other and spread towares the peripheri cells.

ii. Nucleolus, nuclear envleope disappear.

iii. The spindle appratus is organized.

The bivalents now migrate to the equatorial plate of cells; this marks the ends of diakeninsis. Bivalents may be in the form of (1) a closed ring, (2) an open ring or (3) rod shaped.

METAPHASE -I

i. Bivalents are arranged at the metaphase plate

ii. Centomeres of the two homologues of each bivalent lie on the either side of the equatorial plate.

iii. Metaphase terminates as soon as homolgous chromosomes begin to separate from each other and to migrate to opposite poles of the cell.

ANAPHASE -I

i. Separation of the two homologous chromosomes of each bivalent marks the beginning of anaphase stage.

ii. One chromosome from each bivalent begins to migrate to one pole, while the other migrates to the opposite pole.

As a result the numbner of chromosomes at each pole is exactly half (h) and each pole receives one homologue from each of the bivalents present in a cell. Thus the reduction in chromosomes number is not only a quantitative one but a qualitative one as well. Thus at the end of AI, the chromosome present is somatic cells are effectively and precisely separated into two identical groups.

TELOPHASE -I

i. The chromosomes uncoil only partially

ii. Nuclear envelope becomes organized around the two groups of chromosomes.

iii. Nucleolous also reappears.

CYTOKINENSIS

The cytoplasm of each cell divides into two halves, with a single haploid nuclear in each half. The two halves of each cell do not separate, but they staty together, and this two celled structure is known as dyad.

SECOND MEIOTIC DIVISION / MEIOSIS II

During Meiosis II, two sister chromotids of each chromosome separate and migrate to the opposite pole. As a result, the number of chromosomes in each of the two haploid nuclei remains the same (i.e haploid)., at the end of this division. The second division of meiosis is often referred to as equational division. Sometimes, it is called as 'Meiotic Mitosis'. The second meiotic division is also divided into four stages.

i. Prophase II
ii. Metaphase II
iii. Anaphase II and
iv. Telophase II

PROPHASE - II

There is no relationsl coiling between sister chromatids

At the end, nucelus, neclear envelope disappear and spindle apparatus is organised.

Cytokinesis

Dyad divides into two parts. One parent cell produces from haploid daughter cells after meiosis. The four daughter cells present together and are known as tetrad.

LAWS OF MENDEL

Mendel was borne in 1822 near Brunn (Czechoslovakia) in Austria, in the family of a poor farmer. Unable to continue his studies, due to poverty, he joined St. Augustinian Monastry at Brunn in 1843 and became a priest. He was sent to the University of Vienna, where he studied physics, maths and philosophy etc., Then he returned to Brunn in 1854 where he was appointed as a substitute science teacher and his peformance as a science teacher was excellent. In addition he worked as a priest in the local church. He lived in a house located within the premises of the church. He began to collect pea seeds for his experiments in 1857 from commercial seed growers all over the Europe. He conducted all his experiments within the kitchen garden of his house with the help of his own resources.

After 7 years, he presented his findings byne the Natural History Society of Brunn in 1865. This paper entitled " Experiments in plant hybridization" was presented in German language. Later Mendel studied on Honey bee, some other plants and climatology. He died in 1884 at an age of 62 years and long before the world understood and appreaciated his contributions to our understanding of life.

Sixteen years after his demise, three scientists working independently of each other de vries in Hollad, correns in Germany and Tschermak in Austria, arrived at the same conclusions as those of Mendel. After this rediscovery there was a spirit of interest in the Mendel's findings and the science of genetics was timely borne. Although the basic principles of genetics wre enuciated in 1865 itself, the new baby borne was kept in an incubator and forgotten for the next 35 years.

PEA as an experimental material

Pea offered several advantages as an experiment material.

i. In the pea varieties available commercially, several characters had two contrasting form which were easily distinguishable from each other.

Character	Dominent form	Recessive form
Seed shape	Round	Wrinkled
Seed coat colour	Grey	White
Cotyledon colour	Yellow	Green
Pod colour	Green	Yellow
Pod shaped	Full	Constricted
Position of flowers	Axial	Terminal
Length of stem	Tall	Dwarf

ii. The flower strcuture of pear ensured self pollination this was experimentally verified by Mendel. This greatly facilitated the production of F2 and F3 progeny as well as avoided contamination by foreign pollen.

iii. Pea flowers are relatively large. Therefore emasculation and pollination is quite easy, which allows easy artificial hybridization in pea.

iv. The duration of pea crop is of a single season. As a result, every year one generation of pea can be grown.

v. Pea seeds are large and present no problem in germination. Pea plants are relatively easy to grow and each plant occupies only a small space. This persists a large number of plants to be grown in a relatively small area.

(In addition, Mendel worked in Raj mash, *P. vulgaris*)

Reason for Mendel's success

i. Mendel studied the inheritance of only one pair of contrastiang chracters at a time. This allowed him to classify in F2, F2 progenies into two clear cut groups.

ii. He selected pea varieties that had clearly different gorms of one or more chracters.

iii. Mendel classified all the plants of a population on the basin of the contrasting chracters under study and kept an accurate record of the numbner of plants in each category.

iv. Mendel carried out his experiments with great care and elaborators. For e.g. He grew the pea varieties used as parents for two seasons to avoid mechanical

mixtures and the verify homozygosity of varieties and stability of the character difference.

v. His knowledge of maths was a definite asset on interpretation of his findings.
e.g. He was able accept the ratios ranging from 2.82:1 to 3.15:1 over all estimation of 3:1 and not separate ratio.

vi. Mendel was able to formulate appropriate hypothesis on the basis of explanation he offered for his experimental findings. Further, he proceeded to test these hypothesis experimentally to prove the correctness of his explanations.

MENDEL WAS UNDOUBTEDLY LUCKY

i. Seven characters selected by Mendel showed qualitative inheritance.

ii. Each characters is governed by a single dominant gene.

iii. Of the 7 characters, the gene for 2 character were located in one chromosome. While 3 other were in another chromosome. But out the these, only 2 were close enough to distort di hybrid ratio of 9:3:3:1. Luckily Mendel did not study this character pair.

REASONS FOR NEGLECT OF MENDEL'S FINDINGS

i. Mendel used mathematical principles of probability to explain a biological phenomena. This was something new and not radily acceptable to biologist.

ii. He studied constrasting pairs of characters exhibiting discontinueous variation, which is unimportant in evolution.

iii. In this studies, only the parental forms appeared, no new forms (variation) were recovered.

iv. The pheneomenon of fertilization, behaviour of chromosomes during cell division wre not known at the time, when Mendel presented his findings.

v. Mendel failed to demonstrate his conclusion in other species.

LAWS OF MENDEL

Mendel selected 22 distinct varieties of pea *Pisum sativum* for hybridization. Each of these varieties differed from the other with respect of one or more characters. Mendel crossed varieties differing for one pair of contrasting characters. A cross between tow parents differing for a single character is termed as 'Monohybrid ratio'. While those between parents differing for two and three characters are known as dihybrid and tri hybrid crosses respectively. The progeny obtained by crossing are known as 'hybrid' or F1 generation (F1= first filial or progeny generation).

Mendel crossed a variety of pea having rounds seeds with a variety having wrinkled seeds.

Round x Wrinkled

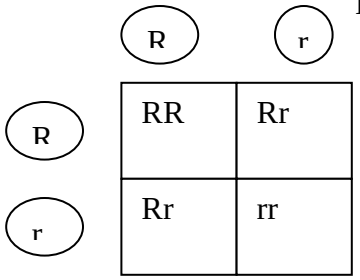
RR rr

(First filial) F1 Rr : Round

F2 3 Round : 1 Wrinkled

RR: Rr, Rr : rr

Round Wrinkled



In F1, all the offspring were uniform and resembled one of the parents so closely that the characters of the other escaped observation completely. Those parental chracters which aappeard in F1 were termed dominant, and those parental characters which entirely disappeared in F1 were termed 'Recessive'.

GENE

Hypothetical unit of inheritance located at (Johannsen) a fixed position (i.e. Locu) on a chromosome. (Factor - (Bateson) determines a character.

ALLELE: - Allelon - one another , Morphus - Form)

Alternative form of a gene. Mendel recognised the presence of constant differentiating characters. These contrasting chracters are attributed to the presence of allelomorphus, situated at the same locus of homologus chromosomes.

GENE SYMBOLS

Dominant gene is represented by capital letter and its recessive allele by the corresponding small letter.

Homozygote (Bateson)

As organism derived from the union of gametes of similar genetic constitution e.g. RR, rr

Heterozygote (Bateson)

An organism derived from the union of gamets of dissimilar genetic constitution e.g Rr.

Phenotype (Pheno- appear) - (Johnnsen)

It is the external appearance of an organism. It is the result of the interaction between genotype and environment.

Gentoype

The entire genetic constitution of an organism e.g. TT - Genotype

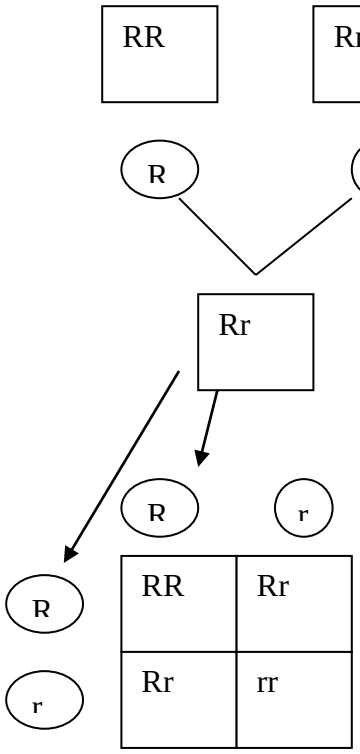
Character - Phenotype.

MENDELS FIRST LAW (LAW OF SEGREGATION)

When a pair of contrastiang characters are brought together in a hybrid, the factors responsible for the character donto belnd or contaminate each other in the hybrid, but when gametes are formed they segregate and pass into different gametes in a difinite proportion.

In fertilization, the gametes combine at random (i.e they unite freely in all possible combinations). The F2 consists of 4 combinations viz., RR, Rr, rR, rr in equal numbers.

RR	have only gene for round
Rr, rR	have gene for round and wrinkle
Rr	have only wrinkeld gene.



Round, Wrinkled - 3:1 ratio

There is no visible indication of the presence of allele 'r' in the F1, the allele R and r do not linked or fuse with each other while they are together in F1. The alleles R and r do not also contaminate or affect each other.

Monohybrid

A cross between parents differing in a single gene. An individual heterozygous for one pair of alleles.

Purity of gametes

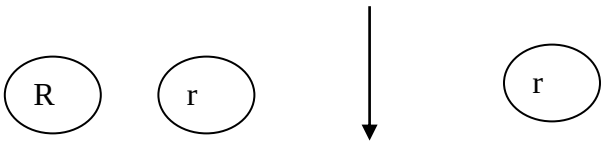
The most important principle of Mendel's Law of segregation is that, even hybrid individuals produce gametes which are always pure. Hybrid individuals (heterozygous) with refererred to one pair of allells produce two kinds of gametes. It is pure and has either dominant allele or recessive allelle but never both. The twokinds of gametes are formed by hybrid in approximately equal numbers, has been shown in several species.

Backcross and testcross

Backcross in a cross between hybrid and any one of the parents, whereas testcross is a cross between hybrid and a recessive homozygote.

F1 Test cross Back cross

Rr x rr Rr x RR or rr



Rr : rr

Round : Wrinkled

1 : 1

Reciprocal crosses

It is a second cross involving the same characters as the first but with the sexes of the parents interchanged.

Whichever way the cross is made, the results will be the same, in case nuclear genes determine the characters. However, when heriditory factors, in the cytoplasm also interact with nuclear genes, receiprocal differences have been observed. In representing crosses, it is conventional to write the female parent first and the male parent second.

Xenia

Effect of pollen on the embryo and endosperm. E.g. in maize, colourless seeded plant is dusted with purple seeded plant pollen, shows the purple seed in the cob.

Purple is dominant over colourless.

Incomplete dominance

Dominance is incomplete and the hybrids resemble neither parent exactly but are more or less intermediate between the two.

e.g. Fowl BB - Black F1 - Bb blue

Bb - While F2 - 1:2:1

bb - Blue 1 Black 2 Blue 1 white

eg. Meiabilis jalapa

RR	- Red					
Rr	- Rose					
Rr	- White	1	:	2	:	1 in F2

Co-dominance

Heterozygote express the phenotype of both the parents mingled together, as neither of allels exhibit either the dominant or recessive expression. Such a condition whre both alleles dominant and recessive are capable of expression equally in heterozygote condition called 'Co-dominance'.

e.g. Cattle coaf coat colour

WW - Red hair

Ww - Roan (Red hair + White hairs)

ww - Whire hair F1 - Roan

F1 - 1:2:1

e.g. Blood group 'MN' - aggluination test based on antigen antibody relationship.

	Phenotype			Reaction to antiserum	'M'	'N'
L^M	L^M	-	M		+	-
L^N	L^N	-	N		-	+
L^M	L^N	-	M^N		+	+

Co dominance is also referred to as "Mosaic dominance' Mosaic expression of both.

LAW OF INDEPENDENT ASSORTMENT (Law of inheritance)

Law: The segregation is one pair of allelles is independent of the segregation in any other pair of allels.

When an individual forms gametes, the member of a pair of alleles always segregate frome ach other but the members of different pair of alleles assort independent of each other.

Dihybrid ratio

RR yy - Round, yellow seeded

Rr yy - Wrinkled and greed seeded

RR	yy	x	rryy	R-Y	9	Round yellow
		↓		R-yy	3	Round green
F1		RrYy		rr-Y	3	Wrinkled yellow
		↓		rr-yy	1	Wrinkled green
F2		9:3:3:1				

Test cross

F1 Rr Yy x rr yy (recessive)

1:1:1:1

Dihybrid

A cross between parents differing in two genes, an individual heterozygous for two pairs of alleles.

Poly hybrid

An individual heterozygours for several genes.

CHROMOSOME

Chromosomes are rod shaped, dark stained bodies seen during metaphase. The term 'chromsome' was first used by Waldeyer in 1888. (Chrom- coloured soma =body), deeply stained, while cytoplasm remained unstained. Each speceies has a definite chromosome number. Each species has a definite chromosome number, represented by 2n. Somatic cells contains two copies of each chromosomes, which are identical in morphology, gene content and gene order and they are known as homologous chromosomes. Gametic chromosome number is precisely one half of the somatic number, is represented by 'n' zygote is produced by fusion of one male and one female gamete (n+n=2n).

MOROPHOLOGY

Cell division, the following structural features can be seen under light microscope by staining.

1. Chromatid
2. Centromere
3. Telomere
4. Secondary constriction and satelite
5. Chromosome

CHROMATID

It is the structural and functional unit of chromosomes. At Metaphase, each chromosome appears to the longitudinally divided into two identical parts, each of which is known a 'Chromotid'. The chromatids of a chromosome appear to joined the giller at a point called 'centromere'. The two chromatid making up a chromosome are produced through replication of a single chromatid, they are referred as 'Sister chromatids'. In contrast the chromatrids of homologous chromosomes are known as non-sister chromatids.

CENTROMERE

The region where thre two sister chromatids of a chromosome appeared to held together is known as 'centomere' under light microscope, centomere generally appears as a constriction in the chromosome, hre it is also termed as 'primary constriction'.

Centromeres are the first part moving towards the opposite poles during anaphase; the remaining regions lag behind and appear as if they wree being pulled by the centomere. Therefore, chromosome movement is due to the centromeres of chromosomes hence they are also known as 'Kinetochoes'.

In most speceis each chromosome has a single centromere in a fixed position which does not change except due to structural chromosome abernations. Therefore, the position of centromere serves as an important land mark in the identification of different chromosomes of a species. Each chromosomes is divided into two transverse parts by its centimre; these parts are called 'Arms'. On the basis of the position of centromere, the chromosome may be divided into your classes.

i. **Metacentric** - Cntremere is at the centre of chromosome having equal arms and appeared as 'V' shaped during anaphase.

ii. **Submeta centric chromosoem** - Centromere is on one side called 'Submedian. 'V' or 'J' shaped during anaphase.

iii. **Actocentric** - When centromere is located close to one end, they are called as "Sub terminal 'j' or rod shaped.

iv. **Telo centric** - Occasionally, the centromere appeared to be at one end of the chromosome, called as 'Terminal' Rod shaped during anaphase. They are unstable.

In most species each chromosomes has a single centromere such chromosomes are termed as'Monocentric'. But in some speceis each chromosomes as 'Poly centric'- Polycentric chromosomes often break into smaller chromosomal units each of which is stable and functions normally.

Centromeres, ccontain highly repetitive DNA called "Satellite -DNA" or "Sat-DNA", distinct from the rest of the Chromosomal DNA. It constitutes about10% of total DNA present in the genome. In many species Sat-DNA consists of only one sequence, while in others more thanone distinct sequences are found.

TELOMERE

The two ends of a chromosomes are known as'Telomeres'. They are highly stable and do not fuse with other chromosomes. It is generally accepted that, the structural integrity and individuality of chromosomes is maintained due to the telomeres and that all stable chromosome ends are composed of telomeres.

SECONDARY CONSTRICTION AND SATELITE

In some chromosomes a sconed constriction, in addition to that due to centromere (primary constriction) is also present. It is known as "Secondary constriction). It is present in short arm near one end, or in many chromosomes they are located in the long arm nearer to the centromere. The region between the secondary constriction and the nearest telomere is known as satellite. Therefore, chromosomes having secondary constitution are called " Satellite Chromosome" or "Sat -Chromosomes. The position of secondary constriction in Sat-Chromsome is fixed and remains constant. The number of Sat-Chromosomes in the genome varies from one species to the other. The number of Sat. Chromosomes may ranged from 2,4,6 or 10, 13,14,15,21 and 22. Human somatic cells have 10 Sat Chromosomes. Nucleolus is always associated with the secondary constriction of Sat. Chromosomes. Therefore secondary constrictions are also called as"Nucleolus oraniser Region" (NOR) and Sat-Chromosomes are often referred as Nucelolus organism chromosome (NOC) NOR contains several hundred copies of the gene coding for ribosomal RNA. (r RNA).

CHROMOSOME

In some species (Maize, amphibia etc.,) chromosomes during Prophase I of meiosis, particularly during pachytene stage, show small head like structures called 'Chromomeres'. The distribution of chromomeres in a chromosome is highly characteristic and constant, the patterns of distribution being different for different chromosomes; homologous chromosomes show an identical pattern.

KARYOTYPE

The general morphology, i.e. the size of chromosomes, the position of centromeres, the presence of secondary constriction and the size of satelite bodies of the somatic chromosomes complement of an individual constitutes its "Karyotype".

It is represented by arranging the chromosomes in a descending order of size keeping their centromeres in a straight line. Each chromosome in the karyotype is designated by a serial number according to its position. A perfectly symmetrical karyotype has all metacentric chromosomes of the same size. Karyotypes showing a deviation from this stateare called asymmertical. It is believed that, perfectly symmetrical karyotypes represent a primitive state from which more advanced asymmetrical Karyotypes have evolved through structural changes in chromosomes.

OVER DOMINANCE

In case of some genes, the intensity of character governed by them is great in heterozygotes than in the two concerned homozygotes. This situation is known as over dominance. e.g. Drosphila - eye pigments.

Ww	-	White eyed
WW Ww	-	Normal dull red eyed
Ww	-	Highher concentration of there two pigments than the two homozygotes.

Overdominance is the consequence of the heterozygous state of the concerned gene.

LETHAL GENE ACTION

A Lethal gene causes the death of all the individuals carrying this gene in the approximate genotype before there individuals reach addulthood.

Lethal genes may grouped into the following five categories;

i. Recessive lethal
ii. Dominant lethal
iii. Conditional lethal
iv. Balanced lethal
v. Gametic lethals.

Recessive lethal

1. e.g. Coat colour in mice.

YY - Die Lethality

Yy - Yellow

yy - Gney

YY die

Yy x Yy

↓

2 yellow : 1 grey

Yy : yy

'Y' gene in mice has a dominant phenotypic effect on coat, colour, but is a recessive lathel.

i. Recessive lethals are always present in the heterozygous state since their homozygotes do not surivie.

ii. A cross between the hetero zygotes for a recessive lethal gene yields a 2:1 ratio (instead of 3:1 ratio).

2. e.g. Albino leaf in barley

AA & Aa - Green leaf

Green Green

Aa x Aa

↓

3 green : 1 albino.

aa- albino - It will die, not able to carry out photosynthesis.

The lethal grenes reduces the survival of zzygotes are known as zygotic lethal.

DOMINANT LETHAL

Some lethal genes reduce viability in the heterozygous state as well. Such genes are known as dominant lethals.

e.g. Epiloia gene is human being causes abnormal skin growths, severe mental defect, multiple tumours in the heterozygote, so that they die before reaching adulthood. Dominant lethals, cannot the maintained in the population, while recessive lethals are maintained in the heterozygour state.

CONDITIONAL LETHAL

Lethal genes that require a specific condition for their lethal action are termed as " Conditional lethal.

e.g. Chlorophyll mutant of Barley permits normal Chlorophyll development at a temperature of 19^{o}C. or above but produces albino seedlings at temperature below 8^{o}C. This conditional lethal is barely requires a lower temperature to exert its lethal effect.

Some conditional lethal requires light, nutrition. So depending upon the genetic background in which lethal gene is present.

BALANCED LETHAL

l_1 L_2 x l_1 L_2

L_1 l_2 L_1 l_2

A balanced lethal system involving two recessive lethal genes (l_1 and l_2). Only two of the four heterozygotes survive. They are heterozygous for both the lethal genes (l_1 L_2 / L_1 and l_2). Thus a balanced lethal system maintains the genes closely linked to the lethal gene in a perpetual heterozygous state.

GAMETIC LETHAL

Some genes lead to the inviability of a class gametes or make them in capable of fertilization. Such genes are called gametic lethals. This phenomenon in commonly known as "Segregation distortion " (SD) or "Meiotic drive". E.g. Drosophila.

X X x X Y Sex ratiq male

Female X X Y Inviable.

XX

Progeny Female

SEMILETHAL GENES

Do not lead to the death of all the individual that carry them in appropriate genotype. They cause death of more than 90% of individuals. Only less than 10% of the individuals survive. Certain Dantha mutants of many plants are semi lethal in homozygours state.

SUBVITAL GENES

Such genes kill less than 90% of the individuals .e.g. miniatue wings in Drosophila viridis mutants of barely etc.,

VITAL GENES

Do not affect the survival of the individuals.

SUPERVITAL GENES

Some mutant alleles enhance the survival of those individuals. Genes for resistance l tolerance to the various abiotic stresses e.g., salinity, alkalinity, high temperature, drought which enhances the fitness of the plants in the presence of concerned stress.

PENETRANCE AND EXPRESSSIVITY

PENETRANCE

The ability of a gene to express itself in all the individuals which carry it in the appropriate genotype (complete penetrance)

Many individuals fail to do so (Incomplete penetrance)

It is the 1% of individuals who carry the gene in proper combination to permit expression.

If a dominant gene is expressed inonly 70% of the individuals, the penetrance of the gene would be 70%.

If a dominant or recessive gene in a homozygous state always produces a detectable effect, it is said to have "complete penetrance". If dominant or homozygous recessive genes fail to show phenotypic expression in every case, it is called ' incomplete' or 'reduced penetance''.

EXPRESSIVITY

The degree of phenotypic expression of a gene in the different individuals it may be uniform or variable.

e.g. In man poly dectytous condition may be penetrated in left hand (6 fingers) and not in the right (5 finges) or it may be penetrant in the feet and not in the hand.

Expressivity of a gene is influenced by termpvating nutrition etc. The character that develop thus depend upon the genotype as well as upon the environment. It is evident that, the expression of genes depend upon the environment in which the organism develops.

PHYSICAL BASIS OF HERIDITY

Mendel had no knowledge of chromosome or genes and he was able to postulate that the inheritance in particualte and that the elements of factors controls the particular character and is transmitted from one generation to the next. His conclusions also gave the fact that;

i. Each of the two parents has two elements for a character and

ii. Only one these transmitted to the next generation through gametes.

In 1900, Sutton studied the chromosome behaviour during Meiosis and found the likeness between segregation of Mendel's factor determines during gametogenesis. It was thre fore concluded that chromosomes are the carriers of hereditary particles and the Mendel's factors are physically located in the chromosomes. In other words, he suggested that, the chromosomes constitute the physical basis of heredity. Johnnson applied the term 'gene' to represent there hereditory factors. There are handed down from parent to progeny thorugh succesive generation.

PLEIOTROPISM

A single gene may sometimes affect more than one chracteristics fo the organism eg. In cotton, Punjab hairy lintless gene ' lic'. It produces;

i. Seeds which are without lint.

ii. In complete laciniation of the bay

iii. Reduction in the number and length of internodes

iv. Reduction in boll size and fertility.

When a gene courses changes in two or more parts or characters that are not obviously related, the gene is called 'pleiotropic gene'.

Multiple or marigold phenotypic expression of a single gene is called 'pleiortropism'.

MULTIPLE ALLELES

Many genes have two alternative forms but some have more than two alternative forms. More than two alleles at the same locus gives rise to a multiple allelic series. It can be defined as a series of forms of genes situated at the same locus homologus chromosome.

The effect similar parts of processes.

The number of possible genotypes in a sew's of multiple alleles is calculated from the formala.

1/2 [n x 1 (n+1)]

Features

1. Multiple alleles are always at the same locus in the homologus chromosome.
2. There is no crossing over with in a multiple allelic series. When two alleles are involved in a crosss, the same two alleles are recovered in the F12 or test cross progeny.
3. Multiple alleles always affect the same characters.
4. The wild type allele is naturally always dominant.

e.g. 1. Colour corolla in Asiatic cotton

Full yellow ⟶ YY, YY^{p} < Yy

Pale ⟶ Y^{p} Y^{p}, Y^{p}y

White ⟶ yy

Degree of dominance $Y > Y^p > y$

eg.2. Coat colour in rabbit, mouse, rat, guinea pig and cat.

C^+ ⟶ Agousi - Full colour (Black)

C^{ch} ⟶ Black + Grey hair

C^h ⟶ Himalayan- white hairs except nose, ear,feet and tail (where it is black)

e ⟶ Albino - Complete white.

$C^+ > C^{ch} > C^h >$ e - Degree of dominance.

eg. 3. A-B-O blood group in human beings three allels I^A . I^B, I^O, Where I^A and I^B are codomiant. $(I^A$ = and $I^B) > I^o$

Genotype		Phenotype
I^A I^A ,	I^A I^O	'A' group
I^B I^B,	I^B I^0	'B' group
I^A I^B		AB group
I^o I^o		'O' group.

PSEUDO ALLELES

Non allele so closely linked as often inherited as one gone, but are separate from each other. (by cross over studies).

These effects are found in Drosophila, corn, cotton, bacteria, Vrisues.

ISO ALLELES

Usually wild type alleles (respresented as +) is dominant over its recessive allels. In some natural populations different wild type allels affecting the same character were found and these wild type alleles had similarallelic dominance or they may differ in their degree of expression, that could be detected in special combinations. Such alleles are called ' Iso allels".

eg. Drosphila - different dominant alleles on red eye 3 wild type alleles. They are alike in homozygous conditions and their difference appeared only in special combination.

PHENOCOPY

Phenotypic denotes the external expression of a a genotype in a particular environment. It may not vary in different environments due to their adaptedness, which is the result of natural selection of the genotype for over a long period of time in the course of evolution.

However, differences in the phenotypic expression of a particular genotype have been observed and certain of such altered phenoypes are similar to some of the naturally occuring phenotypes. They are called ' phenocopies' e.g. Generally, the body colour of D. melanogaster in light brown. A naturally occurring variant resulting out of mutation, with yellow body colour found by Morgan in 1910. The yellow body colour is hereditary.

Rappoport in 1939 found that, when the larvae of normal brown bodied fruit flies were reared on food with silver salts, the emerging adults had yelllow body. They wrere genotypically brown, but phenotypically yellow because of the changed environment.

MODIFYING GENES (MODIFIERS)

Modifiers are a group of genes which enhance and or reduce the phenotypic effect of a major gene such genes have small and cumulative effect on the expression of that major gene, the activity of which they modify. As a result, a continuous variation is generated in the phenotype governed by a single major gene; this converts oan otherwise qualitative character into a quantitative one. Many modifying genes do not have any known effect of their own, but some others are known to affect the same or some other chracters.

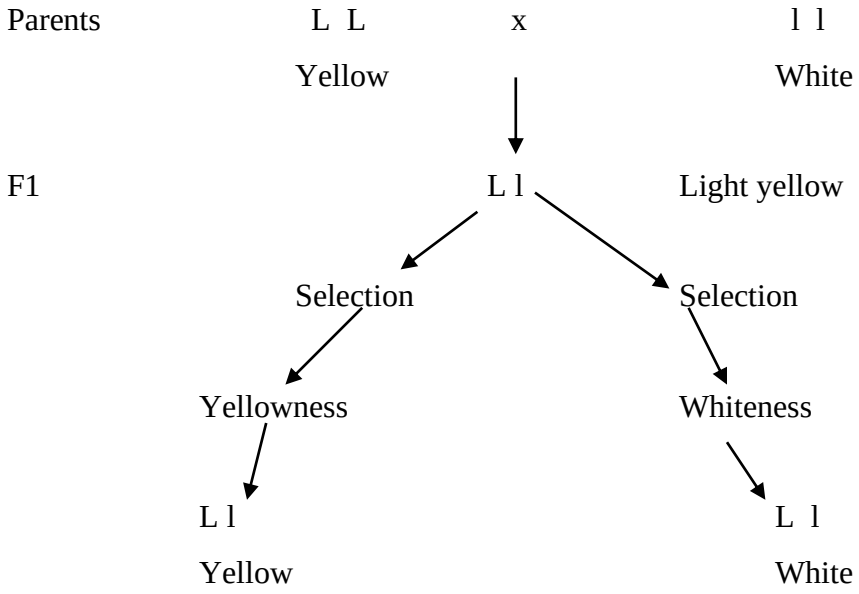
Modifying genes exert a variety of influences which may be summarised as follows.

1. Alteration of dominance relationship at a locus.
2. Generation of quantiative variation in a character produced by a major gene.
3. Suprression of mutant alleles of some gene.

DOMINANCE MODIFICATION

Many genes affect the domiance at a given locus, each gene having a small cumulative effect on dominance . As a result, a continuous grade of dominance is produced at a single locus depending on the number and kind of dominance modifying grenes present in the genetic background.

e.g. In current mth, a gene Lutea (L) produces yellow colour. It is in completely dominant over its allele 'I' which produces white colour.



In some of the strains selected for increased expression, Latea (L) behaved as a completely dominant allele to white (l), but in some other strains selected for decreased expression Lutea was completely recessive to white.

Obviously, specific modifying genes increasing or decreasing the dominance of Lutea gene were selected for these cases.

Major and Minor genes affecting a character

A type of white spotting in mice, rats, guinea pigs and rabbits is produce by a recessive gene 's' when it is in homozygous state (ss). A number of modifying factors, designated as S1, S2, S3 etc., enhances or reduce the expression of this spotting gene. These genes have small, but cumulative effect on spotting obviously, the spotting gene 's'

is a major gene controlling spotting, while the modifying genes are minor genes affecting this trait.

Modifying genes are known to increase as well as decrease the degree of expression of genes for self-incompatibility, disease resistance, cytoplasmic male sterility etc.,

Suppression of mutant alleles

Some modifying genes reduces a completely suprressor phenotypic expression of certain mutant alleles. Some may affect more than one genes. E.g. Drosphila. 'Su-Hw' gene suprresor - Hung wing (HW) forked bristler star eye.

MULTIPLE FACTOR HYPOTHESIS

Polygenic inheritance quantitative characters

It shows more or less continous variation and are governed by a large number of genes called ' multiple gene' or 'multiple factor' or 'polymeric genes' or 'polygenes'.

Nilson -Ehle's studies on kernel colour in wheat

The Swedish geneticist Nilson - Ehle (1908) effected crosses between different true breeding strains of wheat with red kernels and those with white kernels. Careful examinations however revealed that, a red colour of the F1 was not so intense as the red colour of the parent and that in the F2. Some red grains wree as dark as those of parent and others only as dark as those of the F1. It was possible to separate the F2 in to the following;

Dark red	1	-	R1 R2 R2 R2 - 4 contributing genes.
Meidum dark red	4	-	3 contributing genes
Medium red	6	-	"
Light red	4	-	"
White	1	-	No "

	Red			White
Parents	R1 R1 R2 R2	x		r1 r1 r2 r2
F1	R1 r1 R2 r2	Medium red.		
F2	1 : 4 : 6 : 4 : 1			

It is evident that, red colour is due to two pairs of alleles. Each gene is capable of producing red colour. Each is in completely dominant over white and in cumulative in its effect. The intensity of red colour depends upon the number of colour producing gene present.

From these studies, Nilson-Ehle proposed the multiple factor hypothesis for the inheritance of quantitative characters. This assumes that there is a series of independent genes for a given quantitative trait. Dominance is usually in complete, but these genes are cumulative or additive in their effect. Each gene adds something to the strength of expression of the character, whereas its allele does not posses any effect.

Studies on earlength in corn (Emersona nd East 1913).

Long eared sweet corn x Short eared pop corn

(mean ear length) 16.80 cm (6.63 cm)

↓

Intermediate - F1 12.12 cm

Uniform - Small variation by environment

↓

Extreme - F2 plants with longer ears than long parent.

Shorter ears that short parent.

The number of extreme types was small, large number of F2 being intermediate in ear length.

Mean length - 12.89 cm

(approximate intermediate between parents) equal to F1 means.

The increase in variability in the F2 was due to genetic segregation and recombination.

Transgressive segregation

The appearance of individuals in the F2 or a subsequent generation which exceed the parental limits withrespect to one or more characters.

e.g. Skin colour in human beings

White x Negro Mariages -

By Daven port (1913) by multiple factor hypothesis.

Hypothetical example,

Plant height (cm)

200 cm tall 100 cm tall

T1 T1 T2 T2 x t1 t1 t2 t2

↓

F1 T1 t1 T2 t2 150 cm

T1 T2 - Active contributing genes

T1 t2 neutral or inert alleles F2 1 : 4 : 6 : 4 : 1

Cm 200 175 150 125 100 cm.

LINKAGE AND CROSSING OVER

Bateson and Punnett discovered in 1906 that the principle of independent assortment of members of different pairs of alleles at the timeof formation of gametes is not universsal but has same exception. Thomas Hunt Mongan (1910) found similar situations in Droshphila to give a satisfactory explanation for such deviation.

Linkage in maize

'C' for coloured aleurone is dominant over 'C' colourless

Sh for Full endosperm is dominant over 'sh' shrunken.

Parents (Short 'S' , 's'	Col full	x	Colourless,	Shrunken
	CCSS	↓		ccss
		Ce Ss		Colour full
		↓		
	F2	Colour full		7300
		Colourfull shrunken		200
		Colour full		200
		Colouless shrunken		2300

F2 did not show 9: 3: 3 : 1 ratio. There were greater number of colour full, colour shrunken (parental types) than colourfull shrunkern , colour full, If two character considered separately,t hey segregate 3 : 1

i.e .	Colour	7500	Full	- 7500
	Colouless	2500	Shrunken	- 2500

The large deviation of the observed F2 population form the excepted segregation is therefore not because the members of each pair of alleles do not segregate from each other but because of the separation in one pair of alleles is not independent of the separation in the other pair of alleles.

Test cross

	Colour full		x	Colourless shrunken	
	CCSS			eess	
F1		CeSs	x	eess	
F2	F2		Colour full	4800	No expected
			Col. Shrunken	200	ratio 1:1:1:1
			Col. Less full	200	
			Col less shrunken	4800	

The data show that, the two pairs of genes have nto assorted independently.

Segression of two pairs of genes on two pairs of chromosomes

Let us suppose that, gene 'C' is located on chromosome number 9 and 'S' on chromosome number 10 of maize. The segregation of chromosome bearing C and c is entirely independent of segregation of chromosome bearing S and s. So four type of gametes Cs, Cs, eS, eS are formed in F1 and F2 normal dihybrid ratio 9:3:3:1 and test cross 1:1:1:1

Segregation fo two pairs of genes on one pair of chromosomes

Let us suppose that, two genes C and S are located on chromosome No. 9 during meiosis only 2 gametes will be formed Cs and cs gametes.

So, Genes C and S situated on same chromosomes are said to be linked. Linkage is the association of character in inheritance due to fact that genes determining them are physically located on the same chromosomes.

Detectionof Linkage

Compare the number of individuals observed in each class with those expected on the basis of independent assortment and then to test the deviation between these two values by chi-square test.

Linkage Group

The number of linkage groups will be equal to the haploid number of chromosomes which the species possess. Thus maize has 10 pairs chromosomes has 10 linkage groups.

Symbol of linked genes

While representing linked gene, the two homologous chromosomes are indicated by two horizontal links.

e.g. $\frac{CS}{cs}$ $\frac{CS}{cs}$ CS/cs

Coupling

In the condition is linked inheritance in which an individual heterozygous for two pairs of genes receives the two dominant member from one parent and the two recessive members from the other parent.

eg. CS / CS x cs / cs

↓ It is also said to be in C is position.

CS / cs

Repulsion CS / Cs x cS / cS

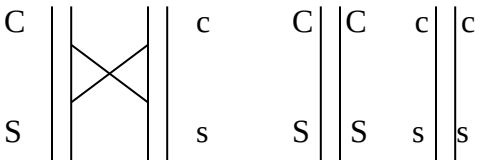
↓

Cs / cS 'Trans' position

Repulsion is the condition is linked inheritance, in which an individual heterozygous for two pairs of linked genes receives the dominant member of one pair and the recessive member of the other pair from one parent and the reverse from the other parent.

Crossing over

Leading to recombination of linked genes is due to the exchange of corresponding segments between the chromatids of homologous chromosomes and was first observed by Belgian cytologist Janssens in 1909.



Parental type CS, cs

Recombination types Cs, cS

Linkage studies revealed the following

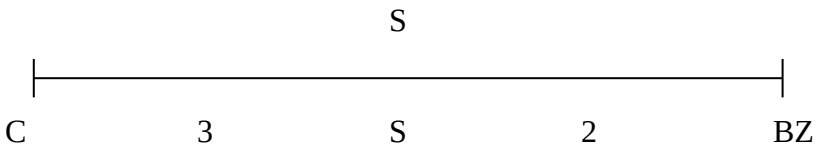
1. Genes that assort at random are non linked genes. Genes that do not segregate at random are linked genes.
2. Linked genes are arranged in a lines fashion on the chromosome. Each linked gene has a definite and constant order in its arrangement.
3. The distance between the linked genes determines the degree of strength of linkage. Closely located genes show stronger linkage that the widely located genes.
4. Linked genes do not always stay together, but are often exchanged reciprocally by cross over.

LINKAGE MAP (Cross over map / chromosome map or genetic map)

Magan postulated that genes are arranged in linear order along with length of chromosome, each gene having a fixed place on the chromosome and its allele, a correspondign position on the homologous chromosome. Under standardized environmental conditions, thre frequency of crossing over of a pair linked genes has been found to be cosntant and Magan put forward the hypothesis that it depends upon the distance between two genes on the chromosome. The greater the distance between the two genes, the greater in the chance that a Chiasma will occur between their loci, and the higher in the percentage of crossing over between them. If therefore , the percentage of crossing over between various genes are determined experimentally, the gene can be mapped in their order on the chromosome.

In mapping genes, a unit of distance must be used and this unit is called a map unit, which is the space within which one percent of crossing over takes palce. If percent of cross over between two linked genes is 1% it means that the map distance between these two linked genes is one unit of map distance or one map unit or one centimaorgan.

If the genes are in the order C, S, BZ,



The genes C and BZ show 5% crossing over . (If the gene are in the order C, BZ and Z, the genes C and BZ should show 1% corssing over. Experimental data revealed that the percentage of crossing over between C and BZ in 5. There three genes C, S and BZ on the ninth chromosome of maize and plotted as above.

Importance of linkage in breeding

When there is a close linkage between desirable and undesirable characters these genes are inherited in blocks and not individually and recombination is practically nil. In such cases linkage has to be broken by ' irradiation'.

SEX DETERMINATION

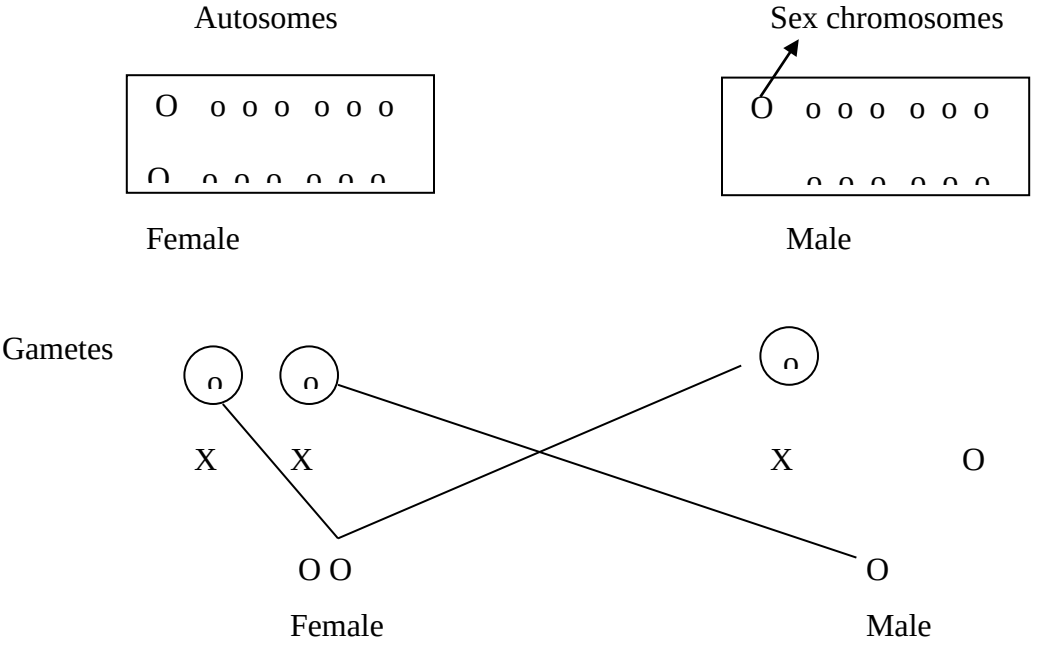
Sex differentiation in living organism into male and female causes morphological, physiological and behavioral differentiation between the two sexes and this pheonomenon is called sexual dimorphism. The precise form of the chromosomal differences between the sexes is not the same in different organism. Four types of sex chromosomes mechanism or heterogamesis have been recognized.

1. Sex chromsomes mechanism

a. Heterogametic male XX - XO type

The chromosome theory of sex determination was put forward by Mc clung (1902) who observed that male grass hopper possessed on odd number of chromosomes in contrast to the female which possessed an even number.

In the squash bug, protenor the femeales have 14 chromosome and the males have only 13 chromosomes in their somatic cells. The odd chromosome of the male thus determines the sex and hence called the sex determiner or Sex chromosme or the 'X' chromosome. The other chromosomes which are alike in females and males are called 'autosomes'. The female is 'XX' and the male is 'XO' (using 'O' to indicate the absence of 'X' chromosome.



XX-YY type

In many animals and palnts, females and males have the same even numbers of chromosomes, but whereas in the females the members of each pair of chromosomes are alike, in the males the memebrs of one pair of chromosomes are disimilar in size or form.

Drossophila melanogaster

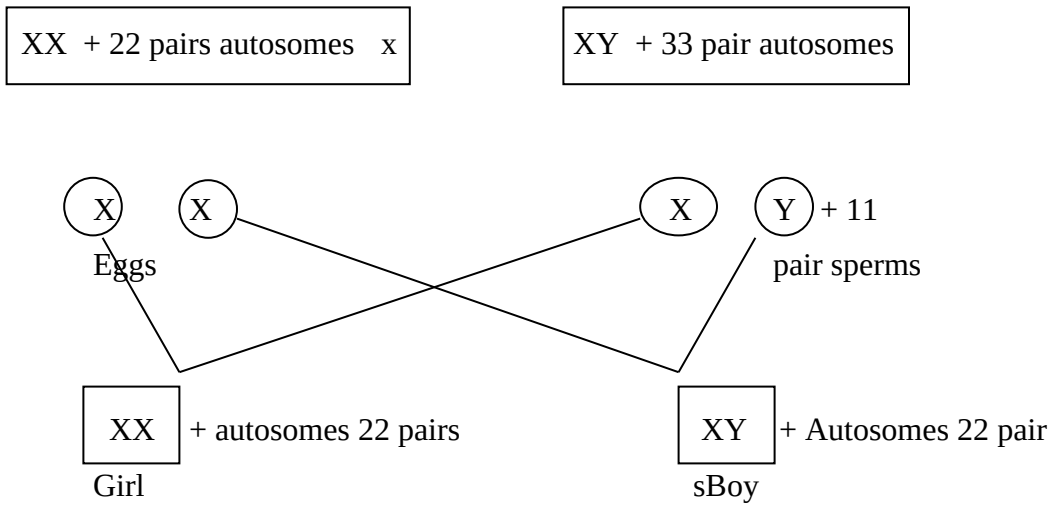
In drosophila, female has four pairs of chromsomes as follows;

1. a pair of rod shaped chromosomes
2. a pair of 'V' shaped chromosomes
3. a pair of slightly longer 'V' shaped chromosomes
4. a pair of very short dot like chromosomes (XX)

In male Drosophila, there is only one rod shaped chromsome (X). the other member of think pair being inverted 'J' shaped (Y) Wilson, who discovered this type of chromosome arrangement in 1905 designated the unlike memebr of their pair in the male as the 'Y' chromosome and the other member which is like the members of onepari in the female as the 'X' chromosome.

Human beings

In human beings 46 chromosome are present in the somatic cells. Females have 22 pair of autosomes and two X chromosomes males have 22 pairs of autosomes and one 'X' and one very short ' Y' chromosomes (considerably smaller than the 'X' chromosome). Each egg carries 22 autosomes and an 'X' chromosome. Sperms, however are of two kinds one kind with 22 autosomes and an 'X' and the other kind 22 autosomes and a 'Y'. The sex of a child in determined at the time of fertilization by the kind of sperm that happens to meet and penetrate, the egg, an X-bearing sperm producing a girl annd a Y-bearing one, a boy.



b. Heterogametic female (ZO - ZZ) type)

ZO - ZZ . The female is the heterogametic sex and the male in the homogametic one. e.g. In amoth, Talacoporia, females have 59 chromosomes and male have 60 chromosomes. The eggs are of two kind (29 and 30). All the sperms have 30 chromosomes each on fertilization an egg with 29 chromosomes gives rise to a female and an egg with 30 chromsomes gives rise to male.

ZW-ZZ type: In birds, certain insects, fishes and reptiles, the female has an unlike pair of chromosomes, Z W, and forms eggs of two sorts, one with a 'W; chromosomes and the other with a 'Z' chromosomes. The male has like pairs (ZZ) of chromozomes. On fertilization an egg with a 'W' chromosome and the other with a 'Z' chromosome. The male has like pairs (ZZ) of chromosomes. On fertilization, an egg with a 'W' chromosomes gives rise to a female and an egg with a 'Z' chromosomes gives rise to a male.

Among plants, *Fragaria elatior* is one in which the female is ZW and the male is ZZ.

Balance theory of sex dtermination

All individuals have genes for both sexes. To quote bridges, both sexes are dut to simultaneous action of two opposed sets of genes, one set tending to produce the characters called ' female' and the other to produce the character called 'male'. Which sex actually develops in decided by the balance i.e. by the prepoderance of the female -

determining or of the male determining genes. The sex chromosomes are merely vehicles of genes which help in tilting the balance in one direction or another.

Suppot for the balance theory of sex determination comes from the work of Bridges (1921) on Drosophila. Bridges observed some females of Drosophila with 'X' chromosomes and 3 sets of autosomes (Triploids). When he crossed them with normal (diploid) males, he found them with normal (diploid) males, he found that same of the progeny had one or more chromosomes less or more thean the normal flies. (i.e. aneuploids).

Bridges found intersexes, super females and super males amogn the progeny. Intersexes are sterile individuals intermediate between females and males super females and super males are sterile individuals which are very weak and very poor in viability.

Bridges interpreted these results as follows:- Sex in Drosophila in determined by the 'X' chromosomes as well as by the autosomes, the ratio of the number of 'X' chromosomes to the number of sets of autosomes being the deciding factor. In a nroma. (diplid) fmeale, the X/A = 1.00, there being two X chromosomes and two sets of autosomes and in a normal (diploid) male the X/A value in 0.50, there being only one X chromosomes and two sets of autosomes.

Relationship of chromosomes to sex in Drosophila

Chromosome constitution

X	Y	A	X/A	Sex
3X	-	2A	1.50	Super female
3X	-	3A	1.00	Female (Triploid)
2X	-	2A	1.00	Female (diploid)
2X	1Y	2A	1.00	Female (diploid)
2X	1Y	3A	0.67	Intersex
2X	-	3A	0.67	Intersex
1X	1Y	2A	0.50	Male
1X	1Y	3A	0.33	Super male

SEX LINKAGE

Mugan crossed a red eyed female with a white eyed male and found that all F1 flies of both sexes were red eyed. In F2, 3 red and 1 white eyed. So, it is due to an allelic pair of genes of which red is dominant.

Red female X White female

Red female Red male

Red female Red female Red male White male

A reciprocal cross was made between white eyed female and red eyed male. It was found that amonf the F1 off spring, alal the females were red eyed and all the males were white eyed. The results wree quite un expected firstly, because the phenotypes of F1 femalen and male wre different.

White female X Red female

Red female White male

White female Red female White male Red male

The different results from the reciprocal crosses could be explained only on the assumption that the gene for eye colour is located on ‘X’ chromosomes and that ‘Y” chromosome has no gene for colour of the eyes.

A white eyed female crossed with a red-eyed male produces red eyed females and whtie eyed males, this method of inheritance, is often referred to as ‘criss-cross inheritance’. The F2 consisted of red eyed and white eyed individuals in equal numbers in both sexes.

Criss cross:- A sex linked gene passes from male to female then back to male.

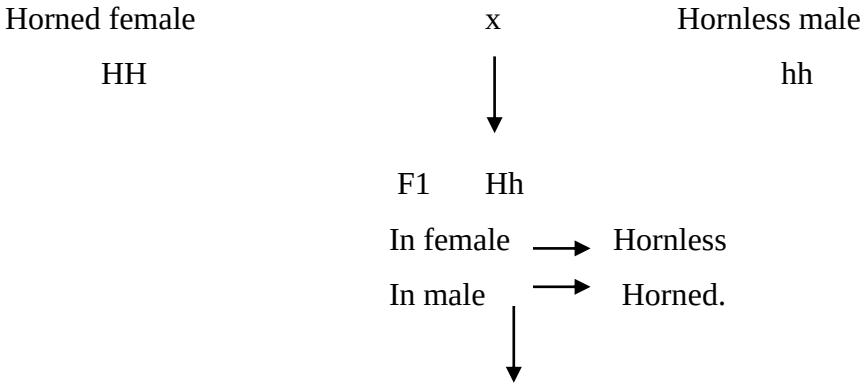
The gene for eye colour is located on ‘X’ chromosome, it is called ‘X’ linked gene. This apttern of inheritance is called ‘Sex linkage’.

There are genes locate on ‘Y’ chromosomes and its allels absent in X chromosome. Such gene are called ‘Y linked’ or Holandric genes. The gene responsible for hypertrichosis causing hairy prina (ear lobes) in human beings is a Y linked gene.

There are certain homologons regions on x and Y chromosomes in which both the allels of a gene may be present as in the case of bobbed bristles (b) and its allele (b+) for normal bristle. Such genes are present both in X and Y chromosomes are called XY linked genes. Eg. Colour blindness.

Sex influenced character

These characters may be expressed differently in the two sexes even when their genotypes are identical. The more influence of the sex of the individual may be sufficient to alter the phenotypic expression of a gene. The most common expression of sex influence in that dominance is reversed between the sexes. Genes determining sex influenced characters are borne on autosomes. E.g. i. Presence of horns in sheep is said to be recessive character in females but a dominant character in males.



	F2	1 hh	: 2 Hh	: 1 hh
Female	:	Horned	Hornless	Hornless
Male	:	Horned	Horned	Hornless

Reciprocal crosses show no differences because the gene is carried by autosomes.

e.g. (2) Boldness in human being.

Bb X BB

Non-Bold ness ↓ Boldness male

Bb

F1 Male ⟶ Bold

Female ⟶ Non bold

F2	BB	Bb	bb
Male	Bold	Bold	Non bold
Female	Bold	Non bold	Non bold

Boldness is recessive is female and dominant in male.

SEX LINKED CHARACTER

Sex limited inheritance is an extreme type of sex influence in which a particular phenotype can be expressed only in one sex. As genes for sex limited characters are borne on autosomes, all genotypes should occur with identical frequencies in both sexes, but the physiological frequences between the sexes are such that certain genotypes can be expressed only in one sex.

e.g. (1) In domestic poultry, cock feathering is a character limited to the male sex.

'H' ⟶ Hen feathering is due the dominant gene.

'h' ⟶ Cock feathering is due to recessive gene.

But females with genotypes 'hh' are hen feathered. (because cock feathering is limited the male only).

Genotypes	Phenotype	
	Female	Male
HH	Hen feathered	Hen feathered
Hh	,,	Hen feathered
Hh	,,	Cock feathered

Removal of the ovaries in hens with genotypes ‘hh’ results in cock feathering. This indicates that female. Sex hormone inhibits the production of cock-feathering in hens with genotype ‘hh’.

e.g. (2) Yellow clover butterfly

‘White” is a character limited to female limited character found only in female.

Genotype	Phenotype	
	Female	Male
WW	White	Yellow
Ww	White	Yellow
ww	Yellow	Yellow

SEX REVERSAL

In several species of plants that are normally bisexual, suppression of male or female strucutres has been observered in nature. The androecium getting converted into petals in ornamental plants or carpels as in carrot and cabbage or pistils as in maize, papaya and primros ehas been observed. When the stamens get converted into rudimentary organ is called the ‘Staminode’ and a similar conversion of the pistil into non-functional redimentary organ is called the ‘pistillode’. The phenomenon in which there is suprression of one sex at the expense of the other is called ‘sex reversal’. The sex reversals are mostly due to physiological and biochemical allterations involving sex hormones.

In maize, rarely it is observed that the male influence, Tassel beans seeds due to sex reversal. The recessive gene ‘ba’ is responsible for barren plants and another recessive gene ‘ts’ is responsible for tassel seed. Sex reversal in maize is due to the genetic constitution of the plants.

Sub linked gene - Colour blindness

Sex linked gene – recessive ‘g’

Normal female GG x Col. Blind mass gy

↓

Gg Gy

Carrier daughter , Gy

(but normal vision) Normal son

Gg x Gy Normal male

Carrier female

GG	GY	Gg	gy
Normal female Female	Male (Normal)	Normal female (carrier)	Male colour bline

Human being → 200 genes → Mostly causes diseases

Drosophila → 150 genes e.g. colour blindness

Haemophilia (inability to blood clot to exposome)

Juvenile glaucoma (hardening eyeball)

Double eyelashes (distichiasis)

CYTOPLASMIC INHERITANCE

It is not only the nuclear genes but also a variety of extra nuclear substances that are transmitted from generation to generation. In plant cells, plastids, mitochondria localized in the cytoplasm have been shown to be responsible for the extra nuclear transmission of inherent qualities like the nuclear genes, they are capable of specific self-duplication. They are transmitted from generation to generation.

They totality of heredity transmitted through the cytoplasm is referred to as plasmon, and all cytoplasmic particles which manifest genic properties viz., self duplication, specificity and mutability are called " plasma genes'.

Inheritance of plastids in Meiabilis:

The inheritance of plastids in Four 'O' clock plant M*eiabilis jalapa* was first described bgh Correns (1908). In M. Jalapa, some of the branches may have normal green leaves, while in the same plant, some other branches may have only pale green or white leaves and still others may have variegated leaves. Flowers on branches with normal green leaves produce seeds that grow into plants with normal green leaves irrespective of whether they are pollinated by pollen from branches with normal green variegated or pale green leaves.

Progeny of a Variegated four 'O' clock plant

Type of branch from which flowers are chosen for pollination	Type of branch from which pollen was obtained	Type of leaf in the progeny grown from seed
Green	Green,	Only green
	variegated,	"
	pale green	"
Variegated	Green	Green, variegated, or pale
	Variegated	"
	Pale green	"
Pale green	Green	Green, pale green
	Variegated	"
	Pale green	"

It is clear that variegation is determined by agencies transmitted through the female and that it is not influenced by the type of pollen used. These agencies are the chloroplast. They are capable of self-duplication and are transmitted from generation to generation through the cytoplasm of the egg. Seeds borne on a green branch have three gene only green plastids, seeds borne on a pale green branch have three gene only pale green plastids and seeds borne on a variegated branch have green or pale green or a mixture of the two types of plastids.

Variegation is thus a heredity character determined by stable, self-duplicating, extra nuclear particles called plastids. Neither the nucleus of the female gamete nor the male gamete is involved in the control of this type of heredity character.

Maternal inheritance by 'iojap' gene in maize

The egg regularly contributes much more cytoplasm to the next generation than does the sperm. It should therefore be expected that in cases of cytoplasmic inheritance, differences between reciprocal crosses would result.

Rhoades (1946) identified the 'iojap' gene (ijij) in maize located in chromosome VII controlling plastid inheritance in the plant. The gene 'Ij' is responsible for the normal green colour of the plant.

When normal green plants with IjIj are used as female and pollinated by pollen from stripped with ijij, F1 plants are wholly green.

1. Green x stripped

↓

E Γ

Ij Ij ij ij

F1 Ijij Green

F2 3 green : 1 Iojap.

When striped with ijij are pollinated by pollen from the normal green plants with IjIj the F1 plants, all of which have the same genotype. Ijij are of 3 different phenotypes.

Stripped ijij X Green Ij Ij

E (Iojap) Γ

F1 Ijij Green, stripped or white (Iojap)

When plants with same genotype Ijij have different phenotype viz., normal green, stripped or white, the differences can be attributed only the differences in plastids.

Cytoplasmic male sterility in Maize

In case of male sterility in maize, pollen grains of such male sterile are aborted. This male sterility is transmitted only through the female and never by the pollen. When all of the chromosomes of the male sterile line were replaced with chromosomes of normal plants, the line still remained male sterile, showing thereby that male sterility in controlled by some agency in the cytoplasm. It was later recognized that cytoplasmic male sterility in maize results from alterations in the heredity units in the mitochondria (mitochondrial DNA).

Inheritance of Kappa particles in Paramecium

In *Paramecium aurelia,* two strains of individuals have been reported. One is called as ‘ Killer’ which secretes a toxic substance ‘ paramecin’ and the other strain in known as ‘ sensitive’ and is killed if comes in contact with the ‘paramecin’. In the cytoplasm of the killer strain the kappa particles (cytoplasmic – DNA) are present kappa particles are absent in sensitive strains. The transmission of kappa particles is through cytoplasm but maintenance of kappa particles and production of paramecin is controlled by ‘k’ we assume that the killer strains carry dominant allele ‘kk; and that sensitive ‘kk’.

Conjugation Rare conjugation (cytoplasmic exchange)

On conjugation, congugents exchange their nuclear material so that ex-conjugants ‘kk’ resulted from conjugants ‘kk’ and ‘kk’ when conjugation is for normal time, then only nuclear material is exchanged and therefore killer will produce killer daughters and sensitive will produce sensitive daughters. But if the conjugation is in longer period, there will be exchange of cytoplasm resulting in the inheritance of kappa particles by both the ex-conjugants so that all the daughter paramecia produced are killers because all in herit the kappa particles through the mixing of cytoplasm. Therefore this trait is transmitted through cytoplasmic heredity. The trait is only stable is killer strains.

Inheritance through mitochondria

Mitochondria can self-replicate and represent another genetic system in the cell. Of course, the amount of mitochondrial DNA is so small, representing less than 1% of the nuclear DNA is mammalian cells and it can code for a part of the protein in the mitochondria. The synthesis of the cytochrome found inmitochondria for example, is known to be present in minute amount in cytoplasm under the control of nuclear genes. Therefore, it is suggested that both mitochondria and chloroplast seem to have a semi-autonomous existence and their DNA forms the basis for genetic systems separate from that in the nucleus.

EPISOME IN BACTERIA

Some hereditary particles have been found to exist in two states, either in an autonomous state in the cytoplasm, where they replicate in dependently, of the chromosomes, or in an integrated state incorporated into the chromosome. Particles with such properties are known as episomes and include such things as the sex factor. The episomes are apparently not essential to the life of the bacteria, because they may or may not be present. If they are absent, they can be acquired only from an external source.

In bacteria, E coli, sex is determined by the presence or absence of the sex factor (F). Male bacterial cells (donor) have the sex factor and this factor is responsible for the transfer of DNA from male to female bacterial cells (Recipient). This sex factor is the cytoplasmic particle.

CHEMICAL BASIS OF HEREDITY

Nature of the genetic material

A Swiss Biologist Miescher (18690 identified a chemical compound in Pus cells and Salmon sperm in the large nuclei of these cells. The chemical was named ‘Nuclein’. As it was found to be acidic, it was called ‘Nucleic acid”. All plant and animal materials were found to contain nucleic acid. Nucleic acid was found associated with various proteins and along with the protein, it was called ‘Nucleo protein”.

There are two kinds of proteins associated with nucleic acid and they are prolamine and histone. Because of the complexity of proteins, they were originally thought as the genetic material. Proteins have long chemical chains consisting of many amino acids and they were considered to be capable of carrying many complex messages that course variation in the biological material.

Considering the proportion of different constituents of cell, nucleic acid was found to be constant in volume in all the cells as compared to other cellular contents and hence it was inferred to be the hereditary material.

There are two types of nucleic acid, the De-oxy ribo nucleic acid (DNA) and Ribo-Nucleic acid (RNA). By staining Nucleic acid, DNA was localized in the nucleus, while the RNA was found to occur outside the nucleus in the cytoplasm.

The experiments of Griffith (1928) with pneumonia bacterium and the inter pretation of results by Avery, Macheod and Mc carty (1944) confirmed the DNA as the hereditary material.

Griffith Experiment

Griffith (1928) worked on the Phenomena causing spherical shaped bacterium, *Diplococcus pneumonia*. Some of the strains of this bacterium have a smooth polysaccharide capsule, which causes the disease and hence called Virulent ‘S’ strains. A mutent strain has no capsule and is a virulent or non- pathogenic and is called ‘R’ strain. In agar medium, the virulent, strain produces smooth surfaced rough surfaced colonies. There are several types of there two strains, SI, SI, SIII, RI, RII, RIII etc., that differ in the type of antigen they produce.

The kind of antigen produced in genetically determined. The ‘S’ type sometimes mutates to ‘R’ type but rot in the reverse.

Griffith injected the lab mice with live RII bacteria and the mice did not get phenomena as RII in avirulent.

When injected with Virulent SIII, the mice suffered of Phenomena and died. When S III bacteria were heat killed at 65^{o}C and then injected into the mice, they did not suffer of the disease and lived.

Later, heat killed SIII strain and the live avirulent RII strain were mixed and injected into the mice. Contrary to expectations, the mice suffered of pneumonia and died. On analyzing the blood sample of the affected mice, live SIII and live R II bacteria were found in it. This could not be possible due to the mutation of avirulent RII the virulent types. Evidently, some heat stable component present in the heat killed and hence dead SIII strain could have conferred the Virulent nature to the live RII strain. Griffith designated this as the 'transferring principle" that transformed the hereditary property of avirulent RII to virulent SIII. This phenomenon is called "Griffith effect" or "Bacterial transformation".

Griffith did not understood the cause of bacterial transformation. Avery, Macleod and Mc Cartly (1944) tested a fraction of the heat killed S III bacteria for the transforming ability. They removed proteins, lipids, polysaccharides and RNA from SIII extract by a variety of chemical and enyzymatic methods without diminishing its ability to transfer RII into SIII strain. They found that a cell- free and highly purified DNA found that a cell- free and highly purified DNA extracts of SIII bacteria could bring about transformation of RIII into SIII and concluded that DNA in transforming principle and hence the genetic material in bacteria.

Transformation

It is the process of adding a foreign DNA fragment from a donor genome into the genome of a recipient cell. The donor fragment passes through the cell membrane of the recipient cell and becomes incorporated in the genome of the recipient cell through recombination.

DNA as the genetic material in viruses

Harshey and Chase (1952) provided direct proof that DNA is the genetic material in certain bacterial viruses.

Bacteriophage is a virus that infects or feeds on certain specific bacteria. T2 bacteriophage that infects the Escherichia coli was involved in the studies.

Bacteriophage is electron microscopic. It has a head and a tail. Inside the head there is a long chain of DNA molecule. The phage attaches itself by its tail to the bacteria and infects the DNA into the bacillus. It dictates the cell to produce many copies of the viral DNA.

Bacteriophages are used in many finer analyses of the genetic material since they are haploid organisms and there is no hiding of mutant effect. As there is no differential sex, there is no need for two different individuals to unite for reproduction. They multiply enormously and have a short life span. Recombination's and mutations, even if in a very low frequency, could be recognized with relative ease. When a population is raised from a single phage all the descendents will be identified. But occasionally, through errors in copying of genetic material, rate mutants appear and such mutants are called 'Cop errors".

In a chemically defined cultural medium known quantities of radioactive isotopes of phosphorus P^{32} and Sulphur S^{35} were added. E coli were grown in the medium and the labelled E coli cells were used as hosts for unlabelled T2 bacteriophage. The virus progeny that multiplied inside the bacteria could be traced in the culture medium on lysis (cell wall breakage) of the bacteria.

The viral DNA was labelled with P^{32} and the viral capsid (protein coat) with S^{35}, since DNA contained 'P' and viral capsid contained 'S'. Then the labelled viruses were allowed to in feet unlabelled E coli and get multiplied. Later the viruses were separated from the bacterial host cell by agitation, and the content of P^{32} and S^{35} of the virus and bacteria was assessed. P^{32} could be traced in the injected bacterial cells. Hershey and chase inferred that DNA of the virus entered the bacterium and played a role in viral multiplication, whereas the protein of the virus did not play any role in the intercellular replication of the virus. Thus it was established that the genetic material of the virus was DNA.

Transduction

The transfer of genetic information (DNA) from one bacterial strand to another, mediated by a phage (virus) that kills the DNA donor and carries some of its DNA to a recipient cell, which is not killed, by the phage is called transduction.

CHEMCIAL COMPOSITION OF DNA

DNA is a complex macromolecular or polymeric chemical compound, which contains four kinds of monomeres (small building blocks) called ,"Deoxy ribo nucleotides". Each deoxy ribo necleotide is made up of ;

i. a phosphoric acid molecule, biologically called phosphate, discovered by Levene (1910).
ii. A penotose sugar called 2-deoxy ribose.
iii. Four nitrogen bases
Adenine (A), Guanine (G) – Purines (two ringed)
Cytosine (c) and thymine (T) – Pyrimidines (one ringed) – discovered by Fischer (1980).

Nucleotide = N- base + sugar + phosphoric acid

Nucleoside = N base + Sugar

Levene and Todd (1910) demonstrated that, the components of DNA were joined together to form along chain of alternating deoxribose and phosphoric acid units with side chains of the nitrogen bases.

Double helical model of DNA

Chargoff (195) found that, the total amount of purines equalled the total amount of pyrimidins (A +G = T + C), that the amount of adenine equalled to amount of thymine (A=T) and the amount of quanine equalled to the amount of cytosine (G=C) and that the ratio between total purines and total pyrimidines was always not far from one, (A+G) : (T+C) = 1.

The double helical model of DNA was constructed by Watson an American biologist and crick a British physicists in 1953. The DNA molecule was conceived as a two stranded structure coiled like a rope and hence called plaetonemic, so that if the ends are permitted to revolve freely, the complementary stands could easily separate. The coil

was propose to the helical and conceived to resemble a circular staircase, maintaining the same diameter through out the length and having a constant width between steps. The steps are connected on liker side by a railing.

The helix has a diameter of 20 A and maked a complete turn at every 34'A along its length. The distance between nucleotides in 3.4^{o} A. Each complete turn has a stack of 10 necleotides.

Adenine pairs with thymine with two H bonds (A=T) and guanine with cytosine with three H bonds (G=C), there N bases are connected to each other by deoxyribose and phosphoric acid.

Chemical composition of RNA

In RNA, there are four nitrogen bases, the purines, consisting of adenine and quanine and pyrimidines consisting of cytosine and uracil. Thymine inDNA in replaced by uracil in RNA.

Organisms which have only RNA employ their RNA in their genetic mechanism. Such RNA called genetic RNA. Organisms having DNA only along with RNA, use the RNA for carrying the orders of DNA and such RNA is called non-genetic RNA. Ribosomal RNA (r RNA), transfer RNA (t RNA), heterogenous RNA (ht RNA) and messenger RNA (m RNA) are nongenetic RNAs.

Replication of DNA

DNA has two important functions as the carrier of genetic information.

i. When DNA directs the synthesis of DNA itself, or in otherwords when DNA replicates, such a function in auto catalytic.

ii. When DNA directs the synthesis of chemical molecules other than itself, such as synthesis of RNA, protein etc., such a function is hetaera catalytic.

The double helical model of DNA provides a template system for self replication. Because of the specificity of base pairing, A with T and G with C, the sequences of bases along one chain automatically determines the base sequence along the other. Hence each chain of the double helix can serve as template for the synthesis of the other.

Replication involves description of H bonds followed by a rotation and separation of the two polynucleotide strands. Each purine and pyrimidine base of each polynucleotide strand attracts complementary free nucleotide available for polymerisation

in the cell and holds it in place on the parental template chain. The free nucleotides are sewn together by formation of phosphate diester bonds for linking adjacent deoxyribose, thus forming a new polynucleotide molecule. Thus two double helical molecules identical to each other are formed.

Three theories were proposed for DNA replication. They are (1) semi conservative theory (2) conservative theory (3) dispersive theory

Semi conservative theory

According to this theory both the complementary strands in a DNA molecule separate and each strand functions as a template or mould to prepare its replica.

Conservative theory

The strands are not supposed to separate from each other, but a new double helix appears within the old double helical stands.

Dispersive theory

Each of the strands of the double helix breaks into pieces and these pieces duplicate. The broken and duplicated pieces are reconstructed into two double helices consisting of strands containing both old and new pieces.

Mostly, DNA replication occurs by the semi-conservative method.

Some of the nucleic acid enzymes play an important role in DNA replication; they are;

i. Nucleases- that catalyze the break down of particular bonds leading to fragmentation of nucleic acids. They may be exo-nucleases that attack nucleic acid at its terminal nucleotide only or endonuceleases that react only with those bonds that occur within the interior of the nucleotide chain to cut into pieces.
ii. Ligases – that join broken ends of two DNA chains
iii. Restriction enzymes that produces breaks only within the sequences.

iv. Polymerases that are involved in the synthesis of nucleic acids.

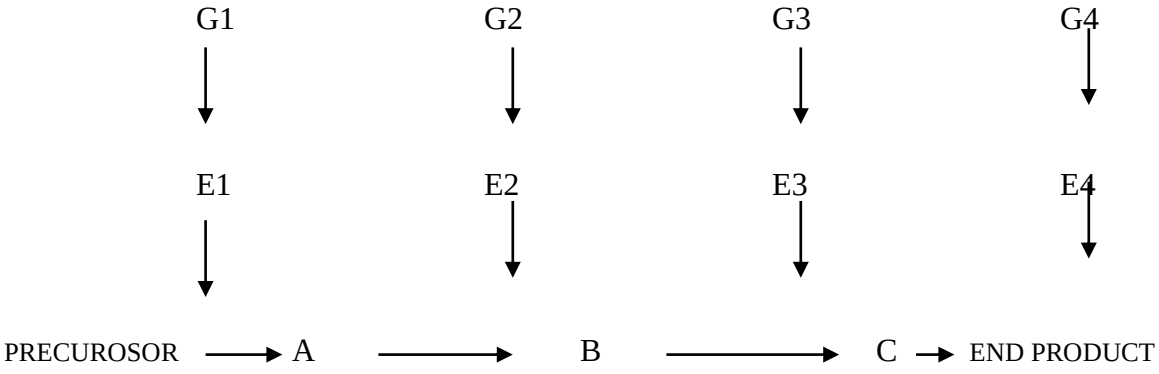
The spread of DNA replication was studied in Vivo and invitro by Kornberg et al., (1967). The speed was 500 to 1000 nucleotides per minute invitro and as high as 100,000 nucleotides per minute in vivo.

Replication of RNA

The genetic RNA of viruses in self-replicating. Its model of replication is called 'RNA dependent RNA synthesis". RNA polymerase enzyme mediates in the replication mechanism keeping the parent RNA as the template and synthesizing a complementary RNA chain.

ONE GENE – ONE ENZYME HYPOTHESIS

When we consider the phenotype of an organism, we should understand that, it is the result or end product of many complicated actions and interactions within and between genes. Phenogenesis in the mechanism by which the phenotype of an organism is produced under the control of DNA in a given environment, which includes not only external factors such as temperature intensity and quality of light, but also internal factors such as enzymes and hormones, but also internal factors such as enzymes and hormones. The phenotype is the result of various embryological and biochemical activities involving enzymatic proteins. Enzymes catalyse in separating or uniting different cellular molecules. A precursor is transformed into an end product through the production of many intermediate products each aided by an enzyme produced by a gene and this constitutes the 'biosynthetic pathway'.



DNA itself does not have enzymatic character and does not directly involve in the biosynthetic pathway. The immediate gene product is a kind of RNA called in RNA, which controls the amino acids, to form enzymes at the surface of cytoplasmic ribosomes. Thus DNA transcribes m RNA which translater protein that ultimately produces a phenotypic trait.

Beadle and Tatum (1941) found that U-V mutants produced defeact in enzyme on loss of specific enzyme. This concept is known as 'One gene-one enzyme hypothesis".

PROTEINS AND ENZYMES

Enzymes are proteins, that composed of sub units called polypeptides, which can be further broken into Aminoacids. The aminoacids are united by peptide linkage.

Though there are 35 different aminoacids in biological systems most of the biological proteins contain only 20 amino acids.

ONE GENE – ONE POLYPEPTIDE CONCEPT

Ingram (1957) brought that each gene controls the production of a single polypeptide chain of protein molecule.

Chick (1958) proposed that the sequence of nucleotides in DNA and of aminoacids in proteins in co-linear. This means that there is a direct correspondence between the base pair sequence in DNA and aminoacid sequence in corresponding protein.

NON GENETIC RNA's

RNA is an intermediary between DNA base pair sequence and aminoacid sequence. Several kinds of RNA have been identified. RNA's differ from one another in molecular weight, structure and role in protein synthesis. The macro molecules are measured in Svedberg (S) units, determined by rate of sedimentation. The rate of sedimentation depends on the size and shape of the molecule.'

1. Messenger RNA (m RNA):

It is made up of single stranded molecule consisting of nucleotides ranging from 300 to 12,000. In Eukaryotis RNA molecules of variable length with sedimentation co-efficieint of 20 S to 100 S are involved. This is called heterogenous nuclear RNA (HnRNA). It is synthesised in nuclear and present out side the nucleus. The hn RNA has 2 fractions, one with coding sequence, that produce mature m RNA and another with non-coding sequences that are degraded in the nucleus. The coding sequences of hn RNA constitutes 'exon' and non-coding sequences constitute 'intron'.

Jacob and Monad (1961) first proposed the existence of m RNA. The life span of mRNA is 2 minutes at 37^{o}C in E coli. The two days in Eukaryotes and several months and years in dormant seeds of plants.

2. Transfer RNA (t RNA)

t RNA molelcules are smaller than m RNA molecule and contain 70 to 80 nucleotides. t RNA molecules have a completely folded tertiary structure due to hydrogen

bonds between the constituent bases and due to the presence of a number of unusal bases such as A-U-G-C situated in the clover of the molecules where no base pairing occurs. Holley (1968) suggested a clover leaf model of alanine t RNA in yeast.

3. Ribosomal – RNA (r RNA)

Ribosomes are ribo molecules present in all types of cells. they occur as 60 s units inmitochondria, 70 S units in bacteria and chloroplast and 80 S units in eukaryotes.

r RNA is the insoluble RNA that constitutes the largest part, even upto 80 per cent of the total cellular RNA. r RNA molecules are sinlge polynucleotide stranded, unbranched and flexible and behave as a random coil or show helical regions with base paring between A-U and G-C. r RNA has a definite role in protein synthesis.

PROTEIN SYNTHESIS

Central dogma of molecular biology

The process of protein synthesis involves one of the central dogma of molecular biology, postulated by crick (1958) according to which genetic information flows from nucleic acid to protein. Protein synthesis involves two steps viz. , transcription and translation.

Transcription : Involves a sequential flow of information from DNA to RNA. This does not involve a change of code since DNA and m RNA are complementary. Translation involves a change of code from nucleotide sequences to aminoacid sequence.

Generally the flow of information in one way from DNA to RNA and from RNA to protein.

DNA —Transcription→ RNA —Translation→ Protein

In certain viruses, the existence of an enzyme 'RNA dependent DNA polymerase (also called in verse transcriptase) was reported and this enzyme could synthesize DNA from a single stranded RNA template.

The findings of Baltimore (1970) and others gave rise to the concept of 'Central dogma reverse'. According to this the sequence of information flower is not necessarily from DNA to RNA to protein , but can also take place from RNA to DNA.

DNA —Transcription→ RNA —Translation→ Protein

←—— Inverse transcription.

TRANSCRIPTION

The process by which the information in the nucleotide sequence of DNA is transferred to complementary sequence of RNA is known as 'Transcription".

Transcription occurs throughout interphase and continues up to early prophase of cell division. 'DNA dependent rNA polymerase" or 'Transcriptase" is the enzyme involved in transcription. The locations of transcription are;

1. The nucleolus where genes from r RNA are transcribed.
2. The remaining chromatin where hnRNA (mRNA) is transcribed.

The system for invitro RNA synthesis contains;

i. Ribo nucleotide triphosphate (ATP, CTP, GTP, UTP)

ii. Enzyme RNA polymerase

iii. Mg^{++} or Mn^{++}

iv. Template DNA

The enzyme RNA polymerase acts only in the presence of DNA, against which the correct sequence of ribonucleotides is arranged and they are linked together by the enzyme. That is why the enzyme is known as 'DNA –dependent RNA polymerase.

The site of transcription is a cristron is called the promotor site. The template strand is called sense strand, while it's complementary strand is known as antisense strand. When only one strand of DNA is transcribed for a given region, it is called asymmetrical transcription. When both the strands of the DNA are transcribed, it is known as symmetrical transcription.

The enzyme RNA polymerase attaches itself at the promotes site. The DNA molecule unwinds over a short region. Then the free bases in the template stand of DNA determine the sequence of ribonucleotide in the newly formed in RNA. The RNA polymerase enzyme join the nucleotides together to produce RNA transcript.

RNA polymerase has give sub units of polypeptides chain (α, β, ,σ and ω) , and catalyze the linkage of ribose nucleotides by phosphodiester bonds. The Γ factor recognizes the start signal in the promotor region of DNA.

TRANSLATION

As soon as the mRNA is formed, it leaves the nucleus and reaches the cytoplasm where translation takes place.

Before the process of protein synthesis, the ribosomes occur in dissociated and inactive state. The m-RNA besides with 30 S ribosomal sub unit in the presence of a protein factor called 'Initiation factor ')IF). The mRNA carries tiplet codons for the synthesis of proteins. Proteins synthesis involves m RNA, ribosomes, aminoacid and their specific t RNAs.

Steps for Translation

i. Attachment of m RNA with 30 S ribosomes and formation of polyribosomes

The m-RNA transcribed inside the nucleus moves to the cytoplasm and binds itself with 30 S sub unit of the ribsome in the presence of initiation factor. Then the t

RNA present in the cytoplasm binds itself with the first triplet codon 5' – AUG – 3' called the chain initiation codon of RNA to form the initiation complex. Later, the 30 S sub unit of ribosome unites with 50 S sub unit to form 70 S ribosome, in the presence of Mg++ ions. The message in the mRNA is not deciphered by one ribosome but many ribosomes are involved in the process and hence they are called polyribosomes.

ii. Activation of the aminoacids

Amino acids present in the cytoplasm are in a dormant stage. Each amino acid is activated by an activating enzyme called aminoacyl synthetase, beside the energy rich ATP. The aminocyl adenylate enzyme complex bound together with specific t RNA molecule. As the enzyme is specific for specific aminoacid, the concerned aminoacid gets attached without error.

iii. Attachment of activated aminoacid to t RNA.

The DHU loop of tRNA recognises the synthetase enzyme. Then the aminoacid residue of the aminoacyl adenylate is transferred to the aminoacid attachment site of tRNA.

iv. Initiation of the polypeptide chain

In the m-RNA, the first riplet codon is AUG at its 5' end. AUG codes for methionine. Hence, protein synthesis commences with coding for methionine. The peptide chain formation starts in 5' end and proceeds towards 3' end and this helps in the correct sequence of protein synthesis.

The mRNA moves across the ribosome. A new codon of mRNA is brought in position. A new tRNA changed with specific amino acid is brought in position in such a way that the anticodon of t RNA pairs with the codon of mRNA. The attachment of two amino acids by polypeptile linkage involves enzymes translocase and peptidyl transferare along with energy rich GTP and t RNA is released.

This process of movement of mRNA from 5' to 3' direction and addition of amino acids to poly peptide chain continues till m RNA is no longer translated.

v. Transmission of the polypeptide chain

Any one of the three terminating codons in mRNA viz., UAA, UAG or UGA can signal the termination of chain elongation.

After chain termination, the enzyme peptidyl transferase hydrolyses the eesterbond between the chain and t RNA, releasign the poly peptide chain the last t RNA and m RNA.

Thus a polypeptide chain with a specific series of aminoacids is formed which results in synthesis of a specific protein that involves in a specific phenotypic expression in the organism.

GENETIC CODE

In the DNA and RNA the re are four types of nucleotide or bases viz., A, G, T, C and A, G, U C respectively. If it is assumed that each base codes for one amino acid, then only four amino acids can be coded. If two bases together are responsible for production of one aminoacid, then they will code for $4^2 = 16$ amino acids. If three bases together code for an amino acid then $4^3 = 64$ amino acids could be coded. As the essential aminoacids in a biological system are 20 in number, the possibility of one or two bases coding for each amino acid is remote.

Crick and Brunner (1961) suggested that the genetic code migth be a triplet code, involving three nucleotide bases to code for an amino acid. Neinberg et al., (1961) constructed a complete genetic code dictionary.

The pattern of genetic code indicates the following:

1. Codons for the aromatic aminoacids begin with uracil

UUC UUC	Phenyl alanine (Phe)
UGG	Tryptophan (Trp)
UUC UUC	Tyrosine (Tyr)

2. Codons for amino acids that form amides begin with Guanine and Adenine

GAU GAC	Asparagin (Asp)
GAA GAG	Glutamin (Glu)

3. For many of the synonymous codon specifiying the same amino acid, the first two bases of the triplet code are constant, while the third varies, being less specific.

CCU CCC CCA CCG	proline (pro)	CGU CGC CCA GGG	Glycine (Gly)

Grick (1966),. The third base trends to Wobble or in unsteady and proposed Wobble hypothesis.

FEATURES OF TRIPLET CODE

1. Some of the nucleotides have to code for more than one amino acid and hence, called ‘ambiguous code” e.g. UUU codes for phenyl alanine – presence of streptomycin, it may code for isoleucine, leucine ro serine.
2. The code contains many synonyms and hence called ‘ degenerate code’. Almost all the amino acids are represented by more than one codon. e.g. Arginine, serine, leucine have six synonymous codons.
3. The code is read continuously without interruption and no codon is reserved for punctuation. Hence it is called ‘commaless code’.
4. There is no overlapping of base sequences specifying for different amino acid, and no single base in a triplet can take part in the formation of more than one codon. Hence, it is called a non-overlapping code. e.g. UCAGAA - UCA – Serine, GAA-Glutamine. But overlapping as UCA, CAG, AGA etc. does not occur to code for other amino acids.
5. As the same code applies for all living systems it is called an ‘Universal code”. (Orgaell DNA’s are found to have different meaning than in nuclear DNA).
6. Among the triplet codons, AUG, is the chain initiation codon as it initiates the synthesis of polypeptile chain. Codons UAA, UAG and UGA are the terminating codons as they terminate translation of the polypeptide chain. As these there codon do not specify any aminoacid they are called non-sense codons.

POLY PLOIDS

Individual with one set of chromosomes – haploid or Monoploids.

Individual with two sets of chromosomes – True diploid

Most plants and animals posses two sets of chromosomes.

Individuals with more than two sets of chromosomes are called ‘ polyploid’. (poly = many; ploid – fold). Poly ploid in otherwise called as ‘Euploidy’.

HAPLOID (Monoploid)

Haploidy in flowering plants was first recorded by Blakeslee (1937) in *Datura stramonium* . One in very 1000 seedlings of maize was found to be a haploid, developed from the unfertilized egg (i.e by female parthenogenesis).

Polyembryony in plants in a possible source of haploids, due to the occurrence of more than one embryosac within a ovule. Out of the four haploid megaspores derived by meiotic divisions from a single megaspore mother cell, more than one may develop into embryo sacs.

Production of embryos from synergids without fertilization is more common than production of embryos from antipodal. For instance, out of about 30,000 seeds of G. Girsutum, 20 were found to give rise to twin embryos of which from were haploids.

Haploids can be obtained by anther and pollenculture using tissue culture techniques and also by wide species crosses.

Characteristics of haploids

Generally smaller in size than diploids. Their guard cells are also smaller than those of diploids. They are highly sterile because none of chromosomes of true haploid has a homologue.

Classification of haploids : 1. Mono-haploid. 2. Poly haploids.

Mono-haploids: are haploids which arise from time diploids and whose chromosomes are therefore non-homologous to one another. Eg. haploids of maize.

Polyhaploids: Haploids arise from polyploids eg; Haploid of triticum aestivum with one representative of each chromosomes of A. B and D genome.

GENOME

The complete set of chromosome found in the gamete of a true diploid is called a genome. e.g. p. glaucm, 14 chromosome 2 sets n=7, 2n=14.

A gamete contains one set of seven chromosomes (I, II, III, IV, V, VI, VII) is called a genome and if this is represented as ‘ A’ the genomic constitution of the plant in ‘ AA’.

BASIC NUMBER

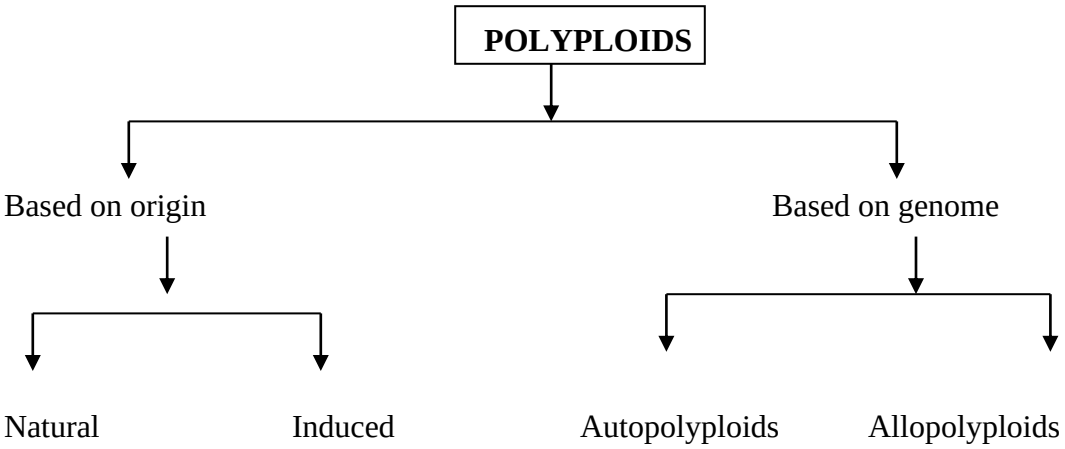
The number of chromosomes constituting a genome is called the basic number. It is the number of chromosomes found in the gamete of a true diploid.

POLYPLOID

Species of solanum which have a chromosome number of 24 are true diploid and species which have somatic no higher than 24, but which are multiples of 12, are called polyploids.

Somatic No. (2n)	Multiples of Basic No.(x-12)	Level of ploidy
24	2x	Diploid
36	3x	Triploid
48	4x	Tetraploid
60	5x	Pentaploid
72	6x	Hexaploid

CLASSIFICATION



Natural polyploids: Polyploids arise in nature by failure of meiosis that result in formation of unreduced gametes. They may also be formed from somatic cells in which a failure of mitosis has resulted in doubling of the chromosome complement. The cultivated banana and tobacco are examples of natural polyploids.