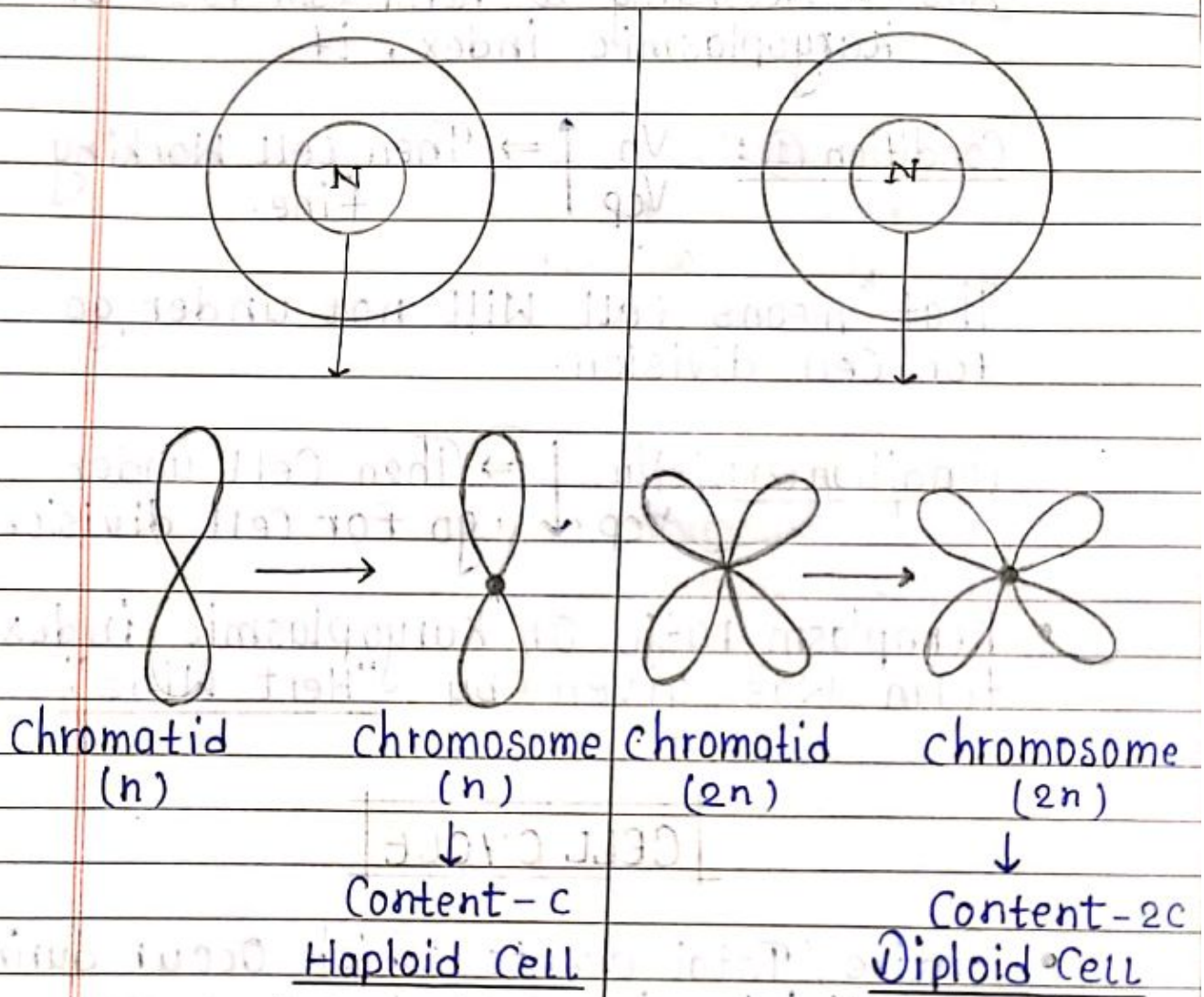


10. CELL CYCLE AND CELL DIVISION



Haploid Cell :- Haploid describes a cell that contains a single set of chromosome.

Diploid Cell :- Diploid describes a cell that contains two copies of each chromosome.

Note :
• $\frac{V_n}{V_{cp}}$ is equivalent to $\frac{S}{V}$. | V_n = Volume of nucleus
 V_{cp} = Volume of cytoplasm

Question : Why Cell Divided?

Ans → According to Kernplasm ratio or karyoplasmic index, if

Condition ① : $\frac{V_n}{V_{cp}} \uparrow \Rightarrow$ Then cell Working fine.

That means Cell Will not under go for Cell division.

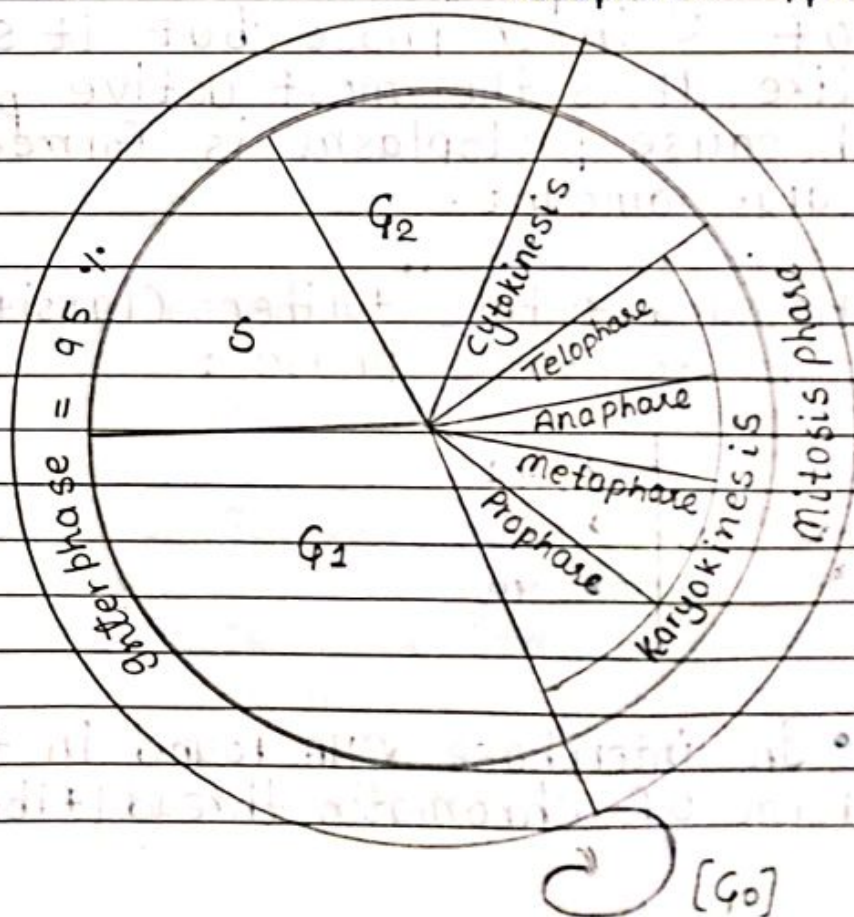
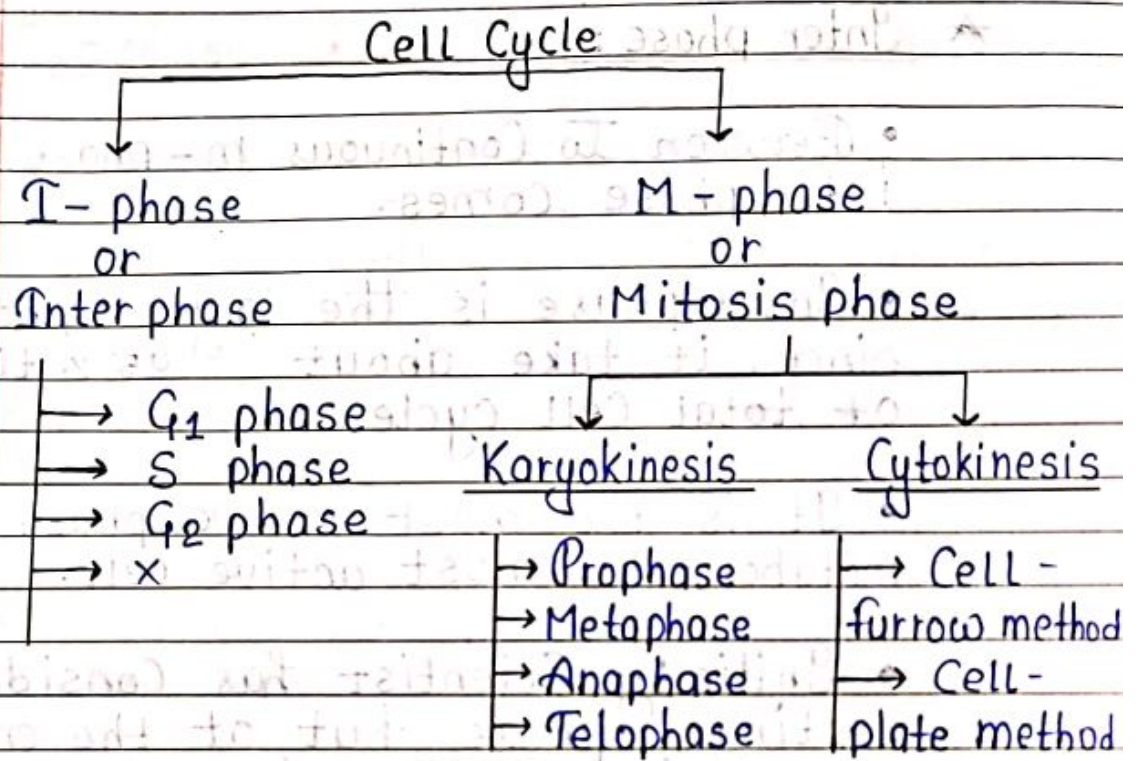
Condition ② : $\frac{V_n}{V_{cp}} \downarrow \Rightarrow$ Then Cell under go for cell division.

- Kernplasm ratio Or karyoplasmic index term was given by "Hert Winz".

CELL CYCLE

- Entire / Total events which occur during Cell division is called cell cycle.

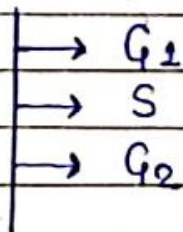
➤ Cell Cycle is Completed into two phase :



★ Inter phase :

- Between to Continuous m-phase a inter phase comes.
- Inter phase is the longest phase. Since, it take about 95% time of total Cell cycle.
- It is the most active phase i.e. metabolically most active cell.
- Initially Scientist has Consider resting phase but at the end of inter phase but it seems like it is the most active phase because protoplasm is formed in large amount.

➤ "Howard + Pelc" further Classified in to three phase :



- In interphase DNA found in the form of Chromatin thread (fiber).

- G₁-phase → It is also called GAP-1 phase, Growth-1 phase, post mitotic phase & pre-synthesis phase.
 - Growth of cell occurs during G₁-phase due to synthesis of new protoplasm.
 - Protoplasm means RNA + Protein.
 - Number of cell organelles start to increase.
 - It is the longest phase of inter phase or cell-cycle.
 - Maximum growth of cell occurs in G₁-phase.
- S-phase → It is also called Synthesis phase, post G₁-phase or pre-G₂ phase.
 - In S-phase synthesis of DNA occurs.
 - That is 2c becomes 4c in S-phase.
 - In S-phase DNA content becomes double but number of chromosomes would be same.

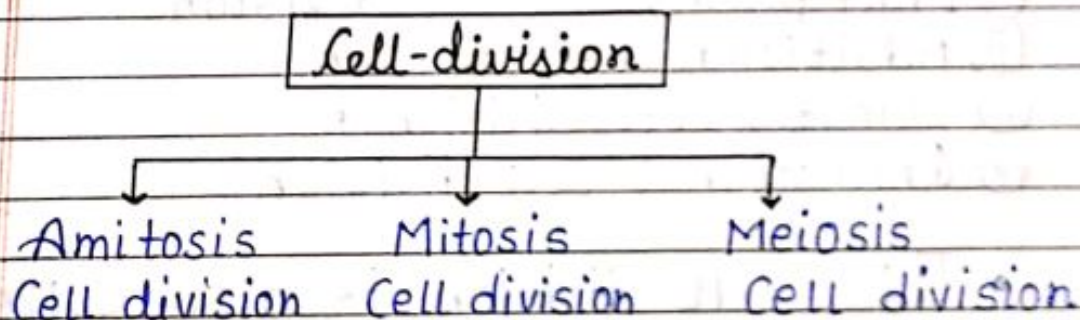
- In S-phase Synthesis of histone protein takes place.
- In S-phase Centriole starts to Replicate.
- In S-phase Only nuclear DNA Replicate during S-phase while Cytoplasmic DNA Synthesize in any phase of Cell-division.
- During S-phase growth of Cell pause.
- G₂ - phase → It is also called Growth-2 phase, GAP-2 phase, pre-mitotic phase or post-Synthesis phase.
- Growth of Cell resume from G₁.
- Number of Cell Organells become double.
- Tubulin protein helps in formation of Spindle fiber.
- In G₂-phase A.T.P Synthesis Occur for coming phase.

Note :

• G₀ - phase :

- It is also called Quiescent phase.
- It is also called Hibernation or stand-by-mode.
- In G₀-phase Cell loose the ability of Cell-division.
- Heart Cell, Nerve Cell, photo Cell are always in G₀-phase.

... Cell-Division ...



★ Amitosis :

- Cell division in which nucleus & Cytoplasm of the Cell divided directly in to 2 part.

• A parent cell divided & give rise to two or more daughter cell.

• It is also called direct Cell division or Karyokinesis.

• Amitosis is mostly occurring in a prokaryotic organism.

Ex:- Bacteria, Acetabularia (a type of algae).

★ Mitosis :

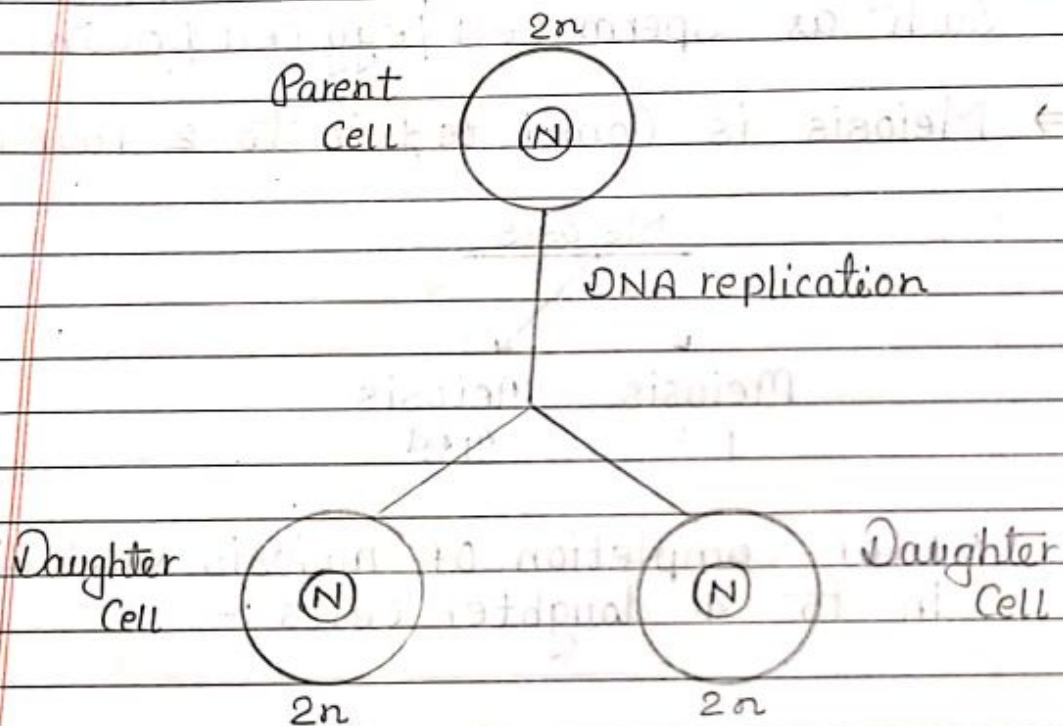
• It is also called —

- (i) Equational Cell division
- (ii) Multiplicational Cell division
- (iii) Additional Cell division
- (iv) Somatic Cell division &
- (v) Promotional Cell division.

• This Cell division is also called Indirect nuclear division.

• In this Cell division parent cell divided into 2 daughter cell having same ploidy.

- In mitosis cell division karyokinesis is followed by cytokinesis. i.e. first nucleus division takes place then cytoplasmic division take place.



★ Meiosis :

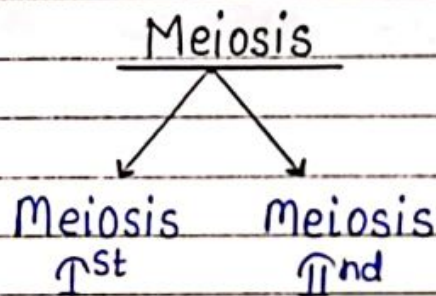
- It is also called —

- | | |
|----------------------------------|-----------------------------|
| (i) Reductional Cell division | (vi) Gametic Cell division. |
| (ii) Demotional Cell division | |
| (iii) Reproductive Cell division | |
| (iv) Germinal Cell division | |
| (v) Germ Cell division | |

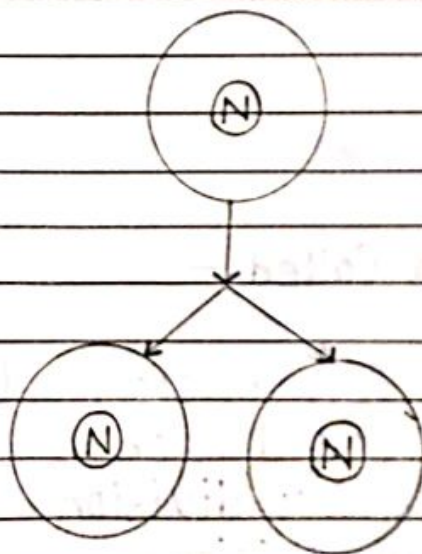
• It is a special type of cell division which is found during sexual reproduction.

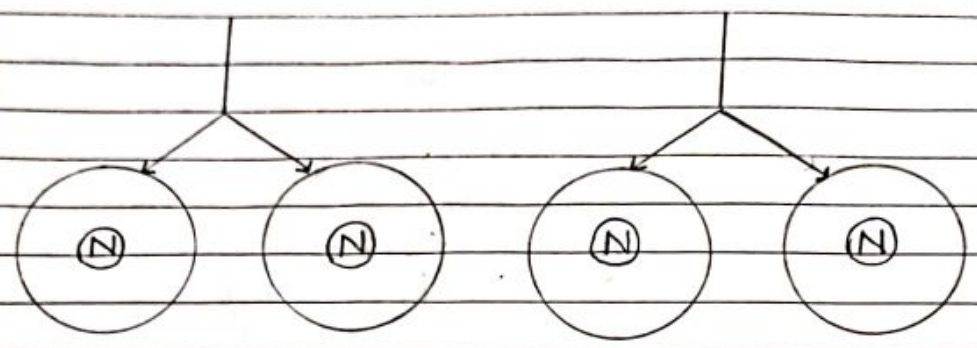
• Organism used to produce the gamete such as sperm cell / egg cell / ovum.

⇒ Meiosis is completed in to 2 round:

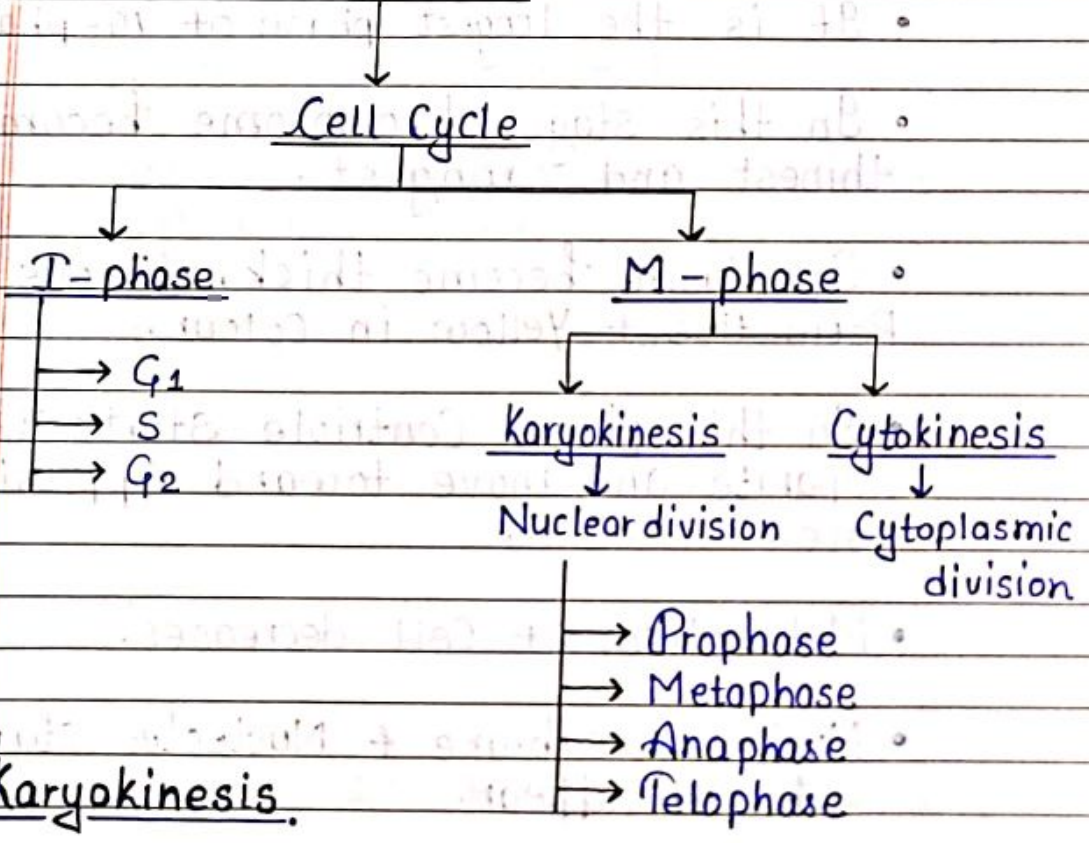


After completion of meiosis cell divided in to 4 daughter cells :-



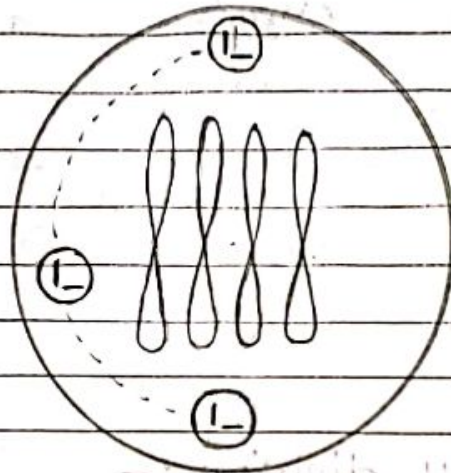


★ Mitosis cell division :-

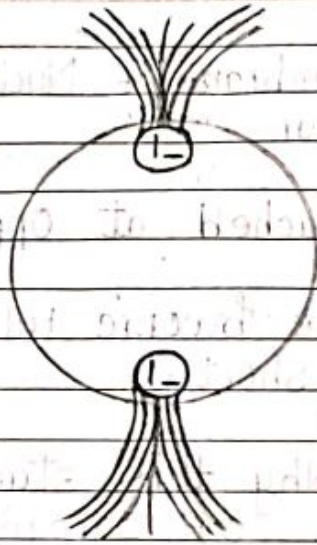


★ Karyokinesis.

* Prophase :-
 ↓
 Pre/ before



- It is the longest phase of M-phase.
- In this stage chromosome become thinnest and longest.
- Cytoplasm become thick, viscous, Refractive & Yellow in Colour.
- In this phase Centriole starts to Separate and move toward Opposite pole.
- Metabolism of Cell decreases.
- Nuclear membrane & Nucleoles starts to disappear.
- From Centriole Astral ray formed!

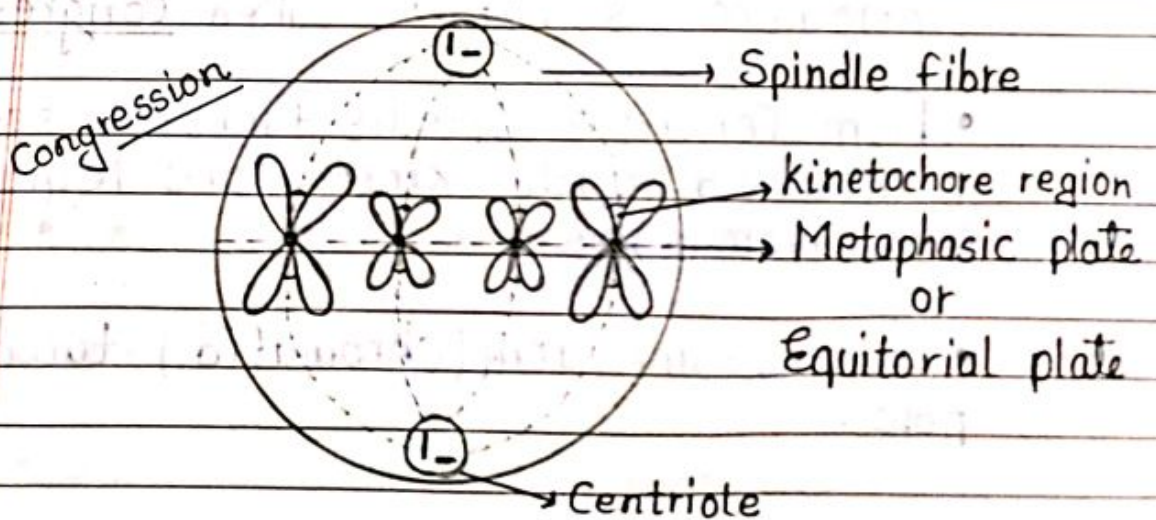


➤ Astral ray is of two type :-

- (i) Amphi astral ray → found in animal
- (ii) Anastral ray → found in plant.

* Metaphase :

↓
Middle / Intermediately

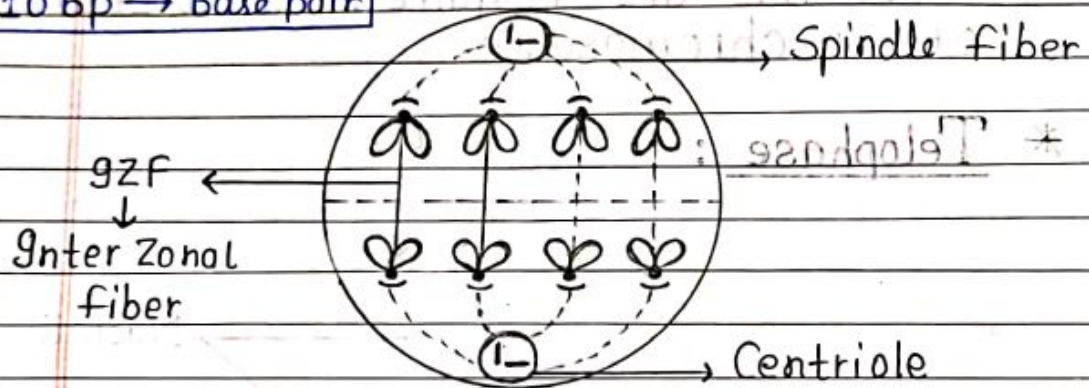


- Nuclear membrane & Nucleoles fully disappear.
- Centriole reached at Opposite pole.
- Chromosome become fully Condensed. So, Thick & short.
- That is why this stage is the based for study of chromosome.
- All chromosomes are Arranged at equitorial plate or metaphasic plate.
- Larger chromosomes are present towards side & smaller chromosome in between the large chromosome.
- Since, All chromosome present at equitorial plate with the help of Centromere. So, it is Called Congression.
- From Centriole Spindle fibre arrises & attached with kinetochore region of Chromosome.
- Chromosome arm (chromatid) toward pole.

* Anaphase :

↳ Alphabetical structure showing.

10 bp → Base pair

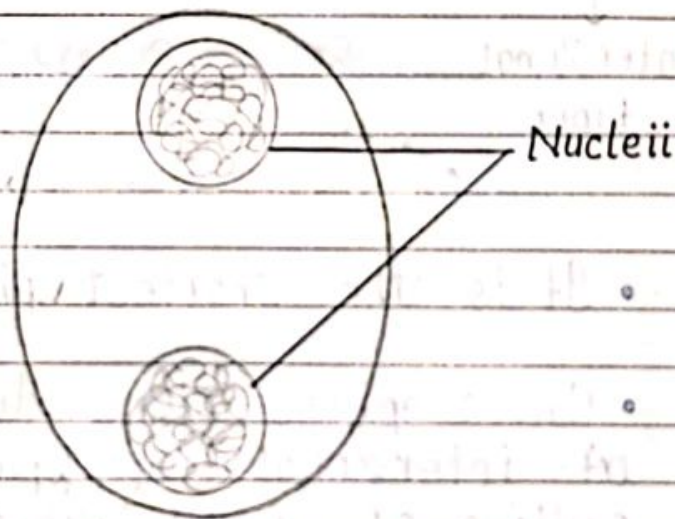


- It is the shortest phase of m-phase.
- In anaphase stage due to expansion of interzonal fibre (pushing force) & pulling of Spindle fibre.
- Centromere divide & both the chromatids are move towards the opposite pole Such as Chromatid toward metaphasic plate. While, Centromere toward pole.
- In Anaphase number of chromosome become double but chromosome identity number same.
- In this phase different structure of

alphabet are showing (V, L, J, i). So, it is also called alphabetical str. showing phase.

- 30 ATP are required for to separation of a chromosome.

* Telophase :



➤ Chromosome accumulated in two ground -

- i) Dyad of nucleii form
- ii) Chromosome loose its identity.

- Nuclear membrane + Nucleoles reappear.

* Cytokinesis

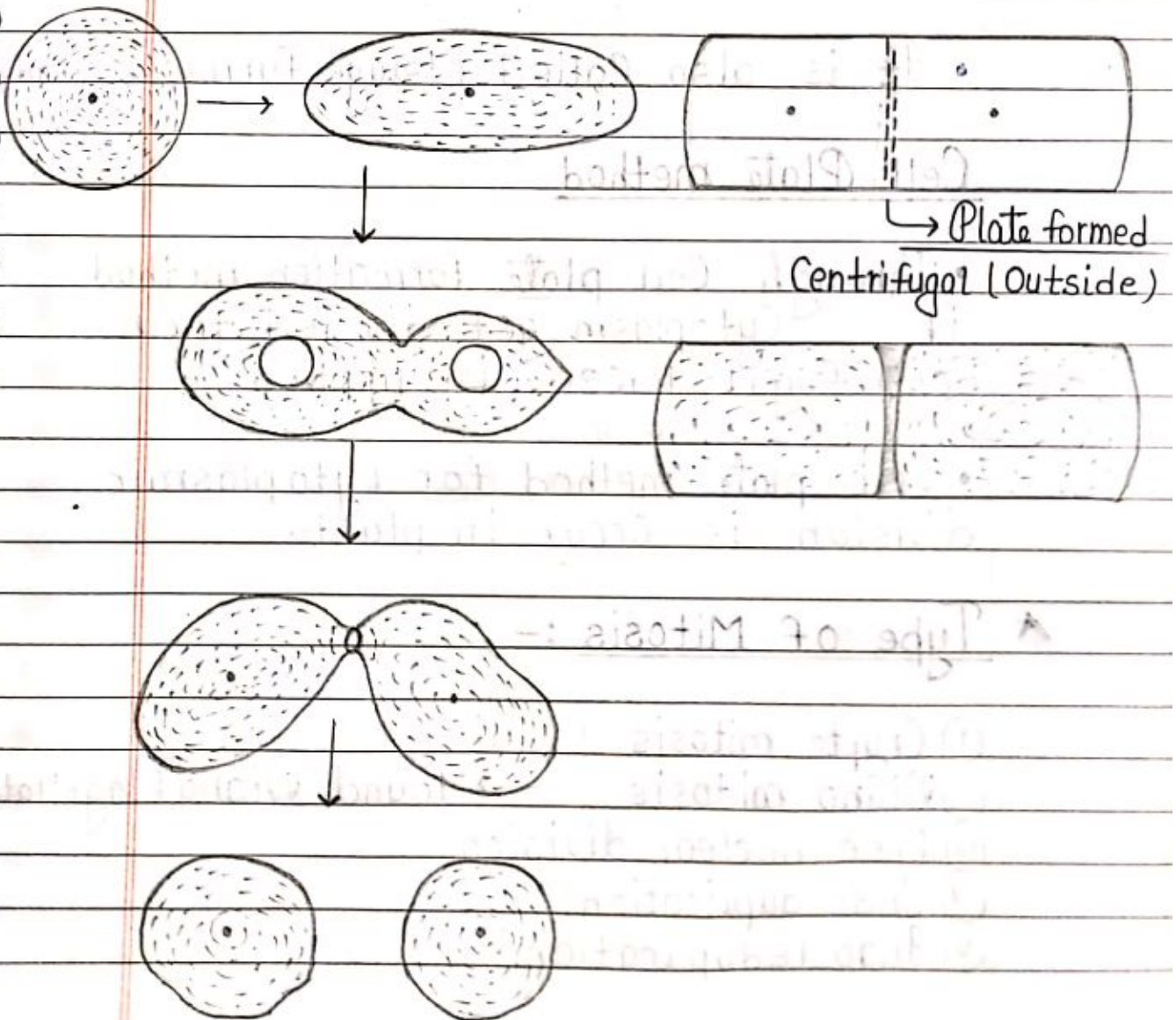
⇒ Division of Cytoplasm

Cell furrow method
or
Cleavage furrow method

Cell plate method

→ Centripetal force

→ Centrifugal force



Cell furrow method

- Cytoplasm divide due to force applied inside is called Cell furrow method.
- During this Cytoplasmic distribution round furrow is formed.
- Cell furrow method is only found in Animal.
- It is also called Cleavage furrow method.

Cell Plate method

- Through Cell plate formation method if Cytoplasm get divided then Centrifugal force is applied.
- Cell plate method for Cytoplasmic division is occur in plant.

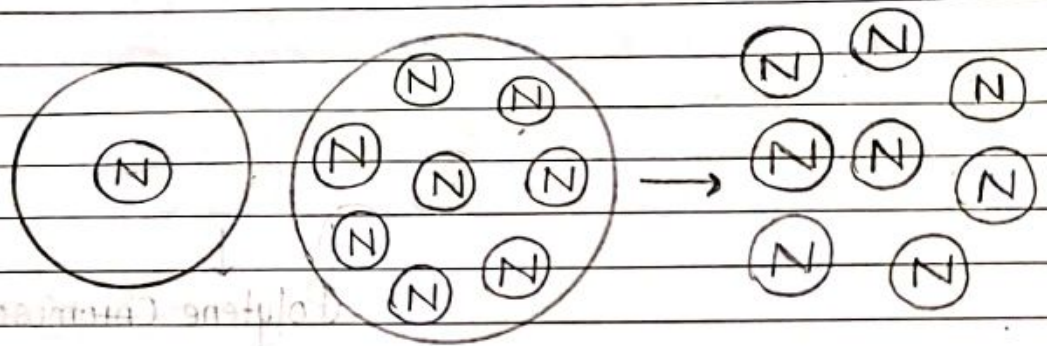
★ Type of Mitosis :-

- (i) Crypto mitosis
- (ii) Diano mitosis → found Diano flagellate
- (iii) Free nuclear division
- (iv) Endo duplication
- (v) Endo reduplication

Date: _____
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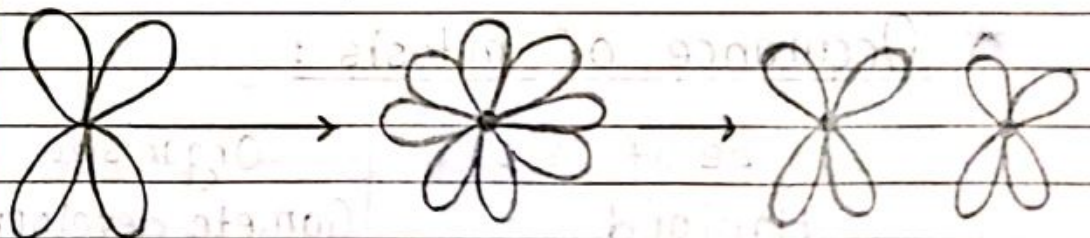
• Free Nuclear division :-

- If a cell divide mitotically & if various nuclear division takes place & each nucleus then divide its cytoplasm is called free nuclear division.



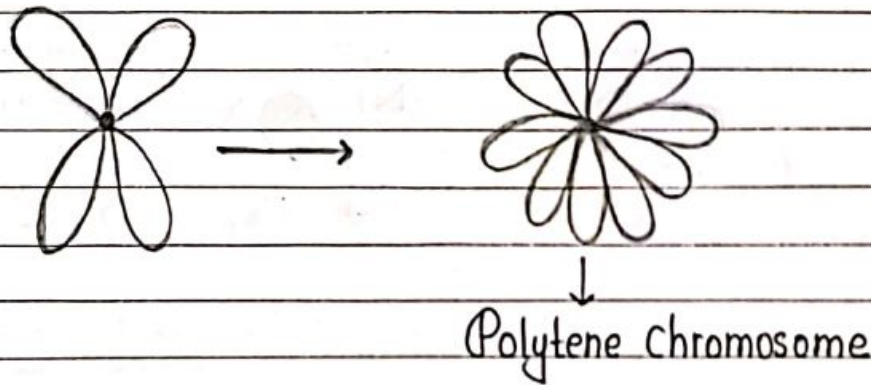
• Indo duplication :-

- A chromosome develops itself & forms two different chromosomes is called indo-duplication.



• Endo reduplication :-

- A chromosome start developing in uncontrolled way. So, a chromosome having multiple ploidy from this stage is called polytene chromosome.



★ Significant of mitosis :-

- (i) Cell repairing
- (ii) Mechanical Support
- (iii) Growth of multicellular organism
- (iv) Somatic development

★ Occurance of mitosis :-

Type of cell	Organism
Haploid	Gamete development
Diploid	Animal
Haploid	← Except - Honey bee
Haploid & Diploid	plant.

Note :

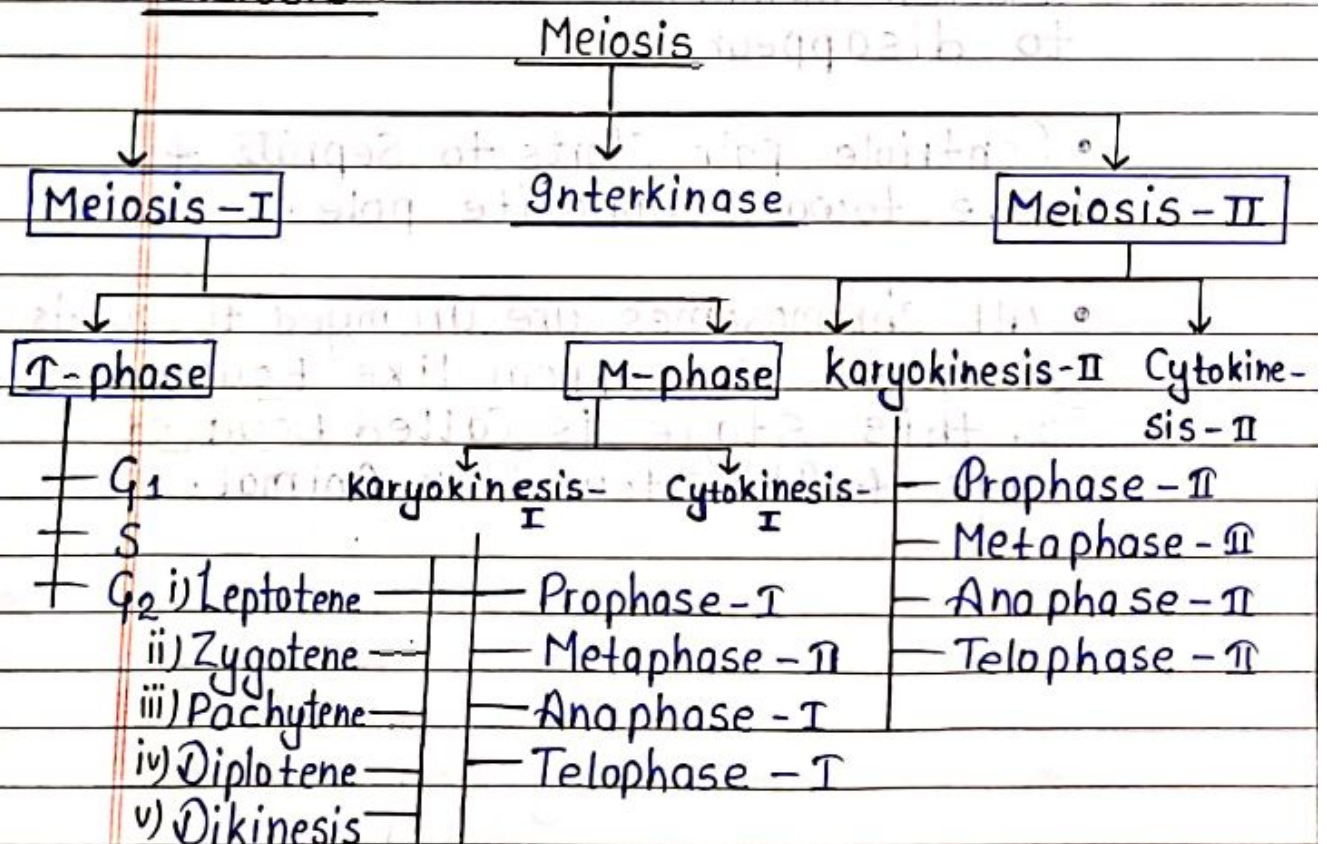
Mitogen → Poison of mitosis
Cell division.

→ It inhibit the mitosis process.

Ex:- Colchicine, Mustard gas, Ribonuclease-p, Azide, Amide, Cyanide, Rotenin, Anthrocynin, Antamysin.

Colchicine → It arrest the spindle fibre at metaphase.

★ Meiosis :



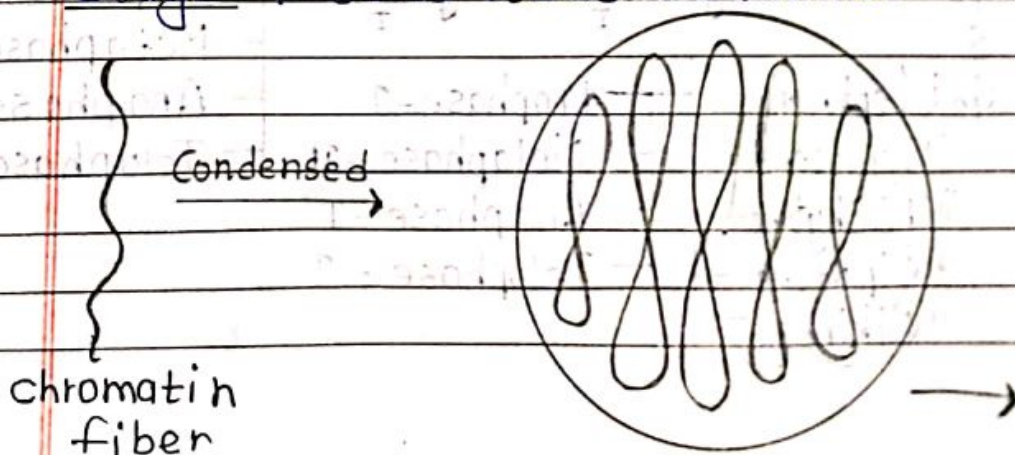
Meiosis-I

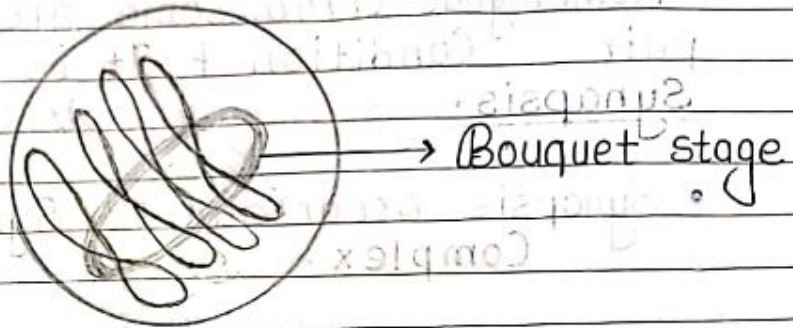
★ Prophase - I

① Leptotene :

Thread
like
Structure

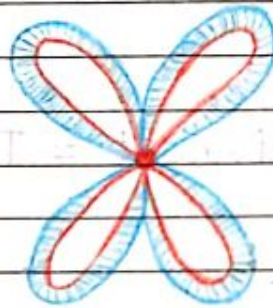
- Metabolism of Cell starts to decrease.
- Chromosome found at chromatin fiber stage.
- Chromatin fiber starts to Condensed to form Chromosome.
- Chromosome is thinnest + longest at this stage.
- Nuclear membrane + Nucleolus starts to disappear.
- Centriole pair Starts to Separate & move toward Opposite pole.
- All chromosomes are arranged towards Centrioles. So, appear like Bouquet. So, this stage is called Bouquet stage & it is found in Animal.





(ii) Zygotene :

Pair → Pairing Structure



- Pairing of Homologous chromosome occur during Zygotene stage.

Homologous chromosome :- Those chromosome which are same in shape, size, location, structure & contained Alleles of similar Gene.

• Homologous chromosome are found in pair Condition & It is called Synapsis.

• Synapsis occur due to Synaptonemal Complex.

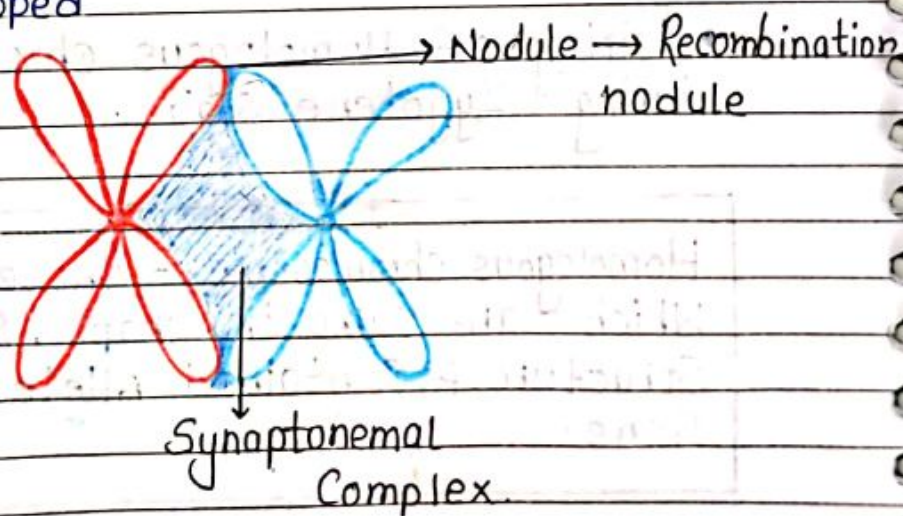
• Synaptonemal Complex made up of DNA + protein: synaptonemal complex (ii)

• In Zygotene stage bivalent of chromosome & tetrad of chromatid form.

• That is Bivalent = Tetrad.

(iii) Pachytene :

↓
Overlapped

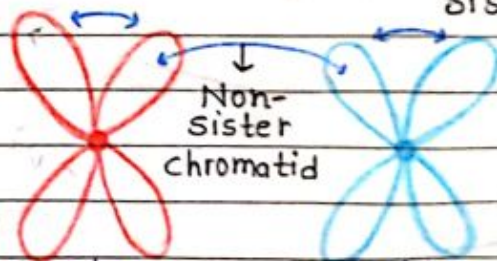


- Synaptonemal nodule formed (temporary).
- It is the longest phase of prophase-I.
- Recombination nodule forms between Synaptonemal Complex which contained enzyme Recombinase.
- Recombinase = Endonuclease + Ligase
- This enzyme helps in Crossing over & recombination.
- In this stage bivalent of chromosome & tetrad of chromatid become fully distinct.
- Crossing Over takes place during pachytene stage (Crossing Over is the exchange of genetic material between two non-sister chromatid of Homologous chr.).

Note :-

sister chromatid

sister chromatid



Non-sister chromatid

Homologous Chromosome

• Crossing Over leads to Variation.

• Variation leads to evolution.

④ Diplotene :

2 thick:
thread

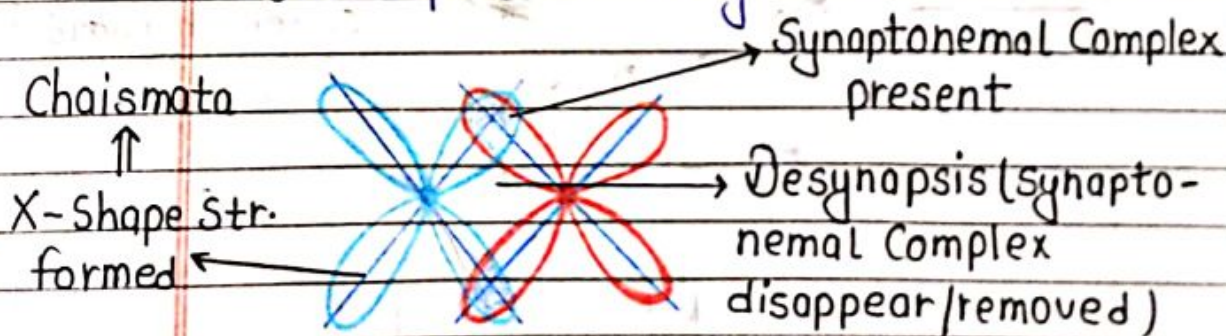
• In diplotene stage Synaptonemal Complex disappear. So, homologous chromosome separate from all the point except at the place of Crossing Over.

• Disappearance of Synaptonemal Complex is called desynapsis.

• Due to desynapsis X-shape structure are appear that is called Chiasmata.

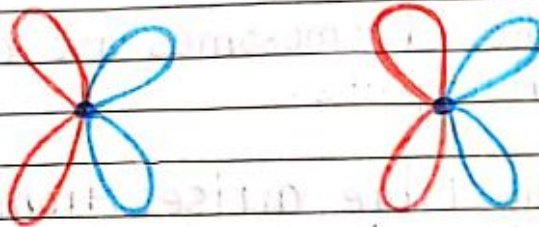
• In some female Vertebrates (Those who have Spinal Cord) may be diplotene Stage prolong form 10 to 12 year.

• The process terminalisation start from diplotene stage.



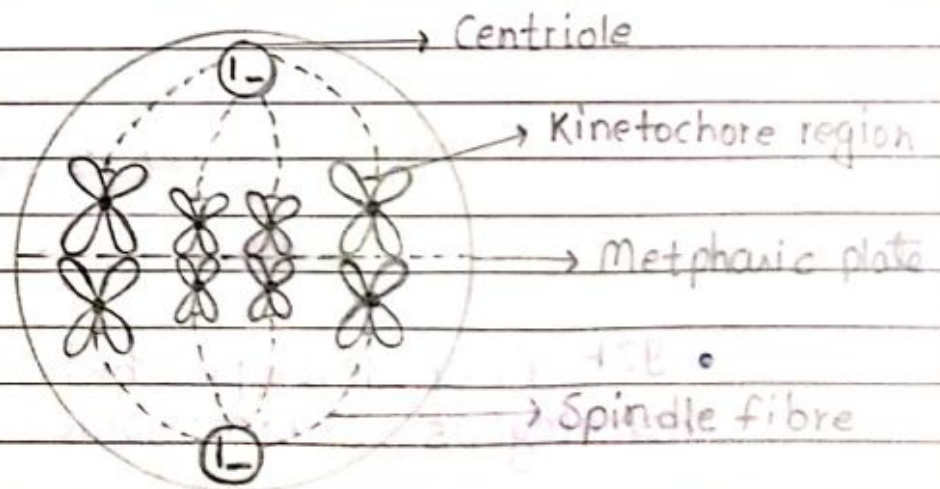
⑤ Dikinesis :

↓
2 Separated



- In dikinesis stage terminalisation of chiasmata completed.
- Nuclear membrane & Nucleoles fully disappear.
- Dikinesis is a final stage of prophase-I.
- Centriole pair reached at Opposite pole.

★ Metaphase - II



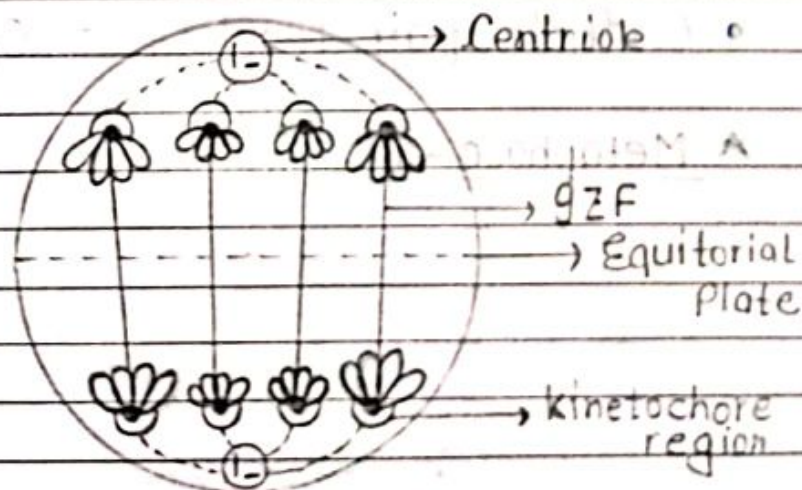
• In metaphase - I Centriole reached at opposite pole.

• All the chromosomes are arranged at equatorial plate.

• Spindle fibre arises from both the Centriole pair & attached with kinetochore region of both the homologous chromosome.

• IZF between homologous chromosome start to develop.

★ Anaphase - I



• SZF fully develop between the homologous chromosome.

- 9ZF involved in pulling & pushing of chromosome.
- Number of chromosome is same in Anaphase first stage as Compare to meiosis first but Number of chromosome reduce in half Compare two parent Cell.
- ~~But~~ Seperation of chromosome or Segregation of gene occur in this phase.
- Process of Cytokinesis about to start in Anaphase - I.
- Dis-junction of chromosome occur during Anaphase - I.
- Dis-junction :- Unequal distribution of chromosome during gamete formation is called dis-junction.

★ Telophase - I

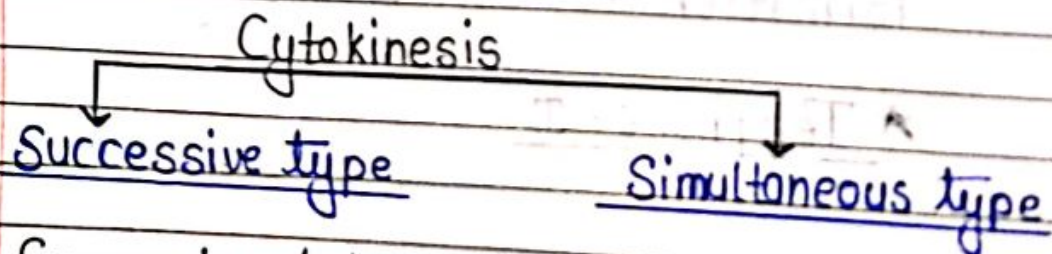


- All chromosome are arranged in two group.
- Nuclear membrane & Nucleolus partially repair.
- Dyad of nuclei form.
- Partial Condensation of chromosome occur.

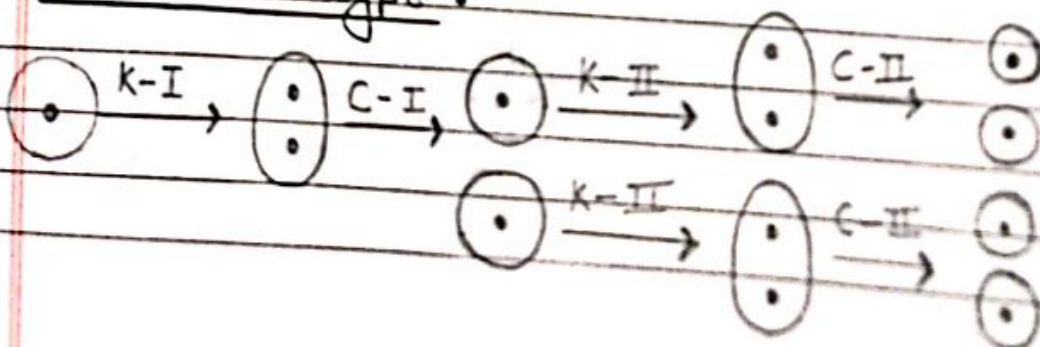
★ Interkinesis :

- Resting phase between meiosis - I & meiosis - II.

★ Cytokinesis :- Division of cytoplasm called cytokinesis.

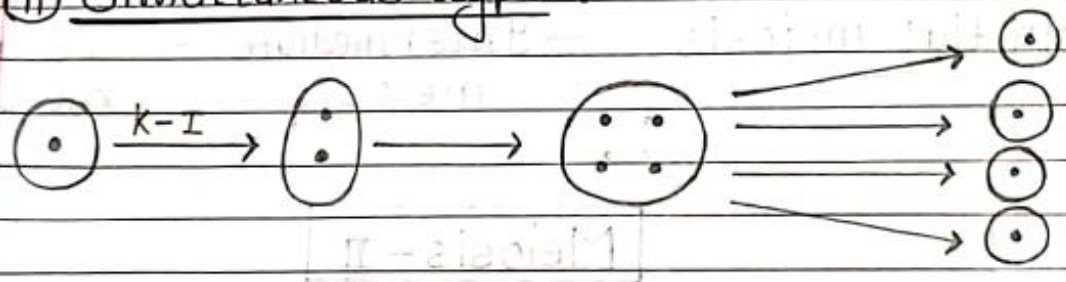


① Successive type :



- In Successive type Cytoplasmic division first karyokinesis takes place & then immediately cytoplasmic division takes place is called Successive type Cytokinesis

(II) Simultaneous type :

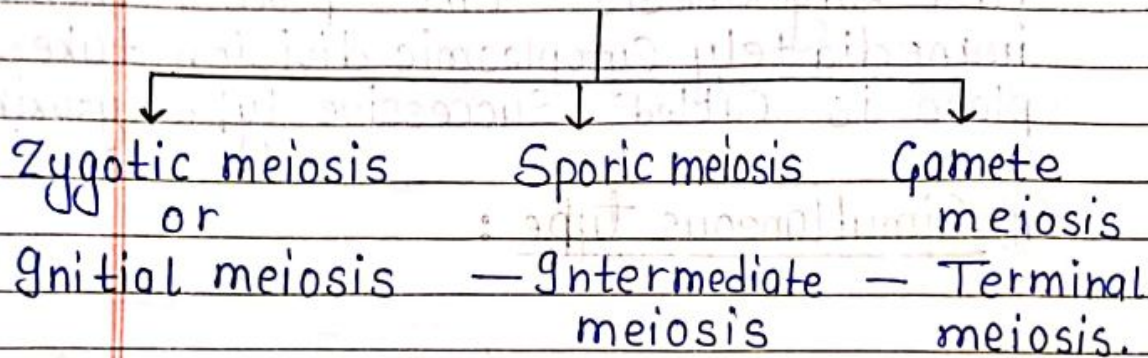


- This type of Cytokinesis - I all karyokinesis division takes place after than Continuous Cytoplasmic division takes place.

★ Significance of meiosis :-

- Meiosis help in maintaining of number of chromosomes or ploidy generation after generation.
- It help in formation of gamete (haploid cell).
- Due to meiosis Crossing over occur.
- Crossing Over leads to Variation and Variation leads to evolution.

➤ Type of meiosis :-



Meiosis - II

- Meiosis - II is just like is mitosis.

★★★