DAY ELEVEN

Cell Cycle and Cell Division

Learning & Revision for the Day

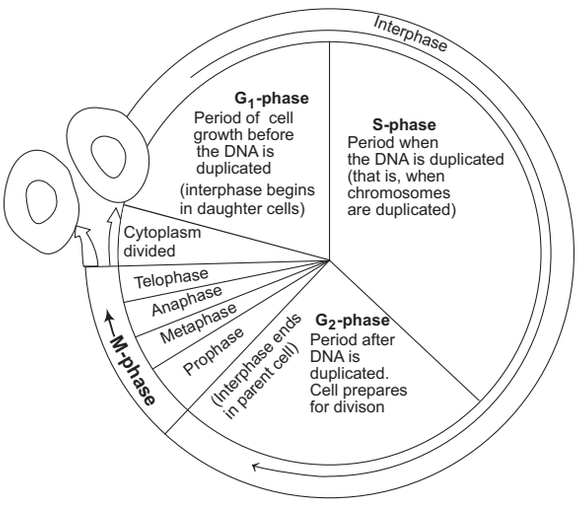
- Cell Cycle
- Amitosis
- Mitosis
- Meiosis
- Other Terms Related to Cell Division

Growth and reproduction are the important characteristics of all living organisms. Life of all multicellular organisms starts with a single cell which is formed by the growth and division of parental cells.

Thus, **cell division** forms the basis of continuity of life. A cell remains either in dividing phase or in non-dividing phase.

Cell Cycle

Cell cycle was first described by Howard and Pelc in 1953. Scientifically the sequence of events by which a cell duplicates its genome and synthesises other cell contents and eventually divides into two daughter cells is termed as cell cycle. Cell cycle is regulated by cyclin dependent protein kinase. Cyclins are proteins that activate protein kinases to regulate eukaryotic cell cycle.



Cell cycle

Phases of Cell Cycle

A cell cycle has two phases, i.e. interphase and dividing phase. Both the phases have substages. In the average duration of 24 hours, dividing phase lasts for approximately one hour and interphase lasts for 10-20 hours.

Complete description of different phases of cell cycle

Phase of cell cycle	Description
G_0	• It is an extension of G_1 -phase and is also known as quiescent stage. • During G_0-phase, the cell neither divides nor synthesises organelles, but its metabolic activity continues. • Cells present in the G_0-phase function as reserve cells, which can join the cell cycle any time.
G_1 (post-mitotic gap phase)	• It is the primary growth phase of the cell. • The centriole divides during this phase. No change occurs in the DNA content of the cell. This phase is involved in the synthesis of major molecules (synthetic phase) like RNA, proteins, lipids, nucleotides, ATP, etc., and multiplication of organelles.
S (synthetic phase)	• It is the synthesis phase in which the cell synthesises a replica of its genome, i.e. DNA replication (*via* enzyme DNA polymerase) occurs along with the synthesis of histone proteins which ultimately results into the duplication of chromosomal material. • A cell normally proceeds to mitosis once it has entered the S-phase.
G_2 (pre-mitotic gap phase)	• The period after DNA synthesis is the G_2-phase or second gap phase. It is the gap between DNA synthesis and next division. In this phase, the preparations are made for genomic separations. • This particular phase is spent in synthesising molecules other than DNA, which are required for cell division, e.g. RNA and proteins mitochondria and other organelles replicate, chromosomes condense and microtubules begin to assemble to form spindles.
M (Mitotic phase)	The M phase represents the phase when the actual cell division occurs.

Cell Division is a dynamic, complex and continuous process in all organisms. In unicellular organisms, cell division is the fundamental requirement to increase in number and to maintain the continuity of life.

- While, in multicellular organisms, it brings about growth, development, repair and reproduction. Cell division occurs in three ways : amitosis, mitosis and meiosis. In each case, division of the nucleus, called karyokinesis, occurs before the division of the cytoplasm, termed as cytokinesis.

Amitosis (Direct Cell Division)

- It was first discovered by Remak in the RBCs of chicken embryo.
- It is the method of asexual reproduction, which occurs in lower organisms like bacteria, protozoans, diseased cells, old cells, mammalian cells and in foetal membranes.
- In this division, there is no spindle formation and no distinct chromosome formation.
- During amitosis, the nucleus of the cell elongates. A constriction appears in the nucleus which gradually deepens and divides the nucleus into two daughter nuclei.
- Then, a constriction appears in the cytoplasm which divides the cytoplasm with the nuclei into two daughter cells, each with a nucleus. Nuclear envelope remains intact. The daughter cells thus formed are approximately two equal halves of the parental cell.

Mitosis

- It was first observed by **Strasburger** (1870) in plant cells.
- The term 'mitosis' was coined by **Flemming** (1882).
- Mitosis occurs in two stages, i.e. karyokinesis, the division of nucleus and cytokinesis, the division of cytoplasm.

Karyokinesis

The substages of karyokinesis (nuclear division) with their events are as follows

1. Prophase

- It is the longest phase of division. Chromosomes are shortened and thickened by coiling and form tighter packaging of their components.
- Each chromosome consists of two chromatids held together by a centromere.
- In animal cells, the centrioles move to opposite poles of the cell.
- Short microtubules may be seen radiating from centriole. These are called **asters**.
- Centrioles are responsible for the formation of spindle fibres.
- In this stage, the nucleoli disappear and at the end of prophase the nuclear envelope is no longer visible.
- Cell organelles like Golgi bodies, endoplasmic reticulum are not present in this phase.

2. Metaphase

- It is marked by the complete disintegration of nuclear envelope. It lasts for 2-10 minutes.
- Spindle fibres get attached to the chromosomes by their kinetochore and bring the chromosomes on the equator of the spindle. This phenomenon is called **congression**.

- The centromeres of all the chromosomes lie on the equator which forms an apparent plate called **equatorial plate**.

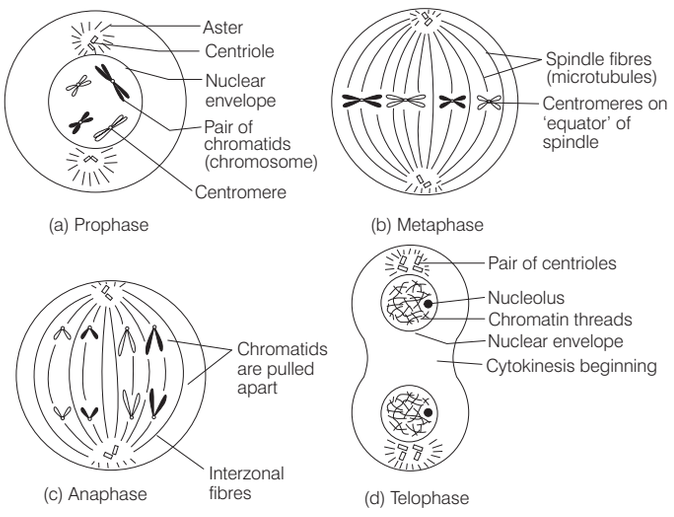
3. Anaphase

- It is very rapid and lasts for 2-3 minutes only. The centromere splits and the spindle fibres pull the daughter centromeres to opposite poles.
- The pulled chromosomes become V-shaped with their arms directed towards centre as they move away from the centre during anaphase.

NOTE
- Anaphase Promoting Complex (APC) Its main function is to trigger the transition from metaphase to anaphase by tagging specific proteins for degradation.
- The three major targets for degradation by the APC are securin and S and M cyclins.
- Securin releases separase after being degraded. The separase triggers the cleavage of cohesin, the protein complex that binds sister chromatids together. Thus, sister chromatids become free to move to opposite poles for anaphase.

4. Telophase

- The chromatids reach the poles of the cell, uncoil and lengthen to form chromatin again.
- The spindle fibres disintegrate and the centrioles replicate.
- Nuclear envelope reforms around the chromosomes at each pole and the nucleoli, Golgi bodies, endoplasmic reticulum reappear.
- Telophase is the last phase of karyokinesis. It is followed by **cytokinesis** which takes place through cell plate formation in plant cells and by cleavage or furrow in animal cells.
- The number of cells within an organism also increases by mitosis and this process is called **hyperplasia.** It forms the basis for growth.
- If mitotic division goes uncontrolled in any part of the body, it results in the formation of malignant cells. These cells continue to divide resulting in the formation of malignant tumours. This condition is called cancer.



Substages of mitosis

Cytokinesis

It occurs by two methods. These are given below:

(i) **Cell furrow method** (characteristic of animal cell) In this method, a furrow appears in plasma membrane at centre of equator, which deepens gradually and finally two daughter cells are separated.

(ii) **Cell plate method** (characteristic of plant cells) In this method, vesicles provided by Golgi apparatus unite to form phragmoplasts, which join to form cell plate.

Cell plate is first laid down in centre and then proceeds towards periphery, (i.e. centrifugal plate formation). Cell wall materials are now laid down on both sides of cell plate, resulting in two daughter cells.

Significance of Mitosis

- It is restricted to the diploid cells only. However, in some plants and social insects, haploid cells also divide by mitosis.
- It results in the production of diploid daughter cells with identical genetic combination usually, resulting in genetic stability.
- The growth of multicellular organisms is due to mitosis, it also restores the nucleo-cytoplasmic ratio and surface volume ratio of cells.
- Mitosis in meristematic tissues like apical and lateral cambium, results in a continuous growth of plants throughout their life.
- Mitosis helps in cell repair and regeneration of injured and lost body parts.
- It forms the basis of asexual reproduction in both plants and animals.

Differences between Mitosis in Animal and Plant Cells

Mitosis in Animal Cell	Mitosis in Plant Cell
Centrioles are involved.	Centrioles are absent.
Spindle is anastral.	Spindle is amphiaster (astral).
Cytokinesis occurs by furrowing of cytoplasm.	Cytokinesis occurs by cell plate formation.
Occurs in tissues throughout the body.	Occurs mainly in the meristems.

Meiosis

- The term meiosis was coined by **Farmer** and **Moore** in 1905. It is a two stage process of cell division in sexually reproducing organisms that results in cell having half the chromosome number of the original cell, thus bringing about a reduction in the chromosome number from a diploid ($2n$) condition to a haploid (n) condition.

- Such a reduction becomes necessary for maintaining the chromosome number during sexual reproduction. Meiosis is necessary for the formation of gametes in animals and spores (microspores and megaspores) in plants.
- Meiosis is completed by two divisions. These two divisions are known as meiosis-I and meiosis-II.

Meiosis-I

Meiosis-I division is called heterotypic or reduction division. It includes the following stages

(i) **Prophase-I** It is the longest phase and requires 90% of the total time required by entire meiosis process. It is subdivided into following stages

(a) **Leptotene** Chromosomes shorten and become thread-like visible structures. These chromosomes may be irregularly arranged or may be polarised towards the centriole.
During this stage, the cytoplasm has many polyribosomes, but endoplasmic vesicles are few. Hence, the chromosomes of this stage appear as beaded structures.

(b) In **zygotene** phase, homologous chromosomes pair up in a process known as **synapsis** and form a complex bivalent structure.
Each pair of bivalent is the association of 4 chromatids and 2 centromeres. One chromosome of the pair comes from the male parent and one from the female parent.

(c) **Pachytene** phase begins when synapsis is completed. It is characterised by the appearance of recombination nodule between the chromosomes pair.

- This stage shows the beginning of **crossing over** process. At this stage, bivalent chromosomes appear as tetrad.
- In crossing over, non-sister chromatids of homologous chromosomes exchange segments between themselves. It is an enzyme-mediated process involving enzyme recombinase.

(d) **Diplotene** stage is marked by the dissolution of the synaptonemal complex and chiasma terminalisation.

- Chiasma is the result of the fact that the chromosomal parts begin to repel each other except in the region where these are in contact. It is an X-shaped structure.
- It is necessary for the separation of homologous chromosomes, which have undergone crossing over.

(e) The stage **diakinesis** is marked by the terminalisation of chiasmata. The chromosomes become more condensed and bivalent remain evenly distributed in the nucleus. The nucleolus disappears and the nuclear membrane breaks completely.

(ii) After this stage, metaphase-I occurs where the bivalents get arranged around the equator of the spindle, attached by their centromeres.

(iii) Next, in **anaphase-I**, the spindle fibres pull the homologous chromosomes towards the opposite poles of the spindle.

This separates the chromosomes into two haploid sets or dyads, one set at each end of the spindle. Chromosome number becomes half in this stage.

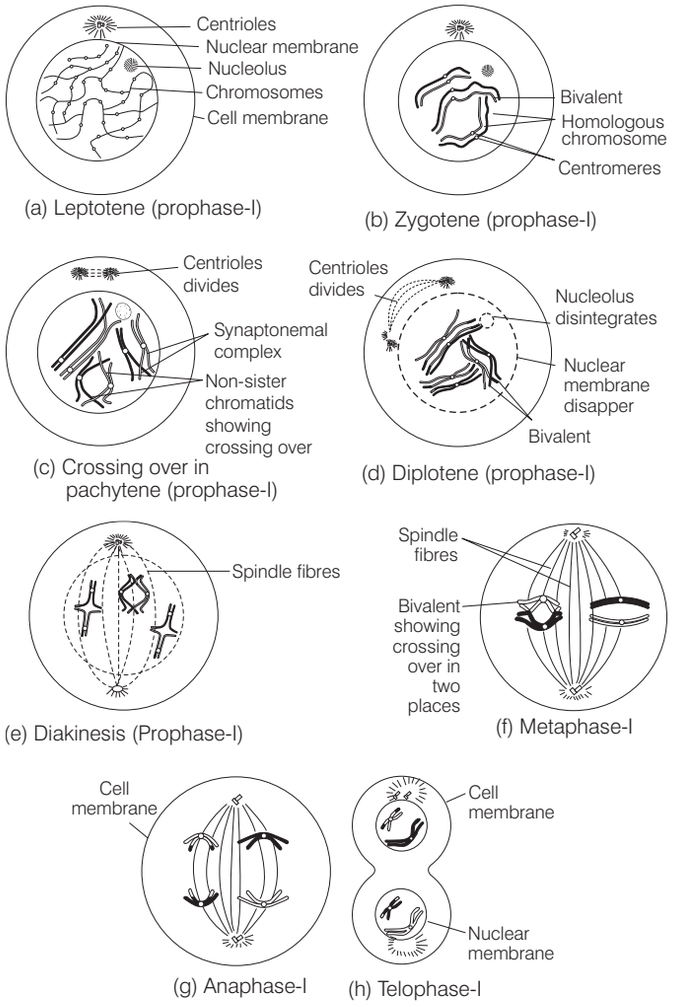
(iv) In **telophase**-I, the chromatids usually uncoil and a nuclear envelope reforms at each pole and the nucleus enters into interphase.

- Cleavage (animal cell) or cell wall formation (plant cell) takes place similar to mitosis.
- Normally, interphase is not seen between two meiotic divisions. Even if it occurs, no DNA replication takes place.

Meiosis-II

Meiosis-II leads to the separation of chromatids and centromere. It is also known as **homotypic** or **equational** division and involves the following substages

- **In prophase-II**, nucleoli and nuclear envelope disperse and the chromatids shorten and thicken. Centrioles if present move to opposite poles of the cells. At the end of prophase-II, new spindle fibres appear.
- These are arranged at right angles to the spindle of meiosis-I.
- Chromosomes line up separately around the equator of the spindle during **metaphase**-II.
- These chromosomes are arranged in a row with the attachment of microtubules to kinetochores. A metaphasic plate is formed.
- This phase is followed by **anaphase**-II, where the centromere divide and the spindle fibres pull the chromatids to opposite poles.
- Four groups of chromosomes are formed at the end of anaphase-II.
- **Telophase**-II is similar to that in mitosis. But here four haploid daughter cells are formed.
- The chromosomes uncoil, lengthen and become very indistinct. The spindle fibres disappear and the centrioles replicate.
- Zygotic or initial meiosis is a type of meiosis, which occurs immediately after fertilisation.



Meiosis-I showing its different substages (a-h)

Significance of Meiosis

- It is the mechanism of conversion of specific chromosome number of each species in sexually reproducing organisms.
- It provides chance for the appearance of new gene combinations, owing to crossing over.
- It increases the genetic variability in the population of organisms from one generation to the next. Variations help in evolution.

Control of Cell Cycle

The cell cycle is controlled by certain proteins at certain points in a cell cycle called **check points**. These proteins are called **Cyclin-dependent protein kinases** (Cdks) and **cyclins**.

A Cdk is infact an enzyme that adds negatively charged phosphate groups to other molecules through phosphorylation process.

This signals the cell to enter the next stage of cell cycle. But, Cdks are dependent on cyclins for their activation.

Cyclins are activating proteins that bind to Cdks to form a cyclin-Cdk complex. The exit from a particular phase of cell cycle takes place when cyclin gets degraded thereby deactivating Cdks.

The checkpoints, Cdks and cyclins involved in cell cycle regulation are

(i) **G_1-checkpoint** It is present at G_1/S boundary and regulated by Cdk_4/cyclin-D, Cdk_6/cyclin-D, etc. It is controlled by cell size, growth factors and cell environment, etc.

(ii) **G_2-checkpoint** It is present at G_2/M boundary and regulated by Cdk_2/cyclin B also, known as **MPF** (M-phase Promoting Factor). It is controlled by completion of DNA replication, DNA damage/mutation, cell size, etc.

(iii) **Metaphase checkpoint** It is present at metaphase/anaphase boundary and is regulated by cyclin-B degradation.

It is controlled by spindle fibre (microtubule) attachment to chromosomes.

Other Terms Related to Cell Division

1. **Mitotic poisons** These are substances that inhibit mitosis, e.g. colchicine, chalones, cyanides and azides.
2. **Phragmoplast** Persistent part of spindle apparatus with an interdigitated array of microtubules at the equator.
3. **Endomitosis** (Endoduplication) It is the replication of chromosomes without corresponding division of nucleus.
4. **Free nuclear division** It is the division of nucleus without being followed by cytokinesis, it gives rise to multinucleate condition.
5. **Internuclear spindle formation** In fungi, many algae, *Amoeba*, etc., the nuclear envelope does not degenerate. However, polar pores may appear. An internal spindle, called intranuclear spindle is formed which helps in equitable distribution of chromosomes.
6. **Dinomitosis** Dinoflagellates possess condensed chromosomes even in interphase. Their nucleus is called mesokaryon. Nuclear envelope and nucleolus persist during mitosis. An intranuclear spindle is also not formed. Instead, cytoplasmic channels develop in the nucleus to help in the passage of replicated chromosomes to the two ends along the nuclear envelope.

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1 Which is the shortest phase in the cell cycle?
(a) G_1-phase (b) G_2-phase
(c) S-phase (d) M-phase

2 Synthesis of RNA and protein takes place in which phase of the cell cycle ?
(a) S - phase (b) M - phase
(c) G_1 and G_2-phase (d) None of these

3 During cell growth, DNA synthesis takes place in ➝ NEET-II 2016
(a) S-phase (b) G_1-phase
(c) G_2-phase (d) M-phase

4 In S-phase of the cell cycle ➝ CBSE-AIPMT 2014
(a) amount of DNA doubles in each cell
(b) amount of DNA remains same in each cell
(c) chromosome number is increased
(d) amount of DNA is reduced to half in each cell

5 At what stage of the cell cycle is histone proteins synthesised in a eukaryotic cell?
(a) During prophase
(b) During telophase
(c) During S-phase
(d) During G_2-stage of prophase

6 A certain species of animal has six pairs of chromosomes. How many molecules of DNA do the nuclei of these animals have during G_2-phase?
(a) 12 (b) 48 (c) 6 (d) 24

7 During which phase(s) of cell cycle, amount of DNA in a cell remains at 4C level if the initial amount is denoted as 2C ? ➝ CBSE-AIPMT 2014
(a) G_0 and G_1 (b) G_1 and S
(c) Only G_2 (d) G_2 and M

8 The DNA content of a cell is measured in the G_2-phase. After meiosis-I, the DNA content of one of the cells produced is
(a) equal to that of the G_2 cell
(b) twice that of the G_2 cell
(c) 1/2 that of the G_2 cell
(d) 1/4 that of the G_2 cell

9 When cell has stalled DNA replication fork, which checkpoint should be predominantly activated ? ➝ NEET-II 2016
(a) G_1/S (b) G_2/M
(c) M (d) Both G_2/M and M

10 Cells which are not dividing they are likely to be at
(a) G_1-phase (b) G_2-phase
(c) G_0-phase (d) S-phase

11 Match the following columns.

	Column I		Column II
A.	G_2 - phase	1.	Centrioles absent
B.	G_0 - phase	2.	Centrioles present
C.	Plant cells	3.	Preparation for division
D.	Regulation of cell cycle	4.	Quiescent phase
		5.	Cyclins

Codes

	A	B	C	D		A	B	C	D
(a)	2	3	1	4	(b)	5	2	3	1
(c)	3	4	1	5	(d)	4	2	1	3

12 During mitosis, ER and nucleolus begin to disappear at
(a) late prophase (b) early metaphase
(c) late metaphase (d) early prophase

13 Which of the following options gives the correct sequences of events during mitosis? ➝ NEET 2017
(a) Condensation → Nuclear membrane disassembly → Crossing over → Segregation → Telophase
(b) Condensation → Nuclear membrane disassembly → Arrangement at equator → Centromere division → Segregation → Telophase
(c) Condensation → Crossing over → Nuclear membrane Disassembly → Segregation → Telophase
(d) Condensation → Arrangement at equator → Centromere division → Segregation → Telophase

14 If you are provided with root tips of onion in your class and are asked to count the chromosomes which of the following stages can you most conveniently look into?
(a) Metaphase (b) Telophase
(c) Anaphase (d) Prophase

15 Spindle fibres attach on to
(a) kinetochore of the chromosome
(b) centromere of the chromosome
(c) kinetosome of the chromosome
(d) telomere of the chromosome

16 Centromere is required for
(a) movement of chromosomes towards poles
(b) cytoplasmic cleavage
(c) crossing over
(d) transcription

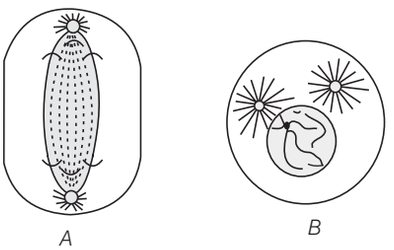
17 A diploid cell was treated with an inhibitor extracted from the corms of *Colchicum autumnale* . On microscopic observation, the cell will appear as a

(a) triploid (b) tetraploid
(c) diploid (d) pentaploid

18 Select the correct option with respect to mitosis.

(a) Chromatids start moving towards opposite poles in telophase
(b) Golgi complex and endoplasmic reticulum are still visible at the end of prophase
(c) Chromosomes move to the spindle equator and get aligned along equatorial plate in metaphase
(d) Chromatids separate but remains in the centre of the cell in anaphase

19 Which stages of cell division do the following figures *A* and *B* represent respectively?



A *B*

A		*B*
(a) Metaphase	_	Telophase
(b) Telophase	_	Metaphase
(c) Late anaphase	_	Prophase
(d) Prophase	_	Anaphase

20 Which of the following is not a characteristic feature during mitosis in somatic cells? ➜ NEET-I 2016

(a) Disappearance of nucleolus
(b) Chromosome movement
(c) Synapsis
(d) Spindle fibres

21 Meiosis - I is reductional division. Meiosis-II is equational division due to

(a) pairing of homologous chromosomes
(b) crossing over
(c) separation of chromatids
(d) disjunction of homologous chromosomes

22 Arrange the following events of meiosis in correct sequences. ➜ CBSE-AIPMT 2015

I. Crossing over
II. Synapsis
III. Terminalisation of chiasmata
IV. Disappearance of nucleolus

(a) II, I, IV, III (b) II, I, III, IV
(c) I, II, III, IV (d) II, III, IV, I

23 The enzyme recombinase is required at which stage of meiosis?

(a) Pachytene (b) Zygotene
(c) Diplotene (d) Diakinesis

24 In meiosis, crossing over is initiated at ➜ NEET-I 2016

(a) leptotene
(b) zygotene
(c) diplotene
(d) pachytene

25 The stage during which separation of the paired homologous chromosomes begins is ➜ NEET 2018

(a) diakinesis (b) diplotene
(c) pachytene (d) zygotene

26 Match the following columns. ➜ NEET-II 2016

	Column I (Stages of meiosis)		**Column II** (Characteristic feature)
A.	Pachytene	1.	Pairing of homologous chromosomes
B.	Metaphase - I	2.	Terminalisation of chiasmata
C.	Diakinesis	3.	Crossing over takes place
D.	Zygotene	4.	Chromosomes align at equatorial plate

Codes

	A	B	C	D		A	B	C	D
(a)	3	4	2	1	(b)	1	4	2	3
(c)	2	4	3	1	(d)	4	3	2	1

27 Meiosis occurs in organisms during

(a) sexual reproduction
(b) vegetative reproduction
(c) Both (a) and (b)
(d) None of the above

28 …… only occur(s) in the gonads to produce gametes.

(a) Mitosis (b) Meiosis
(c) Both (a) and (b) (d) Sporogony

29 Meiosis results in

(a) production of gametes
(b) reduction in the number of chromosomes
(c) introduction of variation
(d) All of the above

30 Meiosis has evolutionary significance because it results in

(a) genetically similar daughters
(b) four daughter cells
(c) eggs and sperms
(d) recombinations

DAY PRACTICE SESSION 2

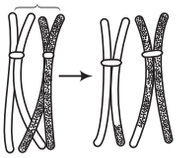
PROGRESSIVE QUESTIONS EXERCISE

1 Synapsis occurs between
(a) a male and a female gamete
(b) *m*RNA and ribosomes
(c) spindle fibres and centromere
(d) two homologous chromosomes

2 Crossing over that results in genetic recombination in higher organisms occurs between
(a) sister chromatids of bivalent
(b) non-sister chromatids of a bivalent
(c) two daughter nuclei
(d) two different bivalents

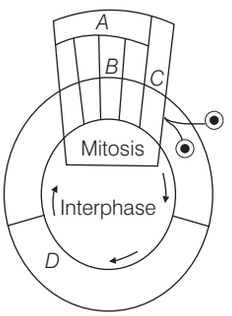
3 The …… occurs between non-sister chromatids, results in genetic exchange between chromosomes, which provides new combinations of genes that are different from either of the parent.
(a) cytokinesis (b) crossing over
(c) mitosis (d) cell division

4 Given below is the representation of certain event at a particular stage of a type of cell division. Which is this stage?
(a) Prophase - I during meiosis
(b) Prophase - II during meiosis
(c) Prophase of mitosis
(d) Both prophase and metaphase of mitosis



5 In the somatic cell cycle,
(a) in G_1-phase DNA content is double the amount of DNA present in the original cell
(b) DNA replication takes place in S-phase
(c) a short interphase is followed by a long mitotic phase
(d) G_2-phase follows mitotic phase

6 Given below is a schematic breakup of the phases / stage of cell cycle



Which one of the following is the correct indication of the stage / phase in the cell cycle?
(a) *B* – Metaphase (b) *C* – Karyokinesis
(c) *D* – Synthetic phase (d) *A* – Cytokinesis

7 The exchange of genetic material between chromatids of paired homologous chromosomes during first meiotic division is called
(a) transformation (b) chiasmata
(c) crossing over (d) synapsis

8 Progression through the cell cycle is regulated by oscillations in the concentration of which type of molecule?
(a) Centrosomes
(b) Cyclin dependent kinases
(c) Cyclins
(d) Both (b) and (c)

9 Which one of the following precedes reformation of the nuclear envelope during M-phase of the cell cycle?
(a) Decondensation from chromosomes and reassembly of the nuclear lamina
(b) Transcription from chromosomes and reassembly of the nuclear lamina
(c) Formation of the contractile ring and formation of the phragmoplast
(d) Formation of the contractile ring and transcription from chromosomes

10 Anaphase Promoting Complex (APC) is a protein degradation machinery necessary for proper mitosis of animal cells. If APC is defective in a human cell, which of the following is expected to occur?
(a) Chromosomes will not condense
(b) Chromosomes will be fragmented
(c) Chromosomes will not segregate
(d) Recombination of chromosome arms will occur

11 During mitosis, it is necessary for the nuclear envelope of the parent cell to dissolve. This is accomplished, at least in part, by phosphorylation of proteins associated with the nuclear envelope. If the enzyme responsible for the phosphorylation event is inhibited, at which phase of mitosis are cells likely to arrest?
(a) Prophase (b) Metaphase
(c) Telophase (d) Anaphase

12 Although the process of chromosome partitioning during mitosis is visible through the light microscope, the process of DNA replication is not. Why?
(a) Chromosomes do not contain protein until mitosis
(b) Chromosomes are too extended during S-phase to be seen by light microscopy
(c) Chromosomes are visible only after DNA has been duplicated
(d) Chromosomes form only during mitosis

13 How would the daughter cells at the end of mitosis and cytokinesis compare with the parent cell when it was in G_1 of the cell cycle?

(a) The daughter cells have half amount of cytoplasm and half amount of DNA
(b) The daughter cells have half number of chromosomes and half amount of DNA
(c) The daughter cells have the same number of chromosomes and half amount of DNA
(d) The daughter cells have the same number of chromosomes and same amount of DNA

14 What are the two most important structures involved in moving chromosomes during mitosis ?

(a) Kinetochores and chromosomes
(b) Kinetochores and mitotic spindle fibres
(c) Centrosomes and chromosomes
(d) Centrosomes and mitotic spindle fibres

15 Match the following columns.

	Column I		Column II
A.	Meiosis	1.	Cancer
B.	p_{53} mutation	2.	Basis of asexual reproduction
C.	p_{27} levels	3.	Diabetes
D.	Mitosis	4.	Reduction division
		5.	Breast cancer

Codes

	A	B	C	D
(a)	5	1	2	4
(b)	1	2	3	4
(c)	4	1	5	2
(d)	2	1	3	4

16 The true statement for mitosis is

(a) the cells formed by it performs diverse functions, i.e. show division of labour than the parent cells
(b) two cells formed as a result of this division are identical in all respects
(c) cells formed by it have half number of chromosomes than that of parent cell
(d) cells formed as a result of mitosis have different genetic characters

17 Taxol is a drug that stabilises microtubules and prevents them from depolymerising. Consequently, treated cells fail to complete mitosis. At which phase of mitosis are cells treated with taxol likely to arrest?

(a) Telophase (b) Prophase
(c) Metaphase (d) Anaphase

18 Match the following columns.

	Column I		Column II
A.	Synapsis aligns homologous	1.	Anaphase-II
B.	Synthesis of RNA and protein	2.	Zygotene
C.	Action of enzyme recombinase	3.	G_2-phase
D.	Centromeres do not separate, but chromatids move towards opposite poles	4.	Anaphase-I
		5.	Pachytene

Codes

	A	B	C	D
(a)	2	1	3	4
(b)	2	3	5	4
(c)	1	2	5	4
(d)	2	3	4	5

ANSWERS

SESSION 1

1 (d)	**2** (c)	**3** (a)	**4** (a)	**5** (c)	**6** (d)	**7** (c)	**8** (c)	**9** (b)	**10** (c)
11 (c)	**12** (d)	**13** (b)	**14** (a)	**15** (a)	**16** (a)	**17** (b)	**18** (c)	**19** (c)	**20** (c)
21 (c)	**22** (b)	**23** (a)	**24** (d)	**25** (b)	**26** (a)	**27** (a)	**28** (b)	**29** (d)	**30** (d)

SESSION 2

1 (d)	**2** (b)	**3** (b)	**4** (a)	**5** (b)	**6** (c)	**7** (c)	**8** (d)	**9** (a)	**10** (c)
11 (a)	**12** (b)	**13** (d)	**14** (b)	**15** (c)	**16** (b)	**17** (d)	**18** (b)		