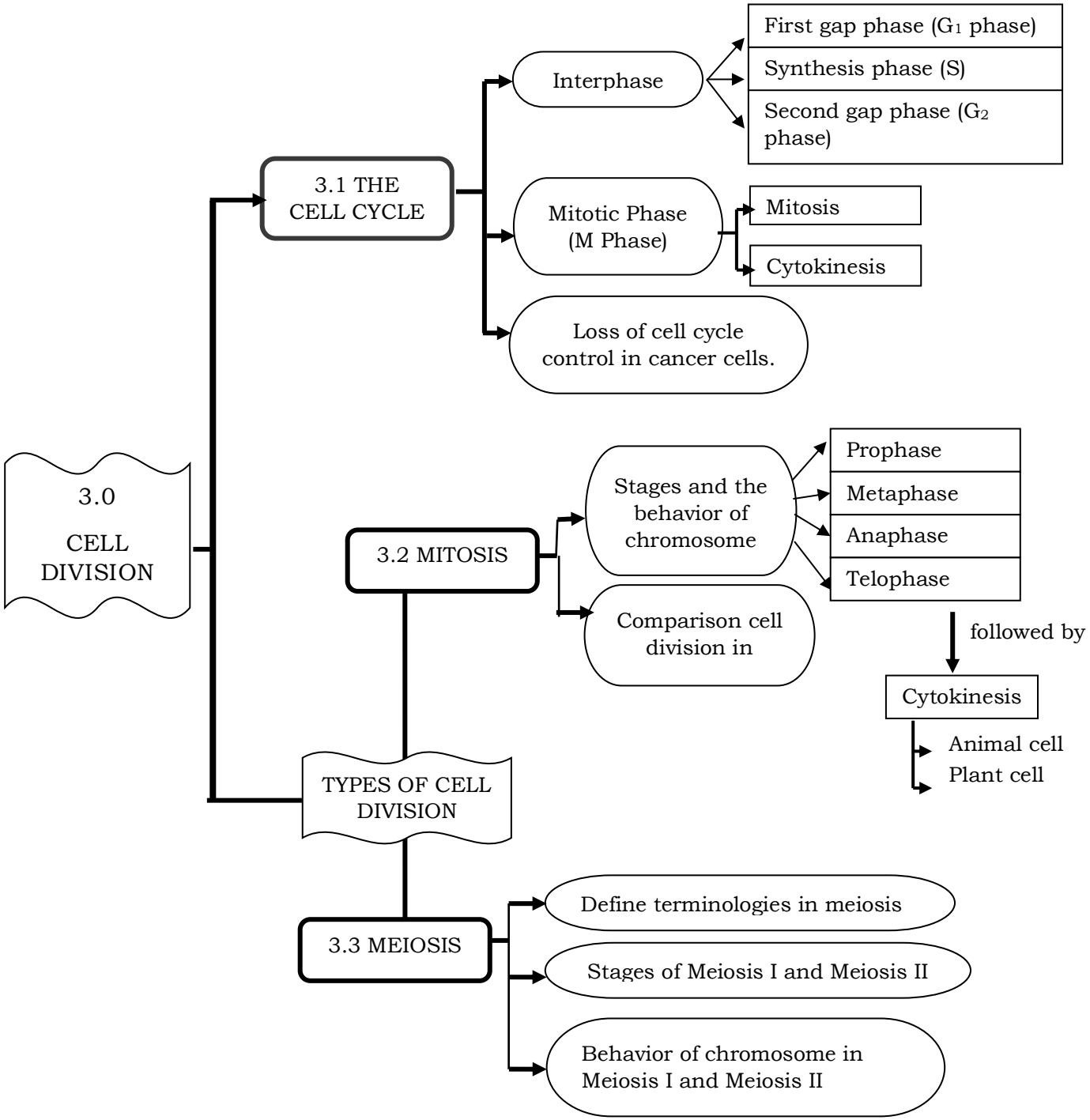
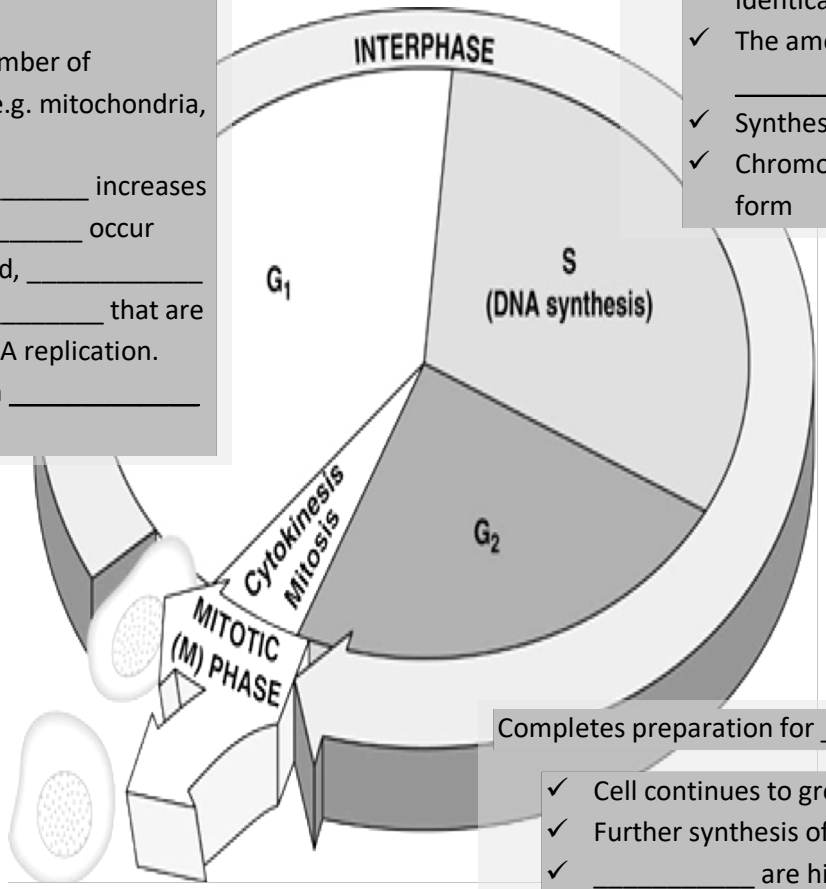

3.0
CELL DIVISION
3.1 THE CELL CYCLE
Interphase
First gap phase (G_1 phase)
Synthesis phase (S)
Second gap phase (G_2 phase)
Mitotic Phase (M Phase)
Mitosis
Cytokinesis
Loss of cell cycle control in cancer cells.
3.2 MITOSIS
Stages and the behavior of chromosome
Prophase
Metaphase
Anaphase
Telophase
Comparison cell division in
followed by
Cytokinesis
Animal cell
Plant cell
TYPES OF CELL DIVISION
3.3 MEIOSIS
Define terminologies in meiosis
Stages of Meiosis I and Meiosis II
Behavior of chromosome in Meiosis I and Meiosis II

CELL CYCLE: Definition:

- INTERPHASE
  -
  -
  -
-
  - Mitosis
  -

Cell grows and increase in _____

- ✓ Increase the number of _____ (e.g. mitochondria, ribosome)
- ✓ Volume of _____ increases
- ✓ Protein _____ occur
- ✓ Synthesis of lipid, _____ and various _____ that are required for DNA replication.
- ✓ Chromosome in _____ form.



DNA _____ phase.

- ✓ DNA replicate & chromosome _____, forming two identical _____.
- ✓ The amount of DNA _____.
- ✓ Synthesis of _____ protein
- ✓ Chromosome in _____ form

1. _____ **(Nuclear Division)**- **d**ivides the nucleus & distributes the chromosomes into 2 daughter _____.

4 stages in mitosis:

- _____
- _____
- _____
- _____

2. **Cytokinesis** (_____ division) - divide cell into two daughter cells

Completes preparation for _____

- ✓ Cell continues to grow
- ✓ Further synthesis of _____
- ✓ _____ are highly replicated
- ✓ Increase _____ stores
- ✓ Centrosome _____
- ✓ Formation of microtubules for development of _____
- ✓ Increase in size of _____

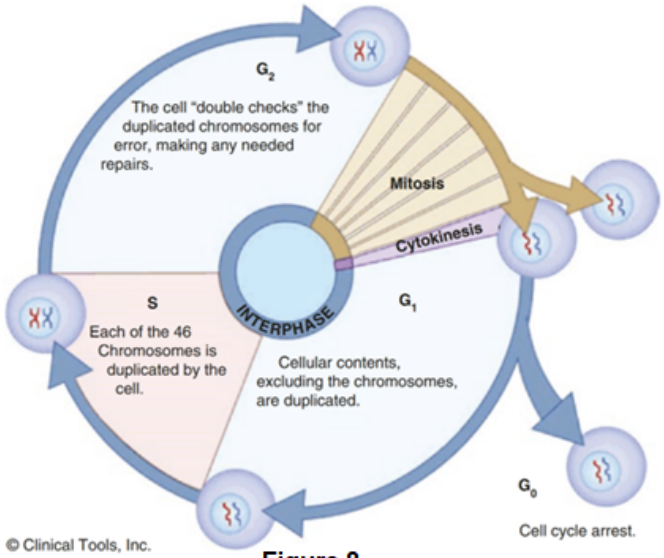


Figure 8

_____ phase

- ✓ Non _____ state occupied by cell that have left the cell cycle
- ✓ If energy is _____ to continue the cycle from G_1, cell will enter G_0 phase
- ✓ Sometimes reversibly

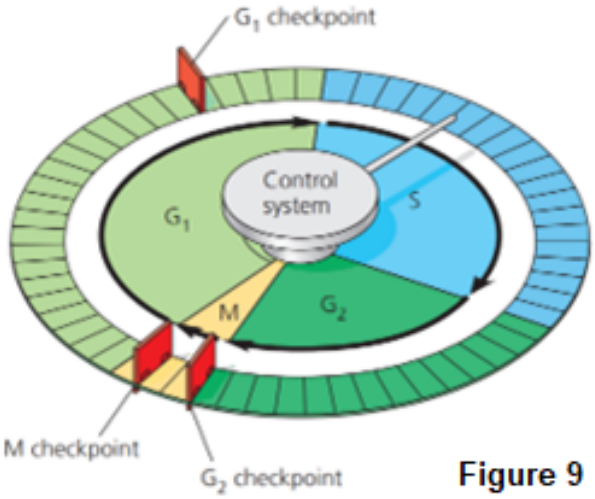


Figure 9

3 specific checkpoints that cell cycle stops until a go-ahead signal is received:

Checkpoint	Check for
	- Adequate cell size - Sufficient _____ and energy reserves - Molecular signals from neighbouring cells eg. growth factor - No _____ damage.
	- Completion of DNA _____ - The replicated DNA is not damaged.
	- All the chromosomes/ sister chromatids are correctly attached to the _____ .

Cell cycle regulators	Explanation
Cyclin	A protein that is cyclically fluctuating concentration in the cell and _____ the cell cycle. Acts as _____ signal
Cyclin- dependent kinase (CDK)	Enzyme that is activated by _____ . Acts as _____ signal
p53 protein	Tumor _____ protein Regulate cell division in controlled manner _____ formation of tumor
p21 protein	Acts as _____ signal Make the cell arrested from dividing

the loss of cell cycle control checkpoints in cancer cells.

The body didn't tell me to divide but I still want to divide!

The body tell me to divide!!



Cancer cell



Normal cell

G1 checkpoint.	
Size	Is the cell _____ enough?
Nutrients	Does the cell have enough _____ ?
Molecular signals	Is the cell receive _____ from neighboring cells?
DNA integrity	Is any of the _____ damaged?

Something went wrong? Let's start again.

Everything ok? Let's go!!

S Phase

G2 checkpoint.	
DNA integrity	Is any of the _____ damaged?
DNA replication	Was the DNA _____ during S phase?

Something went wrong here? Let's go again.

Proto-oncogenes in cancer cells has alter into oncogenes that code for proteins contribute for tumor growth. The oncogene proteins inhibits/inactivate proteins involve in checkpoints of cell cycle. Thus, causing the damage on the dividing cell unable to be detected & fix, thus leading to uncontrolled _____ and producing damaged daughter cells.





Abnormal & damaged cancer cells





Normal daughter cells

Cytokinesis

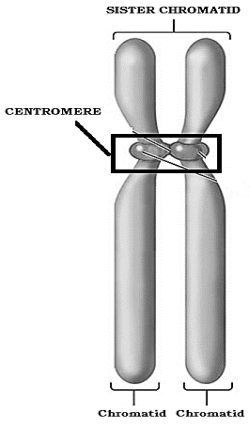
M checkpoint
Occurs during the transition from metaphase to _____ .
The cell examines whether all the _____ are correctly attached to the _____ .

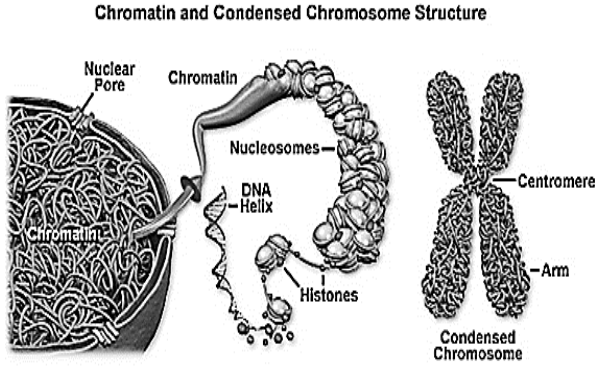
Something went wrong here? Let's go again.

MITOSIS

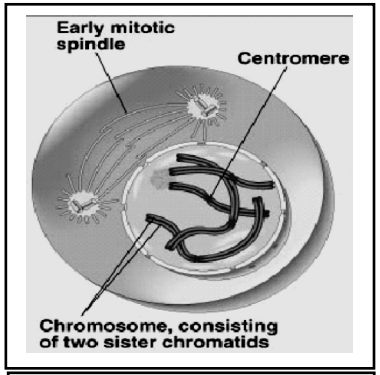
A process of _____ division in eukaryotic cells to produce two daughter cells, each contain the _____ number of chromosomes to the _____ cell (2n). Followed by _____

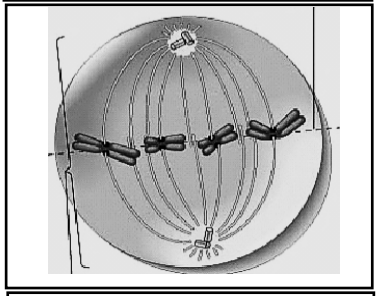
Terms	Explanation
DNA and Chromosome	❖ Chromosomes of eukaryotic cells are composed of DNA and _____ proteins. ❖ The function of histone proteins is to _____ the structure of chromosome and help control the activities of the genes.
	❖ Refer to the chromosomes in the form of '_____'. ❖ Very long and thin; _____ be seen under light microscope.
Sister chromatids	❖ Each duplicated chromosome has _____ sister chromatids, which separate during cell division (both have _____ copies of DNA).
	❖ The central region in which two sister chromatids are _____ to each other.

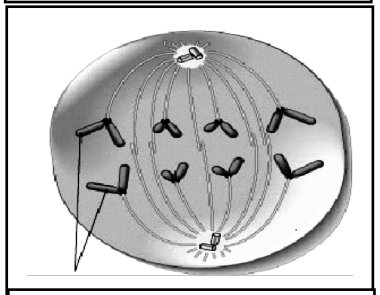


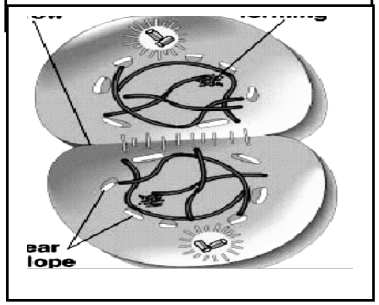


STAGES OF MITOSIS & CHROMOSOMAL BEHAVIOUR AT EACH STAGES









1. PROPHASE
   - Chromatin _____ and _____ (condense)
   - Chromosome becomes _____ (under light microscope)
   - Each chromosome exists as a pair of sister chromatids attached together at _____ .
   - _____ migrates to opposite poles of cell
   - Spindle fibers _____ .
   - Nucleolus disappears & nuclear envelope _____ .

3. METAPHASE
   - Centrosome positioned at _____ poles.
   - Chromosome _____ at metaphase plate.
   - Chromosomes attached to _____ at centromere

3. ANAPHASE
   - Spindle fiber _____ & pull the sister chromatid.
   - Centromere _____ , sister chromatid _____ .
   - Sister chromatids _____ and _____ towards opposite poles.
   - At the end of this phase, each pole contains a complete set of _____ .

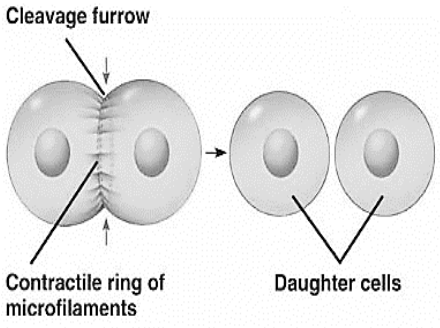
4. TELOPHASE
   - The _____ arrived to the opposite pole.
   - The chromosome _____ and _____ , thus becoming invisible again.
   - A new nuclear _____ forms around each group.
   - The spindle fibers _____ and nucleolus _____ in each new nucleus.

CYTOKINESIS

Division of _____ to form two separate daughter cells immediately after nuclear division

ANIMAL CELL

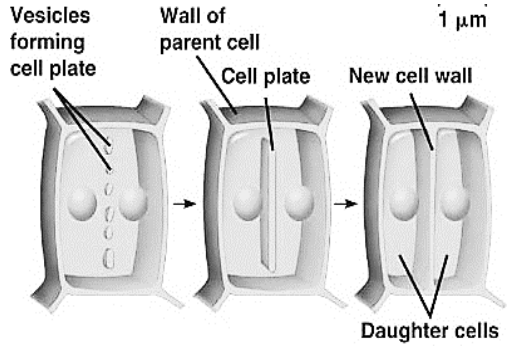
Formation of _____



- Involve the formation of _____
- The cleavage furrow is a _____ ring of microfilament
- Plasma membrane _____ forming cleavage furrow that will deepens until the parent cell pinched into two separate cells

PLANT CELL

Formation of _____



- During telophase, _____ derived from Golgi apparatus move along microtubule to the _____ of the cell.
- Vesicle fused to produce a _____ .
- The cell plate _____ until its surrounding membrane fuse with the plasma membrane forming a new _____ in between the daughter cells

COMPARISON OF CELL DIVISION IN ANIMAL AND PLANT CELL

SIMILARITIES

1. Both cells undergo four stages of mitosis and followed by _____ .
2. Produce _____ daughter cells that possess _____ number of chromosomes to each other & to _____ cell.

ANIMAL CELL

- Formation of spindle fibers by centrosome with _____ .
- Aster formation is _____
- _____ is formed during cytokinesis.
- Occur in _____ cells or tissues throughout the body.

PLANT CELL

- Formation of spindle fibers by centrosome _____ centriole.
- Aster formation is _____ .
- _____ is formed during cytokinesis.
- Occur mainly in _____ cell or tissues

MATCH THIS!

MEIOSIS

A nuclear division (_____) followed by cytokinesis that gives rise to _____ daughter cells (gametes) each with _____ the chromosomes of the parent cell.

Crossing over

Pair of chromosomes that are identical in length, position of centromere and posess genes for the same character at corresponding loci.

Bivalent

A process where homologous chromosomes are come close one another and pairing together.

Tetrad

A pair of homologous chromosomes which undergo synapsis during the Prophase I.

Synapsis

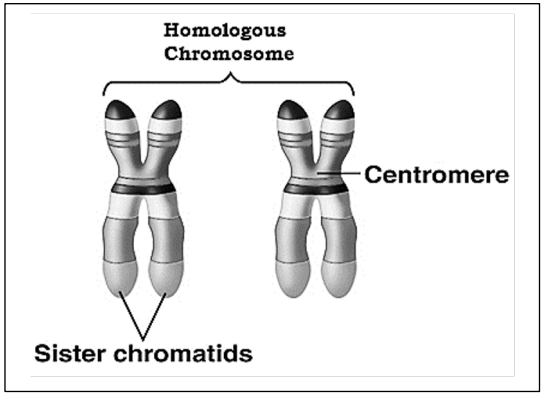
A group of four chromatids of homologus chromosome undergoes synapsis during Prophase I

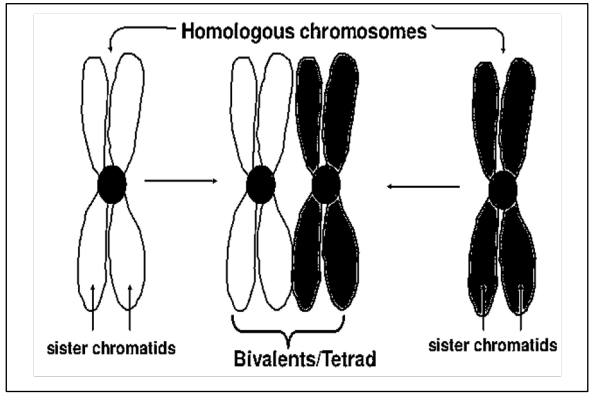
Chiasma

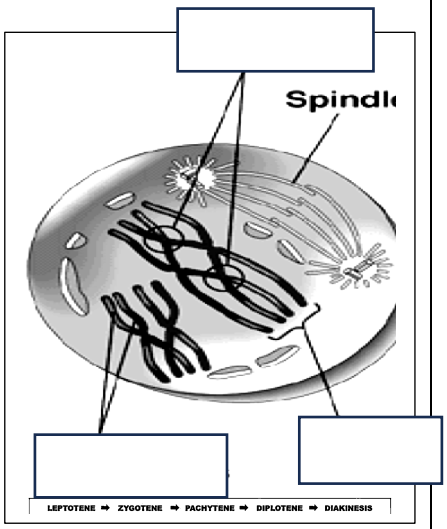
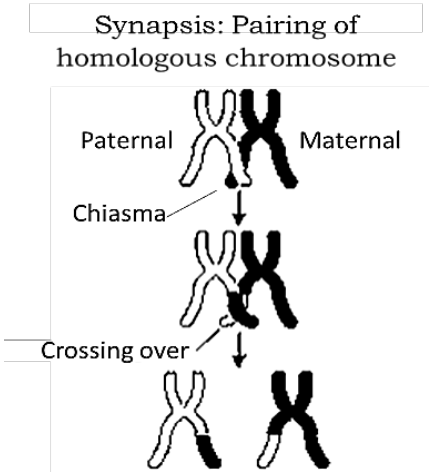
The exchange of genetic material between non-sister chromatids of homologous chromosome.

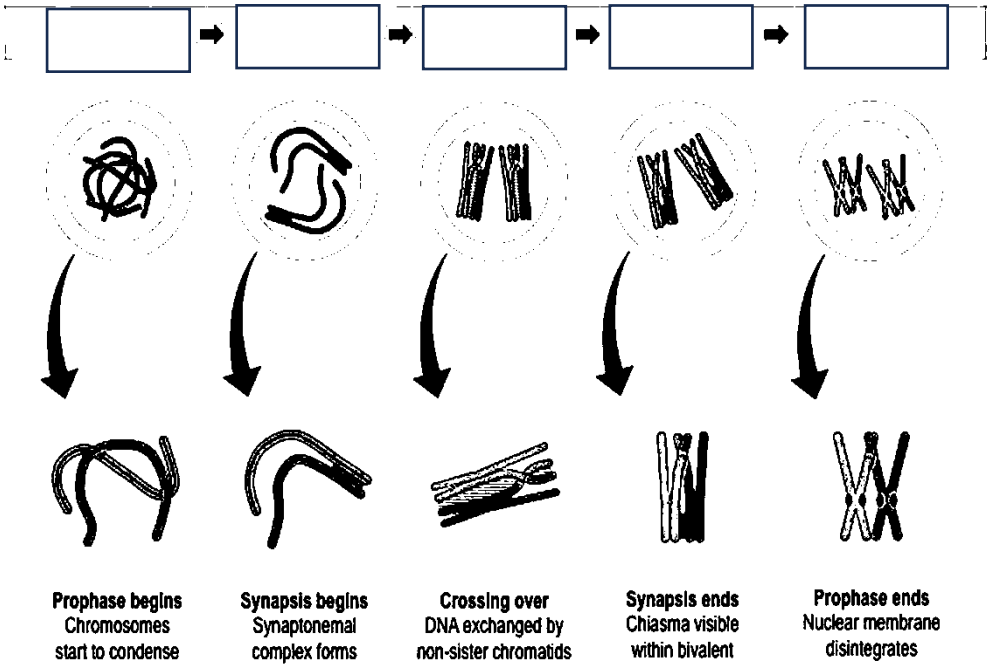
Homologous chromosome

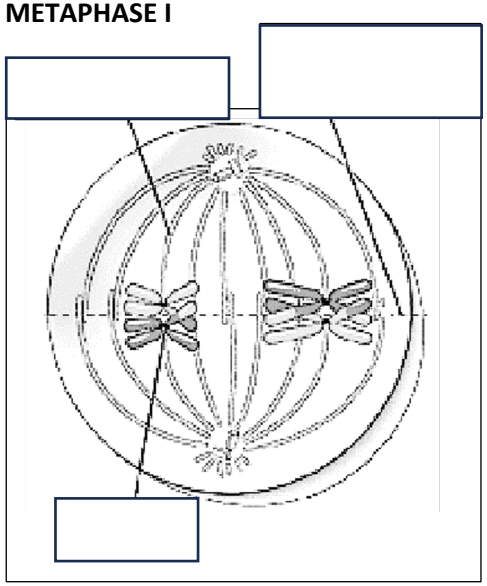
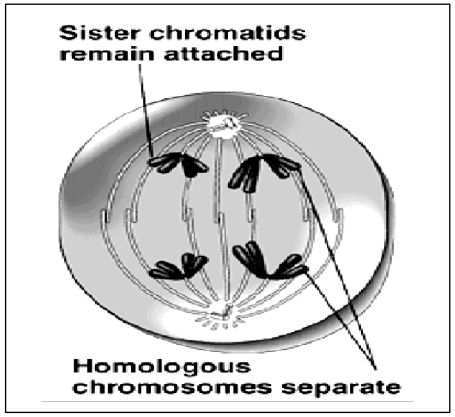
The regions at which crossing over occur between two non-sister chromatid.

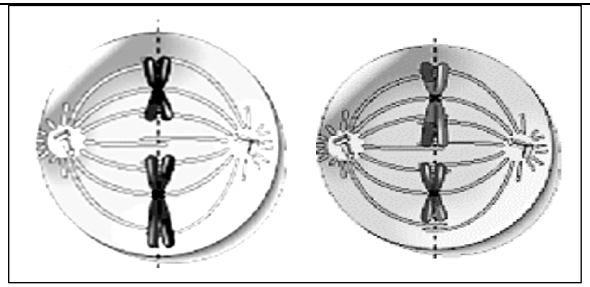
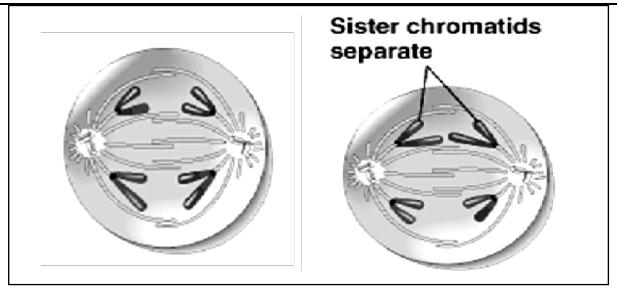




STAGE	EXPLANATION
MEIOSIS I	
PROPHASE I  	➢ _____ disappear and nuclear envelope _____ . ➢ Each pair of _____ moves to opposite pole. ➢ Formation of _____ . ➢ Chromatin condensed (highly coiled,shorten and _____) ➢ Chromosome becomes _____ ➢ Homologous chromosome undergo _____ forming tetrad/bivalent ➢ _____ may occur between non-sister chromatid. 



<table>
<tr>
<td>METAPHASE I
</td>
<td>➢ _____ aligned on the metaphase plate
➢ Mechanism involves _____ assortment.
➢ _____ of homologous chromosome attached at spindle fibers.</td>
<td>TELOPHASE I and CYTOKINESIS
</td>
<td>➢ Chromosome arrive at opposite poles (marks the ends of meiosis I)
➢ But one chromosome is still composed of _____ chromatids.
➢ Chromosome uncoils and _____
➢ _____ the chromosome number (2n → n)
➢ Spindle fibers usually _____.
➢ _____ occur
➢ Each cell contains _____ number of chromosome.</td>
</tr>
<tr>
<td>ANAPHASE I

</td>
<td>➢ Spindle fibers _____ .
➢ Each homologous chromosome pull to opposite pole lead by centromere.
➢ _____ separate and move to opposite pole</td>
<td colspan="2">INTERKINESIS
(Period between meiosis I and meiosis II, No _____ Replication)</td>
</tr>
</table>

MEIOSIS II		
PROPHASE II	➢ The nucleolus disappear and nuclear envelopes disintegrate. ➢ Chromatin become _____ and _____. ➢ Centrosome move to opposite poles of the cells and at the end of Prophase II, new _____ appear.	
METAPHASE II	➢ Chromosomes _____ at metaphase plate.	
ANAPHASE II	➢ The spindle fibers shorten ➢ The _____ split. ➢ _____ separate and move to opposite poles	
TELOPHASE II and CYTOKINESIS	➢ _____ arrived at opposite poles ➢ The chromosomes _____ and lengthen ➢ The spindle fibres _____ . ➢ Nucleolus _____ and nuclear envelope _____ . ➢ _____ occur ➢ _____ haploid daughter cells are formed	

SIMILARITIES BETWEEN MITOSIS AND MEIOSIS: Both have the basic 4 stage for division Both occur in _____ cells

Mitosis	**Differences**	**Meiosis**
Occurs in _____ cells	**Location**	Occurs in _____ cell
Daughter cells maintain _____ chromosome number as the parent cell.	**Chromosome Number**	Daughter cells reduce to _____ number of chromosomes from parent cell.
Daughter cells are _____ (2n).	**Ploidy level of daughter cells**	Daughter cells are _____ (n).
No synapsis occur to form tetrad / bivalent.	**Synapsis**	Synapsis occurs during _____ forming tetrad / bivalent
_____ crossing over occur	**Crossing over**	Crossing over occurs during _____
The content of genetic in daughter cells are genetically _____ to parent cell.	**Genetic content**	The content of genetic in daughter cell is genetically _____ from parent cell.
Produce _____ diploid daughter cells	**Number of daughter cell produced.**	Produce _____ haploid daughter cells
Cytokinesis occurs _____.	**Number of Cytokinesis**	Cytokinesis occurs _____
_____ cell division	**Number of cell division**	Cell division occur _____ (Meiosis I and II)
During metaphase: chromosome align at metaphase plate	**Chromosomal behavior during metaphase**	During metaphase I: _____ aligns at metaphase plate. During metaphase II: _____ align at metaphase plate.
During anaphase _____ separate and move to opposite poles.	**Chromosomal behavior during anaphase**	During anaphase I: _____ separate and move to opposite poles. During anaphase II: sister chromatids separate and move to opposite poles.