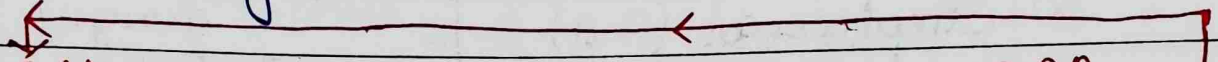
Cell Cycle & Cell Division

Page No.:
Date: / /

- What we observe –
  Single cell zygote conjoun a complete org.
  ↳ Division occurs.

So we can conclude → about two imp events.
- Cell division.
- Cell growth.



* Cell → Growth → Cell division.
- Cytoplasmic content grow.
- DNA/Genomic content double (replication).
- 2 daughter cells.

⇒ Sequence of events by which cell duplicate its genome, synthesize other constituents and divide into daughter cells → Cell cycle.

* Features of CC. –

① **Sequential** –
Growth + DNA rep → Cell division.
- growth in cyto is a continous procell.
- occurs only once.

② **Coordinated** –
Sequence fix, changes fix, duration fix.

③ Genetic control-

Coordination achieved by genetic control.

Q. Cell cycle occurs in-

(a) Nostoc (Bact)
(b) Albugo (fungi).
(c) TMV (virus)
(d) Streptococcus. (Bact)

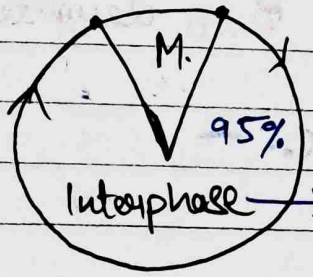
Cell div - ① Pro ✓
② Euk. ✓
Cell cycle - (coordinated changes) in Euk.

* Phases of C.G. —

changes in cell divided into 2 phases—

① Cell Division
normally - Mitosis
[M-phase]

② Interphase.
time gap / time prd. b/w end of division & start of next div.



★ M-phase [Cell-division]
↓
G_1 - Gap 1. [Gap b/w CD & DNA rep (Pre synthetic pase)]
↓
S-phase [DNA double (synthesis)]
↓
G_2 - Gap 2. [Gap b/w DNA rep & CD (Post synthetic phase)]

Page No. :
Date : / /

* Time of diff. phases –

- Human cell in culture = 24 hr

24 →
- M-phase = 1 hr (5%)
- G_1 = 8-12 hr (33-50%)
- S-phase = 6-8 hr (25-33%)
- G_2 = 3-4 hr. (15%)

} Interphase.

$$G_1 > S > G_2 > M.$$

* G_1 phase → most variable.

• Yeast (Fungi) → 90 min.
(Euk).

* Changes in Different phases –

⇒ $G_1 + S + G_2$ = Interphase. (resting phase in compar. to M-phase).

⇒ M-phase → most changes.

① G_1 - Gap 1. :
① Gap b/w M & S.
② Growth → cytoplasm ↑ses, organelle double.
⇒ Growth require enzyme + Nutrition.
[Transcription + Translation.]
G_1 depend on external food nutrition, ∴ time is variable

Page No.:
Date: / /

- After G_1 phase, cell have 3 options—

① Continue CC → enter into S-phase.

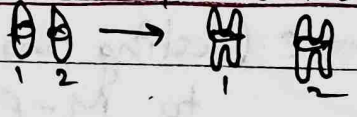
② Cell → not continue CC & become permanent

③. Exit cell cycle & enter G_0 phase.

⇒ If DNA damaged/mutated, cell doesn't enter into S phase until DNA repaired in G_1 phase.

② S-phase: Synthesis phase:

① DNA doubled.
② occurs inside nucleus with help of enzyme
③ DNA polymerase.
④ ~~Spi~~ genetic material doubled.
⑤. Chromatin/chromosome doubled.



⑥ Histone synthesis.

⑦ Centriole doubled in cytoplasm.

Page No.:
Date: / /

③ G_2 - Gap 2 phase :

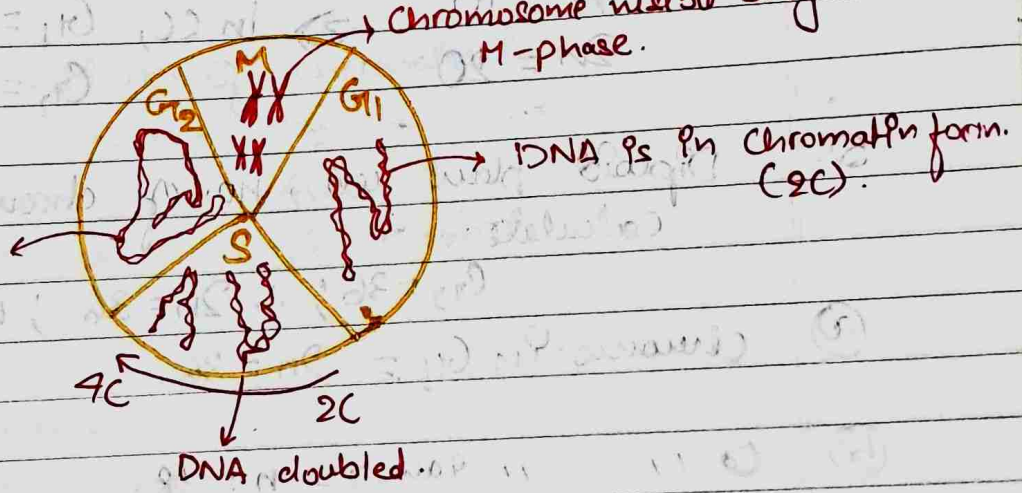
① Cell growth continued.
(Transcription & Translation occur).

② Tubulin protein synthesis (for spindle fibre).

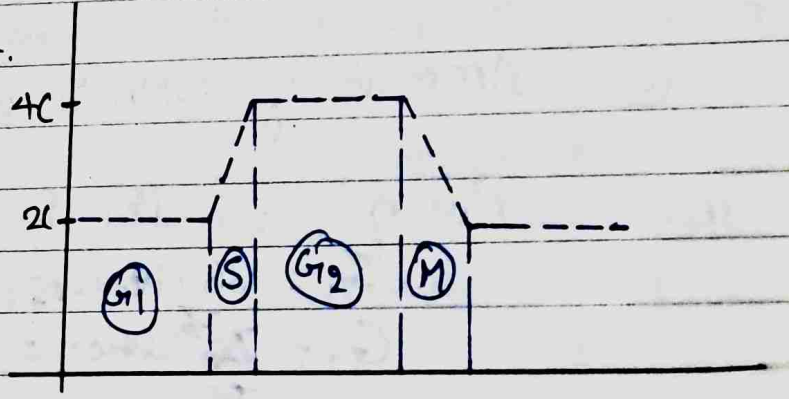
③ Some organelle - Mitochondria & Chloroplast doubled.

* Amount & Ploidy :

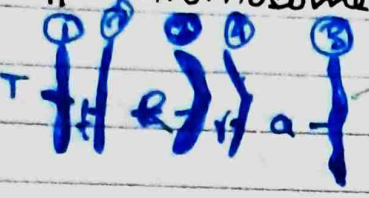
- In diploid cell, DNA normally in form of chromatin.
- Amount (wt) = 2C.



- G_1 = 2C } constant.
- G_2 = 4C. }
- S = 2C → 4C
- M = 4C → 2C.

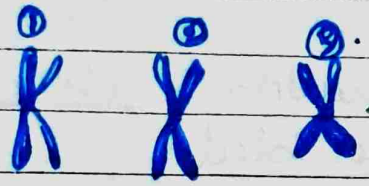


* G_1 - chromosome -



→ Chromosome / chromatid.

* G_2 - chromosome -



→ 1 chromosome = 2 chromatid.

Q. In a pollen grain if no. of chromo is 10, then no. of chromo in Diploid cell of same plant is —

① $G_1 = 20$ (2n)

② $G_2 = 20$ (2n).

$n = 10 \Rightarrow$ In cell, $G_1 = 2n = 20$

$2n = 20$ $\quad G_2 = 2n = 20$.

Q. Diploid plant cell, no. of chromo in $G_2 = 36$, calculate —

$G_2 = 36$; $\therefore 2n = 36$; $n = 18$.

(a) chromo in $G_1 = 2n = 36$.

(b) " " gamete = $n = 18$.

(c) Amount of DNA in G_1 & G_2 = $G_1 = 2C$

$G_2 = 4C$.

(d) No. of chromatid in G_1 & G_2 = ~~$2n = 36$~~

G_1 = 36 chromos = 36 chromatid.

G_2 = ~~36~~ 72 chromo. = 72 chromatid.

④ G₀ Phase–

- Cell exits CC & enters into "Quiescent phase".
- Dividing ✗
  Permanent ✗
- Reservoir of cell ⟶ If required, again enter G_1.
- Don't proliferate.

★ Checkpoints

- Cell doesn't enter from $G_1 \longrightarrow S$ until DNA repaired

① $G_1 \rightarrow S$. [cancer can be caused if missed].
② $G_2 \rightarrow M$.
③ M-phase

Q. Human cell no. of chromatid in–

G_1	G_2.
46 chromo	46 chromo.
46 chroma	92 chroma.

⑤ M-phase–

- Represents Mitosis.
- most dramatic phase– major reorg. in nucleus & cytoplasm.
- equational division (=).

  ◎ 46 chromo ⟶ ◎ 46, ◎ 46 } → single cell → 2 daughter cell.

- Progressive phase– c.d. is a continuous process
  → changes are given name.

- M - phase.
  - Karyokinesis: nucleus divides into 2 - equal half.
  - Cytokinesis: division of cytoplasm which comp. c.d.

PMAT · [Mitosis].

ⓐ Prophase
ⓑ Metaphase
ⓒ Anaphase
ⓓ Telophase.

- Time-

P > T > M > A
Longest → Shortest.

ⓐ Prophase.

→ After G_2, dna (4c, doubled) still continued.

note → phase of cc no protein synthesis cuz no nucleolous (Mpha).

① chromatin starts to condense.

② Centrosome (animal cell) move to opp pole, spindles fibres arise.

③ Chromosome with two chromatid visible.

④ ER, GB, Nucleolous disappear.

⑤ Nuclear membrane disintegrate.

⇒ Centrosome → Aster → Spindle apparatus.

⇒ completion of Prophase can be marked by—

① Chromosomal material condenses → 2 chromatids appear at centromere.

② Initiation of assembly of mitotic spindle [microtubule nucleated].

note— ① last event of Prophase → Breaking of Nuclear memb.

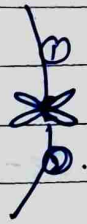
② Mitochondria +nt in cell throout mitosis for energy.

③ Animal cell — two aster (Amphiastral)
Plant cell — spindle formed directly (Anastral).

⑥ Metaphase.

- marked by → Nuclear memb. disintegration.
  after this cell enters into Metaphase.
- Chromosome, come in cytoplasm.
- Condensation of chromosome get comp. in metaphase.
  ↳ Chromosome is clearly visible in microscope
  or
  Best stage to see morphology.

- On chromosome → Kinetochore appears on centromere at which spindle fibre attached.
- Kinetochore → Proteinaceous, disc shaped, +ut on each chromatid centromere.
  1 chromo = 2 chromatids.
  = 4 arms.
- Chromosomal fibre – fibres which have chromosome attached.
  Human = 46 chromosome.
  = ~~96~~ 92 chromosomal fibre.

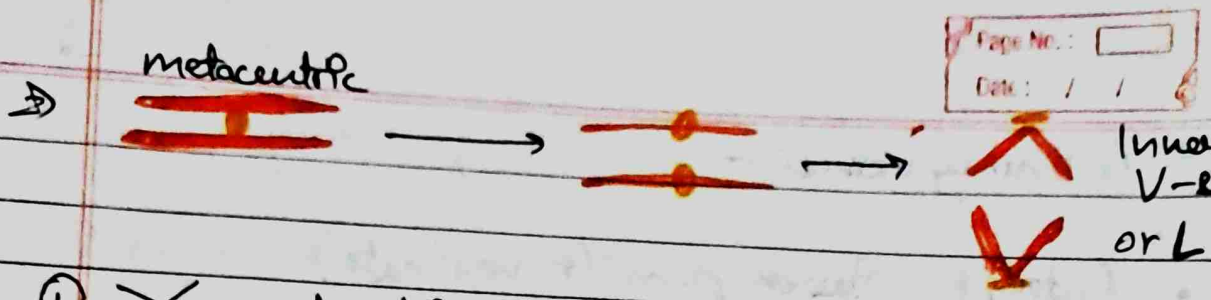


- Chromosomes come at equator of spindle fibre.
  Plane of alignment → Metaphasic plate.

④ Anaphase.

- Before anaphase, chromos attached to metaphasic plate.
- Centromere split & both sister chromatid gets separated & moves towards opp. poles.
- Chromatids pulled by Kinetochores.

After separation, sister chromatids are now chromosomes of future daughter cells.
Arms trailing behind.



① ✕ metacentric → ∧ Inverted V shape.

② ✕ sub-meta. → ⌃ " L "

③ ✕ Acrocentric → ⌃ " J "

④ < telocentric → — " I ".

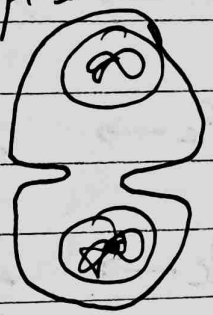
④ Telophase.

- In Anaphase, chromosome is now at opp. pole. Now they get decondensed to form chromatin.
- Nuclear membrane reappear.
- Spindle fibre disintegrate.
- ER, Golgi, Nucleolous reappear.
- Cytokinesis →
  - Animal: P.m. → non-rigid.
  - Plants: Rigid CW (Inextensible).

⇒ Animal cytokinesis–

- Outer to inner p.m. (invaginate)
- Furrow gets deeper, meets at centre, divides the cytoplasm.

① Furrow
② Cleavage
③ Centripetal



⇒ Plant cytokinesis–.

- Inner to outer, Middle lamella formed.
- Same spindle fibre remain (Phragmoplast).

↓

Golgi body vesicles calcium pectate deposit (cell plate).
(Inner to outer)

↓

cell plate or Middle lamella formed.

↓

Cell wall.

↓

Plasma memb.

① ML → ② CW → ③ Pm formed.

★ Significance of Mitosis.

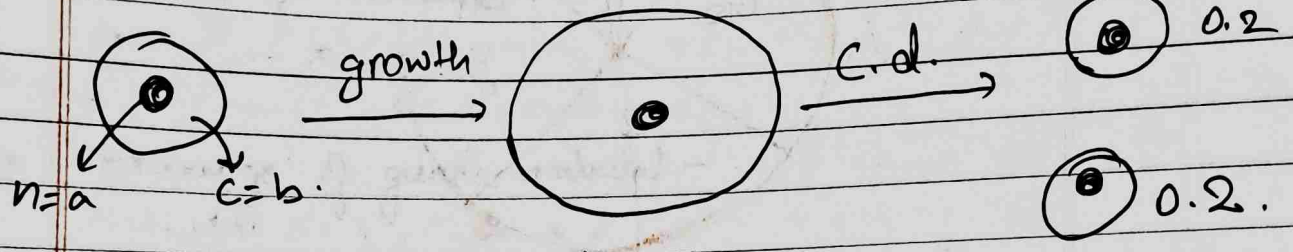
① Location → Plant → ① Apical
② Intercalary.
③ Lateral meristem.

↓

Animal → ① Skin cell
② Gut cell (Inner lining)
③ Blood cells.

② Cell growth, Repair.

③ Nucleus / Cytoplasm ratio restore.



a/b = 0.2 a/b ↓ = 0.1.

Q Does mitosis only occur in Diploid cell?

⇒ In animals, mitosis occur only in diploid cell.

except → Social Insect (drone).

From queen → ⊙ (egg cell ⑤) —mitosis→ drone.

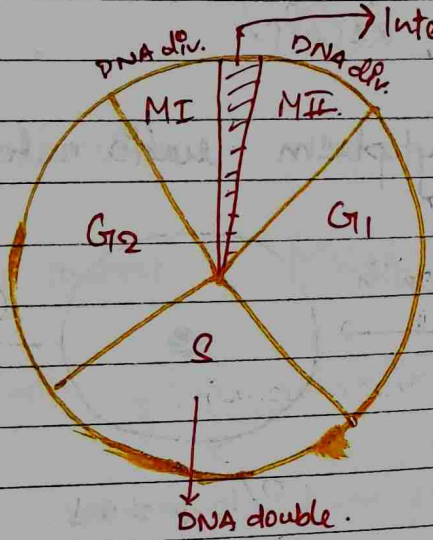
In plants, mitosis occur in both haploid & diploid.

Spore (n) —mitosis→ gametophyte (n).

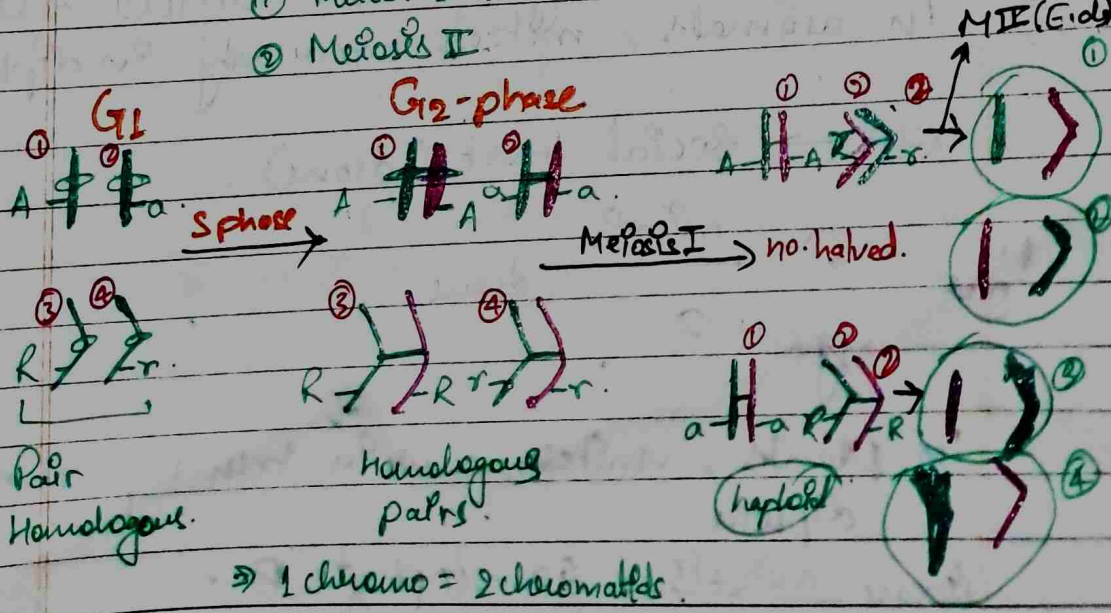
* Meiosis.

- Significance —
- Meiosis has evolved for sexual reproduction.
- Chromosome no. half.
- Variation.

- Meiocyte — cell which shows meiosis.

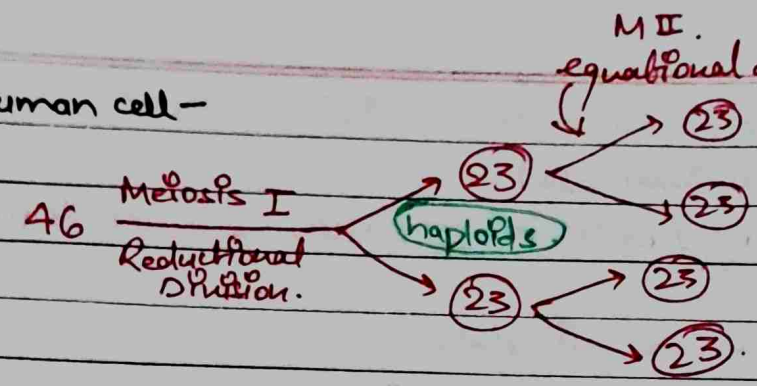


- Only single cycle of DNA divides 2 times — C.D → in S-phase.
  1. Meiosis I.
  2. Meiosis II.



⇒ 1 chromo = 2 chromatids.

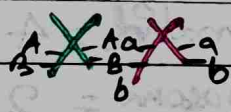
* Human cell –



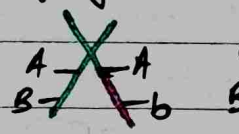
• Meiosis linked to sexual reproduction.
↓
gives variation. (by crossing over).
↓

* Pairing & recombination –

→ Pairing of chromos.



→ Exchange of genetic material –



* Meiosis I
① Prophase I
② Metaphase I
③ Anaphase I
④ Telophase I

Interkinesis
(No MpI & MII)

* Meiosis II
① PII
② MII
③ AII
④ TII.

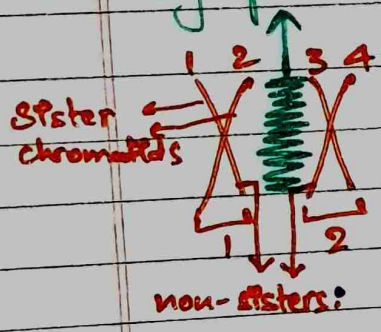
① Prophase I
① Leptotene. — Latakti
② Zygotene — Zulfo k
③ Pachytene — Peechhe
④ Diplotene — Do
⑤ Diakinesis. — Deewane.

① Leptotene. (lepto chromatin)

- Bouquet (Animal cell)
- Chromatin starts to condense & occur thruout.

② Zygotene. (Z ka ulta S).

- Similar chromosomes start to pairing.
  Process → "Synapsis"
  Result → "Tetrad / Bivalent"
- "Synaptonemal complex" → chemical that help in pairing of Homologous pair.



⇒
- no. of chromatid = 4 = "Tetrad"
- no. of chromosome = 2 = "Bivalent"

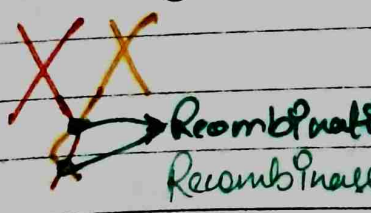
1 pair of chromosome = 1 Bivalent.
1 Tetrad.

eg - ① Human → 46 chromos.
= 23 pairs. = 23 Tetrads.
= 23 Bivalent.

② Maize = 2n = 20.
= 10 pairs = 10 Tetrads
= 10 Bivalents.

③ Pachytene. (PR → Pachytene Recombination nodule).

- Bivalent visible in Zygotene but "clearly visible" on Pachytene.



- **Recombination nodule**- Point of crossing over on chromosomes. Overlapping points on chromo.

- **Recombinase enzyme**- Help in genetic exchange b/w non-sister chromatids of homologous chromos pair.

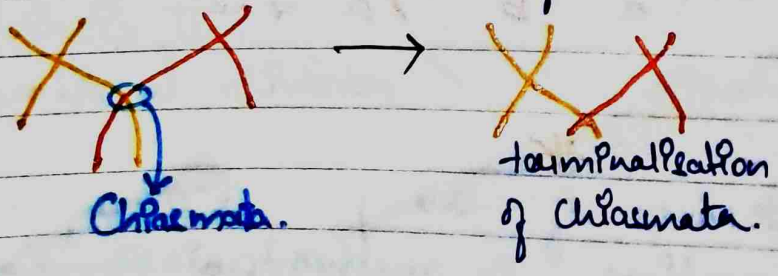
- In Pachytene, Bivalent clearly visible.
- Non-sister chromatids of Homologous pairs form Recombination nodule to exchange genetic material with the help of Recombinase enzyme.
(Synaptonemal complex still present).

Ⓐ **Diplotene.** (D & C → Chiasmata).

- Initiation of dissolution of Synaptonemal complex & chromosomes starts to move apart.
- Chromosomes remain attached only at point of cross over.

⇒ Cross like str. formed = "Chiasmata"

* In mammals → Meiosis I in foetus Arrest in Diplotene.



- Condensation comp in Diplotene in chromatin to form chromosome.
- Meiotic spindle apparatus formed (Centrosome to opp pole)

⑤ Diakinesis. (DC).

- Terminalisation of Chiasmata.

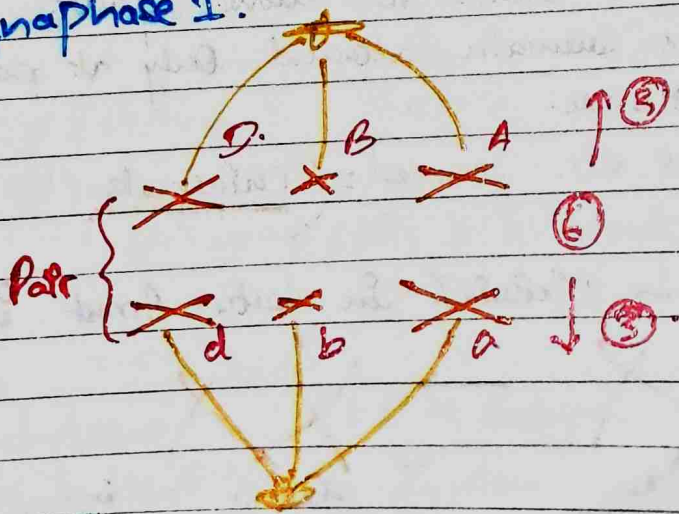
② Metaphase I.

- Nuclear membrane broken, chromosome gets attached to spindle.
- Homologous pair have 2 spindle fibre on opp. pole.
- Human cell—

Mitosis
Metaphase – 46 = 92 s.f.

Meiosis
MetaphaseI – 46 ch.
= 46 s.f.

③ Anaphase I.



- Segregation of one pair is independent to segregation of another pair.

A B D
a b d.
3 pairs.

⇒ Total combinations = $2^3 = 8$.

Human cell = 2^{23} combinations possible.

- Variations (caused by) ⟶ ① Pachytene.
  ② Anaphase I.

④ Telophase I.

- Chromosomes converts into chromatin. (not completely decondensed).

★ Interkinesis.

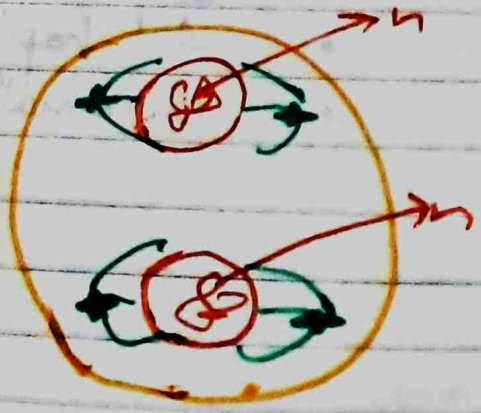
- No DNA rep.
- After MI, → ⊕ ⊖ haploid nuclei.
- Gap b/w Meiosis I (Telophase I) & start of Meiosis II (Prophase II).
  DNA decondense — DNA condense.
  DNA not decondensed completely.

★ Meiosis II.

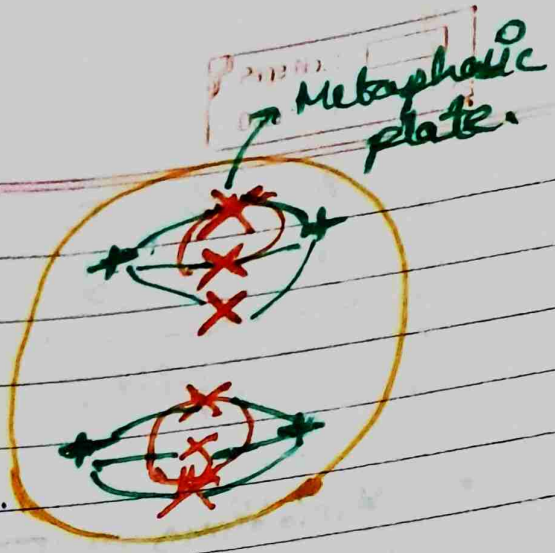
- Equational division.

① Prophase II

- Chromatin condense.
- Centrosome move to opp poles.
- spindle fibre formed.

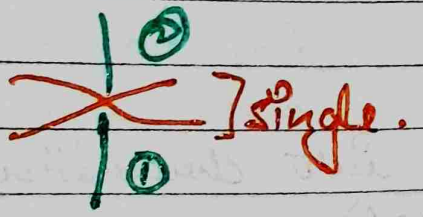


- **Metaphase II.**
- Chromosomes come at
  → Equatorial plate of spindle.



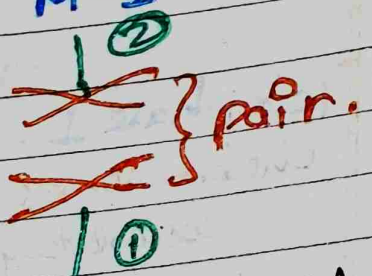
1 chromo = 2 spindle fibre.

M-II



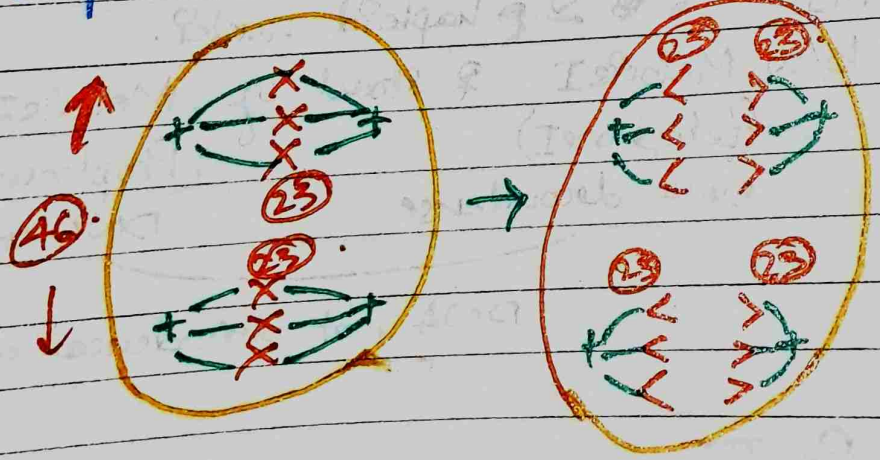
1 chromo = 2 s.f.

M-I.



2 chromo = 2 s.f.

- **Anaphase II.**



- **Telophase II.**
- 4 haploid nuclei.
- chromatin, Nuclear memb. appear.

★ Cytokinesis.

↓ Successive

MI → Cytokinesis → M-II

→ Simultaneous.

M-I → M-II → Cytokinesis

★ Type of Meiosis—

↓ Gametic
Meiosis to form Gametes.
(In Humans)
skin/somatic cell → Mitosis only.
Gonads → Meiosis.

↓ Sporic
Meiosis to form ~~sporophy~~ spores.
(In sporophytes-Bryophytes)

→ Zygotic.
Meiosis ~~to form~~ in Zygote to form spore.
(In Algae).