BIOLOGY

Sindh Textbook board CLASS 9th Notes

Chapter #5 Cell Cycle

Cell Cycle Chapter 5 biology

Q1: What is cell cycle? Describe various phases of interphase of cell cycle with diagram.
Ans: Cell cycle:
The Serious of events that take place in a eukaryotic cell leading to its division is called cell cycle.

Periods of cell cycle:
There are two broad periods of cell cycle
A. Interphase
B. M-Phase (division phase)

I-Interphase:
The period between the end of one mitosis and the start of next mitosis is called interphase. Typically, interphase lasts for at least 90% of the total time required for the cell cycle therefore interphase is called the longest phase/ resting phase/ or growth phase of the cell cycle.

Sub Phase of interphase: -
Interphase has three sub phases.

i. G_1-Phase:
It is the first sub phase of interphase.

Main events:
- In this phase newly produced cells grow in size.
- Internal chemical changes occur in cell.
- Internal chemical changes prepare the daughter cells for DNA replication.
- tRNA and mRNA are synthesized
- Ribosome and several enzymes are synthesized in G_1 Phase.

ii. S-Phase (S-Synthesis):
It is the second phase of interphase

Main events:
- Cell growth continues throughout S-phase.
- The replication of DNA occurs during this phase.
- Both strands of DNA must replicate and new complementary strands are synthesized.
- Once DNA replication is completed the chromosome become duplicated and the cell become ready to enter the next phase called G_2-Phase.

iii. G_2-Phase: -
The gap between the end of S-phase and the start of M-Phase is called G_2 Phase.

Main events:
- Preparation of protein takes place which are essential for next phase (M-Phase) mainly for the formation of spindle fibers.
- Centriole replicate and move to the either end of the nucleus. It indicates the end of interphase.

G_0 Phase:
Cells that have temporarily or permanently stopped dividing called **G_0** Phase.

Q2: Define Mitosis? Describe various stages of mitosis in detail?
Ans: Mitosis:
History:

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A German Biologist Walther Fleming in the 1880s gave the detailed account of the stages of cell division. He observed that in a dividing cell the nucleus passes through a serious of changes which he called mitosis.

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Stage of mitosis:

The process of mitosis can be divided into two main stages.

A. Karyokinesis:

It is the division of the nucleus. “Karyo” means nucleus and “kinesis” mean division.

B. Cytokinesis:

It is the division of cytoplasm. “cyto” mean cell and “kinesis” mean division.

Various phases of Karyokinesis:

I. Prophase:

Main events:

i. Condensation of chromatin network occurs and thread like chromosomes appear.
ii. Each chromosome consists of two chromatids attached with each other at centromere.
iii. Nuclear membrane disappears.
iv. Centrioles move to the opposite poles.
v. Three sets of spindles fibers arise from each centriole.

a. Astral microtubules:

Microtubules radiate outward and form star shaped structure called aster.

b. Kinetochore Microtubules:

Kinetochore microtubules are attached to the kinetochore of chromosome.

c. Polar microtubules:

Polar microtubules arise from one pole and come in contact with the microtubules of other poles.

ii. Metaphase:

Main events:

i. During this phase chromosomes arranged itself at the center of cell to form line of chromosome called metaphase plate or equatorial plate.
ii. Two spindle fibers from both sides attach with one chromosome.

iii. Anaphase:

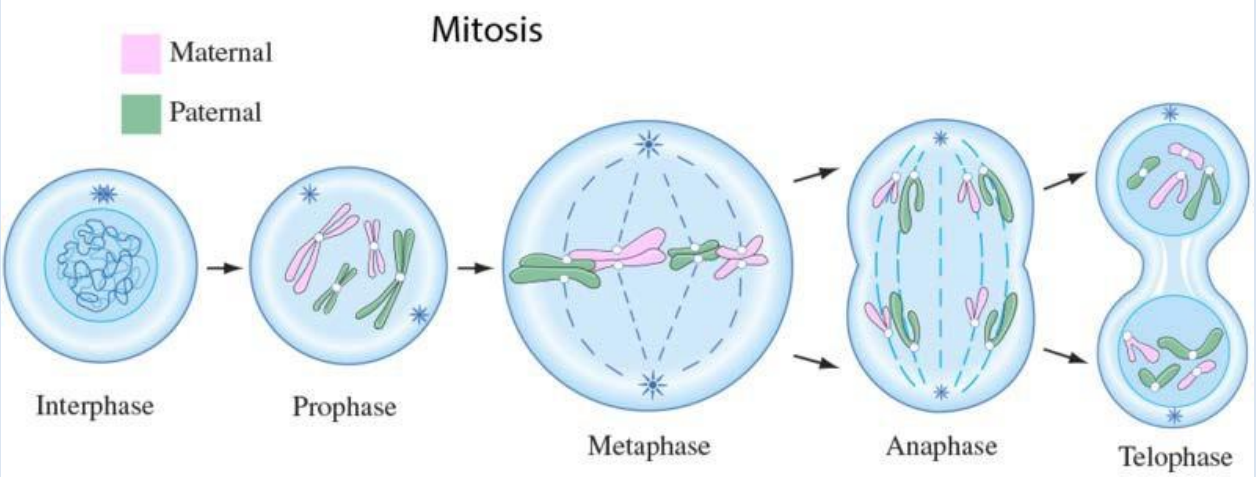
Main events:

i. The centromere of each chromosome splits into two parts.
ii. The spindle fibers contract and they pull the chromatids (daughter chromosomes) towards their respective pole.
iii. Cytokinesis begins in anaphase.

vi . Telophase:

Main events:

i. In telophase, spindle fibers breakdown.
ii. Chromosomes reach to the respective pole.
iii. Chromosomes uncoil to become thin chromatin networks.
iv. Two daughter nuclei are formed, each with the same number of chromosomes as were present in the parent nucleus.



Q3: Define Cytokinesis? Write the mechanism of cytokinesis in animal and plant cells?
Ans: Cytokinesis in animal's cell:
Mechanism:
The plasma membrane in the center of the cell folds inward. This fold deepens and extends the entire equatorial plate and divides the parent cell into daughter cells.
Cytokinesis in plants.
Mechanism:
In plant cells during cytokinesis vesicles derived from the Golgi bodies move to the middle of the cell and fuse to form a membrane bounded disc called the cell plate or phragmoplast. The plate grows outwards and more vesicles fuse with it. Finally, the membrane of the cell plate fuses with the plasma membrane and then to the cell wall this result two daughter cells. Each bounded by its own plasma membrane and cell wall.
Q4: Write the significance of Mitosis?
Ans: Significance of mitosis:
Importance of mitosis is the maintenance of the chromosomal set.
Following are the occasions in the life of organisms where mitosis happens.
i. Development and Growth:
The number of cells within on organism increases by mitosis and this is the basis of development from a single cell zygote to the multicellular body and the growth.
ii. Cell replacement:
Mitosis ensures proper replacement of lost cells by new cells. For example, each time you brush your teeth and rinse your mouth, hundreds of dead and worn-out cheek cells are being shed into your saliva. These dead cells are constantly being replaced by the process of mitosis.
iii. Regeneration:
It is the process of the renewal of organism or the worn-out cells and tissues. For example, Regeneration of tail in lizard. Other organisms have the ability to regenerate the whole body from a piece of the body, e.g. hydra.

iv. Healing of wound.
Mitosis is also responsible for the healing of wound.
v. Asexual reproduction in plant:
Some plants reproduce through asexual reproduction. Asexual reproducing in plants occurs due to mitosis.
Example:
- In plants cutting, grafting, budding etc.
- In animals' hydra reproduce asexually by budding.

Q5: Define Meiosis? Write the various stages of Meiosis.

Meiosis:

History:

Meiosis was discovered in 1876, by a German biologist Oscar Hartwig.

Definition:

The type of cell division during which a single parent cell divides to form four daughter cells and each daughter cell have half number of chromosomes as parent cell is called meiosis.
It is also called reduction division as the diploid number of chromosomes (2n) are reduced to haploid (n).

Stage of meiosis:

There are two stage of meiosis,

A. Meiosis I
B. Meiosis II

Various phases of Meiosis I:

Prophase I:

Main events:

i. Prophase 1 usually accounts for 90% of the total time spent in meiosis.
ii. In this phase chromatin materials condenses and chromosomes become visible.
iii. Homologous chromosomes from pairs. The paring of homologous chromosome is called synapsis.
iv. Each pair is called tetrad because each pair has four chromatids.
v. They are also called bivalent because each pair has two chromosomes.
vi. The two non-sister chromatids of homologous chromosomes become zipped together, forming complexes known as chiasmata.
vii. At the chiasmata, the non-sister chromatids exchange their parts called crossing over.
viii. Centrioles migrate to opposite poles and make spindle fibers.

Metaphase I:

Main events:

i. The homologous chromosomes form a line called metaphase plate or equatorial plate.
ii. Spindle fibers from one pole of the cell attaches to one chromosomes of each pair while from the opposite pole attach to other chromosome of the homologous pair.

Anaphase I:

Main events:

i. During anaphase I spindle fibers shorten and they pull the homologous chromosomes.
ii. Chromosomes separate and move toward opposite poles of the cell.
iii. One haploid set of chromosomes is formed at each pole.

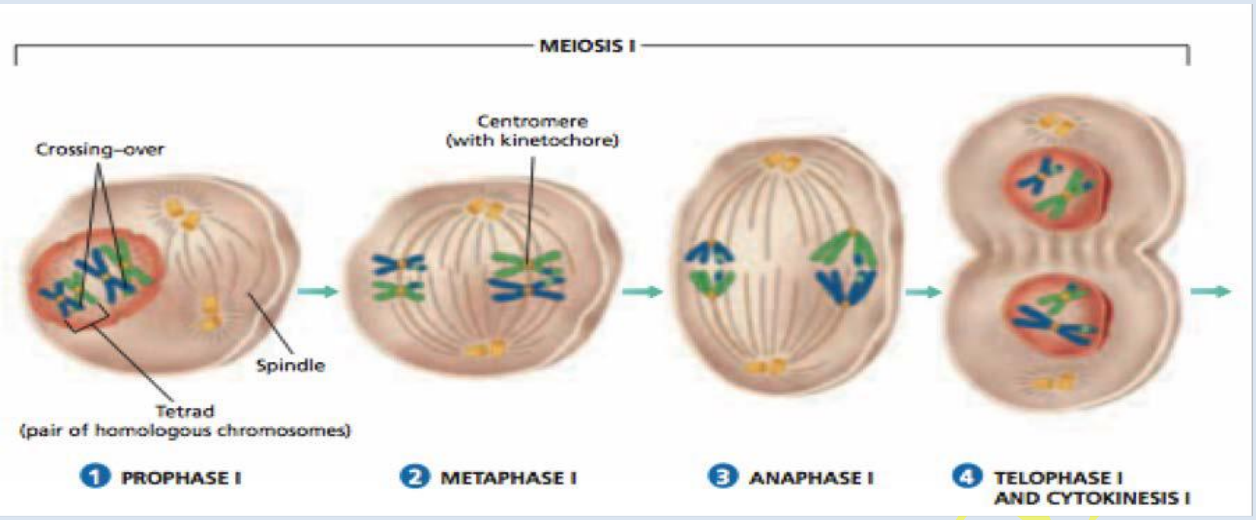
Telophase I.

Main events.

i. Nuclear membrane and nucleoli reappears around each set of chromosomes.
ii. Cytoplasm divides to form two daughter cells.
iii. Each daughter cell has haploid number of chromosomes.

Cytokinesis.

The division of cytoplasm occurs and they form two daughter haploid cells.



Meiosis II:

It is the second part of the meiotic division process. Much of this part is similar to mitosis. However, it differs from mitosis is that, parent cells have haploid numbers of chromosomes and the daughter cells also receive haploid number.

Meiosis II is divided into.

i. Prophase II:

Main events:

- The chromosomes which are already visible become more prominent.
- Each chromosome has two chromatids and centromere.
- Centrioles move to opposite poles and make Spindle Fibers.

ii. Metaphase II:

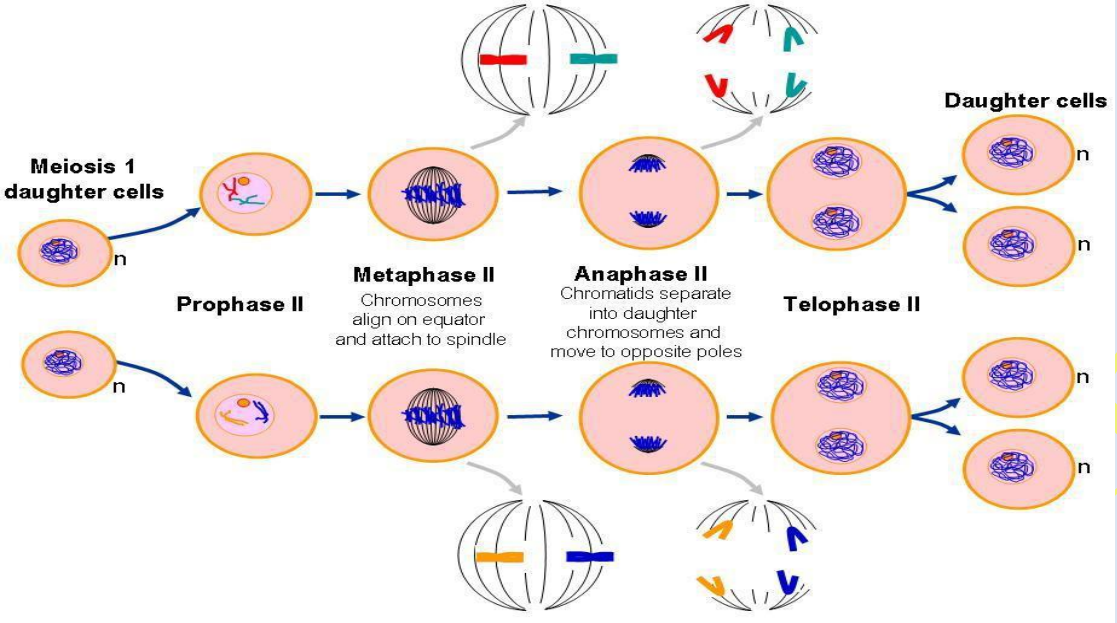
- Chromosomes form a line in the center of cell called metaphase plate or equatorial plate.

iii. Anaphase II:

- Centromere of each chromosome spilt.
- The spindle fibers contract and they pull the chromatids towards respective pole.

vi. Telophase II

- Chromatids reach to their respective poles.
- Nuclei and Nuclear membrane reappear.
- Completion of Cytokinesis occurs in telophase II.
- After the division of cytoplasm four daughter haploid cells are formed.



Q6: What is the significance of meiosis?

Ans: Significance of meiosis:

1-Gametes formation:

Meiosis helps in the formation of male gametes (sperms) and female gametes (ova or eggs)

Animals: -

In animals, the parent cells with diploid number of chromosomes undergo meiosis to produce haploid gametes. The male and female gametes fuse together and make a zygote with diploid number. The zygote undergoes mitosis and develops a new diploid organism.

Plants:

In plants, the spore-mother cells undergo meiosis to make haploid spores. These spores grow into haploid structure which produces haploid gametes by mitosis. The gametes combine to produce the diploid zygote.

The zygote undergoes repeated mitosis to become the diploid plants.

3-Maintain constant number of chromosomes: -

Meiosis maintains constant number of chromosomes in zygote by the union of haploid sperms and haploid egg during sexual reproduction.

4-Genetic variation:

Meiosis helps to create genetic variation among offspring. This variation occurs in chromosomes during genetic recombination.

Q7: Write note on apoptosis and Necrosis?

Ans: i. Apoptosis:

Apoptosis is also called programmed cell death (PCD).

Mechanism:

During apoptosis the cell spilt into small membrane bounded bodies known as apoptotic bodies. Apoptotic bodies cannot damage neighbouring cell. It cannot cause inflammation in neighbouring cells. These apoptotic bodies are engulfed by the neighbouring cells.

Example:

i. Disappearance of tadpole tail during metamorphosis.

ii. Disappearance of web present in human hand and formation of fingers.

iii. In the adult organism, the number of cells is kept relatively constant through apoptosis and division.

ii. Necrosis:

It is also called accidental cell death.

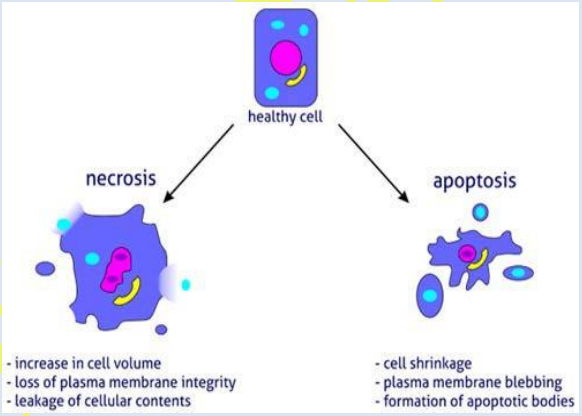
Mechanism:

Necrosis is accompanied by the release of special enzymes from the lysosomes. The lysosomal enzymes break cellular components and may also be released outside the cell to break other surrounding cells. Cells that die by necrosis may also release harmful chemicals that damage other cells.

Causes:

Some physical and chemical events which because necrosis is

i . Radiation
ii. Heat
iii.Trauma
iv.Lack of oxygen
v.Blockage of blood flow etc.



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SHORT QUESTIONS

B. Write short Answer of the following Questions.

Q1: Define cell cycle and how may phases it is divided?

Ans: It is a serious of events that take place in a cell leading to its division and duplication. Cell cycle is divided into two periods.

I. Interphase

It is further divided into three sub-phases.

i. G_1 - Phase
ii. S - Phase
iii. G_2 - Phase

II. Division phase:

In this phase the parent cell divides into two daughter cells.

i. Prophase
ii. Metaphase
iii. Anaphase
iv. Telophase

Q2: In which type of cell, meiosis take place and why it is important?

Ans: Meiosis takes place in germ cells or gametes. It involves reduction in numbers of chromosome. This helps to maintain the chromosome number constant generation after generation. Also reshuffling of genetic material takes place during crossing over in meiosis that lead to variation and serve as raw material for evolution.

Q3: How does normal mitosis ensures normal life?

Ans: Normal mitosis ensures normal life because

i. Mitosis ensures the exact transmission of daughter cells.
ii. When mitosis occurs in normal way growth of organism take place.
iii. Mitosis helps in healing of wounds.
iv. Daughter cells formed by mitosis receive same genetic materials as in parent cell.
v. When each cell has normal number of chromosomes, they perform normal life functions.
vi. Regeneration of lost body parts in same animals and vegetative reproduction in plants occurs by mitosis.

Q4: Give at least four differences between mitosis and meiosis?

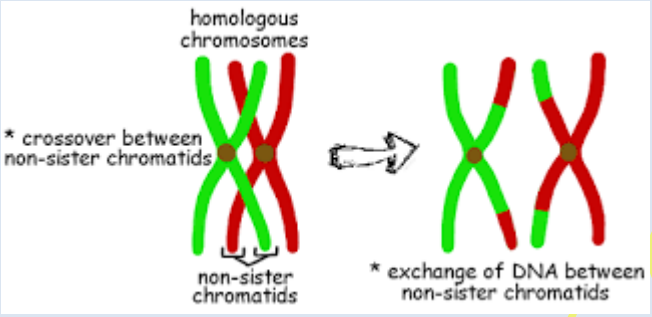
Ans: Difference between mitosis and meiosis;

No	Mitosis	Meiosis
1	The process of mitosis occurs in somatic cells.	The process of meiosis occurs in sex cell or gametes.
2	It produces two daughter cells	It produces four daughter cells
3	The daughter cells receive same number of chromosomes from parent cell	The daughter cells receive half number of chromosomes from their parent cell.
4	Pairing of homologous chromosomes does not occur in mitosis	Pairing of homologous chromosomes occur in meiosis

5	Crossing over does not occur in mitosis	Crossing over occur in meiosis.

Q5: What is chiasma and what is its role in crossing over?
Ans: The point at which two non-sister chromatids of a homologous chromosomes exchange their segments is called chiasma.

At chiasma, the non-sister chromatids of homologous chromosomes exchange their parts. This process is called crossing overs which result in genetic variation.



Long Question

C. Give detailed Answers to the following Question.

Q1: Describe various phases of interphase of cell cycle with diagrams.
Ans: See Q No. 1

Q2: Discuss different events of Meiosis-I with the help of diagram?
Ans: See Q No. 5

Q3: Explain different stages of mitosis with diagrams and at what stage, cytokinesis take place?
Ans: See Q.No 2

Understanding The Concepts

Q.1) What is cell cycle and what are its main phases ?

Answer:
Cell Cycle:

"Cell cycle is the series of events from the time a cell is produced until it completes mitosis and produces new cells".

Main phases of cell cycle:

Cell cycle consists of two major phases i.e.

1) Interphase
2) Mitotic phase (M phase)

1) Interphase:

Interphase is the time when a cell's metabolic activity is very high, as it performs its various functions. It is divided into three phases:

i) G1 (first gap)

ii) S (synthesis)
iii) G2 (second gap)

i) G1 phase:

After its production, a cell starts its cell cycle in the G1 phase. During this phase, cell increases its supply of proteins, increases its supply of proteins, increases the number of organelles (such as mitochondria, ribosomes) and grows in size. This phase is also marked by the synthesis of various enzymes that are required in the next phase i.e. S- phase for the duplication of chromosomes.

ii) S phase:

In this phase, the cell duplicates its chromosomes. As a result, each chromosome consists of two sister chromatids.

iii) G2 phase:

In the G2 phase, cell prepares proteins that are essential for mitosis, mainly for the production of spindle fibers. After the G2 phase of interphase, the cell enters the division phase i.e. M phase. It is characterized by mitosis, in which cell divides into the two daughter cells.

Go Phase:

"Cells that have temporarily or permanently stopped dividing are said to have entered a state of quiescence, called Go phase".

In multicellular eukaryotes, cells enter Go phase from G1 and stop dividing. Some cells remain in Go for an indefinite period e.g. neurons. Some cells enter Go phase semi-permanently e.g. some cells of liver and kidney. Many cells do not enter Go and continue to divide throughout an organism's life, e.g. epithelial cells.

2) Mitotic phase:

Mitotic phase is a relatively short period of the cell cycle. It alternates with the much longer interphase, where cell prepares itself for the division.

Q.2) The S-phase of interphase is important and a cell can never divide without it. Justify.

Answer:

Mitosis is the type of cell division in which a cell divides into two daughter cells, each with the same number of chromosomes as were present in the parent cell. Because each resultant daughter cell should be genetically identical to the parent cell, the parent cell must make a copy of each chromosome before mitosis. This occurs during the S phase of interphase.

The S-phase is known as the replication phase of the cell cycle. During this phase, the cell's genetic material or 'DNA' is copied. Since the DNA contains all of the information that a cell needs to produce essential materials, like proteins and enzymes, a cell can never divide without first going through this phase. DNA must be duplicated in the S-phase before cell division occurs. If not, the result will be 2 daughter cells with missing/un-equal amounts of genetic information. Consequently, the daughter cells will not be able to function properly and are likely to succumb to apoptosis (programmed cell death).

Q.3) How would you state the events of prophase of mitosis?

Answer:

Prophase:

Prophase is the first stage in mitosis and starts after the completion of interphase. Normally, the genetic material in the nucleus is in a loose thread-like form called chromatin.

Condensation of chromatin:

At the onset of prophase, chromatin condenses into highly ordered structures called

chromosomes.

Structure of the chromosome:

Since the genetic material has already been duplicated earlier in S phase, each chromosome is made of two sister chromatids, bound together at the same centromere. Each chromosome also has a kinetochore at the centromere. The kinetochore is a complex protein structure that is the point where spindle fibers attach.

Duplication of centrioles and spindle formation:

There are two centrioles (collectively called a centrosome) close to the nucleus. Each centriole duplicates and thus two daughter centrosomes are formed. Both centrosomes migrate to the opposite poles of the cell. Here, they give rise to microtubules by joining tubulin proteins present in the cytoplasm. The microtubules thus formed are called spindle fibers. Complete set of spindle fibers is known as mitotic spindle.

Degradation of nuclear envelop:

By this time, nucleolus and nuclear envelope have degraded, and spindle fibers have invaded the central space.

Prophase in plants:

In highly vacuolated plant cells, the nucleus has to migrate to the center of the cell before prophase. The cells of plants lack centrioles. So, spindle fibers are formed by the aggregation of tubulin proteins on the surface of the nuclear envelope during prophase.

Prophase in prokaryotes:

Prokaryotes do not have a proper nucleus and do not form spindles during division. That is why their division is not called mitosis.

Q.4) Make a list of the events of mitosis.

Answer:

Events of mitosis:

The process of mitosis is complex and highly regulated. There are two major phases:

1. Karyokinesis-the division of nucleus
2. Cytokinesis-the division of cytoplasm

Karyokinesis is further divided into four phases:

i. Prophase
ii. Metaphase
iii. Anaphase
iv. Telophase

Q.5) How is mitosis significant?

Answer:

Significance of mitosis:

Importance of mitosis is the maintenance of chromosomal set i.e. each daughter cell receives chromosomes that are alike in composition and equal in number to the chromosomes of the parent cell.

Following are the occasions in the lives of organisms where mitosis happens:

1) Development and growth:

The number of cells within an organism increase by mitosis. This is the basis of the development of a multicellular body from a single cell i.e. zygote and also the basis of the growth of the multicellular body.

2) Cell replacement:

In some parts of the body, e.g. skin and digestive tract, cells are constantly sloughed off and

replaced by new ones. New cells are formed by mitosis and so are exact copies of the cells being replaced. Similarly, red blood cells have a short lifespan (about 4 months) and new red blood cells are formed by mitosis.

3) Regeneration:

Some organisms can regenerate parts of their bodies. The production of new cells is achieved by mitosis. For example, sea star regenerates its lost arm through mitosis.

4) Asexual reproduction:

Some organisms produce genetically similar offspring through asexual reproduction. Mitosis is a means of asexual reproduction. For example, hydra reproduces asexually by budding. The cells at the surface of hydra undergo mitosis and form a mass called bud. Mitosis continues in the cells of bud and it grows into a new individual. The same division happens during asexual reproduction (vegetative propagation) in plants.

.6) Describe the events that occur during the phases of meiosis-I.

Answer:

Phases of Meiosis I:

In meiosis I, the homologous chromosomes in a diploid cell separate and so two haploid daughter cells are produced. It is the step in meiosis that generates genetic variations. Meiosis I occurs in two main steps:

1) Karyokinesis
2) Cytokinesis.

1) Karyokinesis of Meiosis I:

The karyokinesis of Meiosis I is subdivided into:

i) Prophase I
ii) Metaphase I
iii) Anaphase I
iv) Telophase I

i) Prophase I:

Prophase I is the longest phase in meiosis. During this stage, chromatin condenses into chromosomes.

Synapsis:

The homologous chromosomes line up with each other and form pairs by a process called synapsis.

Bivalent:

Each pair of homologous chromosomes is called bivalent.

Tetrad:

Each bivalent has four chromatids, so it may also be called a tetrad.

Chiasmata:

The two non-sister chromatids of homologous chromosomes join each other at certain points along their length. These points of attachment are called chiasmata.

Crossing over:

In the next stage, the non-sister chromatids of homologous chromosomes exchange their segments and the phenomenon is known as crossing over.

Genetic recombination:

The exchange of segments results in the recombination of genetic information. After crossing over, each pair of homologous chromosomes remains as a bivalent.

Chromosomes condense further, the nucleoli disappear, and the nuclear envelope disintegrates. Centrioles, which were duplicated during interphase, migrate to the two poles and form spindle

fibers. The kinetochore spindle fibers attach with the kinetochores of chromosomes. While the non-kinetochore spindle fibers from both sides interact with each other. Two kinetochore spindle fibers (from the opposite poles) attach with a pair of chromosomes.

ii) Metaphase I:

The pairs of homologous chromosomes align along an equatorial plane, forming the metaphase plate.

iii) Anaphase I:

Kinetochore spindle fibers shorten. It results in pulling apart the chromosomes of each pair. Since one chromosome is pulled toward one pole, two haploid sets are formed. Each chromosome still contains a pair of sister chromatids.

iv) Telophase I:

Chromosomes arrive at the poles. Each pole now has half the number of chromosomes but each chromosome still consists of two chromatids. Spindle network disappears, and the nuclear envelope is formed around each haploid set. Chromosomes uncoil back into chromatin.

2) Cytokinesis:

Cytokinesis (the pinching of the cell membrane in animal cells or the formation of the cell wall in plant cells) occurs and the creation of two haploid daughter cells is completed.

Q.7) Describe the significance of meiosis.

Answer:

Significance of Meiosis:

The significance of meiosis for reproduction and inheritance was described in 1890 by German biologist August Weismann. He pointed out that meiosis was necessary not only to maintain the number of chromosomes in the next generation but also to produce variations in next generation.

1) Maintenance of the chromosome number in next generation:

Meiosis is essential for sexual reproduction. In humans, diploid gamete-mother cells or germ line cells undergo meiosis to produce haploid gametes. Male and female gametes unite to form diploid zygote, which undergoes repeated mitosis and develops into a new diploid human. Many haploid fungi and protozoans produce haploid gametes through mitosis. Plants' life cycle shows alternation of generations. The cells of diploid sporophyte generation undergo meiosis to produce haploid spores, which grow into haploid gametophyte generations. Gametophyte generation produces haploid gametes through mitosis. The gametes combine to produce diploid zygote. Zygote undergoes repeated mitosis to become diploid sporophyte.

2) Production of variations in next generations:

The chromosome pairs of each parent undergo crossing over during meiosis. So daughter cells i.e. gametes have genetic variations. When gametes fuse and form zygote, its genetic make up is different from both parents. Thus meiosis allows a species to bring variations in the next generations. Beneficial variations help organisms to adapt to the changes in the environment.

1. Q.8) Contrast mitosis and meiosis, emphasizing the events that lead to different outcomes.

Answer:

Factors	Mitosis	Meiosis
Prophase	In this phase, homologous chromosomes do not form pairs. There is no crossing over.	Homologous chromosomes pair up. Crossing over takes place between these homologous chromosomes.

Metaphase	Single chromosomes align to form metaphase plate.	Homologous pairs align to form metaphase plate.
Anaphase	Chromosomes break and individual chromatids are pulled towards poles.	Individual chromosomes are pulled towards poles.
Daughter cells	Daughter nuclei contain diploid number of chromosomes. Each chromosome has single chromatid	Daughter nuclei contain haploid number of chromosomes. Each chromosome has two chromatids
Outcome	Chromosome number remains the same (2n) and yields two diploid cells	Chromosome number reduced to half (n), and yield four haploid cells
Occurrence	Occurs in somatic cells	Occurs in germ cells i.e. egg and sperms

2. Q.9) Describe necrosis and apoptosis.

Answer:

Apoptosis:

"Apoptosis is one of the main types of programmed cell death".

Process of apoptosis:

During apoptosis, cell shrinks and becomes rounded due to the breakdown of the cytoskeleton by enzymes. Its chromatin undergoes condensation and nuclear envelope breaks. In this way, the nucleus spreads in the form of several discrete chromatin bodies. Cell membrane makes irregular buds known as **blebs**. Blebs break off from the cell and are now called **apoptotic bodies,** which are then phagocytosed by the other cells.

Occurrence of apoptosis:

- Apoptosis can occur when a cell is damaged or undergoes stress conditions.
- Apoptosis removes the damaged cell, preventing it from getting further nutrients, or to prevent the spread of infections.
- Apoptosis also gives advantages during development. For example, during the formation of fingers, the cells between them undergo apoptosis and the digits separate.

Necrosis:

"Necrosis the accidental death of cells and living tissues".

Causes of necrosis:

Necrosis is less sequential than apoptosis. There are many causes of necrosis including injury, infection, cancer etc. Necrosis may occur when a cell is given hypoxic (with less oxygen) environments.

Process of necrosis:

During necrosis, there is the release of special enzymes from lysosomes. Lysosomal enzymes break cellular components and may also be released outside the cell to break surrounding cells. Cells that die by necrosis may also release harmful chemicals that damage other cells.

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