RAMA UNIVERSITY

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FACULTY OF AGRICULTURAL SCIENCES

AND ALLIED INDUSTRIES

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.

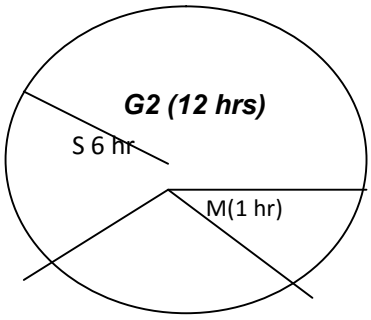
1. G1 (first gap)
2. S (Synthesis of DNA)
3. G2 (Second gap)

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.

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'.

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	**Dominant 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

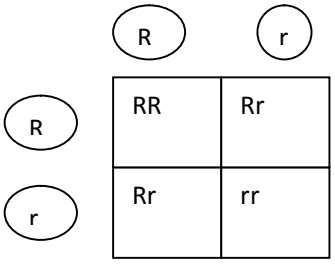
(First filial) F1 Rr : Round

↓

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:

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 (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)

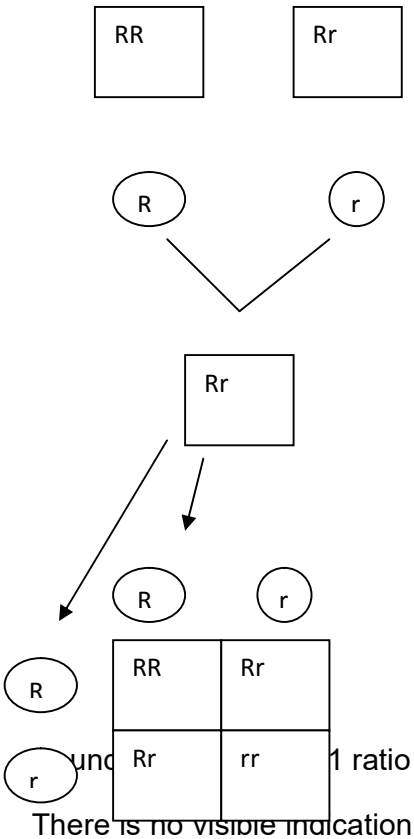
When a pair of contrastiang characters are brought together in a hybrid, the factors responsible for the character donto belnd or contaminate each other in the hybrid, but when gametes are formed they segregate and pass into different gametes in a difinite proportion.

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.



und 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

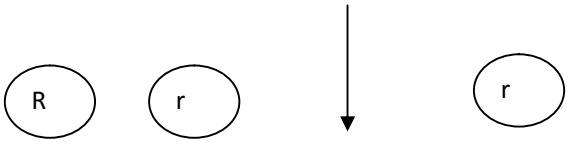
The most important principle of Mendel's Law of segregation is that, even hybrid individuals produce gametes which are always pure. Hybrid individuals (heterozygous) with refererred to one pair of allells produce two kinds of gametes. It is pure and has either dominant allele or recessive allelle but 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 STRUCTURE AND FUNCTION

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 x Yy

↓

2 yellow : 1 grey

YY die : 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

I_1 L_2 x I_1 L_2

L_1 I_2 L_1 I_2

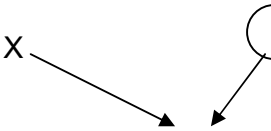
A balanced lethal system involving two recessive lethal genes (I_1 and I_2). Only two of the four heterozygotes survive. They are heterozygous for both the lethal genes (I_1 L_2 / L_1 and I_2). Thus a balanced lethal system maintains the genes closely linked to the lethal gene in a perpetual heterozygous 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

SEMI LETHAL 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 I 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.

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.

Important Questions

1. Describe pre Mendelian concepts of heredity.
2. Explain functions of different cell organelles.
3. Briefly explain the differences between mitosis and meiosis cell division.
4. Describe monohybrid and dihybrid cross with reference to Mendel’s laws of inheritance.
5. Explain karyotype and idiogram.
6. Briefly explain different types of chromosome with their importance.
7. Define penetrance and expressivity.
8. What do you understand by multiple allele? Explain with example.