Cell Cycle and Cell Division

→ The process in which one mother cell divide into 2 daughter cell is called 'Cell division'.

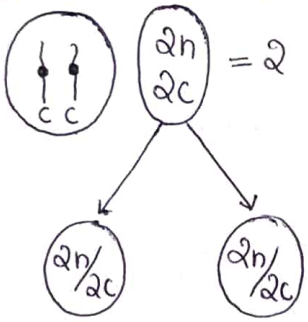
→ This how cell increase their number.
(new cell arise ⟶ Rudolf Virchow).

→ For unicellular growth and Reproduction are mutually inclusive events.

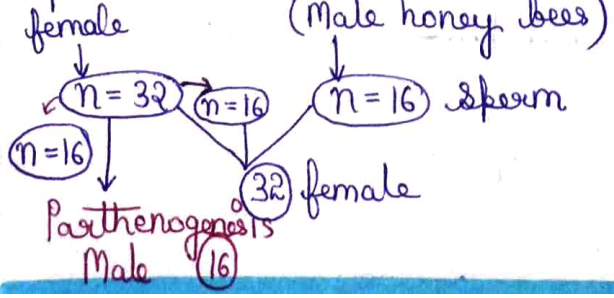
→ But in Multicellular growth and Reproduction are exclusive.

Mitosis (Equational division)

→ One mother cell divide into 2 daughter cell which contain equal no. of chromosomes (n) & equal amount of DNA (c).

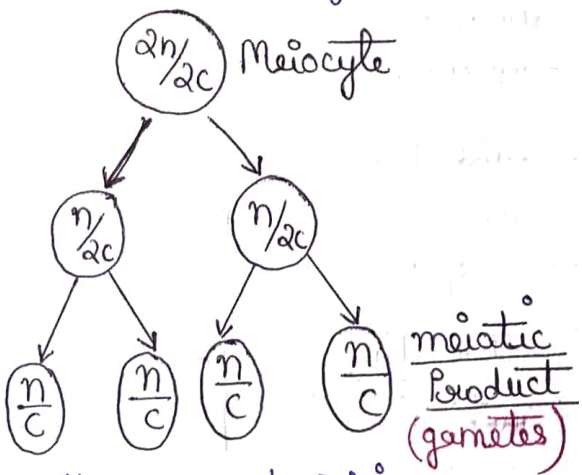


Ex :-
- At the time of growth in Vegetative cells and sex cells.
- Plants ⟶ Common
Mitogametes :- gamates produced by mitosis.
- Animal ⟶ Rare.
- present in drone (Male honey bees)



Meiosis (Reductional division)

→ One mother cell divided into 4 daughter cell in each daughter no. of chromosomes and amount of DNA (c) 'Reduce to half'.



→ It causes Variation

→ Ex :-

1. Gametic Meiosis —
- At the time of gametogenesis. (formation of egg & sperm)

2. Sporic Meiosis —
- Plants ⟶ to produce spores.

3. Zygotic Meiosis —
- There are certain organism which are non-embryonic.
Ex :- fungi & Algae.

Cell Cycle

- It involve Sequencial events in which —
1. Cell prepare for the division, during which it Replicate or duplicate all of its constituents like organelles, DNA and Cytoplasm.
2. then it ultimately duplicated all material between two daughter cells.

⇒ The Cylic representation of these events is k/n as 'Cell Cycle'.

(i). Interphase (preparatory phase)

→ Cell grows and increase its Volume because it duplicate all Components.

→ also k/n as 'Resting phase' because it doesn't involve any physical Movement.

→ It take 95% duration of cell cycle.

→ during this phase karyoplasmic Index decreases.

→ Further divided in to 3 Phase —

1. G_1 (Post mitotic gap)
2. S (Synthesis)
3. G_2 (Pre mitotic gap)

(ii). M Phase (distribution phase)

→ Cell distribute all the duplicated constituents between 2 daughters equally.

→ It is done with the help of spindle fibres.

→ KI is again balance.

→ It involve Physical movement of chromosomes and Organelles.

→ Further divided into —

Karyokinesis (nuclear division)

1. Prophase
2. Metaphase
3. Anaphase
4. Telophase

Cytokinesis (Cytoplasmic division)

G_0 Quisent Phase

→ Cell in G_0 phase remain metabolically active but don't ~~do~~ divide, they get differentiated to perform different function.

→ to be in G_0, cell have to exist Cell cycle.

→ Eg :- RBC, Nerve cell.

Major Check Point
(G1-S Check Point)

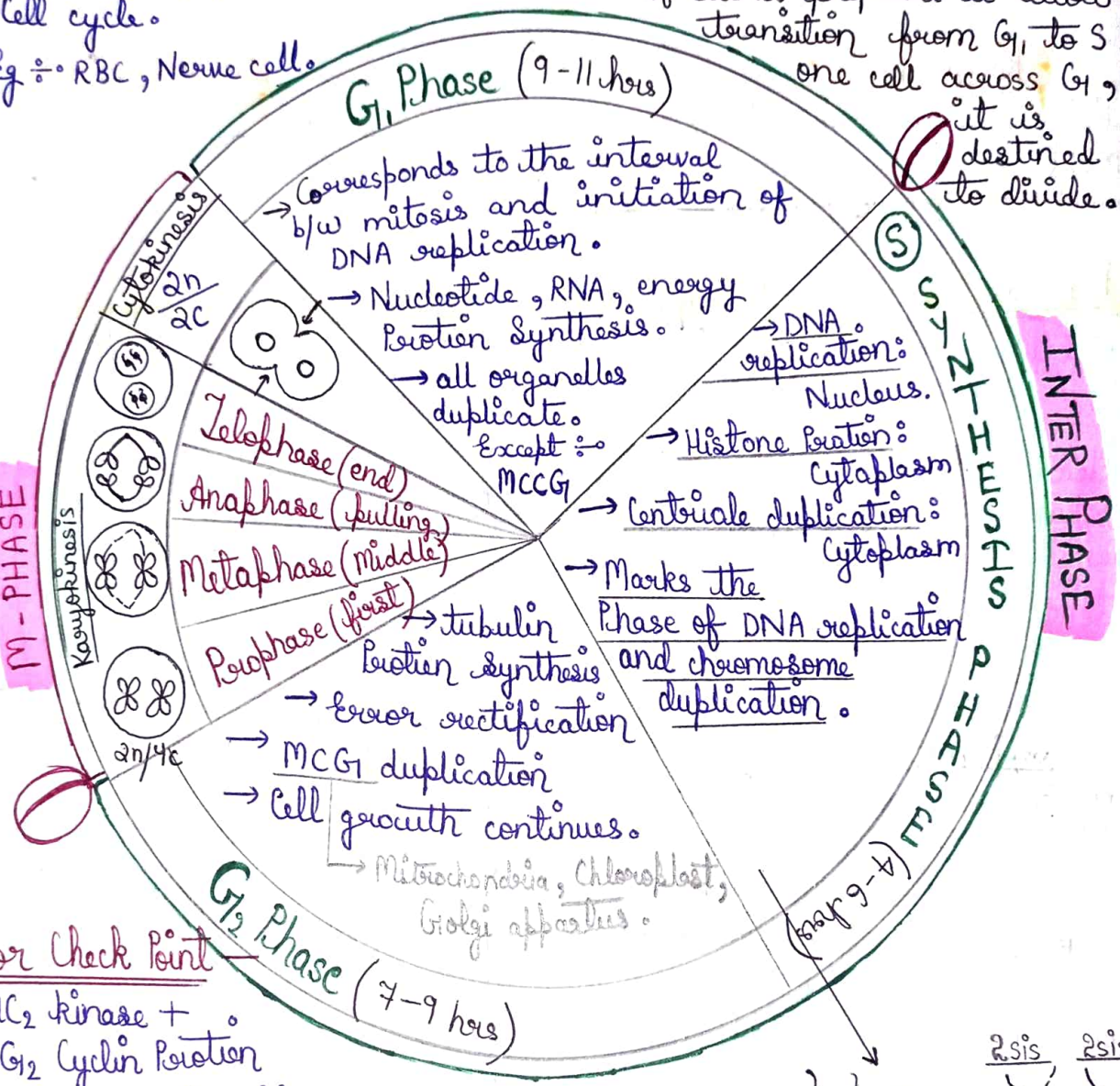
→ transition from G_1 to S.

→ Enzyme CdC_2 kinase (cyclin dependent cell division)

→ If cell isn't prepare it sent the cell to G_0 Phase.

→ If cell is prepared it allow transition from G_1 to S.

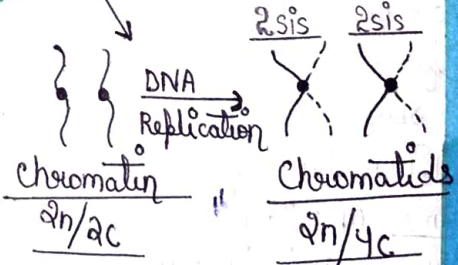
one cell across G_1, it is destined to divide.



Minor Check Point

→ CdC_2 kinase + G_2 Cyclin Protein

→ It can arrest cell for rectification.



⇒ The no. of Chromosomes Remain the same but the amount of DNA double in S phase.

M-Phase

Mitosis → 1882 → Strasburger → Plant cell.
Flemming → animal cell

⇒ k/n as 'Equational division' as daughter contain equal no. of chromosomes.
⇒ Occur at the time of Growth and Repair.

Karyokinesis

→ division of nuclear, cell become binucleated at the end of karyokinesis.
→ Most dramatic phase, physical Moment of chromosomes.
Karyokinesis involve 4 stages —

Prophase

'longest phase'

1. Early prophase —
→ Nuclear membrane, nucleolus and all organelles begins to disappears.
→ Chromatin begins to condensate.
→ k/n as Spireme stage (chromosomes look like wooden ball)

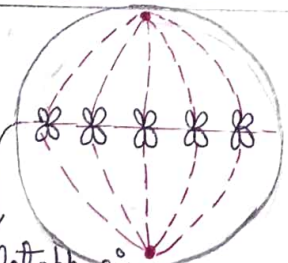
2. Mid prophase —
→ Centriole move towards oppo. pole.
→ form immature spindle k/n as 'Astral Rays'.
Plants: anastral
Animals: amphiastral

3. Late Prophase —
→ Centrosome reaches at opposite poles
→ Nucleolus, organelles, Nuclear membrane disappear completely.
→ end of Prophase.

Metaphase

(study Structure & Size of Chro.)

→ Complete disappearance of nuclear membrane Mark the begining of Metaphase.
→ Condensation of Chromatin continues & reaches to peak as chromosomes becomes 'thickest & shortest' (X shaped)
→ Spindle fibres arises from centriole and get attached to kinetochor plates present on the centromere.



Metaphasic Plate (Plate of centromere)

→ alignment of Chromosomes at the equatorial plate is k/n as Congression.

Anaphase

(study Shape of Chromosome)

(Ana = pulling)
→ Shortest phase.
→ Centriole pull Chromosome with the help of spindle fibres.
→ due to pressure centromere split in 2 parts hence the sis chromatids are now separated & move towards opposite poles. (future chromosome)
→ during movement it gives out V, L, J, I Shape.
→ Mark the begining of Cytokinesis. (as actine & myosine get arranged below the plasma membrane to form Contractile ring.

Telophase

→ Just opposite to prophase.
→ Nucleolus & Organelles reappear.
→ Chromosomes form clusters at the poles.
→ Chromosomes get decondenced to form chromatin.
→ Nuclear membrane is formed around the cluster of chromatids at the opposite poles.
→ Cell became binucleated.
→ begining of furrow formation.

Cytokinesis

Cytokinesis —
(Cytoplasmic division)

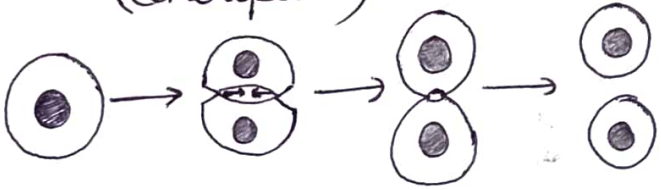
→ Cytokinesis involve division of cytoplasm.
→ Karyokinesis is normally followed by cytokinesis.
→ But in some exceptional cases it may not follow —

Example —
1. Paramecium.
2. Coenocytic hypae of fungi.
3. Synchytrium (member of fungi)
4. free nuclear endosperm.

→ Cytokinesis begin during karyokinesis in the late anaphase.
→ Cytokinesis take place by two Method —

By furrow formation

→ In animal with the help of contractile microfilamements actine & myocine.
→ they foom a contractile ring just below the plasma membrane.
→ Contractile rings foom a foorow in membrane.
→ the membrane move from periphery to Centre. (Centripetal)



By Cell plate formation

→ In plant cell plate is foomed by phragmoplast (golgi.) deposited by carg pectate in between daughter cell.
→ This deposition is foom centre to periphery. (centrifugal).

Special Points —

① Mitogens —

→ Promote mitosis.

→ Eg :- Insulin, Auxin, Giberrelins, Cytokinins.

② Mitotic Poisons —

→ Inhibit mitosis.

→ Eg :- Cynides & Azocynides → Prophase.

Mustard gas → Prophase (Agglutination of Chromosomes)

Cholchicin → inhibit formation of spindle fibres.

- It includes 'polyploidy'.
(increase in no. of chromosomes).

Ex :- Triticum aestivum (wheat) × Secale Cereal (Rye)

2n = 14 — 2n = 28

gamete → n = 7 — n = 14

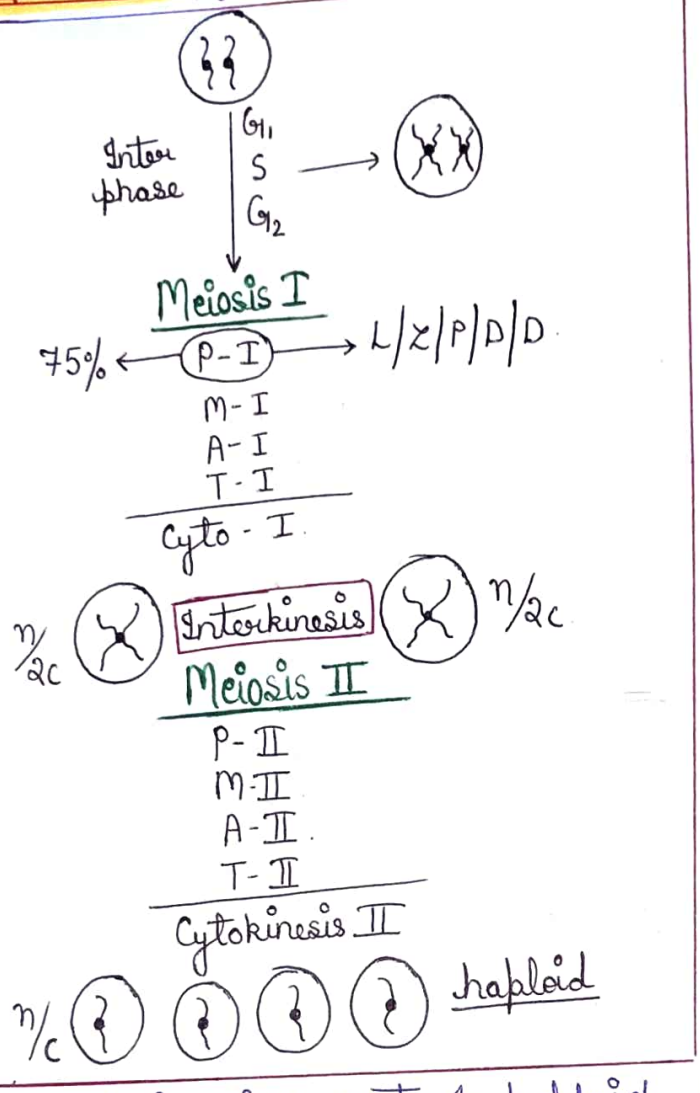
2n = 21 triticale with cholchicin

2n = 42

Significance of Mitosis —

1. Growth
2. Repair
3. Asexual Reproduction
4. Gametogenesis
5. Mitogamates

MEIOSIS (Reductional division)



→ One meiosis gives out 4 haploid daughter cells.
→ Discovery : 1870 → Oscual Hertwing → first observed meiosis.
→ Farmer & Moore → coined the term meiosis.
→ Van Beneden, Winiwarter & Strasburger explained it.
→ One meiosis include two successive division → Meiosis I
→ Meiosis II

Meiosis I (MI)

→ It is the most important, elaborated phase of meiosis.
→ properties of meiosis lie in this division.
→ This phase is k/n as actual Meiosis (actual Reductional).
→ It for 2 cells which are haploid on the basis of no. of chromosomes but double on the basic of amount of DNA.

Further divided into 4 sub phase —

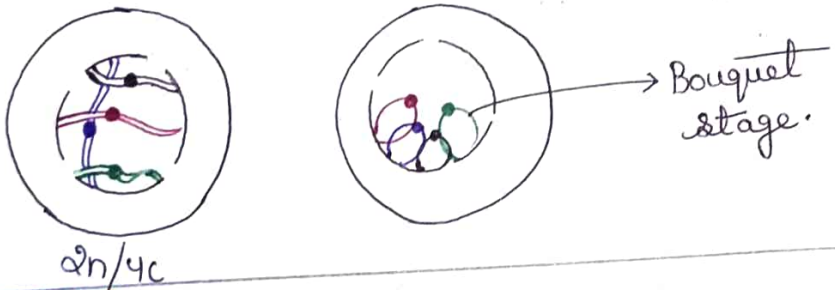
→ Prophase I
→ Metaphase I
→ Anaphase I
→ Telophase I

Prophase I —

→ Most longest, Complicated and dramatic phase of whole meiosis.
→ It include an event called 'Recombination' which is responsible for genetic variation in sexually reproducing individuals.
→ To make the study easier divided into 5 sub phases —

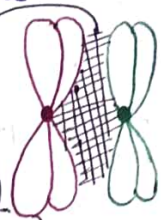
I. LEPTOTENE —

→ Shortest phase of prophase I.
→ Chromatin begins to condensate, but they still remains attached to the nuclear membrane with the help of 'Link Zones'.
→ Nuclear membrane & nucleolus begins to disappears.
→ Link Zones rearrange chromosomes in away that homologous chromosomes are brought near to each other called 'Bouquet stage' and 'Synaptic nobe in plants'.



I. ZYGOTENE —

→ It is characterised by pairing of Homologus chromosomes.
→ This event is called 'Synapsis'.
→ A material (Ribonucleoprotein) get in between the homologus chromosomes This protion is k/n as 'Synaptonimal Complex'.
→ The formed structure is called Bivalent or tetrad (4 Chromatids) but not visible. (2 homologus chromosomes)

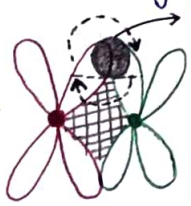


no. of bivalent Chromosomes = total no. of Chromosomes / 2

III. PACHYTENE —

⇒ Condensation of Chromatin increases that's why 'tetrad' become clearly visible.

⇒ Enzyme Recombinase form Recombination nodule between the paired of homologus Chromosomes.

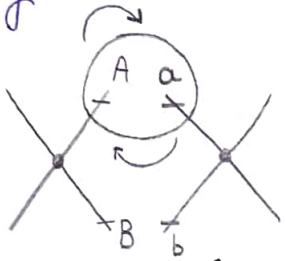


Recombination nodule —
↓
Recombinase (Holozyme)
1. Exonuclease
2. Endonuclease
3. Helicase
4. ligase

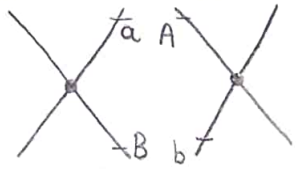
⇒ Recombinase cut the DNA and perform exchange of DNA (genetic material) between two non sister chromatids of 2 homologus chromosomes.

Crossing Over (Recombination)

⇒ Crossing Over lead to 'Recombination' (formation of new combination)



Before crossing over
Cis (AB, ab)



After Crossing over
trans (aB, Ab)

⇒ Cis condition of genes when both dominant genes are one chromatid & Recessive are on one.

⇒ Crossing over depend on Coincidence

Min. Probability ⇒ 0%
Max. Probability ⇒ 50%

IV. DEPLOTENE —

⇒ This phase is characterised by dissolution of 'Synaptonimal Complex' (Ribonucleoprotein) present between two homologus chromosomes.

⇒ Due to this the homologus chromosomes of a bivalent will separate but not Completely they are still attached at the site of crossing over.

dissolution of Synaptonimal complex →

X shaped Connection is called 'Chiasmata'

⇒ Deplotene is characterised by formation of a X shaped structure called 'Chiasmata'.

⇒ Chiasmata represent the site of crossing over.
(no. of Chiasmata = no. of crossing over)

⇒ Deplotene is the longest phase of prophase I (meiosis).

⇒ It may last for few month or years.

⇒ The primary Oocytes of vertebrates arrest in deplotene during embryonal stages and it form lamp brush Chromosomes. they may arrested for years.

Embryonal → (2n) Oocyte
Meiosis I
PI → L Z P Deplotene D → arrest → until onset puberty

⇒ Deplotene is also k/n as 'dictyotene stage'

V. DIKINESIS

⇒ Characterised by terminalization of Chiasmata. as a result homologus chromosomes separate completely.

⇒ Nucleolus and Organelles disappear.

⇒ Nuclear membrane also disappear.

Homologus Chromosomes during Dikinas

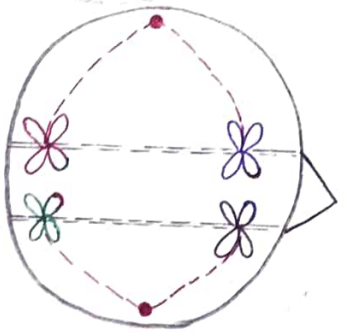
METAPHASE I

⇒ Chromosomes get attached to the centromere of opposite pole by spindle fibres.

⇒ Each Chromosome is attached to only one centromere of one side.

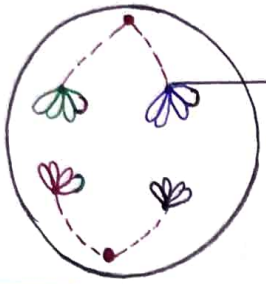
⇒ A pair of homologus chromosomes get attached to both the centriole.

⇒ This lead to the formation of Bimetaphasic plate.



ANAPHASE I

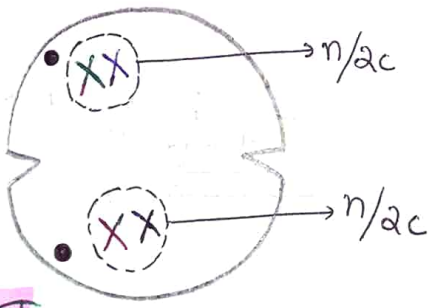
⇒ Pulling of chromosome due to shortening of spindles.
⇒ Each chromosome of homologus pair get pulled towards opposite poles.
⇒ No spliting of centromere because 'homologous chromosomes seperates independently' of each other.
⇒ haploid condition appear for the first time.



→ Each chromosomes has 2 chromatids.
'Separation of homologous chromosomes'

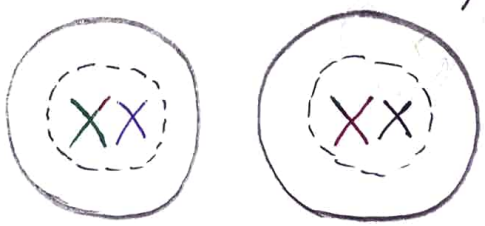
TELOPHASE

⇒ Half set of chromosomes get clustered at opposites poles.
⇒ They begin to decondense to foorm chromatin.
⇒ Nuclear membrane is formed around the clusters of chromatids at poles.
⇒ at this stage each cell consists of 2 nuclei which are haploid on the basis of no. of chromosomes and diploid on basis of Amount of DNA (Pg)



Cytokinesis I

⇒ Cytoplasmic division
⇒ In plants → Cell plate formation
⇒ In animals → furrow formation
⇒ Each cell consist only one chromosorne of homologus pair.



Product of Meiosis I
Dyad

Interkinesis —

⇒ It is a short lived resting phase between 2 successive meiosis.

⇒ Both product (cells) of meiosis prepare for 2nd division during this phase.

→ It involve duplication of all —

1. Cell organelles
2. Synthesis of tubulin protein (for centriole & spindle)
3. Synthesis of RNA
4. ATP synthesis

→ But this phase don't involve duplication of —

→ DNA (no DNA replication, because already duplicate in S-Phase).

→ No histone protein Synthesis.

MEIOSIS II

⇒ It is equational hence it is similar to mitosis.

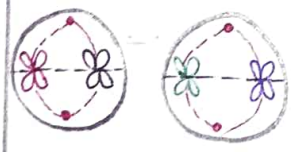
Prophase II

→ Chromatin become partially condensed to form distinct bodies called Chromosomes.

→ all organelles, nucleolus, and nuclear membrane disappear.

Metaphase II

→ Arrangement of chromosomes at equatorial plate called single metaphasic plate.



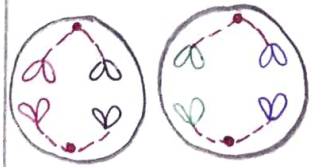
Anaphase II

→ involve pulling of chromosomes at opposite poles.

→ Spliting of Centromere.

→ Separation of sis chromatids.

→ Cell became haploid on basis of both no. of chromosomes and amount of DNA for the first time.



Telophase II

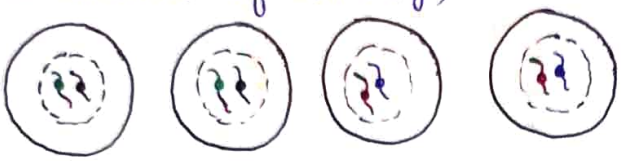
→ Complete decondensation of chromosomes to form chromatin.

2 haploid nucleus

n/c

Cytokinesis II

→ Cytoplasmic division
→ formation of tetrad (4 cells)
→ which are haploid on the basis of both no. of Chromosom and amount of DNA. (P_g)



n/c → Meiotic products
↓
gamates....

Significance of Meiosis

(i). Gametogenesis :- (gamatic meiosis)
⇒ Occur at the time of gamate formation.
(ii). Causes Variations :-
⇒ degree of difference in progeny.
(iii). Evolution and Speciestion :-
(iv). Occur at the time of spore formation (Sporic meiosis)
(v). Haplontic life :-
Algae & fungi → because they perform Zygotic meiosis.

Amitosis or Binary fission (Karyostenosis)

→ Special type of division in which there are no different phases appear because nuclear membrane doesn't distintigrate.
→ There is no significat movement of chromosomes observed.
→ formation of 'Intranuclear spindle fibres'.
→ Example :- Prokaryotes, Protozoans, Embryonal membrane cells, deseased cell or cancerous cell.