Syllabus Paper XV

PAGE:
DATE: / /

Cell & Molecular Biology

Unit - I

cell - structures of p.k cell

cell wall & cell organelles (02)

→ structure & functions of cell wall & cell organelle Golgi complex, E.R. Lysosome (03)

Nucleus :- Ultra structure, Nuclear membrane, nucleolus, chromatin material, nucleoplasm, function of nucleus. (05)

Unit - 2.

1) cell division : (06)

⇒ Cell cycle : A) G_1 phase, S phase, G_2 & M phase

B) Mitosis : defⁿ, process & significance.

C) Meiosis : defn, process & significance.

2) Nucleic Acids :

a). DNA : Defⁿ, structure, chemical composition, purine, pyrimidine, nucleotides, nucleosides, phosphate & sugars, watson & crick model, -DNA, function of DNA.

b) Replication DNA - conservative, semi conservative & dispersive.

c) RNA : Structure of RNA.

Unit 3 :

1) chromosomes : Defⁱⁿ, Morphology, size, shape, Number, Ultra-structure chromatid, chromonema, chromomere, centromere, kinetocore, secondary constrictions, satelite., telomere, hetero chromatin & euchromatin, Nucleosome model funcⁿ of chromosome, Giant chromosome,

polyten & lampbrush chromosomes.

2) chromosomal abbression. (or)

→ structural → deletion ; duplication , inversion & translocation

→ Numerical → euploidy & Anuoploidy.

cell History

PAGE
DATE / /

→ Cytology : study of cells.
→ 1665 : Robert Hook (1635-1703)
→ used microscope to examine (cork plant)
→ Hooke : cells.

Robert brown :
→ Nucleus discovered in 1833

Matthiaus Schieden :
→ germen Botanist, 1838
→ "All plants are composed of cells"

Theodor Schwann : 1838
→ discovered that animals are made up of cells.

Rudolf Virchaw :
→ 1855, german physician.
→ "that cells only come from other cells".
→ His statement debunked of : Theory of spontaneous Generation.

cell theory states that :
1) All living thing are composed of a cells or cell.
2) cells are the basic unit of life.
3) All cells come from prexisting cells.

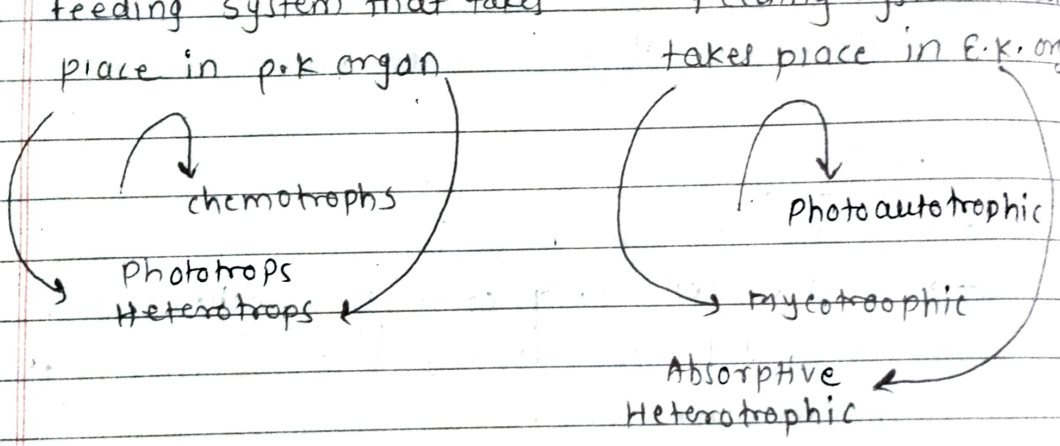
Cell Diversity :-
- cells within the same organism shows enormous Diversity in
① size ② shape ③ Internal organization.

PAGE :
DATE : / /

1) Cell size :-
→ Female egg - largest cell in the human body, seen with out aid of a microscope.
→ most cell are visible only with a microscope.

2) Cell shape :-
→ Diversity of form reflect a diversity of functi
→ cells : Bacterium, Nerve cell, Egg cell, Muscle cell, plant cell, RBC.
→ The shape of a cell Depends on its functions.

Feeding System :-



organism within the kingdom :-
→ p.k includes several types of microorganism such as a bacteria & cyanobacteria.
→ E.k includes such microorganism such as fungi, protozoa & simple algae.

Introduction

→ All living things are made up of cells. Cells are the smallest unit that can be alive, during the 1950's scientist developed the concept that life

on earth is classified into six kingdoms & each have their own charactristics of cell.

→ However the biggest division is betn the cells of the p.k kingdom (Eubacteria & Archeabacteria and those of the other four kingdoms (animals, plants, fungi & protista which are all E.K cells.

Functions :

* p.k cell *	* E.k cell *
1) The cell wall	1) the cell wall
2) The plasma membrane	2) the plasma membrane
3) cytoplasm	3) Nucleus
4) Genetic material	4) nuclear membrane
5) The Ribosomes.	5) nucleus
	6) mitochondria
	7) chloroplast
	8) E.R
	9) Ribosomes
	10) Golgi bodies
	11) Lysosomes
	12) vacuoles
	13) cytoplasm
	14) chromosomes.

DNA $\xrightarrow{\text{Transcription}}$ RNA $\xrightarrow{\text{Translocation}}$ protein.

PAGE
DATE / /

* DNA : the genetic material is located in a non-membrane bound nucleoid region in P.K & a membrane bound nucleus in E.K.

2) Plasma membrane, a phospholipid bilayer with proteins that separate the cell from the surrounding environment & function as a selective barrier for the import & export of materials.

3) Cytoplasm; the rest of the material of the cell within the plasma membrane, excluding the nucleoid region or nucleus, that consists of a fluid portion called the cytosol & the organelles and other particulates suspended in it.

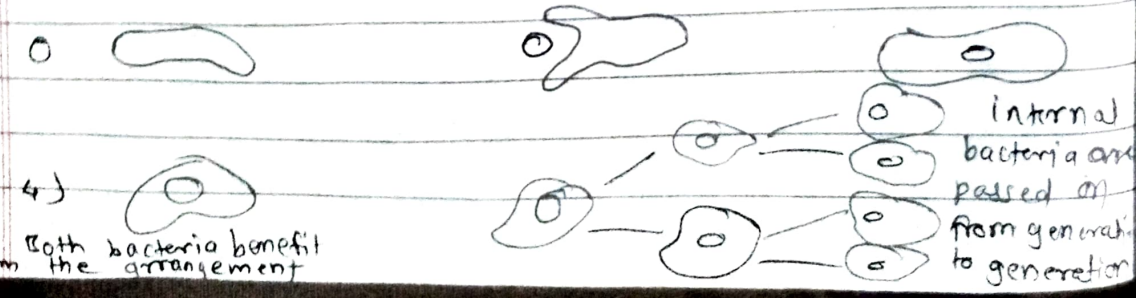
4) Ribosomes : the organelles on which protein synthesis takes place.

* connection *

Prokaryotic → Asexual
Eukaryotic → Asexual / sexual.

Endosymbiosis in a Nutshell:

1. start with two independant bacteria
2. one bacteria engulfs the other
3) one bacterium now lives inside the other
4) Both bacteria benefit from the arrangement
5) internal bacteria are passed on from generation to generation



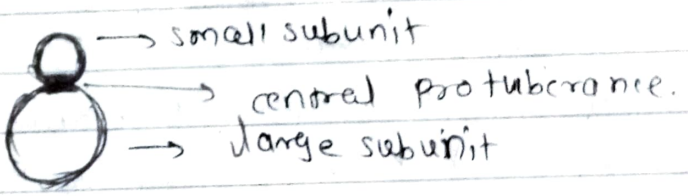
Cellular organelles :

the plasma membrane

- the boundry of the cell.
- composed of three distinct layers.
- Two layers of fat & one layer of protein.

Ribosomes :

- small non-membrane bound organelles.
- contain two subunits.
- site of protein synthesis.
- protein factory of the cell
- either free floating or attached to the E.R.



(Ribosomes)

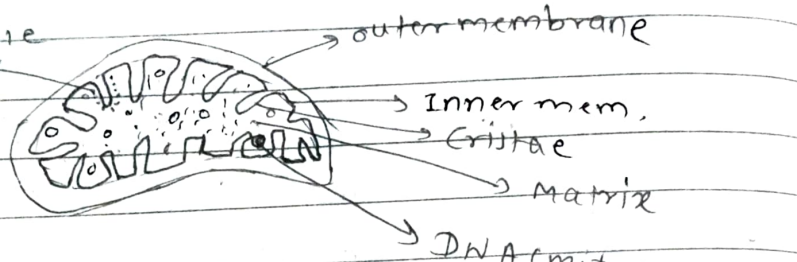
Centrioles :-

1) found only in animals cells.
2) paired organelles found together near the nucleus, at right angles to each other.
3) role in building cilia & flagella.
4) play a role in cellular reproduction.

5) Framework of the cell. ⟶ cytoskeleton.
6) contains small microfilaments and larger microtubules
7) they support the cell, giving it its shape and help with the movements of its organelles.

Mitochondrion :-

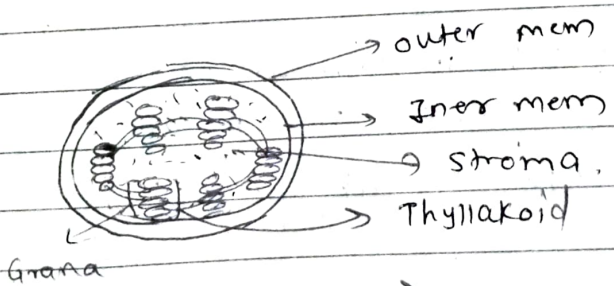
1) Double membraneous.
2) It's the size of the bacterium.
3) Contains its own DNA ; m DNA
4) produces high energy compound ATP



(Fig - mitochondria)

The chloroplast :

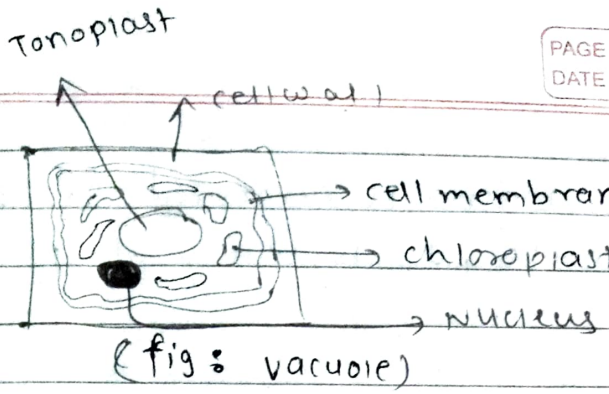
1) Double membrane.
2) centre section contains grana.
3) Thylakoid (coins) make up the grana.
4) stroma - gel-like material surrounding grana.
5) found in plants and algae.



(chloroplast)

The Vacuole :-

1) sacs that helps in food digestion or helping the cell maintain its water balance.
2) found mostly in plants & protists.



(fig :

* plant cell :- 1) Primary cell w. 2) Middle lamella 3) Secondary cell wall 4) Tert. cell wall

plant cell wall :-

1) The plant cell wall is a remarkable structure. It provides the most significance difference betn plant cells & other E.K cells.
2) The wall is rigid (up to many micrometers in thickness) and given plant cells a very defined shape.
3) While most cells have a outer membrane, none is comparable in strength to the plant cell wall. The cell wall is the reason for the diffn betn plant & animals cell functions. Because the plant has evolved this rigid structure.

1) Middle lamella :-

→ It is present betn two adjecent cell.
→ It is situated outside primary cell wall & is made up of calcium & magnesium pectate.
→ It acts as cement which holds the adjecent cells together.

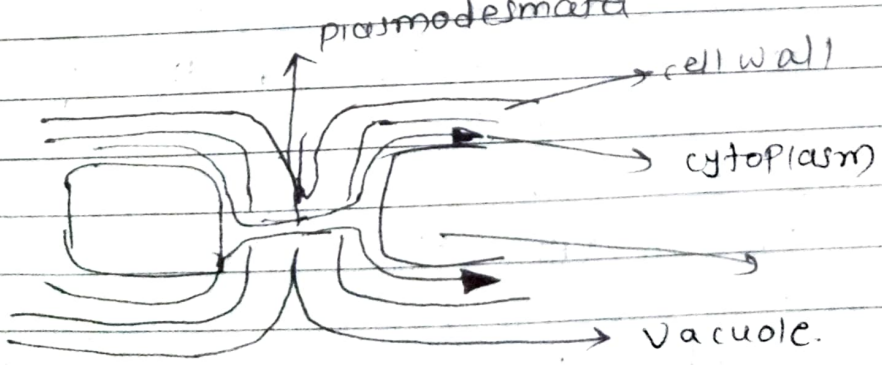
2) primary cell wall.

→ It is formed after the middle lamella.
→ A thin, flexible & extensible layer.
→ It is capable of growth & expansion.
→ The backbone of primary cell wall is formed by the cellulose fibrils.

→ The matrix is composed of hemicellulose, pectic compounds, lipids, structural proteins.

4) Tertiary cell wall :
→ Tert. cell wall is deposited in few cells.
→ It is considered to be dry residue of protoplast.
→ Besides cellulose & Hemicellulose, xylan is also presen

* Plasmodesmata :—
1) plasmodesmata are protoplasmic strands that connect the the protoplasts of neighbouring cells.
2) Diameter is 40–50 cm.



Composition of cell wall :-

- The cell wall is mainly composed of carbohydrate materials.
- The major ~~products~~ componants of cell wall are cellulose, pectins, Hemicellulose, proteins & phenolics.

(1) Cellulose : It provides shape and strength to the cell wall.

→ It compose 20-30% of the dry wt. of primary wall & accounts 40-90% of the dry wt. of secondary wall.

(2) pectins :- They are group of polysaccharides, which are rich in galacteronic acid, rhamnose, arabinose & galactose.

→ pectins are present in high concentration in the middle lamella where they presumably serve the function of cementing adjacent cells together.

(3) Hemi-cellulose :-

→ these are matrix polysaccharides built up of a variety of diffn sugars.

→ They differ in diffn species and in diffn cell types.

(4) xylan :- It is typically made upof roughly 30% of primary cell wall & 20% of sec. cell wall in dicots

→ The hemi cellulosic polysaccharide is linked with xylose & arabinose.

Hydroxiproline (about - 40%)

4) Proteins :- diffn varieties of protein are present in cell wall, most of which are linked with carbohydrate forming glycoprotein.

→ The cell wall glycoprotein extension contain an unusual amino acid hydroxyproline, which is generally absent from the protoplast.

→ Extensions are present in the 1° cell walls of the dicots making up to one to ten percent of the wall.

* Diffn betn the 1° & 2° cell wall *

Sr. No	Features	1° cell wall	2° cell wall
1.	occurance	In all the plant cell	In only mature & non-dividing cell.
2.	position	Inner to M. lamella	Inner to 1° cell wall
3.	Nature	Elastic and thinner	Inelastic, rigid & thick
4.	Nature of growth	Intussuseptional	Accretional
5.	pits	Absent	present
6.	Additional Materials	Absent	present lignin, suberin & cutin.
7.	Amount of cellulose	Low	High
8.	Extensibility	present	generally absent
9.	Arra. of fibrils	wavy & loosely arrangement	closely, straight & parallel arrange
10.	Hydration	More (60+)	low (30-40%)

Functions Of Cell :

→ they determine the morphology, growth & development of plant cell.

→ they protect the protoplasm from invasion by viral, bacterial & fungal pathogens.

→ they are rigid structures & thus help the plant in withstanding the gravitational forces.

→ they are involved in the transport of materials & metabolites into and out of cell.

→ they withstand the turgor pressure which develops within the cell due to high osmotic pressure.

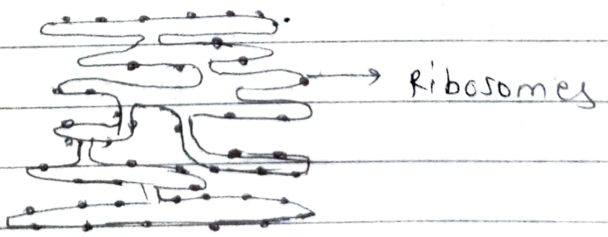
Endoplasmic Reticulum :—

→ complex Network of transport channels.

→ two types :—

1) Smooth : ribosome free and functions in poison de toxification.

2) Rough : contains Ribosomes and releases newly made protein from the cell.



(Fig : Rough en. R)

Golgi Apparatus :

→ A series of flattened sacs that modifies, packages stores and transports materials out of the cell.

→ works with the Ribosomes and Endoplasmic R.

(Fig : Golgi Apparatus)

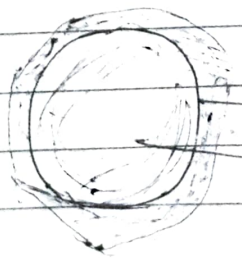
Lysosomes :

→ Recycling centre.
→ Recycling debris.

→ membrane bound organelle containing a variety of enzymes.

→ internal pH is 5.

→ Help digest food particles inside or outside the cell.



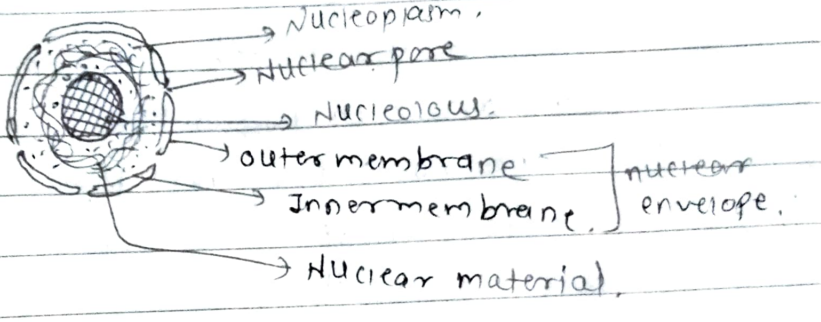
(Fig - Lysosome)

Nucleus

PAGE :
DATE : / /

Why should you buy a nucleus ?

→ The nucleus is the control centre / brain of the cell.
→ Without it, your cell wouldn't be able to function.
→ The nucleus makes sure everything is orderly.
→ The nucleus holds most of the DNA cell, so it has all the hereditary information of the cell.



(Fig: Nucleus)

Basics of Nucleus :-

→ Nucleus was discovered by an English biologist Robert brown. in 1831.
→ It is the important part of the cell, exerting a controlling influence on all cell activities.
→ It is usually spherical & oval structure mostly located in the centre of the cell.
→ Some sieve tube of vascular plants and the red blood cells of mammals lack nuclei at maturity.

PAGE :
DATE : / /

Functions of the Nucleus :-

1) Nucleus contains most of the cell's DNA mostly in the form of chromatin.
2) The chromatin will organize to form chromosomes during cell division.
3) The chromosomes contain a set no. of genes.
4) Genes control every single trait.
5) It directs all activities inside the cell including cell growth, metabolism, protein synthesis & Reproduction (cell division).
6) The nucleus is like the brain in a cell. It controls all of the cell's movements & actions, & even when the cell is about to die, the nucleus never stops working.
7) It has instructions for making proteins & other molecules.

Structure of the Nucleus :-

Average diameter of nucleus - 6 µm

10 % of

1) Nuclear Envelope
2) N. Membrane
3) Nucleolus
4) Chromosomes
5) Nucleoplasm.

PAGE :
DATE :

Nuclear Envelope :-

1) The double-layered membrane enclosing the nucleus of a E.k cell.
2) The nuclear Envelope has pores that allow the passage of materials into & out of the nucleus. Also called Nuclear membrane.
3) A nuclear membrane, also known as the nucleolema or Karyotheca is the phospho lipid bilayer membrane which surrounds the genetic material and nucleous in E.k cells.
4) The nuclear membrane consists of two lipid bilayers the inner nuclear membrane & the outer nuclear membrane.

Nucleolus

1) The nucleolus takes up around 25% of the volume of the nucleus.
2) this structure is made up of protein & ribonucleic acid (RNA)
3) Its main function is to rewrite ribosomal RNA (rRNA) & combine it with proteins.
4) the result in the formation of incomplete ribosomes.

chromosomes *

1) The function of chromosomes. chromosomes are the thread-like structure found in the nuclei of both animals & plant cells.
2) they are made a protein & one molecules of deoxy ribonucleic acid (DNA)

PAGE:
DATE: / /

Cell Division

1) An integral part of the cell cycle.
2) Results in genetically identical daughter cells.
3) cells duplicate their genetic material.
   - Before they divide, ensuring that each daughter cell receives an exact copy of the genetic material, DNA.

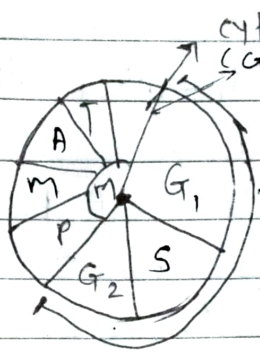
* What is Cell cycle ?

→ The cell cycle is a process in which a cell grows & divides to create a copy of itself.
some organism reproduce through the cell cycle & it in complex multicellular organisms, to cell cycle is used to allow the organism to grow, & to replace cells as they grow worn out.
In animals the whole cell cycle takes around 24 hours from start to finish.
some cells, such as skin cells, are constantly going through the cell cycle. while other cells may divide rarely, if at all;
neurons, for eg: don't grow & divide once they are mature.

phases of the cell cycle :-

Interphase

1) G_1 - primary growth
2) S - genome replicated
3) G_2 - secondary growth
4) M - mitosis
5) C - cytokinesis.



(fig: cell cycle)

G_1 PHASE :-

1) Gap phase ; begins at the completion of mitosis & cytokinesis & lasts until the beginning of S phase.
2) This phase is generally the longest of the four cell cycle phases & is quite variable in length.
3) During this phase, the cell chooses either to replicate the deoxyribonucleic acid (DNA) or to exit the cell cycle & enter a quiescent state (the G_0 phase).

S phase :-

1) Replication of the chromosomes is restricted to one specific portion of interphase, called S phase.
2) which typically lasts about 6 h.
3) In mammalian cells, the start of S phase - the actual initiation of DNA synthesis - takes place several hours after the cell has comitted to carrying out DNA synthesis.

4) During s phase, each chromosome replicate exactly once to form a pair of physically linked sister chromatids.

5) In animal cells, a pair of centrioles is also duplicated during s phase.

G_2 phase :

1) The portion of interphase that follows s phase is called gap phase.

2. some cells can exit the cell cycle from G_2 phase, just as they can from G_1 phase.

* all combination of these three phases is known as interphase.

M phase

→ M phase includes the overlapping processes of mitosis & cytokinesis.

Mitosis is divided into five stages :-

1) prophase
2) prometaphase
3) metaphase
4) Anaphase
5) telophase.

* Mitosis :-

→ The purpose of mitosis is cell division making two cells out of one.

→ Each cell has to have its own cytoplasm & DNA

PAGE :
DATE : / /

2) The DNA is replicated in interphase when two chromosome strands become four strands (two strands per chromatid.)

3) In mitosis the four strands (two sister chromatid) have to break apart so that each new cell only has one double-stranded chromosome.

5) Two sister chromatids together make a chromosome.

* 1) prophase :-

- characterized by 4 events:

1) Chromosomes condense & are more visible.

4) The nuclear membrane (envelope) disappears.

5) Centrioles have separated and taken position on the opposite poles of the cell.

4) spindle fibres form & radiate towards the centre of the cell.

2) Metaphase :- (shortest phase of mitosis)

characterized by two events:

1) chromosomes line up across the middle of the cell.

2) spindle fibre connects the centromere of each sister chromatid to the pole of the cell.

3) Anaphase :-

→ characterised by 3 events:

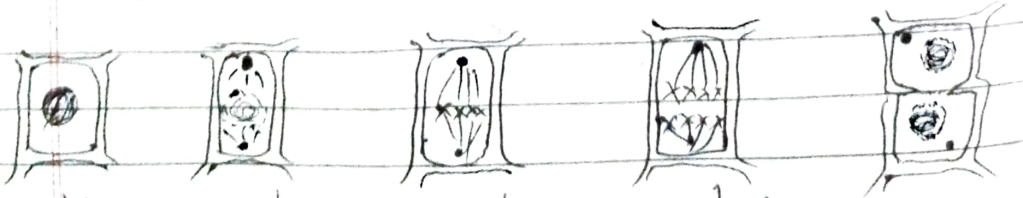
① centromere that join the sister chromatids split.
② sister chromatid seperate becoming individual chromosomes.
③ seperated chromatids move to opposite poles of the cell.

4) Telophase :- (last phase of mitosis)

① chromosomes (each) consisting of a single chromatid uncoil.
② A nuclear envelope forms around the chromosomes at each pole of the cell.
③ spindle fibres break down & dissolve.
④ cytokinesis begins.

~~diagram~~ 5) Cytokinesis :-

① cytokinesis is the division of the cytoplasm into two individual cells.
② The process of cytokinesis differs somewhat in plant & animals cells.
③ In animal cells the cell membrane forms a cleavage furrow that eventually pinches the cell into two nearly equal parts, each part containing its own nucleus & cytoplasmic organelles.



(mitosis)

PAGE :
DATE : / /

cells divide at different rates :-

→ the rate of cell division varies with the need of those types of cells.

[cell division]

cell Type	Approximate Life span
skin cell	2 weeks
RBC	4 months
Liver cell	300 - 500 days
Intestine - internal lining	4 - 5 days
Intestine - muscle & other tissues	16 years.

→ some cells are unlikely to divide (G_0)

meiosis

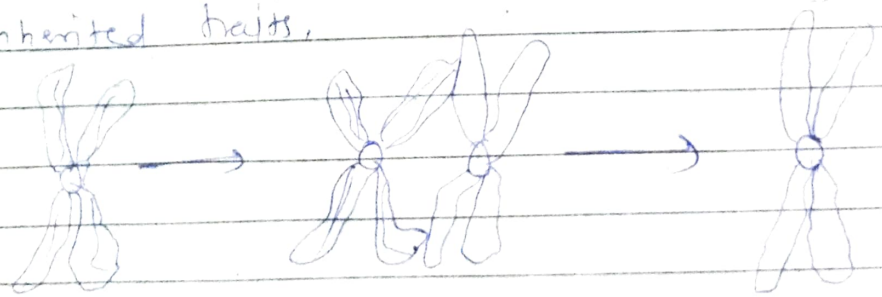
A type of cell division that results in 4 daughter cells each with half the no of chromosomes of the parent cell, as in the production of gametes and plant spores.

sexual reproduction :-

1) cell division that forms gametes (eggs & sperms)
2) gametes have half the no. of chromosomes
3) Two Divisions (meiosis I & meiosis II)
   a) part of each parent is carried out to the 4 cells.
   b) meiosis is similar to mitosis with some chromosomal differences.

Homologous chromosomes :-

1) pair of chromosomes (maternal - paternal) that are similar in shape & size.
2) Homologous pairs carry of homologous chromosomes
   a. 22 pairs of Autosomes
   b. 1 pair of sex chromosomes.
3) Homologous pairs carry genes controlling the same inherited traits.



PAGE :
DATE : / /

Interphase I

→ similar to mitosis interphase
chromosomes replicate (s phase).
② Each duplicated chromosome consist of two identical sister chromatids attached at their centromere.

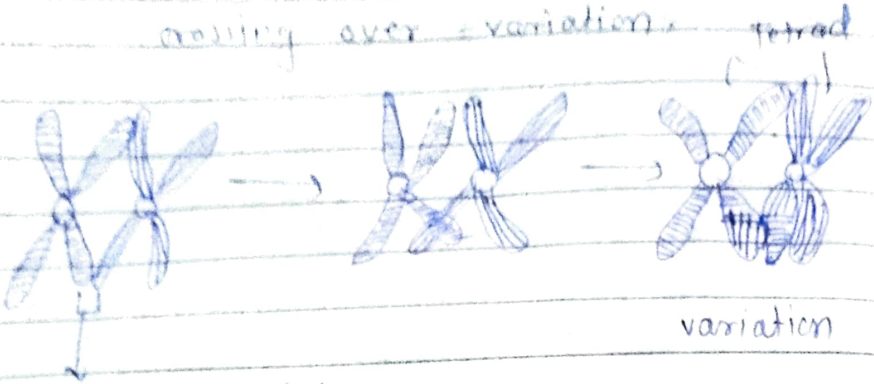
Meiosis I (four phase)

1) cell division that reduces the chromosome no. by one-half.
2) four phase :
a) prophase I
b) Metaphase I
c) Anaphase I
d) Telophase I

* 1) prophase I :-
① prophase : Homologous chromosomes come together to form a tetrad.
② tetrad is two chromosomes or four chromatids (sister and nonsister chromatids).

* Crossing over :
① crossing over segments of non-sister chromatids break & reattach to the other chromatids.
② crossing over causes variation.

crossing over - variation.



(chiasmata : site of crossing over)

c) Metaphase I :-

1) Tetrads align on the in centre of cell on spindle

2)

* Independant Assortment occurs :-

1) Varieation of Homologous pairs to poles in random

2) variation.

3) Anaphase I :-

1) Homologous chromosomes seperate and move towards the poles.

2) Sister chromatids remains attached at their centromere.

4) Telophase :-

1) Each pole now has haploid set of chromosomes.

2) Cytokinesis occurs and two haploid daughter cells are formed.

Meiosis II

No interphase II

meiosis II is similar to mitosis.

Prophase II :-

same as prophase in mitosis.

Metaphase II

same as metaphase in mitosis.

Anaphase II :

same as anaphase in Mitosis.

sister chromatids seperate.

Telophase :

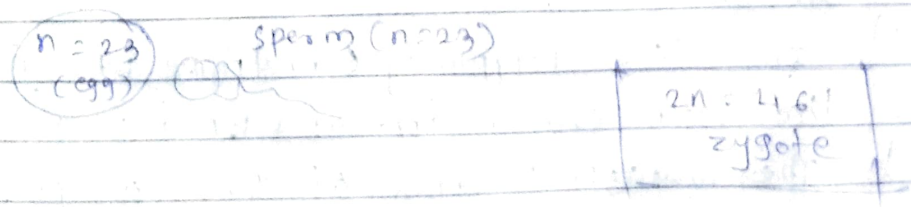
four haploid daughter cells produced.

gametes = sperm or egg

fertilization :-

The fusion of sperm & egg to form a zygote.

A zygote is a fertilized egg.



The Nucleic Acids

* Friedrich Miescher in (1869)
  → Isolated what he called nuclein from the Nuclei of pus cells.
  → Nuclein was shown to have acidic properties, hence it became called nucleic acid.

* Two Types of Nucleic acid are found.
  1) Deoxyribonucleic acid (DNA)
  2) Ribonucleic acid (RNA)

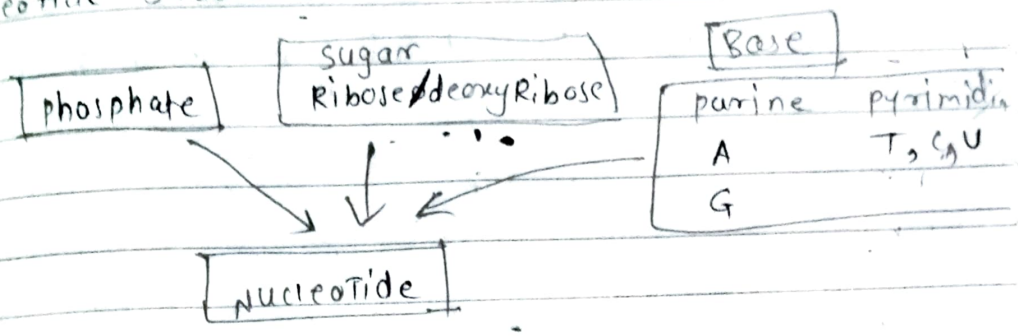
* The distribution of nucleic acids in the E.K cells.
  → DNA is found in the nucleus with small amounts in mitochondria & chloroplasts.
  → RNA is found throughout the cell.

* DNA as genetic material — The circumstantial evidance
  1) present in all cells and vertually restricted to the nucleus.
  2) The ~~amount~~ amount of DNA in somatic cells (body cells) of any given species is constant (like the no. of chromosomes.)
  3) The DNA content of gametes (sex cells) is half that of somati cells.
  4) In case of Polyploidy (multiple sets of chromosomes) the DNA content increases by a proportional factor.
  5) The mutagenic effect of UV light peaks at 253.7 nm. The peak for the absorption of UV light by DNA.

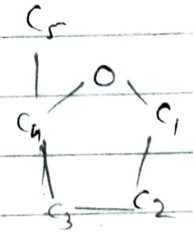
Nucleic Acid structure :-

Nucleic Acids are polynucleotides.
their building blocks are nucleotides.

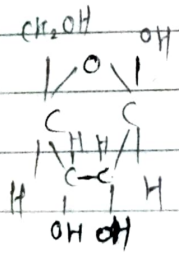
Nucleotide structure :-



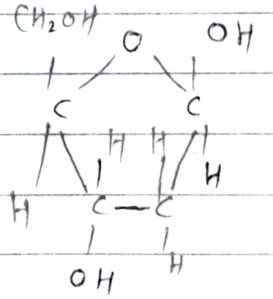
Ribose is a pentose sugar.



Ribose



Deoxy Ribose



The Sugar-phosphate Backbone:

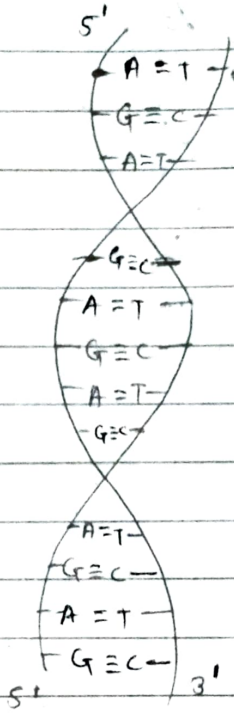
1) The nucleotides are all oriented in the same direction.
2) The phosphate group joins the 3rd carbone of one sugar to the 5th carbone of the next line.

PAGE :
DATE : / /

Adding in the Bases:-

1) The bases are attached to the 1st Carbon.
2) Their order is important It determines the genetic information of the molecules.

DNA is made of TWO strands of polynucleotide

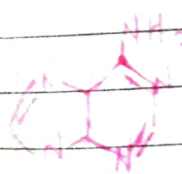


(DNA)

- DNA is made up of two strands of polynucleotide.
- The sister strands of the DNA molecule run in opposite directions (antiparallel).
- They are joined by the bases.
- Each base is paired with a specific partner.
  A is always paired with T
  G is always paired with C
  purine with pyrimidine.
- Thus the sister strands are complementry but not identical.
- The bases are joined by hydrogen bonds individually weak but collective.

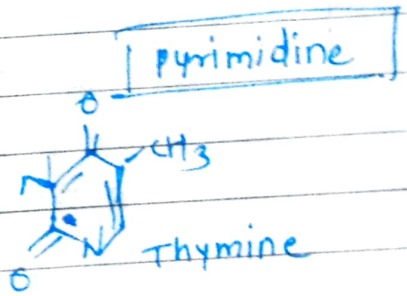
- Purines & Pyrimidens :

Purine (double ring)

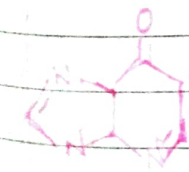


=

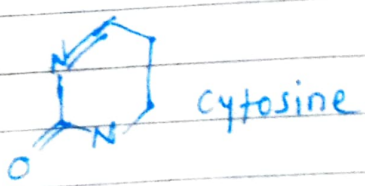
Pyrimidine (single ring str.)



Adenine

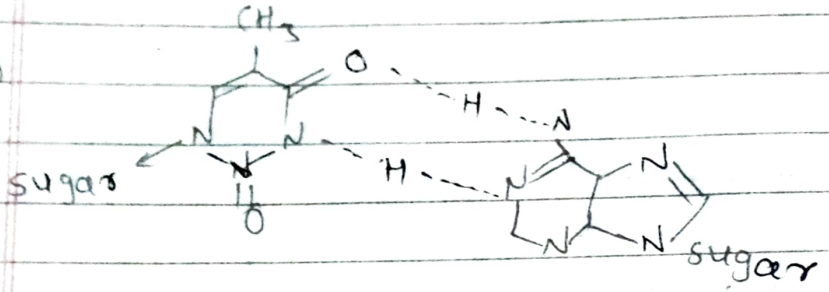


=

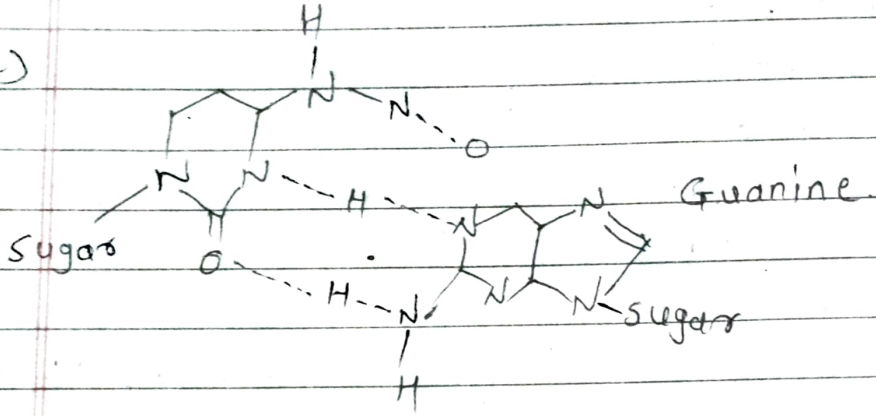


Guanine

1)



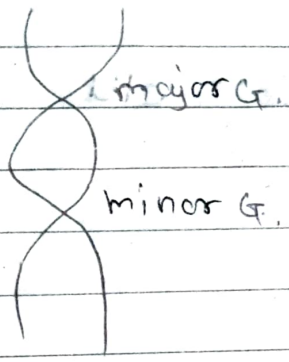
2)



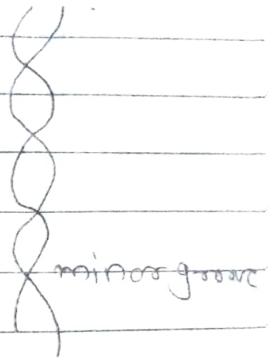
B - DNA

- Right-handed helix
- Intermediate
- planes of the base pairs
- nearly perpendicular to the helix axis.
- & tiny central axis.
- Wide + deep major groove.
- narrow + deep minor groove.

B-form



A form



Z form

Z-DNA :

→ left handed helix.
→ Narrowest
→ planes of the base pairs
→ nearly $\perp^{ar}$ to the helix axis.
→ no internal spaces.
→ no major grooves
→ narrow.

Functions of DNA :-

DNA has 2 major function.

1) Replication in dividing cell allowing accurat copies of DNA for cell division.

2) carring the information for protein synthesis in all cells.

3) DNA is used to store genetic information. It is replicated befor cell division.

4) DNA is very important so it stored in the nucleus

5) It never leaves in the nucleolus.

6) Your DNA store the

7) The DNA get converted to RNA in order to move out into the cytoplasm.

8) In the cytoplasm it meets up with the ribosome, where it can synthesis protein.

9) Store genetic information.

10) Maintains growth & repair.

11) Controls all cellular activities.

12) Contain protein codes.

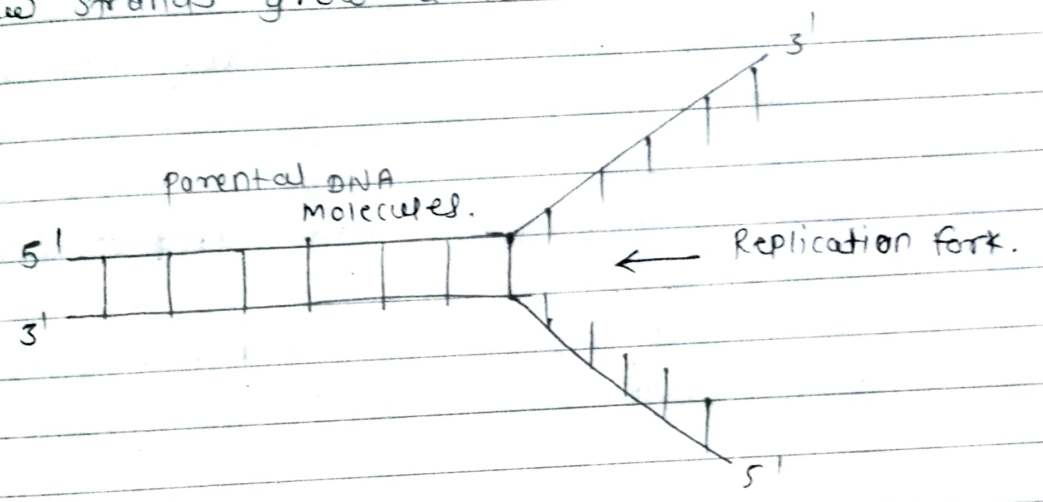
13) Ensures each daughter cell and gamete receives exact genetic information.

DNA Replication

→ DNA has to be copied before a cell divide.
→ DNA is copied during the (S) or synthesis phase or interphase.
→ New cell will identical DNA strands.

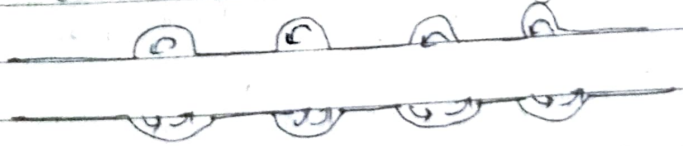
→ Begin at origins of Replication two strand open Replication forks (V shaped origin).

→ New strands grow at forks.

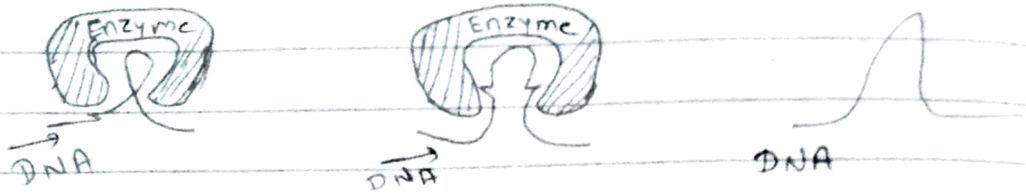


→ As the 2nd DNA strand open at the origin Replication bubbles form.

→ P.K have a single bubble.
→ E.K chromosomes have many bubbles.



Enzymes Topoisomerism attacts to the 2nd fork of the bubble to relieve stress on DNA molecule as it Seperate.



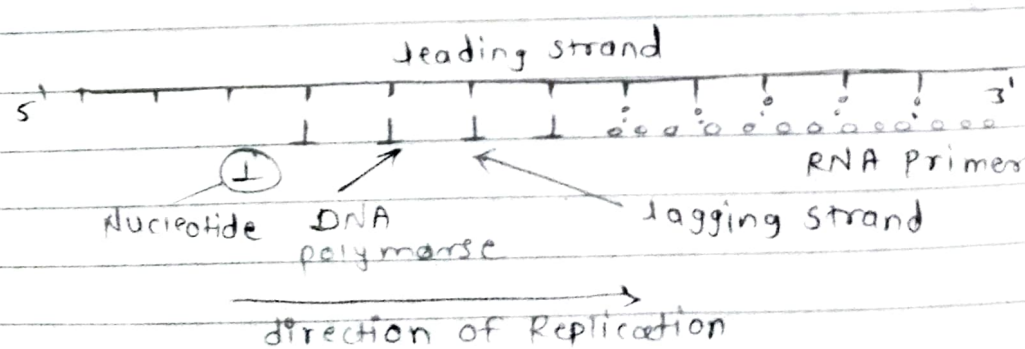
- Before New DNA Strand can form there must be RNA primarase present to start the addition of new nucleotides.

* primarase is the enzymes that - synthesis the RNA primer.

→ DNA polymarase, can then added the new nucleotide

→ DNA polymarse can only add nucleotides to the 3' end of the DNA.

→ This cause the new ~~Strand~~ Strand to but in a 5' to 3' direction.

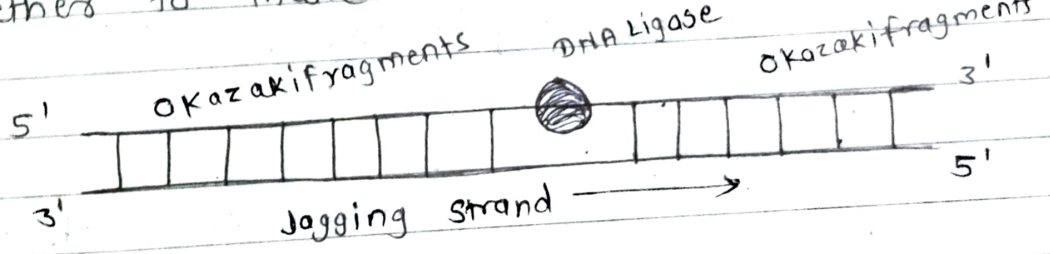


The leading strand is synthesis as a single strand form the point of origin toward the opening ~~fork~~ Replication fork.

→ The lagging strand is synthesized discontinously against overall direction of Replication.

→ This strand is made in many short segments.
→ It is replicated form the Replication fork towards the origin.

* Lagging strand segment :—
→ okazoki fragments series of short segment on the lagging strand.
→ must be joined together by an enzyme.
→ The enzyme Ligase join the okazaki fragments togethers to make one strand.



Model of DNA Replication :->

1) Dispersive
2) Conservative
3) Semi-conservative.

* Models of DNA Replication :-

3 models are —

1) Dispersive :-

In dispersive mode of replication, the old DNA molecule would break into several pices, each frag ment would replicate and the new segments would combine randomly to yield the progeny DNA molecule.

Each progeny molecule would have both old & new segments along it length.

2) Conservative :-

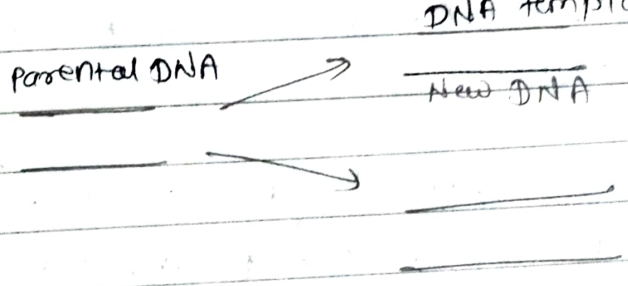
According to conservative scheme, the two newly synthesized strands following the replication of a DNA molecule would associate to form one double helix, while the other two old strands would remain together as one double helix.

3) Semi-conservative Replication :-

1) It was proposed by watson & crick.
2) According to this method both the strands of parental DNA separate from one another.
3) Each old synthesize a new strand.
4) Thus each of two resulting DNA molecules has one parental and one new strand.

Semiconservative model of replication :-

1) Idea presented by Watson & Crick.
2) The two strands of the parental molecule separate, and each acts as a template for a new complementary strand.
3) New DNA consists of 1 parental (original) and 1 new strand of DNA.



RNA

→ sugar = Ribose
→ Thymine gets replaced by Uracil
→ Single stranded.

Structure of RNA.

1) Backbone is sugar & phosphate group.
2) Nitrogenous base linked to sugar moiety proteins from the back bone.
3) Nitrogenous bases are linked to pentose sugar through N-glycosidic linkage of to form a nucleoside.
4) Phosphate group is linked with 3'OH of nucleoside through phosphoester linkage.

5) 2 nucleotides are linked through 3'-5' phophodiester linkage to form a dinucleotide.

6) More & more such groups will be linked to form a poly nucleotide chain.

7) such a polymer has a free phosphate moiety at 5' end of Ribose sugar and it is called as 5' end of poly nucleotide chain.

8) At other end, Ribose has free 3' OH group which is called at the 3'- end of polynucleotide chain.

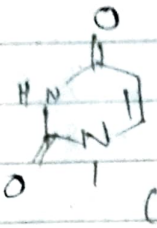
9) In RNA, every nucleotide has an additional -OH present at 2' position of Ribose.

✱ Ribonucleic Acid ✱

1) Ribonucleic acid or RNA is one of the major biological macromolecules that are essential for all known forms of life (along with DNA & proteins).

2) Each nucleotide in RNA contains a ribose sugar, with carbons numbered 1' through 5', A base is attached to the 1' position, in general.

Adenine (A), Guanine (G)
Thymine (T), Uracil (U)



(Uracil)

Synthesis :-

1) Synthesis of RNA is usually catalyzed by an enzyme RNA polymarase.
2) By using DNA as a template.
3) the process is known as transcription.
4) There are also a number of RNA - dependant RNA polymarase that use RNA as their template for synthesis of a new strand of RNA.
5) A number of RNA viruses (such as poliovirsuses) use this type of enzyme to replicate their genetic material.

Types of RNA :

1) Transfer RNA (tRNA)
2) Ribosomal RNA (rRNA)
3) Messenger RNA (mRNA)

Messenger (mRNA)

1) Messenger RNA (mRNA) carries information about a protein sequence to the Ribosomes, the protein synthesis factories in the cell.
2) it is coded so that every three nucleotides correspond to one amino acid.
3) In E.k cells, once precursor mRNA (Pre mRNA) has been transcribed from DNA, it is processed to mature mRNA.
4) This removes its introns - non-coding section of the pre m-RNA.

ARNA → Antisense RNA.

5) the m-RNA is then exported from the nucleus the cytoplasm, where it is bound to ribosomes and translated into its corresponding protein form with the help of tRNA.

2) Ribosomal RNA (rRNA) :—

1) Ribosomal RNA (rRNA) is the catalytic componant of the Ribosomes.

2) E.K Ribosomes contain four diffn rRNA molecules; 18S, 5.8S, 28S & 5S rRNA.

3) three of the rRNA molecules are synthesized in the nucleolus and one is synthesized elsewhere.

4) In the cytoplasm, Ribosomal rRNA & protein combine to form a nucleoprotein called a ribosome.

5) the Ribosome binds mRNA & carries out protein synthesis.

6) Several Ribosome may be attached to a single mRNA at any time.

7) Nearly all the RNA found in a typical E.K cells is rRNA.

3) Transfer RNA (t-RNA) :—

1) Transfer RNA (tRNA) is a small RNA chain of about 80 nucleotides.

2) It transfers a specific amino acid to a growing polypeptide chain at the ribosomal site of protein synthesis during translation.

3) It has sites for amino acid attachment and an anticodon region.

4) for codon recognition that binds to a specific sequence on the messenger RNA chain through hydrogen bonding.

(snRNAs) — Small Nuclear RNAs
(miRNAs) → Micro RNAs
(SiRNAs) → small interfering RNAs

CRNA
↓
Complement any RNA

functions of Different RNA :-

1) mRNA — It carries genetic information of DNA (Gene) for protein synthesis from nucleus to ribosome in the form of genetic code.

2) t-RNA : Acts as adapter molecule, carries amino acids and drops it to particular location by recognising codon on mRNA by virtue of having anticodon.

3) r-RNA- : It makes complexe with proteins and form ribosomal subunits which provide space for protein synthesis single ribosomal RNA of smaller ~~unit~~ subunit helps correct orientation of mRNA during attachment with respect to P & A sites.

PAGE :
DATE : / /

Unit III
Chromosome

Introduction & History :-

→ • defin^n :- chromosomes are the rod-shaped, darkly stained bodies seen during metaphase stage is mitosis

* Strausberger discovered chromosome in 1875.
* The term chromosome was coined by Waldeyer in 1
* Term initiated as (Chroma - colour ; soma - body)

Features Of E.K chromosome :-

1. chromosome are best visible during metaphase.
2. chromosomes bear genes in a linear fashion.
3. chromosome vary in shape, size & number in diffn species of plants & animals.
4. chromosome have property of self duplication & mutation.
5. chromosomes are composed of DNA, RNA & protein.

chromosome Size :-

1. chromosome size is measured at mitotic metaphase generally measured in length & diameter.
2. plants usually have longer chromosome than animals.
3. plants chromosome are generally 0.8 - 7 um. in length where as animal chromosomes are 0.5 - 4 um in length.
4. chromosomes size varies from speics to species.

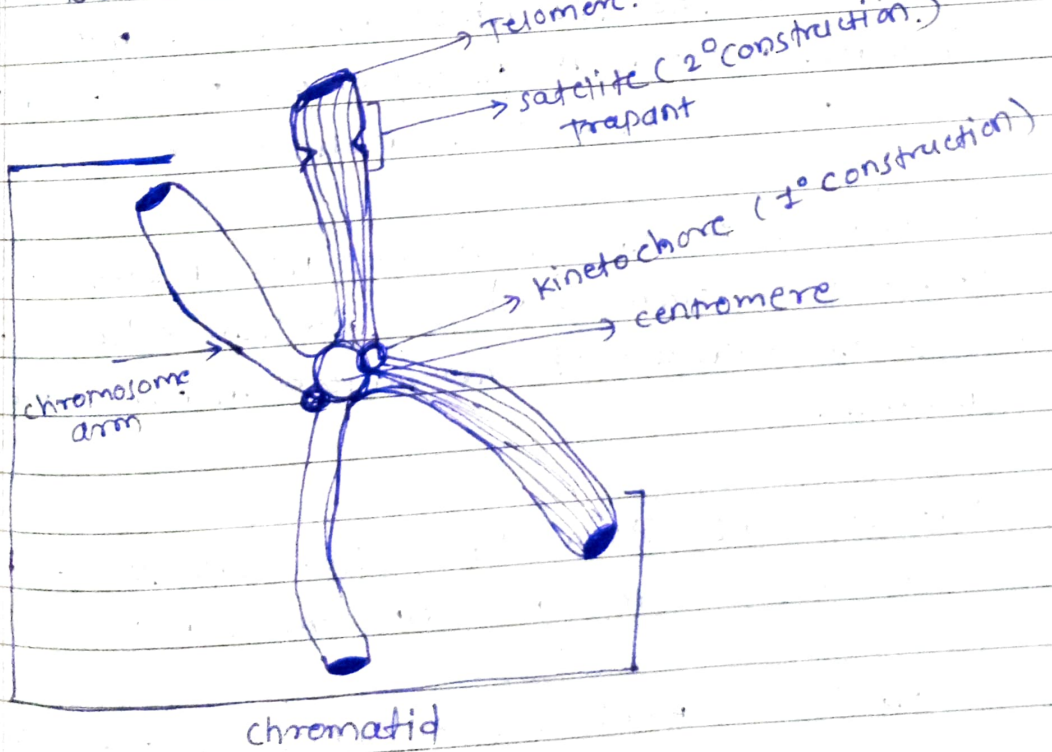
chromosome Num shape :-

1. The shape of chromosome is generally determined by the position of centromere.
2. chromosome generally exists in three diffn shapes viz rod shape, J shape & V shape.

Chromosome Number :-

1) each species has definite & constant somatic & genetic chromosome number.
2) Somatic chromosome no. is no. of chromosome found in somatic cell while genetic chromosom number is the no. of chromosome found in gamatic cell.
3) somatic chromosomes are always diploid and are denoted as 2n where as genetic chromosome are always haploid & are denoted as n.
3) In human being somatic chromsome are XX & XY where as genetic chromosome number is X & Y.

Chromosome Structure :-



PAGE :
DATE : / /

1) centromere – it is a localized region of the chromos with which spindle fibres attached is known as centrom or primary constriction or kinetocore.

2) Chromatid – one of the two distinct longitudenal subun of a chromosome is called as chromatid. chromatids o of two types sister chromatids & non-sister chromatids.

3) secondary constrictions – some chromosome ~~which~~ exhi ts secondary construction in addition to primary constructi The chromosomal region betn telomere is called as satellite or trapant. the chromosome having satellite called as satelite chromosome.

4) Telomere :- The two ends of chromosome are called as telomeres. telomers are highly stable & they do not fus or unite with telomere of other chromosome.

5) chromomere :- the chromosomes are of some of the species shows small bead like structure called as chrom meres. The structure of chromomeres in chromosome is constant.

6) chromonema :- Thread like coiled structure found inth chromosome & chromatids are known as chromonema.

7) matrix : it is fluid part in which chromonemata ar embedded is called as matrix. matrix is

PAGE :
DATE : / /

Somatic Chromosome number of Some common plants & Animals:

S.No.	Scientific Name	common Name	chromosome Number	
			somatic	Gametic
1)	Homo sapiens	Human	46	23
2)	Oryza sativa	Rice	24	12
3)	Rattus norvegicus	Rat	42	21
4)	Pisum sativum	pea	14	7
5)	Daucus carota	carrot	20	10
6)	Allium cepa.	onion	16	8
7)	Zea mays	Maize	20	10
8)	Apis mellifera	Honey bee	32	16
9)	Musca domestica	House fly	12	6
10)	Felis domesticum	cat	38	19
11)	Drosophilia melano gaster.	fruit fly	8	4
12)	Neurospora crassa.	Bread mold.	14	7

PAGE :
DATE : / /

Chemical composition of chromosome :-

1) Chemically chromosomes are nucleoprotein in nature means are composed of RNA, DNA & protein.

2) Generally chromosomes conteins 30-40% DNA, 50-65% protein & 0.5-10% RNA.

1) **DNA :-**

The amount of DNA present in somatic cell is constant. DNA content of genetic cell is half of that of somatic cell.

DNA of chromosome is of two types
i) Unique DNA ii) Repetitive DNA.

i) Unique DNA - unique DNA consist of those DNA sequence which are present in a single copy per genome & are unique in nature.

→ unique DNA is also call non repetitive DNA. codes for protein which requires in large quantity of cell
eg : storage protein.

ii) Repetitive DNA — Repetitive DNA consist of DNA nucleotide or base sequence, which are few to several hundred base pair long & are present to several to a million copies per genome. Human genome contains 30% repetitive DNA. Repetitive DNA is further divided into
i) Highly repetitive DNA &
ii) Moderate repetitive DNA.

2) RNA - purified chromatin contain 10-15% RNA. RNA associated with chromosome is messenger RNA, transfer RNA & Ribosomal RNA.

3) Protein :- protein associated which chromosome is classified into two broad groups.

i) Histone / basic protein

ii) Non Histone protein.

Non Histone proteins are acidic in nature & histone proteins are basic in nature because of basic amino acids.

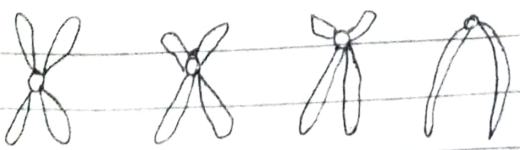
i) Histone protein - Histones constitutes about 80% of the total chromosomal protein. they are present in an almost 1:1 ratio with DNA. Five fractions of histones are present like $1H_1$, $2H_2a$, $2H_2b$, $2H_3$ & $2H_4$.

ii) Non Histone protein - non histone proteins make upto 20% of the total protein mass. content of non histone protein is different from species to species. Non Histone protein includes many imp enzymes like DNA & RNA polymarase.

Types of chromosome :-

→ According to the relative position of centromere chromosomes are divided into 4 types.

centromere localization.



Metacentric sub metacentric acro centric telocentric

Karyotype :

1) Complete set of chromosome in a speciel, or in an individual organism is known as karyotype.

2) The basic no. of chromosome in the somatic cell of an individual or a species is called the somatic number & is designated 2n. Thus in humans 2n = 46.

Idiogram :

→ A diagrammatic representation of chromosome morphology characteristic of a species or a population is known as idiogram.

Heterochromatin & Euchromatin :

Introduction :-

1) the term Heterochromatin & euchromatin was coined by Emil Heitz in 1928.
2) Heterochromatin & Euchromatin are the parts of the chromatin.
3) DNA protein complexe found in the E.K.
4) These take part in the ~~prod~~ protection of DNA inside the nucleus.

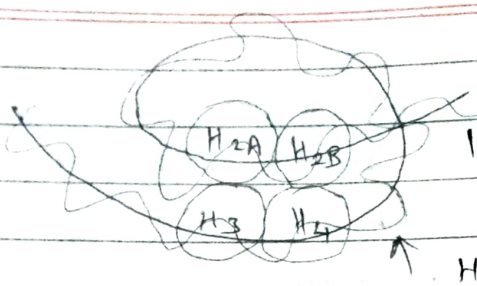
PAGE :
DATE : / /

1) Heterochromatin

1) The regions of the chromosome that appear relatively condensed and stained deeply with DNA specific strains.
2) It is tightly packed form of DNA.
3) there are two type of, ~~do~~As Heterochromatin, constitutive heterochromatin & facultative heterochromatin.
4) Both of the constitutive hetero. & facultative hetero. play a role in the expression of gene.
5) Transcriptionally inactive.
6) Facultative heterochromatin is the result of genes that are silenced through a mechanism such as Histone methylation of siRNA through RNAi
7) constitutive heterochromatin is usually repetitive and forms structural functions such as centromeres or telomeres.

2) Euchromatin

1) Euchromatin is tightly packed form of chromatin that is rich in concentration.
2) it is under active transcription.
3) Euchromatin comprises the most active portion of the genome within the nucleus 92% of human genome is euchromatin.
4) the structure of Euchromatin is reminist of an unfolded set of beads represents, Nucleosome, Nucleosomes consists of eight proteins known as Histone, with app. 147 base pairs of DNA wound around them.
5) In Euchromatin the wrapping is loose so that the raw DNA may be accessed.
6) The basic structure of Euchromatin is an elongated, open 10 nm micro fibril, as noted by electron microscopy.
7) Euchromatin participates in the active transcription of DNA to mRNA products.



(Nucleosome N.1)

* DNA packaging *

1) electron micrograph shows unfolded chromatin and they look like beads on a string.
2) These "beads" are refered to as nucleosomes (the basic unit of DNA packing), and the string is DNA.

* The Nucleosome & DNA packing *

1) A nucleosome is a piece of DNA wound around a protein core.
2) This DNA-Histone Association remains in tact throughout the cell cycle.
3) Histone only leave the DNA very briefly during DNA replication.
4) with very few exceptions, histones stay with the DNA during transcription.

* Refer fig Nucleosome (N.1)

The Nucleosome is the subunit of allo chromatin:

1) microbial Nuclease releases individual nucleosome from Chromatin as III particles.
2) A nucleosom contains
   ① ~ 200 bp of DNA
   ② two copies of each core histone (H_2A, H_2B, H_3, H_4)
   ③ 1 copy of H_1

5) DNA is wrapped around the outside surface of the protein octamer.

4) ~~micro~~ Greater than 95% of the DNA's is recovered in nucleosomes or multimers when micrococcal nuclease cleavage DNA of chromatin.

5) The length of DNA per nucleosome varies ~~form the point where DNA~~ invividual tissues in a range from 154-260 bp.

6) Nucleosomal DNA is divided into the core DNA and linker DNA depending on its susceptibility to micrococcal nuclease.

7) The core DNA is length of 146 bp that is found on the core particles produced by prolonged digestion with micrococcal nuclease.

* Linker DNA is the region of 8-114 bp that is susceptible to early cleavage by the enzyme.

2) Changes in the length of linker DNA account for the variation in total length of nucleosomal DNA.

3) H1 is associated with linker DNA & may lie at.

DNA structure varies on the nucleosomal surface:

1) 1.65 turns of DNA are wound around the histone octamer.

2) the structure of the DNA is altered so that it has:
   a) an increased no. of base pairs in the middle
   b) but a decreased no. at the ends.

PAGE :
DATE : / /

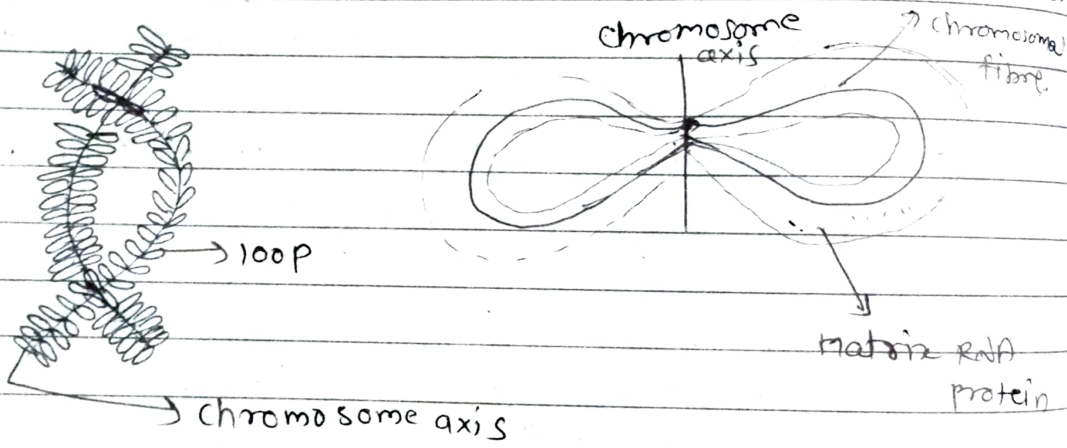
* Organization of the Histone Octamer :-

1) The histone octamer has a kernel of $H_3{}_2$. $H_4{}_2$ tetramer associated with two H_2A . H_2B dimers.

2) Each Histone is extensively interdigited with its partner,

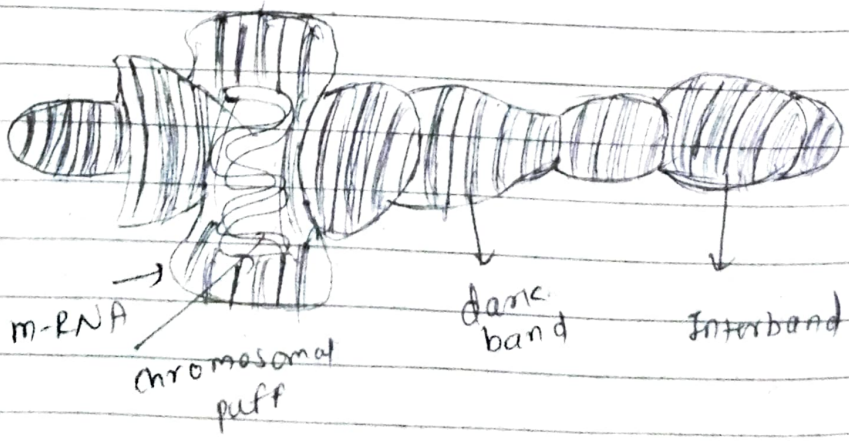
6.12) Lampbrush chromosomes are extended :-

1) life of gene expression on lampbrush chromosomes show loops that ~~are~~ are extended from the chromosomal axis.



6.13) Polytene chromosomes from bands :

1) Polytene chromosomes of Dipterans have a series of bands that can be used as cytological map.



FISH

PAGE :
DATE : / /

1) since, chromatin fibre are highly coiled in chromosomes, they strain deeply.

2) on the other hand, the chromatin fibres in the interbrand region are fully extended, as a result these region take up very light stain.

3) In drosophilia the location of many gene is correlated with specific bands in the connected chromosomes.

4) In interband region do not have atleast functional genes.

chromosomal Aberrations *

" variation in chromosomal structure or number is called chromosomal Aberration."

they can refer to change in the no. of sets of chromo, changes in the no. of individual chromosomes, or changes in appearance of individual chromosomes (somy), or changes in appearance of individual chromosomes through mutation-induced rearrangements. They can be associated with genetic disease or with species differences.

FISH and bonding techniques are used to detect chromosomal aberrations.

* Structural Aberrations. *

1) The chromosomal Abberation in which alternation of the structure of chromosome (sequence of genes or kind of genes in chromosome or no. of genes) occur - structural Aberration.

Types of structural Aberration :→

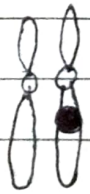
1) changes in the no. of genes:
   I) deletion / Deficiency (Terminal, Intercalary).
   II) Duplication (Intrachromosomal, Interchromosomal).

II) changes in the location of genes.
   1) Inversions (Paracentric, pericentric)
   2) Translocations (Intrachromosomal, Interchromosomal)

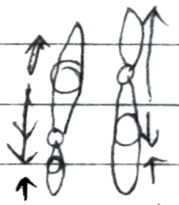
chromosomal structure Abnormalities :—

Translocation

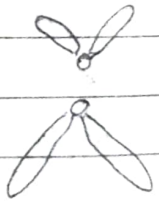
Deletion



Insertion.

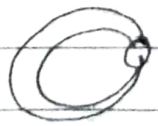


Inversion



Isochromosome

Derivative Chromosome



Ring chromosome.

Deletion :-

"loss of a (generally small) segment of chromosome"

1) Spontaneously or may be induced (radiation, UV, chemicals viruses).
2) Detection is based on unpaired region of normal chromosome that produces a loop during pachytene stage.
3) It observed by Bridges in 1917 in Drosophila.

Terminal Deletion :-

"loss of either terminal segment of a chromosome."

1) In 1938, Muller postulated that loss of telomere makes chromosome unstable so it is not commonly observed.
2) eg : maize.

Intercalary Deletion :-

"loss of segment in betn centromere & telomere."

- it is commonly occured in Drosophila.

Effects of Deletion :-

1) crossing over not occur.
2) Harmful effects on diploid organism.
3) morphological effects.

A B C D E F G ⟶ A B D E F G

C deletion.

PAGE
DATE / /

Duplication :-

"occurance of a segment twice in the chromosomes"

1) Given by bridges in 1919.
2) occurs due to unequal crossing over or crossing over in inversion or translocated heterozygotes.
3) It is detected by presence of loop in duplicated region during pachytene stage.

Intrachromosomal Duplication :-

1) Tandem :- in this case sequence of genes in the duplicated segment is similar to be the sequences of genes in

2) Reverse Tandem :- the sequence of genes in the duplicate segment is reverse to the sequence of genes in the orignal segment of a chromosome.

* Interchromosomal Duplication :-

1) Displaced :- Duplicating segment in corporated away from corresponding segment on the same chromosome

2) Translocated :- Duplicated chromosomal segment is incorporated on diffn chromosome.

A B C D E f G ⟶ A B C D E f f G.

Effects of Duplication :-

1) origin of new genes mainly due to duplication results in evolution.

2) Activity of certain enzymes may be doubled.

g: chromosome 6 of barley increased the activity of α-amylase.

* Inversion *

" A chromosomal segment is oriented in a reverse position (180° reversal)"

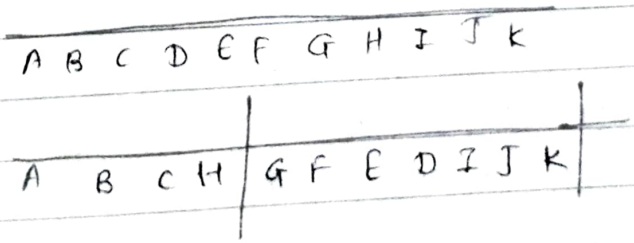
1) studied by sturtevant & punnet in 1921 in Drosophila.
2) Detected by presence of inversion loop during pachytene
3) absence of crossing over

* Paracentric Inversion :
" Inverted segment does not include centromere & confined to one arm."

* pericentric Inversion :
"Included the centromere"

Effects of Inversion :-

1) partial male sterility.
2) formation of Recessive mutation.
3) Move active genes to sites generally inactive ; loose gene function & vice versa.



Translocation

" In translocation, change in position of the segment occurs in such a way that they become integrated into same or homologues or non homologues chromosome."

→ Detected by formation of cross shaped configuration at pachytene betn two non homologues chromosomes.

→ occurs spontaneously or may be induced by mutagen.

* Types :

→ Based on involvement of chromosome.

Intrachromosomal Translocation :

① Intraradial : shift occurs in same arm.

② Extraradial : shift occurs in diffn arm.

Interchromosomal Translocation :

① fraternal : shift occurs to homologous chromosome.

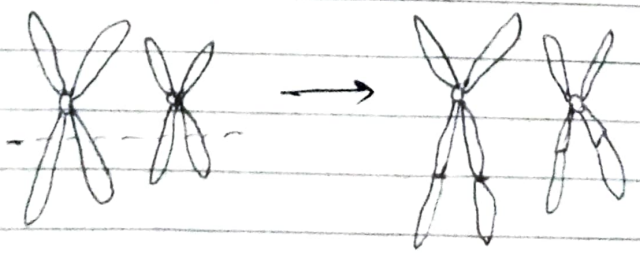
② External :- shift occurs to non-homologous chromosome.

* Reciprocal Translocation :

" Exchange betn segments of non-homologous chromosomes or regions of same chromosome".

* Non-reciprocal Translocation :

" movement of chromosome segment to non-homologous chromosome or region of same chromosome without reciprocal change".



→ Based on no. of breaks involved:

1) simple Translocation :-

"It involves one break, Terminal segment of chromosome integrated at the end of non homologus chromosome."

2) Shift translocation :-

"It requires three breaks, Intercalary segment of a chromosome is integrated within a non-homologus chromosomes."

3) Ring chromosome :

"Break occurs in each arm & the 2 sticky ends join while distal fragments are lost."

4) Robertsonian Translocation :-

"Brakage of 2 Acrocentric chromosome. near centromeres & fusion of long arms. short arm are lost.

Effects of Translocation :-

1) Alters the chromosome morphology.
2) Damage to DNA may result in formation of recessive lethals.
3) Lead to impaired fertility.

Use of structural Abberation :-

1) Study of chromosome pairing & its behaviour during cell division.
2) for locating gene on particular chromosome.
3) Used in plant breeding by increasing the dosage of certain desirable genes for increasing the activity.
4) imp role in revolution.
5) Desirable charator can be detected using inversion.

Numerical Abberations :-

"change in the no. of chromosome is called as numerical aberration or numerical abnormality."

→ Numerical Abberations have two type :

1) Aneuploidy (Hyperploidy, Hypoploidy)
2) Euploidy (monoploidy, diploidy, triploidy, polyploidy)