CELL CYCLE AND CELL DIVISION

SIGNIFICANCE OF MEIOSIS

SIGNIFICANCE OF MEIOSIS:

(a) Variations: Variations are important for evolution.

(i) Independent assortment of chromosomes

(ii) Crossing over

(iii) Irregular disjunction

(iv) Gene mutation during replication & nicking for crossing over.

(b) Polyploidy: Failure of chromosomes to separate during anaphase-I leads to polyploidy.

(c) Maintenance of chromosome number

(d) Sexual reproduction

Key points of Meiosis:

Types of Meiosis:

(i) Zygotic or Initial meiosis: It occurs during zygote or zygospore germination **e.g. Ulothrix, Spirogyra and Chlamydomonas.**

(ii) Sporic or Intermediate meiosis: Meiosis occurs at the time of microspore or megaspore formation **e.g. Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.**

(iii) Gametic meiosis or Terminal meiosis: It occurs at the time of gamete formation **e.g. Animals**

Meiosis-I

1. **Prophase-I: Devided into five stages on the basis of chromosomal behaviour.**

(a) Leptotene - **Bouquet stage**

(b) Zygotene - **Formation of synaptonemal complex, Synapsis or pairing of homologous chromosomes and appearance of bivalent.**

(c) Pachytene - **Formation of recombination nodule, activity of recombinase enzymes,**

crossing over between non-sister chromatids of homologous chromosomes, appearance of tetrad and persistence of synaptonemal complex.

(d) Diplotene - Dissolution of synaptonemal complex, chiasmata formation due to motion of cross overed chromatids apart.

(e) Diakinesis - Terminalisation of chiasmata, disappearance of nuclear membrane, nucleolus, ER and golgi body.

2. Metaphase-I: Two metaphasic plates.
3. Anaphase-I: Separation of homologous chromosomes.
4. Telophase-I: Completion of karyokinesis-I
5. Cytokinesis-I: Two cells are formed with just half number of chromosomes as that of parent cell.

   Note: Now two cells will enter into successive steps.

   Interkinesis: Only deficient proteins are synthesized.

Meiosis-II

1. Prophase-II : Disappearance of nuclear membrane, nucleolus, ER and golgi body.
2. Metaphase-II: Single metaphasic plane.
3. Anaphase-II: Sister Chromatids move apart.
4. Telophase-II: Completion of karyokinesis-II.
5. Cytokinesis-II: In total four cells will be formed with half the chromosomes and DNA content that of parent cell (cell of G_1 phase).

Difference between Mitosis and Meiosis

Difference between Mitosis and Meiosis			
	Mitosis		**Meiosis**
1	The cells undergoing mitosis may be haploid or diploid.	1	The cells undergoing meiosis are always diploid.

2	It is a single division which produces two cells.	2	Meiosis is a double division. It gives rise to four cells.
3	Subsequent mitotic divisions are similar to earlier ones.	3	The two divisions of meiosis are not similar. The first one is the heterotypic or reductional while the second one is homo typic or equational like mitosis.
4	Each chromosome replicates in the interphase before every division.	4	The chromosomes replicate only once, prior to meiosis.
5	The number of chromosomes remains the same after mitosis.	5	The number of chromosomes is reduced to one half after Meiosis.
Prophase			
6	Prophase is of shorter duration.	6	Prophase I is of longer duration while prophase II is very brief.
7	Each chromosome has two distinct chromatids.	7	Chromosomes of prophase I do not show distinct chromatids.
8	No bouquet stage is recorded.	8	Chromosomes of animals and some plants show convergence towards one side during early prophase I. It is known as bouquet stage.
9	Pairing of chromosomes does not occur in mitosis	9	Pairing or synapsis of homologous chromosomes takes place during zygotene of prophase I and continues up to metaphase-I
10	A synaptonemal complex is absent.	10	Synapsed homologous chromosome develop a synaptonemal complex.

11	Crossing over is absent.	11	Crossing over or exchange of similar segments between nonsister chromatids of homologous chromosomes usually takes place during pachytene stage.
12	Chiasmata are absent.	12	Chiasmata or visible connections between homologous chromosomes of bivalents are observed during diplotene, diakinesis

Metaphase			
13	Centromeres produce a single metaphasic plate.	13	A double metaphasic plate is formed by centromeres in metaphase I but only one in metaphase II.
14	Only the centromeres lie at the equator. The limbs of chromosomes are oriented in various directions.	14	Limbs of the chromosomes mostly lie at the equator while the centromeres project towards the poles in metaphase I.
15	A centromere is connected with both the spindle poles.	15	A centromere is connected to one spindle pole in metaphase I but both in metaphase II.
16	Two chromatids of a chromosome are genetically similar.	16	The two chromatids of a chromosome are often genetically dissimilar due to crossing over.
Anaphase			
17	A centromere splits length-wise to form two centromeres in the beginning of anaphase.	17	Centromeres do not divide during anaphase I but do so in anaphase II.
18	Anaphasic chromosomes are single stranded.	18	Chromosomes are double stranded in anaphase I but single stranded in anaphase II.
Telophase			
19	Telophase is longer and produces interphase nuclei.	19	Telophase I is shorter and nuclei never enter the inter-phase.
Cytokinesis			
20	Cytokinesis follows every mitosis. It produces two cells.	20	Cytokinesis often does not occur after the first or reductional division. It is then simultaneous after second division to result in four new cells.

Table: Displays the various parameters changing during cell cycle (Human somatic cell with 2C DNA content for 46 chromosomes)

S.No.	Phase of Cell cycle		DNA content	No. of chromosomes[1]	No. of Chromatids[2]	No. of Centromeres[3]
1.	Interphase	G_1	2C	46	46	46
		S	Early - 2C Late - 4C	Early - 46 Late - 46	Early - 46 Late - 92	Early - 46 Late - 46
		G_2	4C	46	92	46
2.	Mitosis	Prophase	4C	46	92	46
		Metaphase	4C	46	92	46
		Anaphase	4C	92	92	92
		Telophase	4C	92	92	92
3.	Cytokinesis - Per cell		2C	46	46	46

1. In interphase, there are no chromosomes as the genetic material is present in the form of chromatin material.
2. In interphase, there are no chromatids as the genetic material is present in the form of chromatin material.
3. In interphase as genetic material is not packaged in the form of chromosomes so, as such centromeres are also not defined.

   Note: In all (1, 2 and 3) we have genetic material for that many chromosomes, chromatids and centromeres which will appear later in prophase.

Table: Displays the various parameters changing during cell cycle (Human germ cell with 2C DNA content for 46 chromosomes)

S.No.	Phase of Cell cycle		DNA content	No. of chromosomes[4]	No. of Chromatids[5]	No. of Centromeres[6]
1.	Interphase	G_1	2C	46	46	46
		S	Early - 2C Late - 4C	Early - 46 Late - 46	Early - 46 Late - 92	Early - 46 Late - 46
		G_2	4C	46	92	46
2.	Meiosis-I	Prophase-I	4C	46	92	46
		Metaphase-I	4C	46	92	46
		Anaphase-I	4C	46	92	46
		Telophase-I	4C	46	92	46
3.	Cytokinesis-I Per cell		2C	23	46	23
4.	Interkinesis Per cell		2C	23	46	23
5.	Meiosis-II	Prophase-II	2C	23	46	23
		Metaphase-II	2C	23	46	23
		Anaphase-II	2C	46	46	46
		Telophase-II	2C	46	46	46
6.	Cytokinesis-II Per cell		C	23	23	23

1. In interphase, there are no chromosomes as the genetic material is present in the form of chromatin material.
2. In interphase, there are no chromatids as the genetic material is present in the form of chromatin material.
3. In interphase as genetic material is not packaged in the form of chromosomes so, as such centromeres are also not defined.

Note: In all (1, 2 and 3) we have genetic material for that many chromosomes, chromatids and centromeres which will appear later in prophase.

Types of Meiosis:

(i) **Zygotic or Initial meiosis:** It occurs during zygote or zygospore germination **e.g. Ulothrix, Spirogyra and Chlamydomonas.**

(ii) **Sporic or Intermediate meiosis:** Meiosis occurs at the time of microspore or megaspore formation

e.g. Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.

(iii) **Gametic meiosis or Terminal meiosis:** It occurs at the time of gamete formation

e.g. Animals