Class: 12th

Subject: Biology

Chapter 21: Cell Cycle

Important MCQs:

1. The sequence of growth, DNA replication, and cell division is known as:

(a) Cell division

(b) Cell growth

(c) Cell cycle ✅

(d) Cytokinesis

2. The period of non-apparent division in the cell cycle is called:

(a) Mitotic phase

(b) Prophase

(c) Interphase ✅

(d) Anaphase

3. The interphase is also called the:

(a) Active phase

(b) Resting phase ✅

(c) Dividing phase

(d) Maturing phase

4. In which phase of interphase does DNA synthesis occur?

(a) G_1-phase

(b) G_2-phase

(c) S-phase ✅

(d) Go-phase

5. Cells that stop dividing permanently enter which phase?

(a) S-phase

(b) G_1-phase

(c) Go-phase ✅

(d) G_2-phase

6. The duration of the complete cell cycle in human cells is approximately:

(a) 12 hours

(b) 18 hours

(c) 24 hours ✅

(d) 48 hours

7. In human cells, mitosis takes approximately:

(a) 10 minutes

(b) 30 minutes ✅

(c) 1 hour

(d) 90 minutes

8. The type of cell division that maintains the same number of chromosomes as in parent cells is:

(a) Meiosis

(b) Amitosis

(c) Mitosis ✅

(d) Binary fission

9. The division of nucleus during mitosis is called:

(a) Cytokinesis

(b) Karyokinesis ✅

(c) Cell division

(d) Replication

10. The spindle fibers are composed of which protein?

(a) Myosin

(b) Actin

(c) Tubulin ✅

(d) Collagen

11. The structure formed by aster and spindle during mitosis is called:

(a) Chromosome complex

(b) Mitotic apparatus ✅

(c) Phragmoplast

(d) Nucleosome

12. During which stage do chromosomes become visible as two sister chromatids attached at a centromere?

(a) Prophase ✅

(b) Metaphase

(c) Anaphase

(d) Telophase

13. During which stage do chromosomes align at the equatorial plate of the spindle?

(a) Prophase

(b) Metaphase ✅

(c) Anaphase

(d) Telophase

14. The most critical stage of mitosis ensuring equal distribution of chromatids is:

(a) Prophase

(b) Metaphase

(c) Anaphase ✅

(d) Telophase

15. The stage where nuclear membrane and nucleoli reappear is:

(a) Metaphase

(b) Anaphase

(c) Telophase ✅

(d) Cytokinesis

16. The contractile ring responsible for cell division during cytokinesis in animal cells is formed by:

(a) Tubulin and actin

(b) Actin and myosin ✅

(c) Myosin and collagen

(d) Actin and tubulin

17. In plant cells, the structure that replaces the contractile ring during cytokinesis is:

(a) Aster

(b) Phragmoplast ✅

(c) Spindle

(d) Centriole

18. In plant cells, vesicles forming the phragmoplast originate from:

(a) Endoplasmic reticulum

(b) Nucleus

(c) Golgi complex ✅

(d) Ribosomes

19. The equal distribution of hereditary material in daughter cells during mitosis ensures:

(a) Genetic variation

(b) Mutation

(c) Continuity of genetic information ✅

(d) Chromosome reduction

20. Uncontrolled or improper mitosis in cells may lead to:

(a) Growth and development

(b) Regeneration

(c) Cancer and tumors ✅

(d) Normal cell repair

21. The process of cell growth and death in the body is normally:

(a) Irregular

(b) Uncontrolled

(c) Balanced ✅

(d) Interrupted

22. An unwanted clone of rapidly dividing cells is called a:

(a) Gamete

(b) Tumor ✅

(c) Spindle

(d) Chromatid

23. Tumors that remain small and localized are known as:

(a) Malignant tumors

(b) Benign tumors ✅

(c) Cancer cells

(d) Metastatic cells

24. The spread of tumor cells to other parts of the body is called:

(a) Cloning

(b) Differentiation

(c) Metastasis ✅

(d) Regeneration

25. The main cause of cancer is:

(a) Viral infection

(b) Mutations in somatic cells ✅

(c) Excessive mitosis

(d) Bacterial invasion

26. Cancer cells can be distinguished from normal cells because they have:

(a) Low nucleus-to-cytoplasm ratio

(b) High nucleus-to-cytoplasm ratio ✅

(c) No nucleoli

(d) Small nuclei

27. The cell division that reduces the number of chromosomes to half is called:

(a) Mitosis

(b) Meiosis ✅

(c) Binary fission

(d) Amitosis

28. In animals, meiosis occurs during the formation of:

(a) Somatic cells

(b) Gametes ✅

(c) Zygotes

(d) Nerve cells

29. The first division of meiosis is known as:

(a) Equational division

(b) Reduction division ✅

(c) Replication division

(d) Nuclear division

30. During which stage of meiosis does crossing over take place?

(a) Leptotene

(b) Zygotene

(c) Pachytene ✅

(d) Diplotene

31. The exchange of chromosome segments between homologous chromosomes during meiosis is called:

(a) Mutation

(b) Crossing over ✅

(c) Replication

(d) Segregation

32. Random assortment of chromosomes during meiosis results in:

(a) Identical offspring

(b) Genetic variation ✅

(c) Mutation elimination

(d) Chromosome reduction

33. Which of the following is the main importance of meiosis?

(a) Increases chromosome number

(b) Maintains chromosome number generation after generation ✅

(c) Causes genetic uniformity

(d) Produces identical gametes

34. If meiosis did not occur, the chromosome number in each generation would:

(a) Remain constant

(b) Reduce to half

(c) Double ✅

(d) Become zero

35. Failure of chromosomes to separate properly during meiosis is called:

(a) Crossing over

(b) Non-disjunction ✅

(c) Mutation

(d) Duplication

36. Down's Syndrome is caused by:

(a) Failure of sex chromosome segregation

(b) Mutation in Y chromosome

(c) Non-disjunction of 21st chromosome ✅

(d) Lack of X chromosome

37. Individuals with Klinefelter's Syndrome have the chromosome composition:

(a) 44 + XY

(b) 44 + XXY ✅

(c) 44 + XO

(d) 44 + XYY

38. A female with short stature, webbed neck, and only one X chromosome suffers from:

(a) Down's Syndrome

(b) Klinefelter's Syndrome

(c) Turner's Syndrome ✅

(d) Cancer

39. Programmed cell death in multicellular organisms is called:

(a) Mutation

(b) Apoptosis ✅

(c) Necrosis

(d) Autolysis

40. The main difference between apoptosis and necrosis is that in apoptosis:

(a) Cells swell and burst

(b) Intracellular contents are released

(c) Dying cells shrink and form apoptotic bodies ✅

(d) It causes inflammation in tissues

🧫 Q.4 — Short Questions and Answers

1. Differentiate between necrosis and apoptosis.

Answer:

👉 Apoptosis is a programmed cell death in which the cell shrinks, forms apoptotic bodies, and is safely removed without harming nearby cells.

👉 Necrosis is an accidental or injury-induced cell death in which the cell swells, bursts, and releases its contents, causing inflammation and damage to surrounding tissues.

2. What are the functions of mitotic apparatus?

Answer:

👉 The mitotic apparatus (spindle and aster) ensures:

- Proper attachment of chromosomes to spindle fibers.
- Alignment of chromosomes at the cell equator.
- Equal separation of chromatids to opposite poles during cell division.

Thus, it guarantees accurate distribution of chromosomes to daughter cells.

3. How can you identify cancer cells?

Answer:

👉 Cancer cells can be identified by:

- High nucleus-to-cytoplasm ratio.
- Prominent nucleoli.
- Rapid and uncontrolled mitosis.
- Less differentiation compared to normal cells.
- These characteristics distinguish them from normal, regulated cells.

4. Give importance and significance to meiosis.

Answer:

👉 Meiosis is important because:

- It maintains the chromosome number constant generation after generation.
- It produces genetic variation through crossing over and random assortment.
- It is essential for gamete and spore formation in animals and plants.

Thus, it plays a vital role in evolution and individuality.

5. Define chromosomal non-disjunction.

Answer:

👉 Chromosomal non-disjunction is the failure of chromosomes to separate properly during anaphase of meiosis, resulting in gametes with abnormal chromosome numbers (either extra or missing chromosomes).

6. What are symptoms of Turner's Syndrome?

Answer:

👉 Individuals with Turner's Syndrome (45, X) show:

- Short stature and webbed neck.
- Absence of ovaries and germ cells.
- Underdeveloped secondary sex characteristics.
- Female appearance but infertility.

7. Define cell cycle. Highlight its importance and significance.

Answer:

👉 The cell cycle is the sequence of events that a cell undergoes during its life — including growth, DNA replication, and cell division.

📘 **Importance:**

- It ensures orderly cell growth and division.
- Maintains the genetic stability of the organism.
- Replaces worn-out cells and supports growth and repair.

8. Is interphase a resting phase? Why?

Answer:

👉 Interphase is not truly a resting phase because during this period, the cell actively grows, performs metabolic activities, synthesizes DNA, RNA, and proteins, and prepares for division — even though no visible division occurs.

9. In what respect does mitosis in plant cells differ from that in animal cells?

Answer:

👉 Differences between plant and animal mitosis:

- **Plant cells** lack centrioles, while animal cells have them.
- Plant cells form a phragmoplast and cell plate during cytokinesis, while animal cells form a cleavage furrow.
- The shape of the plant cell remains rigid due to the cell wall, while the animal cell shape changes during division.

Important Short Questions:

1. What is meant by cell cycle?

Answer:

👉 The cell cycle is the sequence of changes that a cell undergoes during growth, DNA replication, and division to form two daughter cells.

2. Name the two main phases of the cell cycle.

Answer:

👉 **The two main phases are:**

1. Interphase (period of non-apparent division)

2. Mitotic phase (period of actual division)

3. What is interphase and why is it called a "resting phase"?

Answer:

👉 Interphase is the period between two cell divisions when the cell grows and prepares for division.

It is called "resting" because no visible division occurs, though active metabolism continues.

4. Name the sub-phases of interphase and write their main functions.

Answer:

👉 **Sub-phases: G_1, S, and G_2**

- **G_1:** Cell grows and synthesizes enzymes.
- **S:** DNA replication occurs.
- **G_2:** Preparation for mitosis (formation of proteins and microtubules).

5. What happens during the G_1 phase of interphase?

Answer:

👉 The cell grows in size, performs active metabolism, and accumulates materials needed for DNA synthesis.

6. What is G_0 phase? Give one example of cells that remain in this phase.

Answer:

👉 The G_0 phase is a resting stage where cells stop dividing temporarily or permanently.

Example: Nerve cells and eye lens cells remain in this phase throughout life.

7. During which phase of interphase does DNA replication occur?

Answer:

👉 DNA replication takes place during the S-phase (synthesis phase) of interphase.

8. What is the importance of checkpoints in the cell cycle?

Answer:

👉 Checkpoints control the progression of the cell cycle, ensuring each phase completes correctly before the next begins to prevent errors.

9. Define mitosis. What is its main significance?

Answer:

👉 Mitosis is a type of cell division in which one cell divides to form two genetically identical daughter cells.

- It maintains the same chromosome number as the parent cell.

10. What is the difference between karyokinesis and cytokinesis?

Answer:

👉 Karyokinesis is the division of the nucleus, while cytokinesis is the division of the cytoplasm to form two separate cells.

11. Describe the main events of prophase in mitosis.

Answer:

👉 Chromatin condenses into visible chromosomes, each with two sister chromatids.

- Nuclear envelope and nucleolus disappear, and spindle fibers begin to form.

12. What happens to chromosomes during metaphase?

Answer:

👉 Chromosomes align at the cell's equator forming the metaphase plate, and spindle fibers attach to their centromeres.

13. Why is anaphase called the most critical phase of mitosis?

Answer:

👉 Because sister chromatids separate at the centromere and move to opposite poles, ensuring equal distribution of chromosomes.

14. What are two major differences between mitosis in plant and animal cells?

Answer:

1. Plant cells lack centrioles, while animal cells have them.

2. Cytokinesis in plants occurs by cell plate formation, while in animals by cleavage furrow.

15. Write any three importance points of mitosis in living organisms.

Answer:

1. Ensures equal distribution of hereditary material.

2. Helps in growth and development.

3. Aids in repair and replacement of damaged or old cells.

16. What is cancer?

Answer:

👉 Cancer is a disease in which cells lose control over their division and begin to grow and divide in an unregulated manner, forming abnormal cell masses or tumors.

17. Define tumor and name its two basic types.

Answer:

👉 A tumor is an unwanted mass of cells produced due to uncontrolled cell division.

It is of two types: benign (localized) and malignant (cancerous, spreading).

18. Differentiate between benign and malignant tumors.

Answer:

👉 Benign tumors are small, localized, and do not spread to other parts of the body.

👉 Malignant tumors invade surrounding tissues, spread through blood, and cause cancer.

19. What is metastasis?

Answer:

👉 The process by which malignant cancer cells spread from their original site to other parts of the body and form new tumors is called metastasis.

20. How can cancer cells be distinguished from normal cells?

Answer:

👉 Cancer cells are less differentiated, have a large nucleus-to-cytoplasm ratio, prominent nucleoli, and show rapid, uncontrolled mitosis.

21. What are the main causes of cancer?

Answer:

👉 Cancer mainly results from mutations in somatic cells, which disturb genes controlling cell division. It may involve several mutations (3–20) in regulatory genes.

22. Write two major changes that occur in cancer cells due to mutations.

Answer:

👉 (i) Cancer cells lose contact inhibition and can invade other tissues.

👉 (ii) They proliferate indefinitely without obeying normal growth controls.

23. Define meiosis.

Answer:

👉 Meiosis is a special type of cell division in which the chromosome number is reduced to half, producing four haploid daughter cells from one diploid parent cell.

24. In which type of cells does meiosis occur in animals and plants?

Answer:

👉 In animals, meiosis occurs during gamete formation.

👉 In plants, it occurs during spore formation.

25. Why is meiosis-I called reduction division?

Answer:

👉 Meiosis-I is called reduction division because homologous chromosomes separate, reducing the chromosome number to half in daughter cells.

26. What are the two significant happenings of meiosis?

Answer:

👉 Crossing over and random assortment of chromosomes are the two major events of meiosis.

27. What is crossing over and why is it important?

Answer:

👉 Crossing over is the exchange of chromosome segments between homologous chromosomes during pachytene, producing genetic recombinations and variations.

28. What is random assortment of chromosomes?

Answer:

👉 It is the random separation of homologous chromosomes during anaphase I that results in different combinations of maternal and paternal chromosomes in gametes.

29. How does meiosis help in maintaining constant chromosome number in generations?

Answer:

👉 Meiosis reduces the chromosome number to half in gametes; fertilization restores the diploid number, maintaining constancy generation after generation.

30. What would happen if meiosis did not occur?

Answer:

👉 Without meiosis, chromosome number would double in every generation, causing genetic imbalance and abnormal development.

31. What is chromosomal non-disjunction?

Answer:

👉 Non-disjunction is the failure of homologous chromosomes or chromatids to separate properly during anaphase, leading to abnormal chromosome numbers.

32. How does non-disjunction affect the number of chromosomes in daughter cells?

Answer:

👉 It produces gametes with extra or missing chromosomes, resulting in disorders such as Down's, Klinefelter's, or Turner's syndromes.

33. What are the causes and symptoms of Down's syndrome?

Answer:

👉 It is caused by autosomal non-disjunction of the 21st chromosome; patients show flat faces, squint eyes, protruding tongues, and mental retardation.

34. Write two symptoms of Klinefelter's syndrome.

Answer:

👉 Klinefelter males (XXY) have enlarged breasts, small testes without sperms, tallness, and under-developed secondary sex characters.

35. What is apoptosis and how does it differ from necrosis?

Answer:

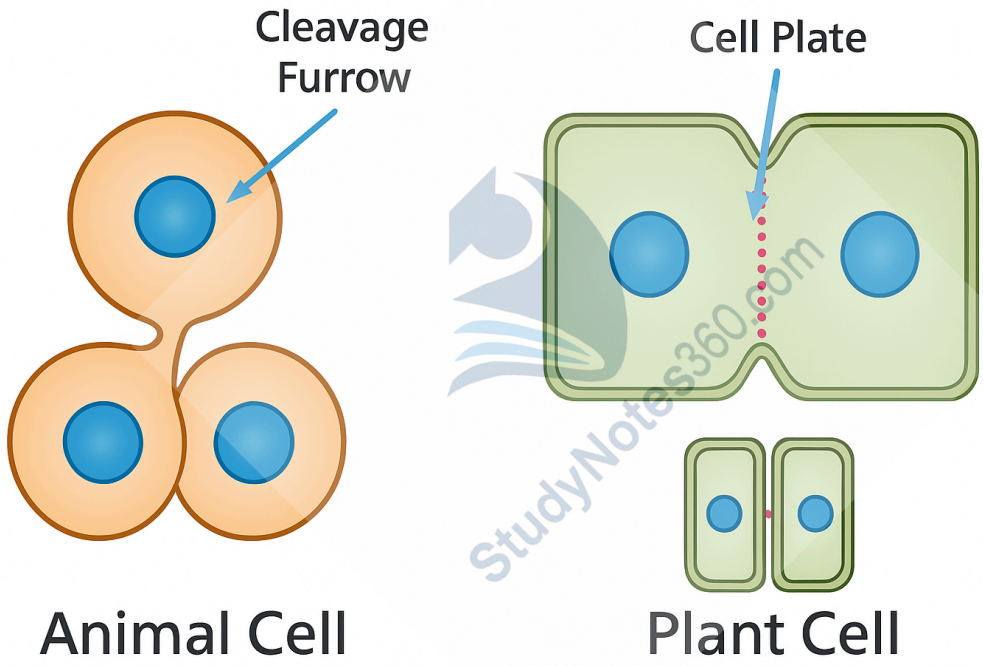
👉 Apoptosis is programmed cell death where cells shrink and are safely removed; necrosis is accidental cell death causing cell swelling, bursting, and inflammation.

Q5: Extensive questions:

🌟 Q1: How does cytokinesis occur in animal cells? In which way does it differ from that in plant cells?

❖ Definition:

- Cytokinesis is the process of division of cytoplasm after the completion of nuclear division (mitosis or meiosis).
- It ensures that each daughter cell receives an equal share of cytoplasm and organelles, completing the cell division process.



🔹 Cytokinesis in Animal Cells:

- In animal cells, cytokinesis begins during telophase of mitosis.
- At this stage, a shallow groove known as the cleavage furrow appears on the plasma membrane at the equator of the cell.

- This furrow forms due to the contraction of microfilaments (mainly actin and myosin) present beneath the plasma membrane.
- As the furrow deepens, it moves inward, squeezing the cell membrane towards the center.

Finally, the furrow meets in the middle of the cell and divides the cytoplasm into two separate daughter cells, each having its own nucleus and cell organelles.

➤ This process is called cytokinesis by cleavage or furrow formation.

🔹 Cytokinesis in Plant Cells:

- In plant cells, cytokinesis occurs in a different way because plant cells possess a rigid cell wall, which cannot be pinched inward like an animal cell membrane.
- Instead of forming a furrow, plant cells form a cell plate in the center of the cell.
- Tiny vesicles produced by the Golgi apparatus move to the center of the cell and fuse together to form the cell plate.
- The cell plate gradually enlarges outward until it joins with the existing plasma membrane.

Then, materials like cellulose and pectin are deposited on both sides of the cell plate, developing into a new cell wall between the two daughter cells.

Thus, two new daughter cells are formed, each with its own nucleus and complete set of organelles.

🔹 Difference in Mechanism (Explained in Words):

- In animal cells, cytokinesis occurs through the formation of a constricting furrow at the equator.
- In plant cells, cytokinesis occurs through the formation of a new partition (cell plate) at the center due to the rigid wall.

Hence, the main difference is due to the presence of a cell wall in plant cells, which prevents furrow formation.

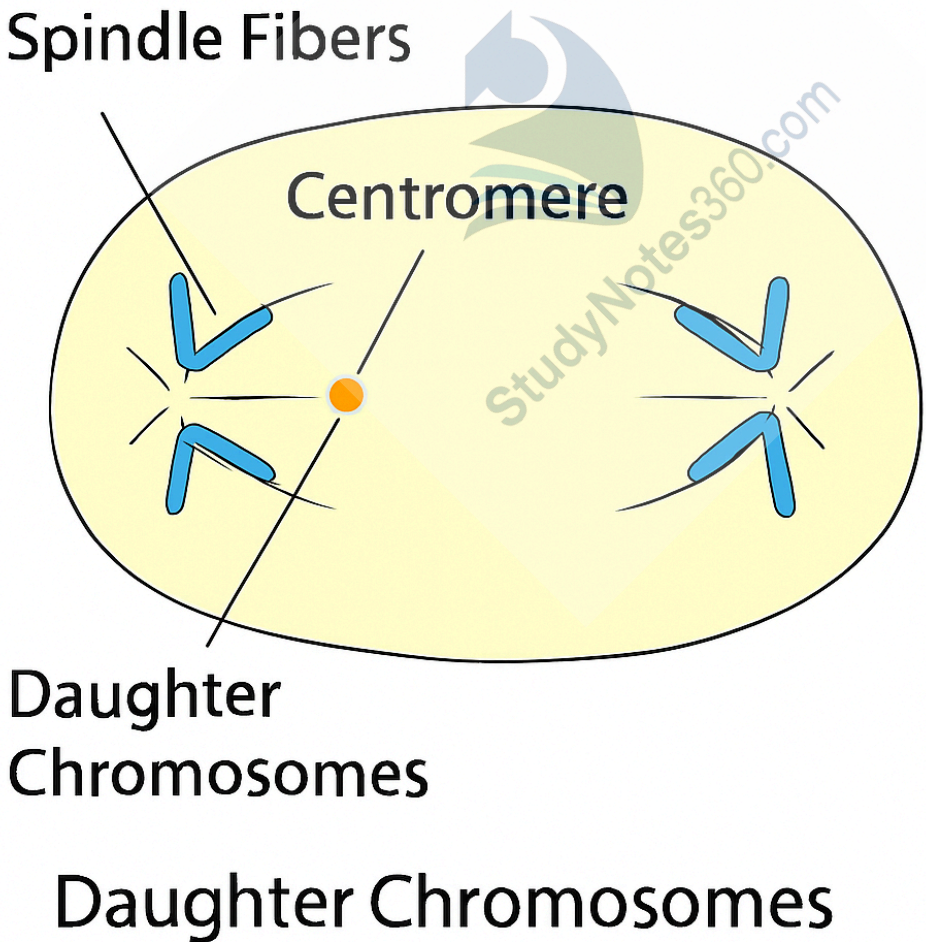
✦ Summary:

- Cytokinesis is the final stage of cell division.
- In animal cells, it occurs by cleavage furrow formation, while in plant cells, it occurs by cell plate formation.
- Both methods ensure equal division of cytoplasm and organelles between the two daughter cells, completing the process of cell reproduction.

🌟 Q2: Why and how do the chromosomes get separated during anaphase of mitosis?

❖ Introduction:

- Mitosis is the process of equational cell division, in which one parent cell divides into two identical daughter cells, each containing the same number of chromosomes as the parent cell.
- It occurs in several stages: prophase, metaphase, anaphase, and telophase.
- Among these, anaphase is the most crucial stage because it ensures the equal separation of chromosomes to opposite poles of the cell.



🔹 Why Chromosomes Get Separated:

- Chromosome separation during anaphase is essential for maintaining genetic stability in daughter cells.
- If the chromosomes fail to separate accurately, one daughter cell may receive extra chromosomes and the other fewer — leading to serious genetic abnormalities.

Thus, separation guarantees that:

- Each daughter cell gets an identical set of chromosomes,
- The chromosome number remains constant generation after generation,
- The genetic information is equally distributed.

🔹 How Chromosomes Get Separated During Anaphase:

When the cell enters anaphase, several well-coordinated changes occur inside:

1. Splitting of Centromeres:

- Each duplicated chromosome (consisting of two sister chromatids) splits at the centromere.
- This converts each chromatid into an independent daughter chromosome.

2. Attachment to Spindle Fibers:

- The spindle fibers attached to the centromeres begin to shorten.
- These fibers are made up of microtubules, which contract and pull the chromosomes.

3. Movement Toward Opposite Poles:

- As the spindle fibers shorten, they pull the daughter chromosomes toward the opposite poles of the cell.
- At the same time, the spindle fibers between the poles elongate, helping to stretch the cell lengthwise.

4. Energy Requirement:

- This process requires ATP energy, which is provided by mitochondria to drive the contraction of spindle fibers.

5. Result:

- By the end of anaphase, two equal groups of chromosomes reach the two poles of the cell.
- Each pole now contains the same number and type of chromosomes as the parent nucleus.

🔹 Significance of Anaphase:

- Ensures equal distribution of genetic material.

- Maintains chromosome number constant in all somatic cells.
- Prepares the cell for the final stage (telophase) and cytokinesis.
- Prevents genetic disorders caused by unequal chromosome division.

✦ **Summary:**

- During anaphase of mitosis, the centromeres split, and spindle fibers pull the sister chromatids toward opposite poles.
- This separation ensures that each daughter cell receives an identical set of chromosomes, maintaining genetic stability and uniformity in all cells of the organism.

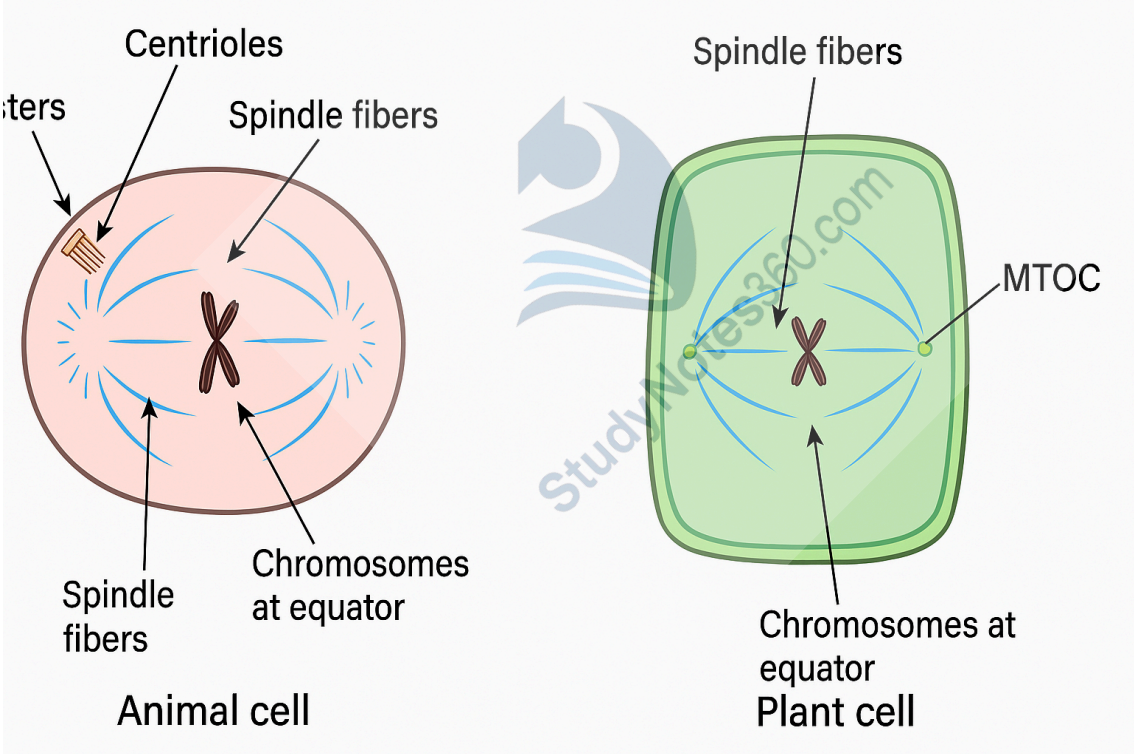
🌟 **Q3: What is the role of centriole in an animal cell? How is this function carried out in plant cell?**

❖ **Introduction:**

- In eukaryotic cells, the centrioles play a vital role during cell division.
- They are small, cylindrical, hollow structures made of microtubules and are usually present in pairs, located near the nucleus within a region called the centrosome.
- Each pair of centrioles helps in organizing the mitotic spindle apparatus, which ensures the equal division of chromosomes during mitosis and meiosis.

Structure of Centriole:

- Each centriole is a cylindrical organelle made up of nine triplets of microtubules arranged in a circular pattern (9 × 3 arrangement).
- The two centrioles are positioned at right angles to each other within the centrosome.
- This unique structure helps them act as organizing centers for microtubule formation.



Role of Centriole in Animal Cell:

Centriole performs several crucial functions during cell division:

1. Formation of Spindle Apparatus:

- Before mitosis begins, centrioles duplicate and move to opposite poles of the cell.
- From each pair, spindle fibers (microtubules) radiate outward, forming the mitotic spindle.
- This structure helps attach and separate chromosomes during anaphase.

2. Formation of Asters:

- Around each centriole, small fibers radiate outward forming a structure called an aster.
- The aster helps to anchor the spindle and maintain its position inside the cell.

3. Establishing Bipolarity:

- The two opposite centrioles mark the poles of the dividing cell, creating a bipolar spindle, which is essential for equal chromosome distribution.

4. Organization of Cytoskeleton:

- Even in non-dividing cells, centrioles help in organizing microtubules that support the shape and movement of the cell.

5. Formation of Cilia and Flagella (Additional Function):

- Centrioles also act as basal bodies for the formation of cilia and flagella, structures involved in cell movement and fluid transport.

🔹 How the Same Function is Carried Out in Plant Cells:

Unlike animal cells, most higher plant cells lack centrioles.

However, they can still carry out cell division efficiently by using analogous structures.

1. Microtubule Organizing Centers (MTOCs):

- In plant cells, spindle fibers arise from microtubule organizing centers located near the nucleus instead of centrioles.
- These centers perform the same function — organizing spindle microtubules.

2. Formation of Spindle Fibers Without Centrioles:

- The plant cell cytoplasm contains specific regions from which microtubules spontaneously assemble to form a bipolar spindle.

Thus, even without centrioles, plant cells can successfully align and separate chromosomes.

3. Phragmoplast Formation in Cytokinesis:

- During plant cell division, a unique structure called the phragmoplast is formed from vesicles originating from the Golgi complex.
- This phragmoplast helps in the formation of the new cell wall between daughter cells — a process that replaces the cleavage furrow seen in animals.

✦ **Summary:**

- Centriole in animal cells is the spindle organizer, ensuring equal chromosome distribution during cell division.
- Plant cells, however, perform this same role through microtubule organizing centers, showing that centrioles are not essential but supportive structures in cell division.

Both types of cells ultimately achieve the same goal — accurate separation of chromosomes and formation of two identical daughter cells.

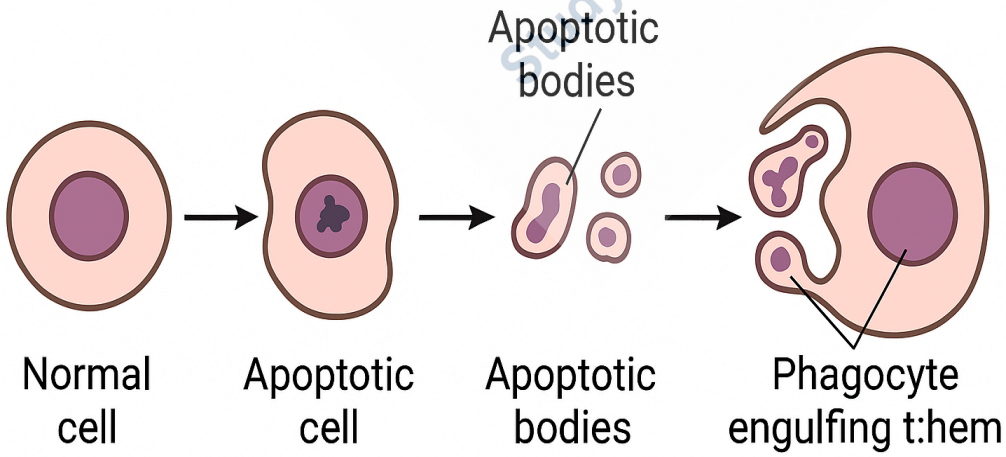
🌟 Q4: In what respect can cell death be regarded beneficial?

❖ Introduction:

- Cell death is a natural and essential process in living organisms.
- Although it may sound harmful, cell death is actually beneficial and necessary for maintaining the health, development, and balance of multicellular organisms.

➢ There are two main types of cell death: apoptosis (programmed cell death) and necrosis (accidental death due to injury).

Among these, apoptosis is the beneficial and controlled form of cell death.



Normal cell Apoptotic cell Phagocyte

🔹 1. Concept of Programmed Cell Death (Apoptosis):

- Apoptosis is a genetically controlled and highly organized process through which cells destroy themselves when they are no longer needed or when they are damaged beyond repair.
- It acts like a "cellular cleaning system" that removes unwanted or harmful cells without causing damage to surrounding tissues.
- The word apoptosis comes from Greek, meaning "falling off" — just like leaves falling from a tree when no longer useful.

🔹 2. How Cell Death Occurs (Mechanism):

During apoptosis:

- The cell shrinks and condenses.
- The nucleus breaks down into fragments.
- The cytoplasm divides into small membrane-bound vesicles called apoptotic bodies.
- These bodies are then phagocytosed (engulfed) by nearby healthy cells or immune cells.

Importantly, no toxic or harmful substances are released outside — so no inflammation occurs.

🔹 3. Beneficial Roles of Cell Death:

🧩 (a) Shaping and Development of Body Structures:

- During the development of embryos, apoptosis helps shape organs and body parts.

For example:

- Human embryo tail disappears due to apoptosis.
- Spaces between developing fingers and toes are formed when cells between them die naturally.

🧩 (b) Regulation of Cell Number:

- Apoptosis maintains the balance between cell division and cell death.
- This ensures tissues do not grow excessively, preventing disorders like tumors or cancer.

🧬 (c) Elimination of Damaged or Abnormal Cells:

- Cells with DNA damage, mutations, or infections are removed by apoptosis before they can cause harm.
- This acts as a protective mechanism against cancer and other diseases.

💪 (d) Control of Immune System:

- After an immune response, extra white blood cells (especially lymphocytes) are no longer needed.
- These cells undergo apoptosis to restore normal immune balance and prevent autoimmune diseases.

🌱 (e) Role in Plant Development:

- In plants, apoptosis-like processes occur during leaf fall (abscission) and xylem formation.
- Dead xylem cells form hollow tubes for water transport — an essential process for plant survival.

🔹 4. Difference Between Apoptosis and Necrosis:

- Apoptosis = controlled, beneficial, no inflammation.
- Necrosis = uncontrolled, harmful, causes inflammation and tissue damage.

Thus, only apoptosis is regarded as beneficial cell death.

✦ Summary:

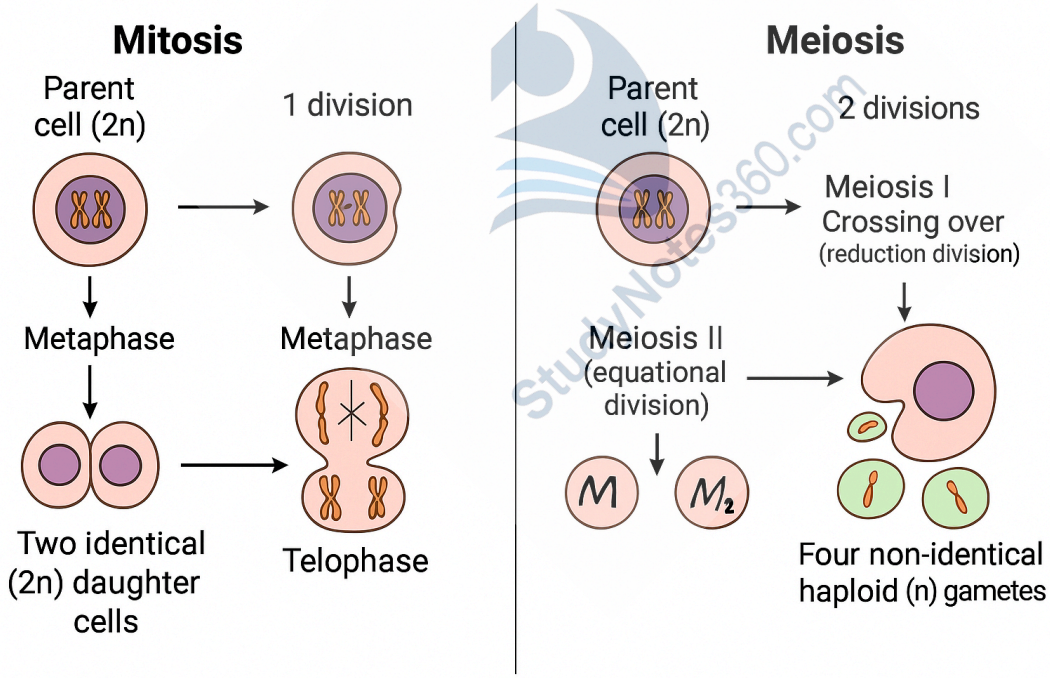
- Cell death, especially through apoptosis, is a vital and beneficial biological event.
- It helps in shaping organs, maintaining tissue balance, removing harmful cells, and ensuring the healthy development of both plants and animals.

- Without this controlled death, the body would accumulate defective or unnecessary cells, leading to diseases like cancer or developmental deformities.

🌟 Q5: Compare mitosis with meiosis and describe their importance.

❖ Introduction:

- Cell division is a fundamental process that enables growth, repair, and reproduction in living organisms.



There are two main types of cell division:

1. **Mitosis**
2. **Meiosis.**

Although both result in the formation of new cells, they differ in their purpose, process, and genetic outcome.

🔹 1. What is Mitosis?

- Mitosis is a type of cell division in which a parent cell divides to form two identical daughter cells having the same number of chromosomes as the parent cell.

👉 Example:

If a cell has 46 chromosomes (2n), each daughter cell will also have 46 (2n).

- **Occurs in:** Somatic (body) cells.
- **Purpose:** Growth, repair, and replacement of old or damaged cells.

🔹 2. What is Meiosis?

- Meiosis is a type of cell division in which a diploid cell (2n) divides twice to form four haploid (n) gametes, each having half the number of chromosomes of the parent cell.

👉 Example:

If a parent cell has 46 chromosomes, each gamete will have 23.

- **Occurs in:** Reproductive organs (testes and ovaries).
- **Purpose:** Formation of gametes (sperms and eggs) for sexual reproduction.

🔹 3. Major Differences Between Mitosis and Meiosis (Explained in Words):

🧩 (a) Number of Divisions:

- **Mitosis**: One division ⟶ two cells.
- **Meiosis:** Two successive divisions ⟶ four cells.

🧩 (b) Chromosome Number:

- **Mitosis:** Daughter cells remain diploid (same as parent).
- **Meiosis:** Daughter cells become haploid (half the chromosomes).

🧩 (c) Genetic Identity:

- **Mitosis:** Daughter cells are genetically identical to each other and to the parent cell.
- **Meiosis:** Daughter cells differ genetically due to crossing over and random assortment.

🧩 (d) Occurrence:

- **Mitosis:** In body (somatic) cells.
- **Meiosis:** In reproductive (germ) cells only.

🧩 (e) Role in Life:

- **Mitosis:** Growth, tissue repair, asexual reproduction.
- **Meiosis:** Sexual reproduction and variation in offspring.

🔹 4. Importance of Mitosis:

🌱 (a) Growth and Development:

- Mitosis increases the number of cells, allowing organisms to grow from a single zygote to a fully developed body.

🩹 (b) Repair and Healing:

- Damaged tissues (like skin or bone) are repaired by mitotic cell division.

🌿 (c) Asexual Reproduction:

- In many plants and lower organisms (like Amoeba), new individuals are produced by mitosis.

🧬 (d) Genetic Stability:

- Mitosis maintains the chromosome number and genetic information from one cell generation to the next.

🔹 5. Importance of Meiosis:

🌸 (a) Formation of Gametes:

- Meiosis produces haploid sperm and egg cells necessary for sexual reproduction.

🧩 (b) Maintenance of Chromosome Number:

- When two gametes fuse during fertilization, the diploid number is restored, preventing chromosome doubling in each generation.

🧬 (c) Genetic Variation:

- Through crossing over an independent assortment, meiosis creates new combinations of genes, leading to variation in offspring — the basis of evolution and adaptability.

🌿 (d) Evolutionary Significance:

- Variations produced by meiosis help species adapt to changing environments and evolve over time.

🔹 6. Relationship Between Mitosis and Meiosis:

Both processes are essential for the survival of species:

- Mitosis ensures body growth and cell renewal.
- Meiosis ensures reproduction and genetic diversity.

Together, they maintain continuity of life with variation.

✦ Summary:

- Mitosis and meiosis are two distinct but equally important processes of cell division.
- Mitosis maintains the organism's structure and function by producing identical cells.
- Meiosis ensures the continuation of species by forming gametes and introducing genetic variety.

Hence, both processes are vital for life — one for growth and maintenance, and the other for reproduction and evolution.

🌟 Q.6. Define disjunction and discuss its effects.

❖ Definition of Disjunction:

Disjunction is the process during anaphase of meiosis or mitosis in which homologous chromosomes (in meiosis) or sister chromatids (in mitosis) separate and move toward opposite poles of the cell.

👉 It ensures that each daughter cell receives the correct number of chromosomes during cell division.

In simple words:

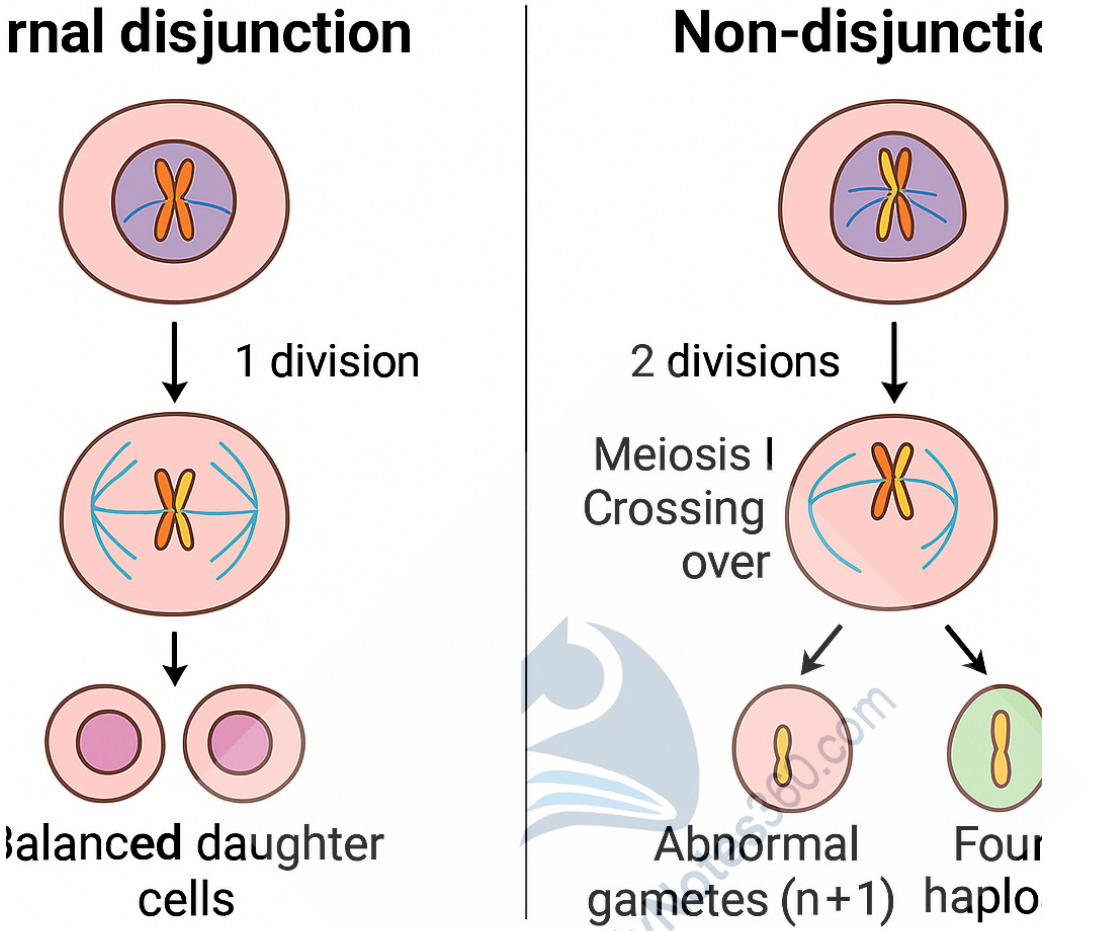
- Disjunction means normal separation of chromosomes during cell division.

🔹 How Disjunction Occurs:

- During Anaphase I of Meiosis, homologous chromosomes (each consisting of two chromatids) separate and move to opposite poles.
- During Anaphase II of Meiosis, sister chromatids separate and move apart.

Similarly, in Anaphase of Mitosis, the centromere divides and sister chromatids move to opposite poles.

This separation is guided by the spindle fibres attached to centromeres.



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- **Importance of Disjunction:**

1. Maintains Chromosome Number:

- Ensures that daughter cells receive the correct number of chromosomes.
- Keeps the chromosome number constant generation after generation.

2. Formation of Healthy Gametes:

- During meiosis, disjunction allows gametes to have half the chromosome number (haploid), which restores normal diploid number after fertilization.

3. Genetic Stability:

- Prevents abnormal distribution of genetic material, maintaining balance in heredity.

4. Ensures Proper Development:

- Proper chromosome separation ensures the formation of normal, functional organisms.

🔹 When Disjunction Fails (Non-Disjunction):

- **Sometimes**, disjunction does not occur properly, and chromosomes fail to separate.
- This phenomenon is called Non-disjunction.

👉 Definition of Non-Disjunction:

- Failure of homologous chromosomes (in Meiosis I) or sister chromatids (in Meiosis II) to separate properly is called non-disjunction.

🔹 Effects of Non-Disjunction:

1. Abnormal Chromosome Number (Aneuploidy):

- One gamete receives an extra chromosome (n + 1).
- The other gamete receives one less (n − 1).
- After fertilization, this results in zygotes with abnormal chromosome numbers such as 2n + 1 (trisomy) or 2n − 1 (monosomy).

2. Genetic Disorders Caused by Non-Disjunction:

Down's Syndrome (Trisomy 21):

- An extra chromosome at 21st pair → 47 chromosomes.
- Results in mental retardation, flat face, and developmental delay.

Turner's Syndrome (Monosomy X):

- Missing one X chromosome → 45 chromosomes (44 + X).
- Female with short stature, webbed neck, and no ovaries.

Klinefelter's Syndrome (XXY):

- One extra X chromosome in males → 47 chromosomes (44 + XXY).

- Male with small testes, infertility, and some female features.

3. Early Death or Miscarriage:

- Severe chromosomal imbalance may cause embryo death or early abortion.

✦ **Summary:**

- Disjunction is the normal separation of chromosomes during cell division.
- It is essential for genetic stability and proper distribution of chromosomes.
- Failure of disjunction (non-disjunction) causes serious genetic disorders and developmental defects such as Down's, Turner's, and Klinefelter's syndromes.

🌟 **Q7: Describe meiosis and explain its significance.**

❖ **Definition of Meiosis:**

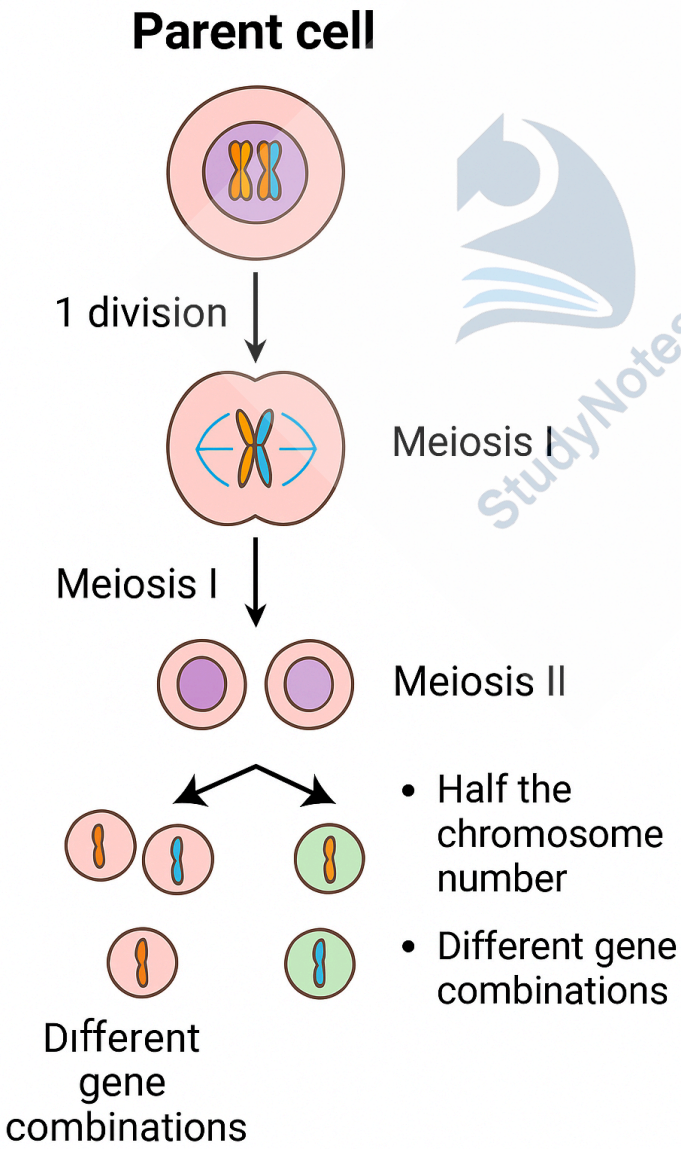
- Meiosis is a special type of cell division in which the chromosome number is reduced to half in the daughter cells as compared to the parent cell.
- It occurs in reproductive cells (gamete formation in animals and spore formation in plants).

👉 **In short:**

- Meiosis = Reduction Division
- (one diploid cell ⟶ four haploid cells)

🔹 Where It Occurs:

- In animals, meiosis takes place during formation of gametes (sperms and ova).
- In plants, it occurs during spore formation.



🔹 Phases of Meiosis:

Meiosis consists of two successive divisions after one replication of DNA:

1. Meiosis I (Reduction Division):

- Chromosome number is reduced to half.
- Homologous chromosomes separate.

It includes 4 stages:

(i) Prophase I:

- Longest and most complex phase.
- Homologous chromosomes pair up (synapsis) forming bivalents (tetrads).
- Crossing over occurs (exchange of segments between non-sister chromatids).
- Results in genetic recombination.

(ii) Metaphase I:

- Bivalents arrange along the equatorial plane.
- Spindle fibres attach to centromeres of homologous chromosomes.

(iii) Anaphase I:

- Homologous chromosomes separate and move to opposite poles.
- Each pole receives half of the total chromosomes → reduction division.

(iv) Telophase I:

- Nuclear membrane reappears around each set of chromosomes.

Two nuclei are formed → 2 haploid cells.

2. Meiosis II (Equational Division):

- Similar to mitosis.
- Sister chromatids separate.

It also includes 4 stages:

(i) Prophase II: Chromosomes condense; new spindle forms.

(ii) Metaphase II: Chromosomes align at the equator.

(iii) Anaphase II: Sister chromatids move to opposite poles.

(iv) Telophase II: Nuclear membrane reforms ⟶ 4 haploid daughter cells formed.

🔹 End Result of Meiosis:

- One diploid parent cell ⟶ four haploid daughter cells
- Each daughter cell has half the number of chromosomes.
- Each daughter cell is genetically unique due to crossing over and random assortment.

🔹 Significance / Importance of Meiosis:

1. Maintenance of Chromosome Number:

- Meiosis ensures that gametes have half the chromosome number.
- After fertilization, the diploid number is restored — keeping the chromosome number constant generation after generation.

2. Genetic Variation:

- Crossing over (exchange of genetic material) and random assortment of chromosomes produce new combinations of genes.
- This leads to variations among offspring — the basis of evolution.

3. Formation of Gametes:

- In animals, meiosis forms haploid gametes (sperm and egg).
- In plants, it forms spores which later develop into gametophytes.

4. Evolutionary Advantage:

- Variations produced by meiosis help species to adapt and evolve in changing environments.

5. Prevention of Chromosomal Doubling:

- Without meiosis, chromosome number would double after every generation — leading to instability and abnormalities.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content

has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

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Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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