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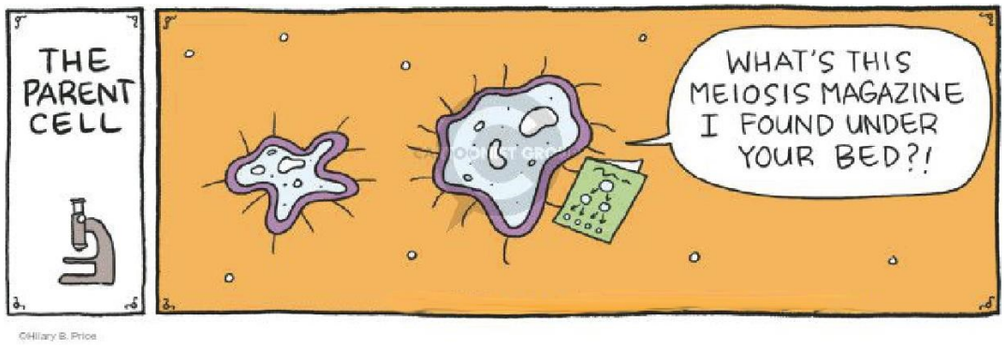

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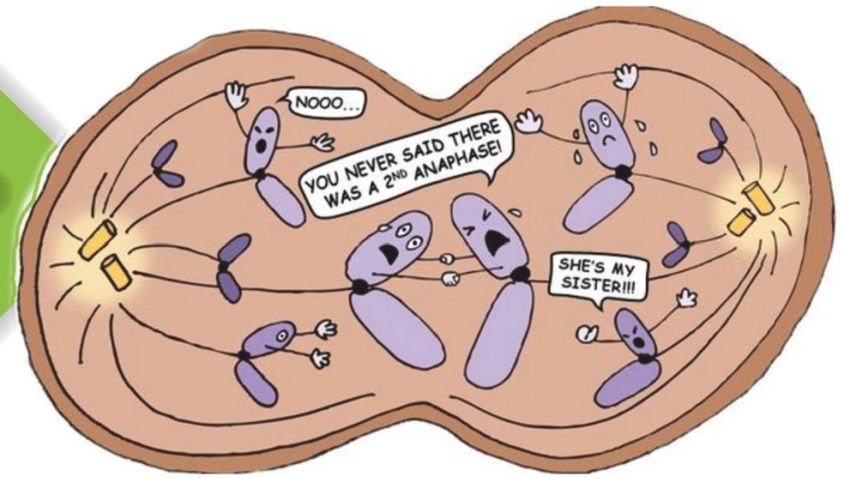


UNIT 02

Cell Cycle

Cell cycle and the process of cell division

SAMPATH LANKADHEERA
B.Sc. (Hons), M.Sc.

The cell cycle and the process of cell division

- ……
  ……
  At the end of the cell division, two genetically identical daughter cells resembling the parent cell are produced in mitosis.

23. Spindle disintegrates.
24. Chromosomes decondensed into chromatin.
25. Genetically non identical, haploid, two daughter nuclei are formed within one cell. Meiosis II Prophase II
26. Centrosomes start producing spindle apparatus (spindle fibers, aster centrosome).
27. Chromatin fibers condense and produce chromosomes with two sister chromatids.
28. Nuclear envelope breaks down into fragments.
29. Nucleolus disappears.
30. During the late prophase II centromere of the chromosomes are moved to the metaphase II plate.
Metaphase II
31. All Chromosomes get attached to the microtubules at their centromere and aligned on the metaphase plate.
32. Kinetochores of sister chromatids are attached to microtubules extending from both poles.
33. Meiosis II usually takes place in the perpendicular direction of Meiosis I.
34. Therefore, metaphase plate of meiosis II is perpendicular to the metaphase plate of meiosis I.
Anaphase II

Due to the breakdown of proteins attaching sister chromatids, they are separated at centromere.

As a result of shortening of microtubules , sister chromatids of each chromosome move towards opposite poles.
Telophase II

Nuclear envelope and nucleolus reform.

Chromosomes decondense into chromatin.
39. Spindle disassembles.
40. Genetically non identical, haploid, four daughter nuclei are formed from one parent cell.

(b) Explain the importance of meiosis.

1. Maintain the constant number of chromosomes through generations in sexually reproducing species.
2. Produce new genetic variations leading to evolution.
3. Genetic variation occur due to crossing over , recombination and independent assortment.

4. Describe the nuclear division where the chromosome number is reduced during meiosis. AL 2022

1. This cell division is meiosis I.
It consists of four phases.
2. 3. 4. 5. Prophase l. Metaphase I, Anaphase l and Telophase I.
Prophase I:
6. Chromosomes begin to condense.
7. Nucleolus begins to disappear.
8. Synaptonemal complex is formed.
9. synapsis occur
10. 11. due to pairing and physically connecting of homologous chromosomes.
12. Crossing over takes place
13. where the part of DNA molecule /strand of non-sister chromatids of paired (homologous) chromosomes breaks.
14. 15. exchange and re-join at corresponding points)
16. (and these are visible) as chiasmata.
17. Synaptonemal complex breaks/dissembles and
18. homologous chromosomes slightly part from each other.
19. Nuclear envelope breaks.
20. Centrosomes move towards opposite poles.
21. Forming Spindle in animal cells.
22. Kinetochore of each homologue attaches to microtubules from one pole.
23. Homologous pair moves towards metaphase plate.

Metaphase I

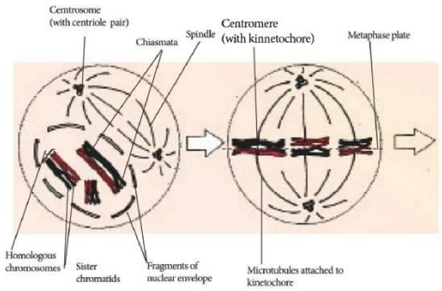
24. Homologous pairs (of chromosomes) arrange on metaphase plate
25. randomly,
26 one chromosome of each pair facing each pole. :

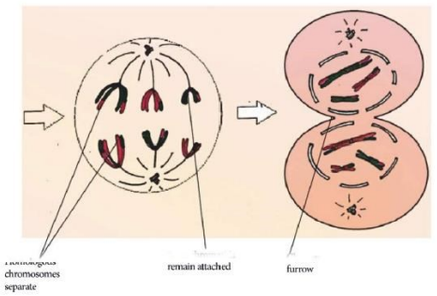
Anaphase I

27 Kinetochore microtubules of the spindle shorten.
28. Homologous pairs separate.
29. One chromosome of each pair moves towards the opposite pole.
30. Sister chromatids remain attached at the centromere and
31. move as a single unit towards the same pole.

Telophase I

32. One complete haploid set of chromosomes accumulate at each pole.
33. Nuclear envelope forms.
34. around each set of chromosomes.
35. Nucleolus reappears.
36. Spindle disintegrate.
37. Chromosomes decondensed in to chromatin.
38. Genetically non-identical two daughter nuclei are formed.





Any 34 points x 4 = 136 marks
Diagrams of Pro phase I, Metaphase I,
Anaphase I and Telophase l - 3 marks each = 12 marks
Fully labelled diagram = 3 marks
Partially labelled/Unlabeled diagram = 2 marks
If more than 34 points are written add 2 marks = 2 marks
Total = 150 marks

Eukaryotic cell cycle

- Eukaryotic cell cycle may divide into two major phases.

  ……...

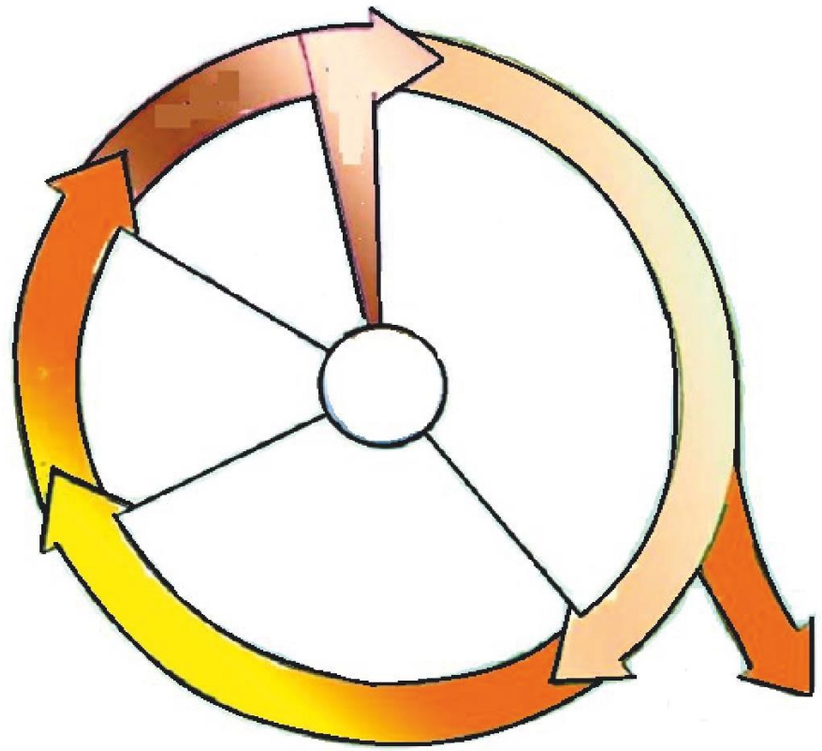
  ……...

- Interphase is the longer phase of cell cycle. It covers about 90% of the cell cycle. Interphase could be divided into three phases;

  …….... (first gap phase)

  …….... (synthetic phase)

  …….... (second gap phase)

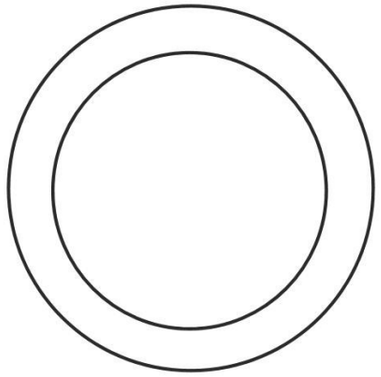


G1 phase

- In this phase synthesis of proteins and production of cellular organelles leading to cell growth occur. Proteins essential for …….. are produced during this phase.

S phase

- DNA replication occurs and synthesis of ……... proteins takes place. DNA wind around histone beads and form chromatin.



10. Genetic composition of daughter cells are different in meiosis and similar in mitosis.
11. Chromosome number reduced to half during meiosis and does not reduce during mitosis.

Diagrams:

1. Pairing of homologous chromosomes
2. Chromosomes at equatorial plane.
3. Crossover

(b) 1. When homologous chromosomes align at the equator they assort independently therefore parental chromosomes randomly segregate among daughter cells.
2. Exchange of sister chromatid pieces among homologous chromosomes in meiosis reorganize alleles.
11 x 10 marks = 110/
Diagrams 10 = 10/15 + 15 = 30/ = 150 marks

2. (a) Describe cell division occur in growth.
(Model Question) Answer

1. Prophase
2. Chromatin fibers get condensed by shortening and thickening and transformed into chromosomes.
3. As a result chromosomes will be visible through light microscope.
4. Nucleoli get disappeared and chromosomes appear with two sister chromatids attached at the centromere.
5. Chromosomal arms of sister chromatids attached by special proteins called cohesion.
6. The formation of mitotic spindles begins.
   Spindle includes the centrosomes, the spindle microtubules and the aster.
8. Centrosomes move toward opposite poles of the cell due to the lengthening of microtubules between them.
9. Prometaphase
10. The nuclear envelope fragments.
11. Chromosomes get even more condensed.
12. A special protein called kinetochore attaches the sister chromatids of each chromosome at their centromere.
13. Some of the microtubules that attach to the kinetochore of the chromosomes move the chromosomes back and forth.
14. Microtubules which are not attached to the kinetochore interact with those from the opposite poles.
15. Metaphase
16. Centrosomes reach the opposite poles.
17. The chromosomes have arrived to a place called metaphase plate which is located in equal distance from each pole.
18. The centromeres of all chromosomes are located in the metaphase plate.
19. At the end of this phase, each chromosome of the cell get attached to the kinetochore microtubule at their centromere and aligned at the metaphase plate.
20. Anaphase
21. Sister chromatids are separated at the centromere.
22. Microtubules attached to kinetochore get shorten and pull sister chromatids towards the opposite poles.
23. Cell elongates as the non kinetochore microtubules are lengthen.
24. By the end of anaphase equal and complete set of chromosomes found at each pole of the cell.
25. Telophase
26. Nuclear envelope reforms around each set of chromosomes at opposite poles. Nucleoli reappears.
27. Spindle microtubules get deplolymerized.
28. Chromosomes unwind and become less condense to form
29. chromatin. Two genetically identical daughter nuclei are formed telophase. Therefore at the end of the mitosis
31. two genetically identical daughter cells are produced.
32. In animal cells- a cleavage furrow forms. This produces two genetically identical daughter cells.
33. In plant cells- cell plate forms as a result of vesicle produced by golgi apparatus. This divides the
34. cytoplasm in to two and generates two genetically identical daughter cells to the parent cell.

(b) State significance of mitosis for living organisms.

1. Maintains the genetic stability
2. Growth and development
3. Cell repair, replacement and regeneration
4. Asexual reproduction

3. (a) Describe meiosis. (Model Question) Answer

1. Meiosis is a type of nuclear division which gives rise to four haploid, genetically non identical daughter nuclei, from a diploid mother nucleus.
2. Meiosis involves two consecutive nuclear divisions, Meiosis I and Meiosis II.
3. Meiosis I is a reduction division and Meiosis II is similar to mitosis.
4. Each stage consists of four sub phases: prophase, metaphase, anaphase, and telophase.
5. Before meiosis one cell is in interphase, during S phase of the interphase DNA replication occur.
   Meiosis I, Prophase I
6. Chromosomes begin to condense. Nucleolus begins to disappear.
7. Next the formation of zipper like structure called the synaptonemal complex by a specific proteins holds two homologous chromosomes tightly together.
8. The pairing and physical connection of homologous chromosomes is called synapsis.
9. During synapsis part of the DNA molecule of non-sister chromatids of paired homologous chromosomes break, exchange and re-join at corresponding point.
10. This process is called crossing over.
11. These points of crossing over become visible as chiasmata after the synaptonemal complex dissembles and the homologous chromosomes slightly apart from each other.
12. Nuclear envelop breaks. Centrosomes move towards opposite poles forming spindle in animal cells.
13. The kinetochore of each homologue attach to microtubule from one pole or the other.
14. The homologous pair then moves toward the metaphase plate.
    Metaphase I
15. The pair of homologous chromosomes get arranged on the metaphase plate with one chromosome of each pair faces each pole.
16. Both chromatids of a homologue are attached to kinetochore microtubules from one pole and those of the other homolog are attached to kinetochore microtubules from the opposite pole.
17. Homologous chromosome arrange randomly at metaphase plate. Anaphase I
18. Kinetochore microtubules of the spindle get shorten. Homologous pair separates and one chromosome of each pair moves towards the opposite pole.
19. Sister chromatids of each chromosome remain attached at the centromere and move as a single unit towards the same pole.
    Telophase I
20. One complete haploid set of chromosomes accumulate at each pole.
21. Nuclear envelope reforms around each set of chromosomes.

18. A - Centrosomes move towards opposite poles forming spindle.
B - Formation of synaptonemal complex C - Pairs of homologous chromosomes arrange on metaphase plate. D - Crossing over of chromatids
Which one of the following is the correct sequence of occurrence of above events?
(1) A, B, D, C (2) A, C, B, D (3) B, C, A, D (4) B, D, A, C (5) B, D, C, A (A/L 2021)

19. Select the response which correctly indicates the event and phase in the eukaryotic cell cycle.
(1) DNA replication — Go phase (2) Synthesis of proteins — G1 phase
(3) Chromatin formation — G2 phase (4) Production of cellular organelles — S phase
(5) Duplication of centrosome — M phase (A/L 2023)

Structured Essays

AL 2021

(ii) State an event that occurs in mitosis and meiosis II, but does not occur in meiosis I of the eukaryotic cell cycle.

.....

AL 2014

1. Indicate with a cross (x) in the appropriate column, which of the following structures are present or processes occur during meiosis only or during both mitosis and meiosis.

	In meiosis only	In both meiosis and mitosis
Bivalent		
Centriole		
Centromeres		
Chiasmata		
Chromatids		
Cytokinesis		
Microtubules		
Aster		
Spindles		
Telophase		

Essay B

AL/1991

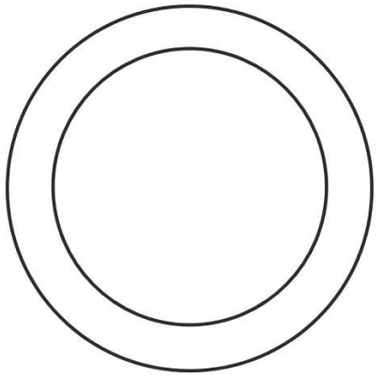
1. (a) What differences can be observed in form and behavior of chromosomes in mitosis and meiosis?
(b) Explain how heritable variations are increased during meiosis.

Answer

(a) 1. Homologous chromosomes pair in meiosis but does not happen in mitosis.
2. Chiasma formation occurs between homologous chromosomes during meiosis but does not occur during mitosis.
3. Homologous chromosomes exchange between sister chromatids but does not occur during mitosis.
4. After changing sister chromatid pieces homologous chromosomes segregate with a genetic recombination but does not occur in mitosis.
5. Homologous chromosomes aline along either side of equator in meiosis but they aline along equator during mitosis.
6. During meiosis one homologous chromosome attach only to spindle fibers coming from one pole and in mitosis they attach to spindle fibers coming from opposite poles.
7. No division of centromere in meiosis I but centromere split during mitosis.
8. During meiosis I chromosomes move to opposite poles but in mitosis sister chromatids move to opposite poles.
Chromosomes does not fully disappear at the end of meiosis I but disappear at the end of mitosis.

G2 phase

- Cells continue to grow through protein synthesis as well as cellular organelles.
..... essential for ..... will be synthesized. Duplication of centrosomes takes place. There are cell cycle controlling checkpoints available at ....., ... and ..... phases to ensure that the cell is ready for moving into upcoming phases of cell division. Some cells receive a go head signal at the G1 check point, it will usually complete the G1, S, G2 and M phases and divide. If it does not receive a go head signal at that point it may exit the cycle, entering into a non dividing stage called the G0 phase. The most cells of the human body are actually in the G0 phase.
eg. ..... and .....



Mitotic phase/M phase

- M phase covers only about 10% of cell cycle. This includes mitosis and cytokinesis.

I. Mitosis

- Mitosis is referred to ……..…
  ……
  ……..…… This may get divided into five stages;
  ……... ……..., ……...,
  …….. and ……... in order to ease the learning of activities of cell cycle.

1. Prophase

- Chromatin fibers get condensed by shortening and thickening and transformed into chromosomes. As a result chromosomes will be visible through ……... microscope.
  ……... get disappeared and chromosomes appear with two sister

6. Migration of chromatids from equatorial plane to poles occurs during.
   (1) Prophase of meiosis (2) Metaphase of meiosis (3) Anaphase II of meiosis
   (4) Telophase of meiosis (5) Inter phase II

7. As a result of meiosis,
   (1) number of chromosomes double (2) haploid cells is formed from a diploid cell
   (3) 4 nuclei with similar genetic composition result (4) diploid cells are produced before fertilization
   (5) daughter cells with higher DNA content than parental cell produced

8. As a result of meiosis.
   (1) 4 nuclei similar to parental nuclei form (2) 2 nuclei similar to parental nuclei form
   (3) 4 daughter cells with identical genetic makeup formed
   (4) 4 daughter cells with equal chromosome number result
   (5) 2 daughter nuclei with identical genetic makeup result

9. In meiosis segregation of chromatids occurs during.
   (1) Anaphase l (2) Metaphase l (3) Telophase l (4) Metaphase II (5) Anaphase II

10. Two sets of 6 chromosomes present in two opposite poles of a dividing cell with a spindle apparatus. Each chromosome has sister chromatids. What is the dividing stage of this cell?
    (1) Anaphase of mitosis (2) Telophase of mitosis (3) Anaphase I (4) Anaphase II (5) Telophase II

11. Which of the following is not an essential during meiosis?
    (1) Reduction of nuclear DNA (2) Pairing of homologous chromosomes
    (3) Exchanging of DNA between homologous (4) Form 4 daughter cells (5) Two nuclear divisions

12. Cross over take place at.
    (1) Prophase l (2) Metaphase l (3) Prophase ll (4) Metaphase II (5) Interphase

13. Some of the steps of meiosis are shown below. Correct order is shown in
    (A) Form 4 daughter cells (B) Homologous chromosomes separate
    (C) Exchange of genetic materials (D) Replication of chromosomes (E) Pairing of homologous chromosome
    (1) A,C,B,E,A (2) D,B,C,E,A (3) D,C,B,E,A (4) D,E,C,B,A (5) D,B,E,C,A

14. Which of the following statements are incorrect regarding inter phase.
    (1) This is most prominent phase of a cell (2) Interphase is sub divided to 4 sub phases
    (3) DNA replication occurs during inter phase (4) Formation of cell organelles take place during inter phase (5) Duration of the interphase depend on cell type

15. If the amount of DNA in a sperm of an individual is 3.4×10^{-12}g, the amount of DNA in mature liver cell of this individual just before prophase would be.
    (1) 1.7×10^{-12} (2) 3.4×10^{-12} (3) 6.8×10^{-12} (4) 10.2×10^{-12} (5) 13.6×10^{-12} (A/L 1997)

16. Select the incorrect statement about mitosis.
    (1) Chromosomes can be observed through L.M. (2) Chromosomes can be stained with dyes
    (3) Homologous chromosomes pair (4) Chromosomes shorten (5) Results genetically similar cells

17. Which of the following statements regarding eukaryotic cell cycle is correct?
    (l) Crossing over takes place in metaphase of meiosis I.
    (2) Formation of chromatin occurs in G1 phase.
    (3) DNA replication occurs in G2 phase.
    (4) Nuclear envelope reforms during cytokinesis.
    (5) Formation of mitotic spindle begins in prophase. (A/L 2020/5)

AL/2013

3. (i) The major events/processes that take place in a nucleus of an eukaryotic cell during mitosis are given below. Put a X mark in the appropriate column in the table to indicate in which phase of mitosis each of the following events/processes occur.

	Interphase	Prophase	Pro-metaphase	Metaphase	Anaphase	Telophase
Chromosome condensation						
DNA replication						
Attachment of chromosomes to the spindle						
Movement of chromosomes towards the spindle poles						
Breakdown of nuclear membrane						
Alignment of chromosomes at the center of the cell						
Centromere separation						
Reformation of nuclear membrane						

Meiosis

1. Which of the following statement is correct regarding Meiosis?
   (1) Happens in prokaryotes. (2) Resulting daughter cells are genetically dissimilar
   (3) Homologous chromosome pairing happens in prophase II.
   (4) Replication of chromosomes happens at Prophase I.
   (5) Newly formed daughter at the end of meiosis l have half of the DNA compared to mother cell.

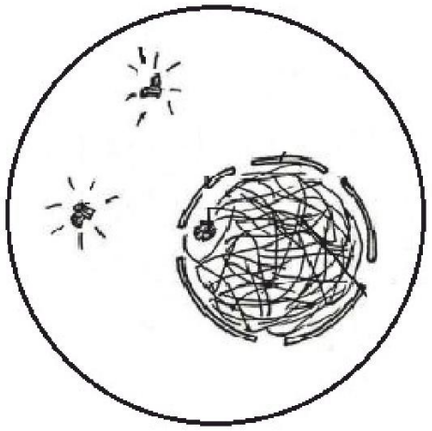
2. Meiosis takes place in,
   (1) Cambium (2) Cortex (3) Pith (4) Leaf buds (5) Anther

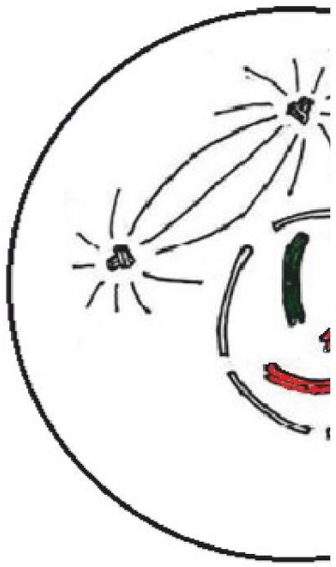
3. Absent in Meiosis,
   (1) Pairing of heterologous chromosomes (2) Segregation of homologous chromosomes
   (3) Crossover (4) Synapse (5) Chromosomes become chromatids

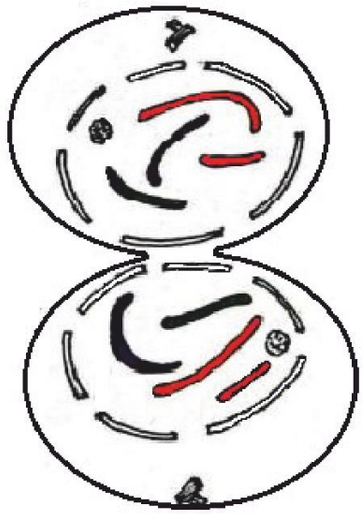
4. Most important step in Meiosis is,
   (1) Separation of chromatids (2) Homologous chromosome pairing and separation.
   (3) Formation of the spindle apparatus (4) Dissociation of the nuclear envelope
   (5) Formation of daughter cells

5. Longest phase of the Meiosis.
   (1) Prophase I (2) Metaphase I (3) Anaphase I (4) Telophase I (5) Telophase 11

chromatids attached at the ……... Chromosomal arms of sister chromatids attached by special proteins called …….. The formation of mitotic spindles begins. Spindle is formed by accumulated …….. complex which includes the …….. the spindle microtubules and the aster. Centrosomes move toward opposite poles of the cell due to the lengthening of microtubules between them. Centrosomes or centrioles are not available in plant cells. However, spindle is formed during cell division from …….. …….. complex.



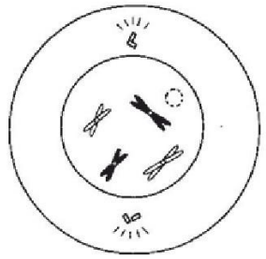


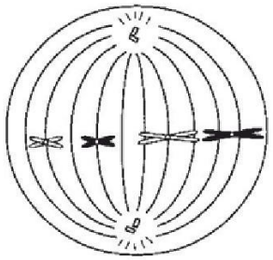


AL/2001

1. (ii) Figures P and Q show two stages of mitosis. Name these stages and write below three major events taking place during each of these stages.

P - ..... Q - .....





Changes occur at P	Changes occur at Q

(iii) State the significance of mitosis.

.....

.....

.....

AL/2004

2. (i) Name the *5* phases of mitosis and state main changes occur during phase.

Phase	Changes
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....

MCQ

1. What is the best property that a dividing cell should posses?
   (1) Live (2) Store food (3) Nucleic Acids (4) Cell wall (5) Intercellular space

2. Which of the following process is not permitted during Mitotic cell cycle?
   (1) Mutation (2) Crossover (3) DNA replication (4) Protein synthesis (5) Aerobic respiration

3. Mitosis is absent in,
   (1) Cambium (2) Parenchyma cells (3) Collenchyma cells (4) Sclerenchyma cells (5) Epidermal cells

4. Which is the least important structure for plant cell division?
   (1) Chromosomes (2) Plasma membrane (3) Golgi body (4) ATP (5) Centrioles

5. What is the most suited tissue to observe the stages of Mitosis
   (1) Root tip cells (2) Cells in ovary (3) Leaf cells (4) Stigmas (5) Secondary xylem cells

6. DNA replication occurs at,
   (1) Prophase (2) Metaphase (3) Anaphase (4) lnterphase (5) Telophase

7. Mitochondria replication occurs at,
   (1) Prophase (2) Metaphase (3) Anaphase (4) Interphase (5) Telophase

9. Which of the following is absent in a dividing cell.
   (1) Water (2) Cellulose (3) Lignin (4) Stored food (5) Enzymes

10. What is the phase of replication of nuclear DNA
    (1) Prophase (2) Metaphase (3) Anaphase (4) Telophase (5) Inter phase

11. Number of chromosome pairs of a cell is 10. How many chormatids present at the stage of disappearance of nuclear envelope during mitosis.
    (1) 00 (2) 05 (3) 10 (4) 20 (5) 40

12. During cell division
    (1) DNA replicate during prophase (2) Some spindle fibers are attached to centomere
    (3) Dividing plate is parallel to the plane of the spindle
    (4) Before the replication of centrioles chromosomes appear (5) All cell organelle replicate

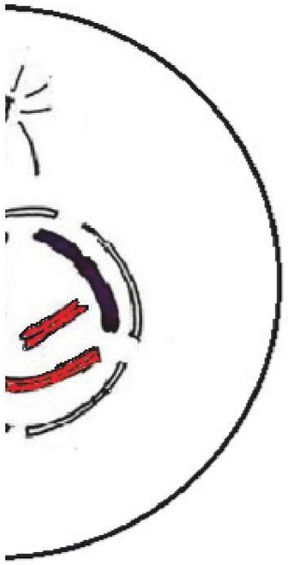
13. What is the characteristic feature of metaphase of mitosis?
    (1) Migration of chromosomes to opposite poles (2) Shortening of chromosomes
    (3) Replication of chromosomes (4) Arrangement of chromosomes on metaphase plate
    (5) Disappearance of nucleus

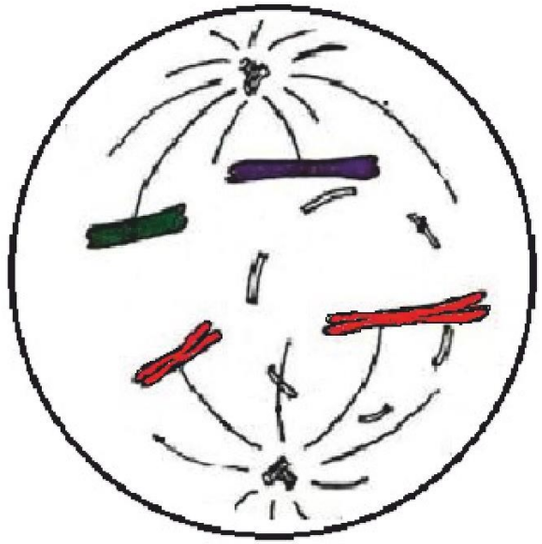
14. Replication of DNA in Mitosis takes place.
    (1) Prophase (2) Metaphase (3) Anaphase (4) Telophase (5) Inter phase

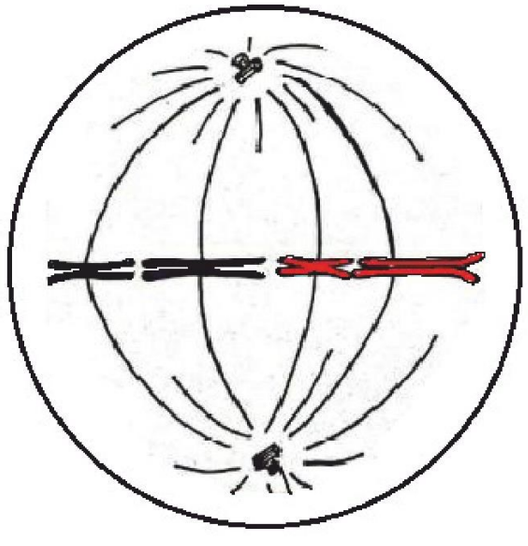
15. What is the best phase of mitosis to count the number of chromosomes?
    (1) Prophase (2) Metaphase (3) Anaphase (4) Telophase (5) Inter phase

16. In mitosis, the movement of chromosomes from the equatorial plane to the poles occur during
    (1) prophase. (2) metaphase. (3) anaphase. (4) telophase (5) interphase.

17. Which of the following stages of the cell cycle is seen in the diagram given below?
    (1) Anaphase (2) Prophase (3) Metaphase (4) Telophase (5) Interphase







2. Prometaphase

- The …….. ……. fragments. Chromosomes get even …….. condensed. A special protein called …… attaches the sister chromatids of each chromosome at their centromere. Some of the microtubules that attach to the kinetochore of the chromosomes move the chromosomes back and forth. Microtubules which are …….. ……. to the kinetochore interact with those from the opposite poles.

3. Metaphase

- Centrosomes reach the ……. …….... The chromosomes have arrived to a place called ……. plate which is located in equal distance from each pole. The ……. of all chromosomes are located in the metaphase plate. At the end of this phase. each chromosome of the cell get ……. to the kinetochore microtubule at their centromere and aligned at the metaphase plate.

4. Anaphase

- Sister chromatids are …….. at the centromere. Microtubules attached to kinetochore get ……. and pull sister chromatids towards the opposite poles. Cell elongates as the non kinetochore microtubules are …….. By the end of anaphase equal and complete set of chromosomes found at each pole of the cell.

5. Telophase

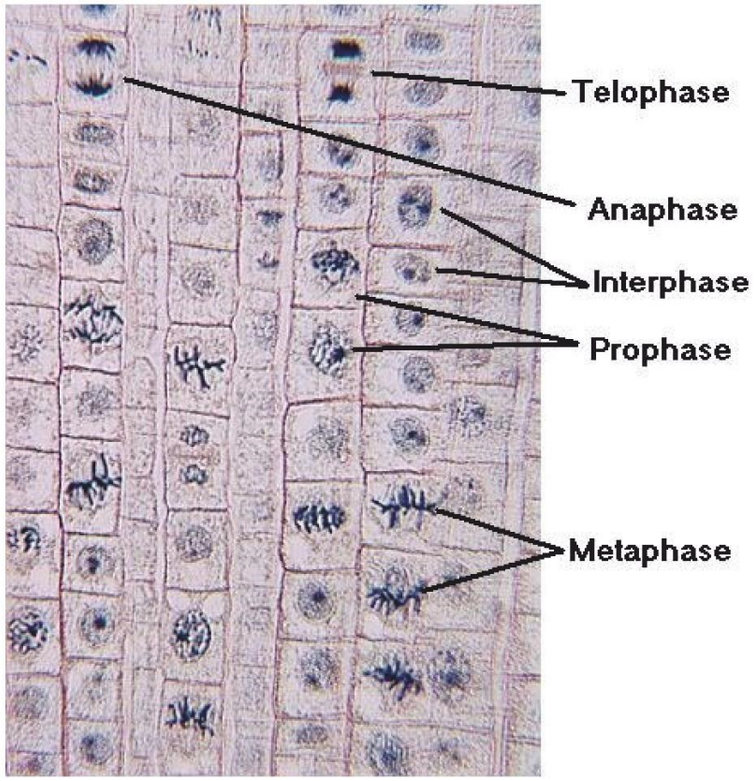
- Nuclear envelope …….. around each set of chromosomes at opposite poles. ……. reappears. Spindle microtubules get …….. Chromosomes unwind and become less condense to form ……... Two genetically identical daughter ……... are formed.

II. Cytokinesis

- The division of the cytoplasm starts at the end of the telophase. Therefore at the end of the mitosis two genetically identical …….. cells are produced. In animal cells- a cleavage ……. …….. This produces two genetically identical daughter cells.
- In plant cells— …… ……. forms as a result of vesicle produced by ……..... …….. This divides the cytoplasm in to two and generates two genetically identical daughter cells to the parent cell.

Instructions

- Let the students observe each of the slides under low, medium and high powers of the microscope respectively.
- Ask them to identify the cells which show the main stages of mitosis and meiosis using the positions and shapes of the chromosomes.
- Direct students to identify, carefully the various positions and shapes of the chromosomes and the changes that take place.
- Direct students to draw the observed stages of mitosis and meiosis in correct sequence.
- Assist students to describe major events of cells undergoing mitosis and meiosis using computer animations.



PRACTICAL NO.4

Identification of different stages of mitosis and meiosis using microscopic slides

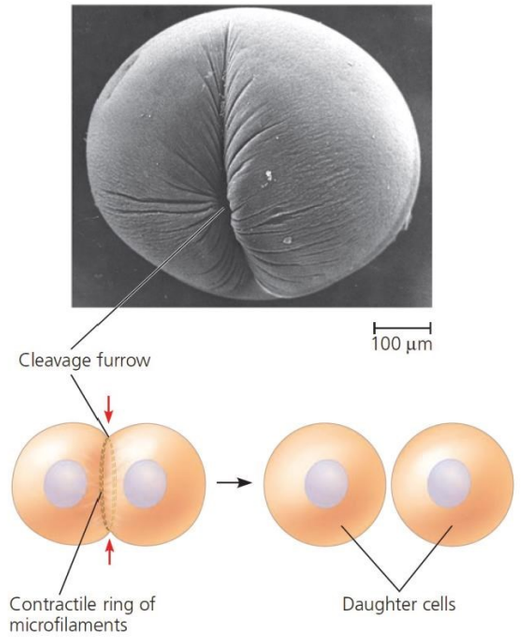
Objectives

- Students should be able to

1. identify the major/main stages of cells in the process of mitosis and meiosis,
2. observe and record the behavior of chromosomes during the two types of cell division,
3. state the observable differences between mitosis and meiosis from their microscopic observations.

Materials and equipment

- Light microscope
- Onion root tips (permanent/ temporary slides) for studying mitosis
- Anther of Rhoeo/Tradescantia (permanent/ temporary slides) for studying meiosis
- Computer animations



Significances of mitosis

1. .....
2. .....
3. .....
4. .....

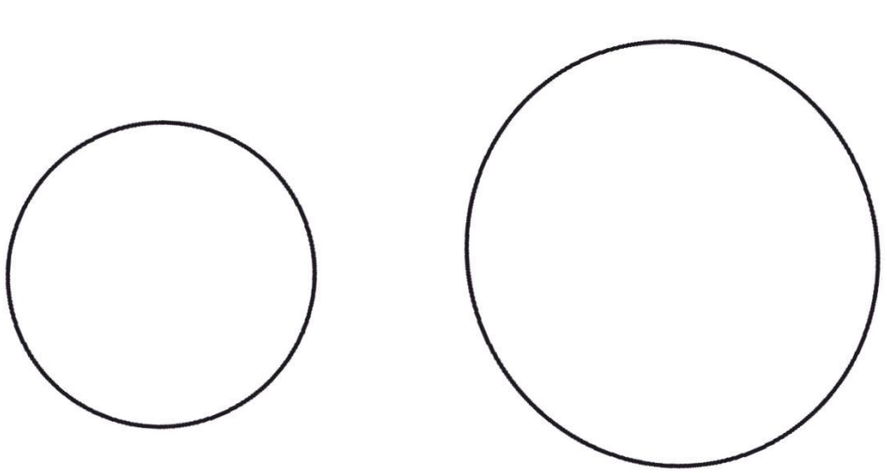
Meiosis

- Sexually reproducing organisms undergo different type of cell division called meiosis.
  ……
  ……....
  Meiosis involves two consecutive nuclear divisions, Meiosis I and Meiosis II.
- Meiosis I is a ……. …….. and Meiosis II is …….. to ……..., each stage consists of four sub phases: ……..., ……..., ……..., and …….... Before meiosis one cell is in interphase, during ……... phase of the interphase DNA replication occur. (refer interphase of mitosis)

Meiosis I

1. Prophase I

- Cell enters to the prophase from interphase. Chromosomes begin to ……... Nucleolus begins to …….. Next the formation of ……... like structure called the …….. complex by a specific proteins holds two ……... tightly together. The …….. and physical connection of homologous chromosomes is called ……... During synapsis part of the DNA molecule of ……. chromatids paired homologous chromosomes ……..., …….. and ……. at corresponding point.



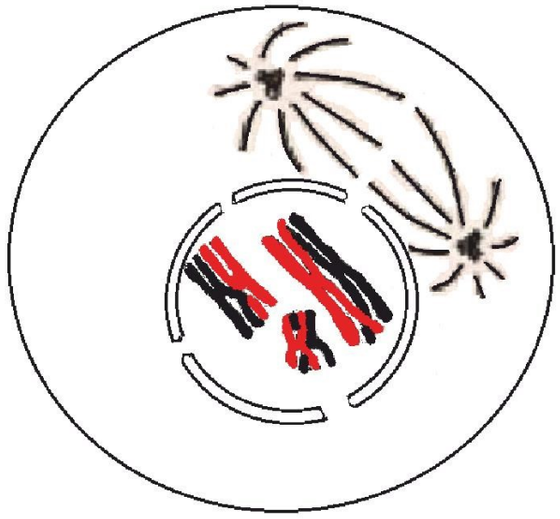
Tumor, cancer and galls

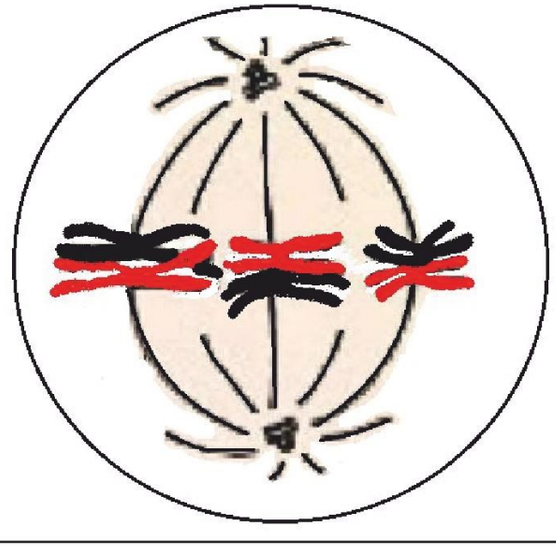
- Cell division is driven by external and internal factors. They may be chemical or physical factors
- Cancer cells do not respond normally to the body's control mechanism
- They divide excessively and invade other tissues. If unchecked they can kill the organism.
- Cancer cells do not consider the normal signals that regulate the cell cycle.
- They do not need growth factors. They may make required growth factors themselves or giving signals to continue cell cycle without growth factors.
- They possess an abnormal cell cycle control system.
- The problem begins when a single cell in a tissue undergoes transformation, the process converts a normal cell to abnormal cell.
- If the body immune system can not recognize and destroy it, it may leads to proliferation of cells and formation of a tumor.
- If the abnormal cells remain at the original site, the lump is called benign tumor. Most benign tumors do not cause serious problems and can be completely removed by a surgery.
- A malignant tumor becomes invasive and attack one or more organs. An individual with a malignant tumor is said to have a cancer.
- A few tumor cells may separate from the original tumor, enter blood vessels or lymph vessels and travel to other parts of the body. They may proliferate and form a new tumor.
- This spread of cancer cells to locations distant from their original site is called metastasis.

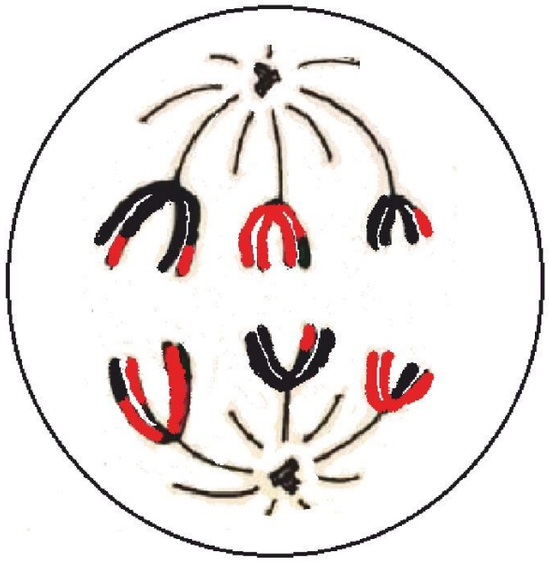
Galls in plants

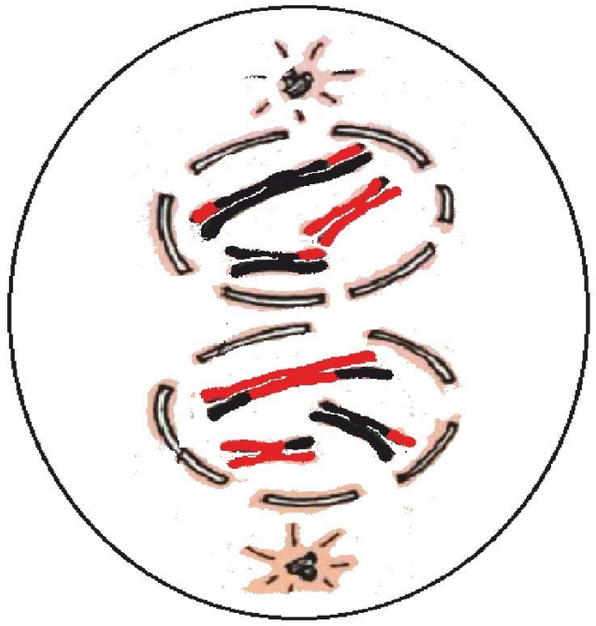
- This occurs due to uncontrolled mitotic division of plant cell.
- The plant cell division is controlled by maintaining a proper balance between plant growth regulators such as auxins and cytokinins. When this balance is lost plant cells produce undifferentiated mass of cells.
- Galls are the bumps and growths that develop on different parts of plants after being invaded by some very unique organisms.
- Galls have range of causes, including viruses, fungi, bacteria, insects and mites.
- Usually the gall causers in some way attack or penetrate the plants growing tissues and causes the host to reorganize its cells and to develop an abnormal growth.

- This process is called …….. These points of crossing over become visible as ……...after the ……..…. complex disassembles and the homologous chromosomes slightly apart from each other. Nuclear envelop breaks. …….. move towards opposite poles forming spindle in animal cells. The kinetochore of each homologue attach to microtubule from one pole or the other. The homologous pair then moves toward the metaphase plate.









Significance of meiosis

- Maintains the constant number of chromosomes through generations in sexually reproducing species.
- Produces new genetic variations leading to evolution.
- Genetic variation occurs due to crossing over ,recombination and independent assortment.

Meiosis II

1. Prophase II

- Centrosomes start producing spindle apparatus (spindle fibers, aster centrosome). Chromatin fibers condense and produce chromosomes with two sister chromatids. Nuclear envelope breaks down into fragments. Nucleolus disappears. During the late prophase II centromere of the chromosomes are moved to the metaphase II plate.

1. Metaphase II

- All Chromosomes get attached to the microtubules at their centromere and aligned on the metaphase plate. Kinetochores of sister chromatids are attached to microtubules extending from both poles. Due to the crossing over in meiosis I, the two sister chromatids of each chromosome are not genetically identical. Meiosis II usually takes place in the perpendicular direction of Meiosis I. Therefore, metaphase plate of meiosis II is perpendicular to the metaphase plate of meiosis I.

Anaphase II

- Due to the breakdown of proteins attaching sister chromatids, they are separated at centromere. As a result of shortening of microtubules , sister chromatids of each chromosome move towards opposite poles

4. Telophase II

- Nuclear envelope and nucleolus reform. Chromosomes decondense into chromatin. Spindle disassembles. Genetically non identical, haploid, four daughter nuclei are formed from one parent cell.

Cytokinesis

- Cytokinesis occurs as in mitosis. Genetically non identical, haploid, four daughter cells are formed. These four daughter cells are not even identical to their parent cell

2. Metaphase I

- The pair of homologous chromosomes get arranged on the metaphase plate with one chromosome of each pair faces each pole. Both chromatids of a ……. are attached to kinetochore microtubules from one pole and those of the other homolog are attached to kinetochore microtubules from the opposite pole. Homologous chromosomes arrange ……. at metaphase plate.

3. Anaphase I

- Kinetochore microtubules of the spindle get ……... Homologous pair separates and one chromosome of each pair moves towards the opposite pole. ……. ……... of each chromosome ……. attached at the centromere and move as a single unit towards the same pole.

3. Telophase I

- One complete haploid set of chromosomes accumulate at each pole. Nuclear envelope reforms around each set of chromosomes. Nucleoli reappear. Spindle disintegrates. Chromosomes decondensed into chromatin. Genetically non identical, haploid, two daughter nuclei are formed within one cell.

Cytokinesis

- Usually occurs simultaneously with telophase I. Genetically non identical, haploid, two daughter cells are formed. In animal cells, cleavage furrow is formed. In plant cells a cell plate is formed. No DNA replication occurs between meiosis I and meiosis II