CELL CYCLE & CELL DIVISION

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Cytoplasmic Streaming –

What is cell ?

→ Structural and functional unit of life.

→ Acc to me – Cell = compartment (chamber)

★ Metabolic Rxn – Chemical Rxn occuring inside cell
– occur due to Enzyme.

A → B
C → D

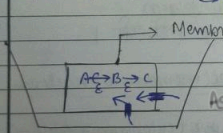
• Cell = chamber = compartment

→ Inside Cell = water = [water + chemical Rxn] = Cytoplasm

→ Enzyme can act outside the cell.

→ Cell membrane (made up of lipid) separates outside and inner environment

→ Lipid is phospholid → Hydrophilic (outer)
→ Hydrophobic (inner)



– Membrane need some gate / channel

Some subst move inside

Which subst to move (control)

→ Membrane = +nt in all living cell
= Have channel (protein)
= Control movement of substance.

Qus Max^m function Perform by
1) Lipid
2) Protein
3) Carbohydrate
4) Nucleic Acid.

→ Cell need control → DNA data ✓

(Many rxns)

→ All type of cell must have DNA. (except some) (RBC, sieve tube)

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⇒ So cell have following features
a) Cell membrane
b) Protein channel / Pump
c) Cytoplasm (Chemical Rxn / Enzyme present)
d) DNA – information store (for complete function of cell)
e) DNA ⟶ RNA ⟶ Protein
(information) (Ribosome) ↳ function)

S-I All living cells have organelle
SII Phloem fibres is dead cell, not have membrane & cytoplasm
→ Both are correct.

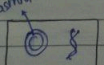
S-I Channels are fnt on membrane and inside cytoplasm
S-II DNA store information for cell.
→ S-I (wrong), S-II (correct)
Ashtica

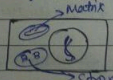
→ In prokaryotes, All Rxn in cytoplasm
↳ cytoplasmic streaming नहीं होती ।

★ Cytoplasm – Cell – cell wall – cell membrane – nucleus.
★ Protoplast – Cell – cell wall Remove
★ Protoplasm – cell membrane remove (cytoplasm + nucleus)

What is DNA ? (Thread like)

→ DNA → thread like structure which is chemically nucleic acid
↳ Function: store information (for all fun" of cell)
↳ so DNA is genetic material.





Location – Prokaryotic = Cytoplasm (Bacteria)
Eukaryotic = Nucleus (Yeast, Amoeba)

→ Some organelle [Chloroplast = stroma
Mitochondria = Matrix]

(Histone = only in Eukaryotes)

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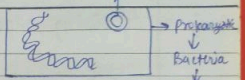
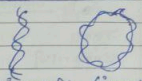
Plasmid

DNA in Prokaryotic cell



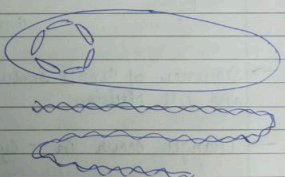
location = cytoplasm
= DNA of prok cell = circular, Ds
= DNA need to be folded
↓ → All essential gene
and kept at place = nucleoid
Associated
→ Some basic protein [not histone]
(+ve. charge)



★ We consider : Nucleoid is a single chromosome.

→ Plasmid → cytoplasm Ashtika
→ Extrachromosomal
→ Not Genetic Material
→ Circular [Ds]
→ Non essential gene.

DNA in Eukaryotic Cell

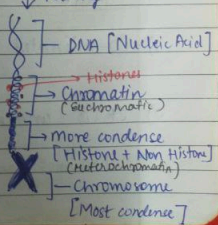


location = Nucleus
Structure – Linear, Ds
Histones – Protein, Basic, help in folding.

→ Eu, Hetero Chromatin
↳ Normal cell

→ Chromosome → Dividing all.

↓ Folding



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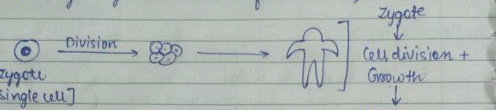
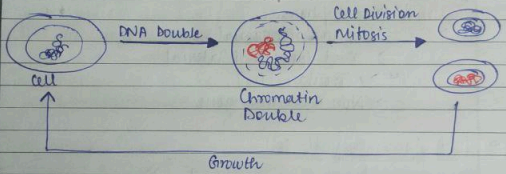
Basic – All living organism start life from Single cell.



- Cell Division
- Cell Growth
- Cell Differentiation

CELL CYCLE

Ashtika



→ Sequence of Events including growth, DNA Duplication and cell Division.

→ Changes occur in – Cytoplasm and Nucleus

Feature :-

1) Co-ordinated Event → Properly, DNA double and distribute equally into 2 daughter

2) It is under Genetic control

3) Occur in Eukaryotes

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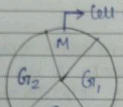
Phases of cell cycle

→ Cell process - DNA Replication, Division, Growth
↳ all are continuous process

→ In cell changes occur in → Cytoplasm
Nucleus

→ Changes are Given with name of phase.
Most Important change = Cell Division = Phase

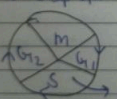


→ Cell division = M-phase = Mitosis
[Cell Divide]

S phase [DNA Replication]
↳ Synthesis

Ashtika

→ In Eukaryotic cell → Cell cycle → phase present
→ Most Important = Most changes occur = M phase = Cell division
→ S- phase → DNA Synthesis occur
→ G_1 → Gap b/w (time gap — some change occur) M phase & S-phase
→ G_2 → Gap b/w S & M



In Eukaryotic Cell
(Two phase)

[M-phase] [Cell division]
- Karyokinesis [Nucleus divide]
- Cytokinesis [Cytoplasm divide]

[Interphase] [$G_1 + S + G_2$]
→ Gap B/w End of cell Division and start of Next Division
↳ It is also known as Resting Phase
Less change occur as compare to M phase

Cell cycle → Yeast = 90 min
Human cell = 24 hr (culture)

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Study

Interphases — Detail → G_1, S, G_2 → (a) changes (nucleus and cytoplasm) (b) time (c) Amount of DNA (d) G_0 phase

⇒ Interganism – time can be different for 2 different cells.
2 different organism = also require different time for division.

24hr
M phase = 1 hr → 5%
G_1 = 8–12 hr
S = 6–8 hr
G_2 = 3–4 hr
→ 95% (Interphase)

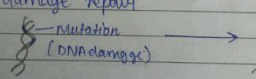
Ques Which phase in interphase takes max time – G_1 phase
Ques In Apical Meristem, having dividing cells
Cells are present in which phase = G_1 phase.
Ques Which phase is most variable phase = G_1 phase.
→ Cells undergoing cleavage will not have = G_1 and G_2 phase

Ashtika

Changes occur in Each phases.

★ Gap b/w M and G_1 [Gap-1]

G_1 phase
- Growth occur
- Cytoplasm increase
- Enzyme Require [Transcription / Translation process occur]
- Organelle double = Increase = golgi body, ER
- DNA damage repair



nucleus n = 5 → n = 5
cytoplasm c = 10 → c = 20

- Nucleus / cytoplasm ratio decreases in G_1 phase.

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S phase – Synthesis phase

- In this phase DNA Replication occur inside the nucleus
- Total all DNA not get decondence at once
- In cytoplasm of animal cell = centriole gets double.
- Histones get double
- Euchromatin and Heterochromatin = Replication first [Euchromatin]

• Centriole = α tubulin + β tubulin.

G_2 phase Gap-2 [Gap b/w End of s-phase and start of m phase]

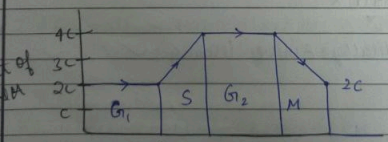
- Cell prepare itself for M-phase
- In M-phase [Spindle fibre form]
  - → So large no of microtubule (tubulin) protein require.
    - → Now this protein get synthesise in G_2 phase
- Organelles like mitochondria & plastid double here
- Transcription and translation also occur here.

Ashtika

Amount of DNA

→ In a diploid cell
Amount of DNA in G_1 phase = 2C

→ In S-phase – Amount of DNA increase from 2C to 4C
→ In M-phase – Amount again become 2C in each daughter cell.



G_1 = 2C
G_2 = 4C

S → phase → Increase
M → phase → decrease

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Ploidy of Chromosome :-

G_1, S, G_2 ⟶ chromatin visible

M ⟶ phase ⟶ chromosome visible

G_1 ⇒ chromatin (2C)
G_2 ⇒ chromatin (4C)

Q1 In a gamete of plant X have (n = 13) chromosome
Answer the following:-

1) No. of chromosome in Diploid cell in G_1 phase = 26 (2C)
2) No. of chromosome in Diploid cell in G_2 phase = 26 (4C)
3) No. of chromatid in G_1 phase (Diploid) = 26
4) No. of chromatid in G_2 phase (Diploid) = 52

G_0 phase — Quiscent phase. Ashtika

G_1 phase ⟶ cells have option ⟶ Cell become permanent
↳ Cell Enter into S-phase [It has to decide]
↳ Cell Exit G_1 phase.

→ When cell Exit G_1 phase it enter into G_0 phase.
- Cell growth ✗
- Cell proliferate ✗
- Cell divide ✗
- Cell metabolically Active (Living) ✓

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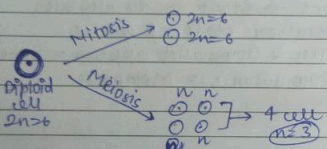
Mitosis (M-phase) [Equational Division]

→ Major Reorganisation of all component

→ Mitosis → 2n (Diploid cell) → 2n ⊙ + 2n ⊙ [cytoplasm, organelle, chromatin]

→ Meiosis → Diploid cell (2n) → ⊙ ⊙ ⊙ ⊙ 4 haploid cells

→ Mitosis also occur in haploid → n ⊙ → Mitosis → ⊙n ⊙n



Ashtika

Haploid cell (n=3) → Mitosis occur → ⊙ ⊙ → Two haploid cell

→ Mitosis can occur in Both haploid and Diploid cell.

→ Meiosis only occur in Diploid cells.

- In Animals = Haploid not show mitosis
- In plants = Both Diploid and haploid show ~~only~~ mitosis.

⇒ 2 steps.

1) Karyokinesis (nucleus Divide)
   - prophase
   - Metaphase
   - Anaphase
   - Telophase
2) Cytokinesis (cytoplasm Divide)

Acc to time
P > T > M > A
↓ longest ↓ Smallest

Date:

Prophase

→ Start with untangling of DNA and chromatin start to condense ⟶ chromosome start to visible with 2 sister chromatid

- Centrosome move to opposite pole.
- Microtubule develop Around centrosome.
- Aster form which give spindle fibre
  [Aster + spindle = Spindle Apparatus]

- ER, Golgi body, nucleolus disappear.
- Nuclear Membrane → Start to disintegrate.
- Chromatin condensation start = prophase
- Chromosome with 2 chromatid appear = prorophase
- fully condensed chromosome = Metaphase

Metaphase

Ashtika

— Nuclear membrane disappear
— Chromosome now in cytoplasm
— condensation of chromosome complete (fully condensed chromosom)
  [Best phase – to see a) morphology b) Number c) size]
— On chromosome ⟶ Centromere present on which kinetochore present
— Spindle fibre from Both pole attach to one chromosome on kinetochore.
— 1chromosome = 2 chromatid, 2 kinetochore, 2 spindle fibre
— All chromosome are bring at Equator or Centre of spindle fibre.
  [Plane of Alignment of Chromosome = Metaphasic plate]
— Chromosome fibre – spinde fibre attachon chromosome
  { Human cell (2n = 46)
  total chromosomal fibre = 92
  1 chromosome = 2 fibre }

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- Kinetochore – Disc shape (made up of protein)
  In Mitosis – 1 chromosome have 2 kinetochore.

Anaphase

- All chromosome split at centromere and 2 sister chromatid separate.
- Metaphase = 1 chromosome = 2 chromatid
  ↓ After split
  Each chromatid now a chromosome
  [Future daughter cell]
- Spindle fibre pull chromosome towards – pole
  ↳ centromere is directed towards pole and Arms trailing Behind.
- Note = For short time number of chromosome get double in Anaphase.

Telophase

Ashtika

- Chromosome are now on Poles.
- Chromosome decondense to form chromatin
- Nuclear Membrane reappear
- Nucleolus, ER, golgi body, appear again
- On Both pole → 2 nuclei form.

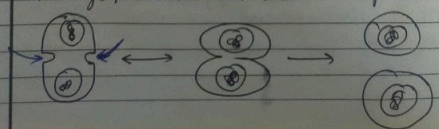
CYTOKINESIS

- After Karyokinesis (nuclear Division) Cytokinesis occur.

→ 2 method

a) Cleavage or furrow method = Animal cell
b) Cell plate Method = Plant cell.

Cleavage / Furrow Method [Centripetal cytokinesis (out to in)]



Furrow develops
↓
deepens
↓
meet at centre
↓
2 daughter cells.

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Cell plate Method [Centrifugal]

Cell plate = Middle lamella = Calcium pectate



— Around spindle fibre golgi body some chemical deposit [Inner to outer]

MEIOSIS — Reductional Division

→ First a-sexual Reproduction Evolved — no variation or less variation.

→ To increase variation — Sexual Reproduction Evolve
↓
→ Meiosis in diploid organism produce gamete. 2 cells from different organism fuse
↓ Due to
Chromosome get Double
↓
Ashtika To reduce chromosome number (Meiosis Evolve)

⇒ What meiosis do → Produce Haploid stage in organism —
(Gamete — Diploid organism
spore — Haploid organism)
— showing Reproduction.

⇒ Why meiosis occur
- Meiosis produce Haploid stage
- In Diploid organism — produce gametes
- In haploid org — restore haploid stage by meiosis in zygote.

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Meiosis

Meiosis I	Meiosis II
Prophase I	Prophase II
Metaphase I	Metaphase II
Anaphase I	Anaphase II
Telophase I	Telophase II

Few points about meiosis
- Meiosis occurs only in diploid cell
- Meiosis is Divided into Meiosis I and Meiosis II
- No DNA replication occurs in B/w Meiosis I and Meiosis II

MEIOSIS I

Prophase-I (Leptotene, Zygotene, Pachytene, Diplotene, Diakinesis)

1) Leptotene :- 1st phase after G_2

- Chromatin start to condense
- Compaction / condensation throughout Leptotene.
- Condensed thread visible / chromosome in compound microscope.

2) Zygotene :- Ashtika

- Chromosome start to pair
- Process of pairing = Synapsis
- Result of synapsis is = Bivalent or tetrad.
- Synaptonemal complex keep chromosome pair together. [Visible in Electron microscope]

- Bivalent visible in — Normal compound microscope in → Zygotene
  More clearly visible in next stage ↳ pachytene.

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3) Pachytene (Crossing over)
- Bivalent or tetrad clearly visible in Pachytene
- Recombination nodule form b/w non-sister chromatid of Homologous pair.
- Exchange of genetic material B/w non-sister chromatid
- Variation occur (as sister chromatid is not genetically same after crossing)

- Crossing over is an enzyme-mediated process and the enzyme involved is recombinase.

4) Diplotene
Ashtika
- Dissolution of synaptonemal complex start
- Homologous tend to move apart
- But still attach at site of cross over.
- Chiasmata visible [Cross like structure]

5) Diakinesis
- Terminilization of chiasmata
- Chromosome condensation complete
- Centrosome move to opposite pole
- ER, golgi, Nucleolus Disappear, also NM disappear.

Metaphase I
- End of prophase - chromosome are in cytoplasm
- Spindle fibre attach to chromosome pair from opposite pole.
- Double metaphasic plate
- 1 pair = 2 spindle fibre

Anaphase I
- Chromosome pair separate (Segregate)
- Disjunction and segregation occur and spindle fibre pull complete chromosome (2 chromatid) on opposite pole.

- If non-disjunction occur → complete pair move to one pole.

46 < 23 / 23 (Normal) 46 < 24 / 22 (Non-disjunction)

Telophase I (Dyads of cells)
- haploid number of chromosome are now on each pole.
- Chromosome decondense to form chromatin
- Nucleolus, ER, Golgi body nuclear membrane.

Interkinesis
- Gap b/w Meiosis I and Meiosis II
- No. DNA replication
- Centrosome double only.

Ashtika

(MEIOSIS - II)
- It is like Mitosis
- Sister chromatid get separated

Mitosis	Meiosis II
- occur in haploid and Diploid cell	- Always occur after meiosis I (Always occur in Haploid)
- Sister chromatid identical which get separated	- Sister chromatid (non-identical)

Prophase II
- haploid cells → chromatin condense
- ER, Golgi body, Nucleolus dissapear
- Nuclear Membrane Break

Metaphase II
- Chromosome align on metaphasic plate
- 1 chromosome = 2 spindle fibre.

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Anaphase II
- Sister chromatid separate and move to opp pole of spindle
- Chromosome number same.

Telophase II
- Chromosome decondense
- Nuclear membrane form
- Then cytokinesis.

SIGNIFICANCE OF MITOSIS

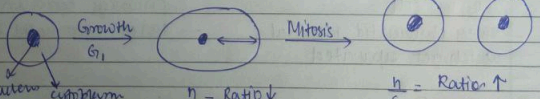
1) Occur in Diploid and haploid cell.
   Plant – occur in diploid cell and haploid
   Animal — occur in diploid (except - honeybee)

2) Produce Genetically identical cell

   $2n$ —Mitosis→ $2n$ $2n$ Two Daughter cell (genetically same)

   n —Mitosis→ n n (2 Daughter cell — genetically same)

3) Nucleus upon cytoplasmic Ratio increase

4) Repair – Mitosis Division help in Repair

5) Example:- Plants – Apical meristem, vascular cambium, Intercalary meristem, Intercalary.

   Animals – Skin, Alimentary canal, Blood cell

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SIGNIFICANCE OF MEIOSIS

1) Maintain chromosome number

Sexual Repro → 2 cell fuse (gametes) → Chromosome Double

2) Meiosis produce variation — Pachytene
- Anaphase I

Ashtika

— Thank You ♡ with love