The cell cycle

1. **Interphase :**
   - **a- G1 (the first gap phase).**
   - **b- S (the synthesis phase).**
   - **c- G2 (the second gap phase).**
2. **Cell division :**
   - **a- Nuclear division (mitosis) :**
     - **1- Prophase .**
     - **2- Metaphase .**
     - **3- Anaphase .**
     - **4- Telophase .**
   - **b- Cytoplasm division . cytokinesis**
   - **c- Meiosis (occur in sexual cells) Meiotic**

Meiosis I	Meiosis II
---	Reducing the chromosome number
Prophase I	Prophase II
Metaphase I	Metaphase II
Anaphase I	Anaphase II
Telophase I	Telophase II

3. **Comparison of meiosis with mitosis .**

Cell life cycle :

The cell life cycle includes (nuclear division and cytokinesis) to produce two new cells.

The changes a cell undergoes from the time it is formed until it divides to produce two new cells . the life cycle of a cell has two stages :

1. **Interphase .**
2. **Cell division stage .**

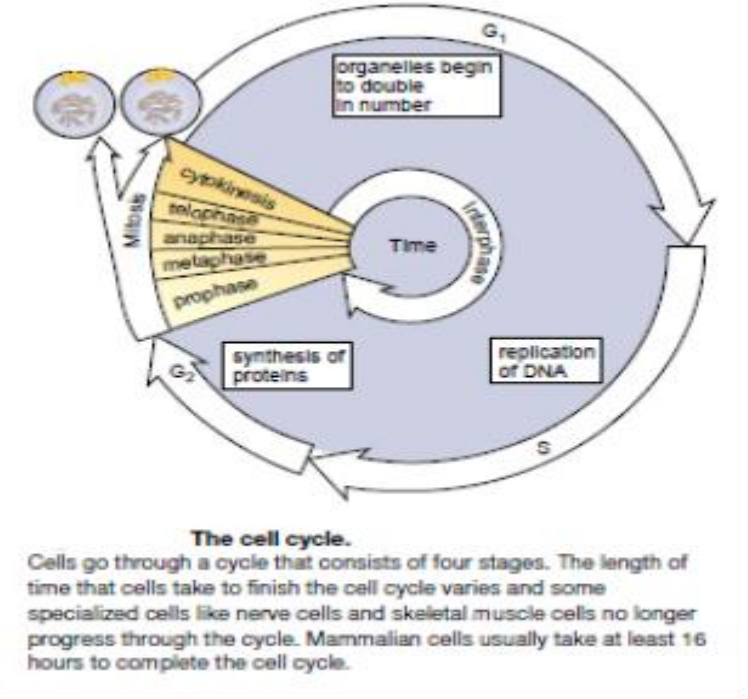
Interphase :

Is the phase between cell divisions 90 % or more of the life cycle of a typical cell is spent in interphase during in this time,The cell carries out metabolic activities or functions such as :

1- **Secreting digestive enzymes .**
2- **Increase in size , because many cell components double in quantity. (cellular organelles increase in number).**
3- **Replication of the cell's DNA .**
4- **The centrioles with the centrosome are also duplicated .**

Interphase can be divided into three sub-phases called G1, S , and G2. during G1 (the first gap phase) and G2 (the second gap phase), the cell carries out routine metabolic activities . during the (S) phase (the synthesis phase), the DNA is replicated (new DNA is synthesized). Many cell in the body do not divide for days , months or even years .

These " resting " cells exit the cell cycle and enter what is called the Go phase , in which they remain stimulated to divide (produce the cyclin enzyme and Kinase).



The cell cycle.
Cells go through a cycle that consists of four stages. The length of time that cells take to finish the cell cycle varies and some specialized cells like nerve cells and skeletal muscle cells no longer progress through the cycle. Mammalian cells usually take at least 16 hours to complete the cell cycle.

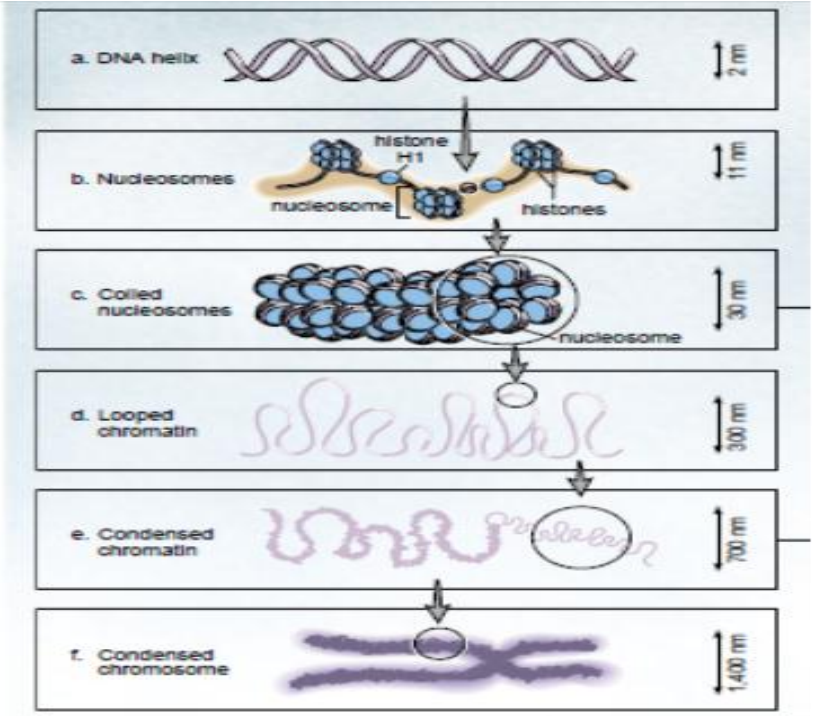
DNA replication :

DNA replication is the process by which two new strands of DNA are made, using the two existing (olds) strands as templates . during interphase , DNA and its associated proteins appear as dispersed chromatin threads within the nucleus .

When DNA replication begins , the two strands of DNA molecule separate from each other for some distance . each strand then functions as a template , or pattern for the production of a new strand of DNA , which is formed as new nucleotides pair , with the existing (old)

nucleotides of each strand of the separated DNA molecule . the production of the new nucleotide strands is catalyzed by DNA polymerase , which adds new nucleotides at the 3' end of the growing strands .

One strand , called " leading strand " is formed as a continuous strand , whereas the other strand , called the " lagging strand " , is formed in short segments going in the opposite direction . the short segments are then spliced by DNA ligase . as a result of DNA replication , two identical DNA molecules are produced each of the two new DNA molecules has one strand of nucleotides derived from the original DNA molecule and one newly synthesized strand , so this replication is semiconservative .



Levels of chromosome structure.
Each drawing has a scale giving a measurement of length for that drawing. Notice that each measurement represents an ever-increasing length; therefore, it would take a much higher magnification to see the structure in **(a)** than in **(f)**.

1. Cell division :

New cells necessary for growth and tissue repair are produced by cell division.

A parent cell divides to form two daughter cells , each of which has the same amount and type of DNA as the parent cell . because DNA determines cell structure and function , the daughter cells have the same structure and perform the same functions as the parent cell .

Cell division involves two major events :

1- **The division of the nucleus to form two new nuclei (nuclear division).**
2- **The division of the cytoplasm to form to new cells . (cytokinesis).**

Each of the new cells contains one of the newly formed nuclei . the division of the nucleus occurs by mitosis , and the division of the cytoplasm is called cytokinesis .

Mitosis (M) :

(a type of nuclear division)

Is the division of nucleus , into two nuclei , each of one has the same amount and type of DNA as the original nucleus . the DNA , which was dispersed as chromatin in interphase , condenses in mitosis to form chromosomes . all human " somatic" cells , which include all cells except the sex cell , contain 46 chromosomes , which are referred to as a diploid (2n) number of chromosomes . sex cells have half the number of chromosomes as somatic cells .

The 46 chromosomes in somatic cells are organized into 23 pairs of chromosomes . twenty – two (22) of these pairs of chromosomes are called " autosomes" each number of an autosomal pair of chromosomes looks structurally a like , and together they are called a " homologous " pair of chromosomes . one member of each autosomal pair is derived from the person's father , and the other is derived from the mother . the remaining pair of chromosomes are the sex chromosomes . in females , the sex chromosomes lookalike , and each is called an " x chromosome". In males , the sex chromosomes do not look dike. One chromosomes is an "X chromes" and the other is smaller and is called " y chromosomes ".

Mitosis is divided into four phases :

Prophase , metaphase , anaphase , and telophase .

Although each phase represent major events , mitosis is a continuous process . the major events of mitosis are summarized in coming figures .

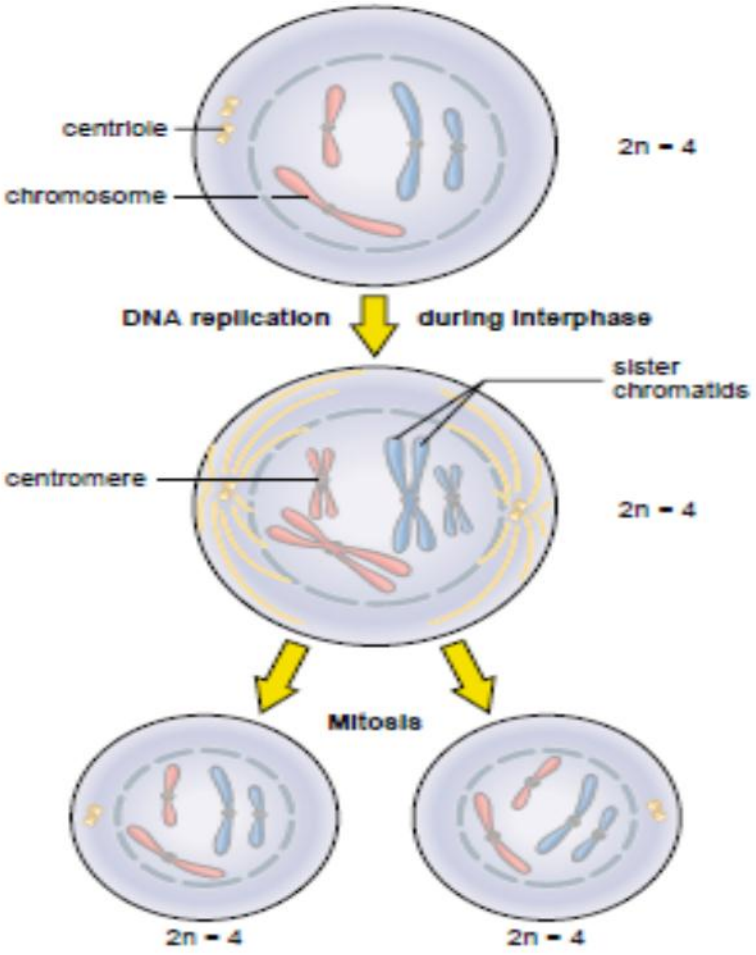
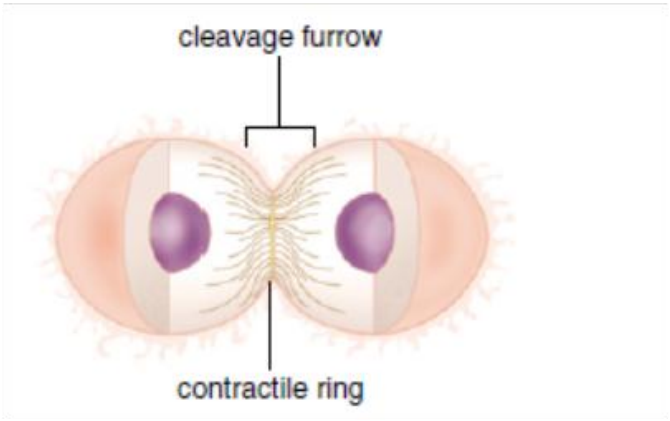


Figure 5.1 Mitosis overview.
Following DNA replication during interphase, each chromosome in the parental nucleus is duplicated and consists of two sister chromatids. During mitosis, the centromeres divide and the sister chromatids separate, becoming daughter chromosomes that move into the daughter nuclei. Therefore, daughter cells have the same number and kinds of chromosomes as the parental cell. (The blue chromosomes were inherited from the father, and the red chromosomes were inherited from the mother.)

Cytokinesis :

Is the division of the cytoplasm of the cell to produce two new cells . cytokinesis begins in anaphase continues through telophase , and ends in the following interphase . the first sign of cytokinesis is the formation of a cleavage furrow , or puckering of the plasma membrane , with forms midway the centrioles .

A contractile ring composed primarily of actin filaments pulls the plasma membrane inward , dividing the cell into two halves . cytokinesis is complete when the membranes of the two halves separate at the cleavage furrow to form two separate cells .



Cytokinesis in an animal cell.
A single cell becomes two cells by a furrowing process. A contractile ring composed of actin filaments gradually gets smaller, and the cleavage furrow pinches the cell into two cells.

Meiosis :

All cells of the body , except sex cells , are formed by mitosis , sex cells are formed by meiosis . in meiosis (another type of nuclear division) the nucleus undergoes two divisions resulting in four nuclei . each containing half as many chromosomes as the parent cell . the daughter cells that are produced by cytokinesis differentiate into " gametes " , or sex cells . the gametes are reproductive cells – sperm cells – in males and oocytes (egg cells) in females . each gamete not only has half the number of chromosomes found in a somatic cell but also has one chromosomes from each of the homologous pairs found in the parent cell .

The complement of chromosomes in a gamete is referred to as a haploid (n) number . oocyte contain one autosomal chromosome from each of the 22 homologous pairs and an x chromosomes . sperm cells have 22 autosomal chromosomes and either an x or y chromosome .

During fertilization , when a sperm cell fuses with an oocyte , the normal number of 46 chromosomes in 23 pairs is reestablished . the sex of the baby is determined by the sperm cell that fertilizes the oocyte .

Meiosis is divided into two divisions , Meiosis I , and Meiosis II .

<u>Meiosis I :</u> (another the nuclear division).

The first division during meiosis divided into four phases :

(prophase I , metaphase I , anaphase I, and telophase I see the figures below). As in prophase of mitosis ,

1. **The nuclear envelope degenerates .**

2. **The spindle fibers form .**
3. **The already duplicated chromosomes become visible .**

Each chromosomes consists of two chromatids joined by a centromere . in prophase I, however , the four chromatids of a homologous pair of chromosomes join together , or " synapse ", to form a tetrad (four) . in metaphase I the tetrads align of equatorial plane , and in anaphase I each pair of homologous chromosomes separate and move toward opposite pole of the cell . For each pair of homologous chromosomes , one daughter cell receives one member of the pair , and the other daughter cell receives the member .

Thus each daughter cell has 23 chromosomes , each of which is composed of two chromatids . telophase I, with cytokinesis , is similar to telophase of mitosis , and two daughter cells are produced .

" Interkinesis " is the phase between the formation of the daughter cells and the second meiotic division . " no duplication of DNA occurs during interkinesis ."

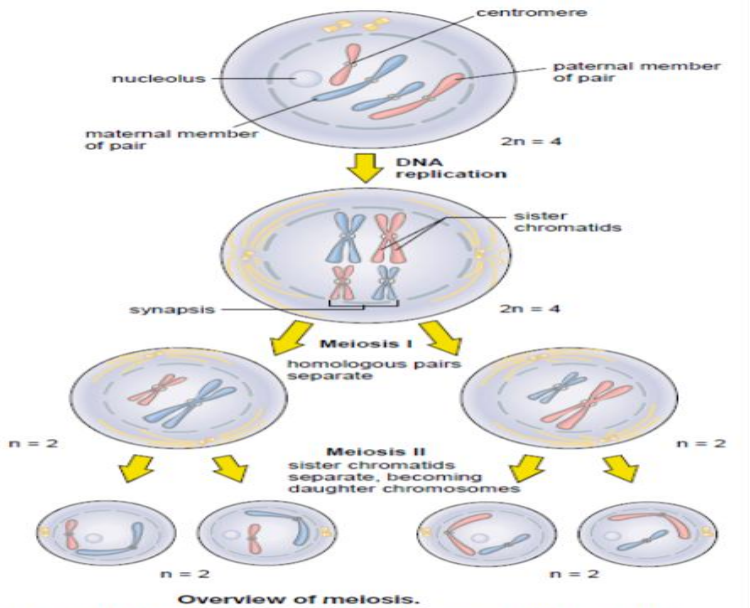
<u>Meiosis II :</u>

The second division of meiosis also has four phases :

Prophase II , metaphase II , anaphase II, and telophase II .

These stages occur much as they do in mitosis, except that 23 chromosomes are present instead of 46.the chromosomes align at the equatorial plane in metaphase II and their chromatids split a part in anaphase II. The chromatids then are called chromosomes , and each

new cell receives 23 chromosomes , when tetrads are formed , some of the chromatids may break a part , and part of one chromatid from one homologous pair may be exchanged for part of another chromatid from the other homologous pair (see the figures below). This exchange is called crossing-over , as a result , chromatids which different DNA content are formed . (during meiosis) , crossing-over mixes . the genetic information of maternal and paternal . chromosomes and independent assortment leads to different combinations of these chromosomes in gametes and offspring. With random assortment of homologous chromosomes and crossing – over , the possible number of gametes with different genetic makeup is practically unlimited . when the different gametes of two individuals unite , it is virtually certain that the resulting genetic makeup never has occurred before and never will occur again . the genetic makeup of each new human being is unique .



Overview of meiosis.
Following DNA replication, each chromosome is duplicated. During meiosis I, the homologous chromosomes pair during synapsis and then separate. During meiosis II, the centromeres divide and the sister chromatids separate, becoming daughter chromosomes that move into the daughter nuclei.

Comparison of mitosis with meiosis :

Meiosis differs from mitosis both in occurrence and in process .

Occurrence :

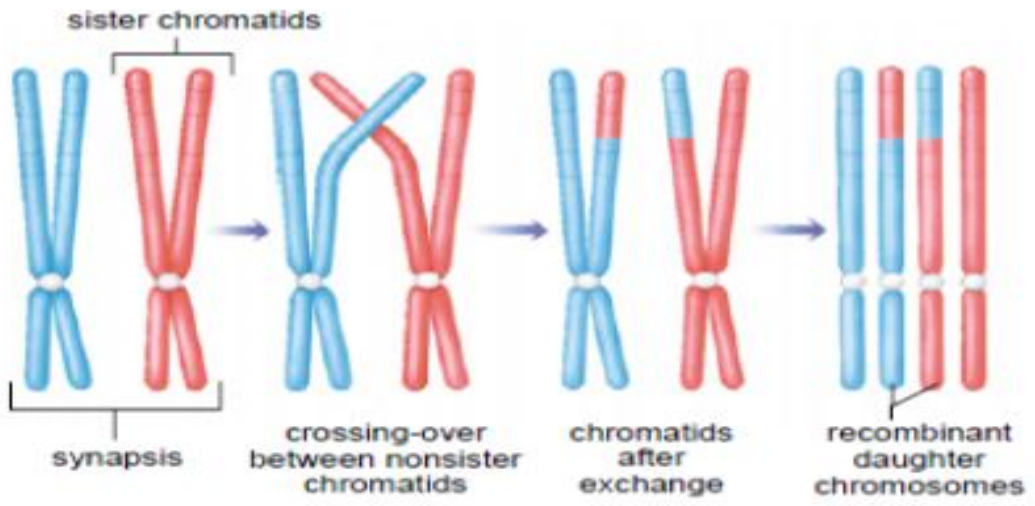
Meiosis occurs only certain times in the life cycle of sexually reproducing organisms . in humans , meiosis occurs only in the reproductive organs and produces the gametes .

Mitosis is more common because it occurs in all tissues during growth and repair .

Process : (property)

Property (process)	Meiosis	Mitosis
1.DNA replication :	Occur during interphase before meiosis I beings.	Occur during interphase before mitosis beings .
2.Number of divisions :	Two, each including prophase I+II, metaphase I+II, anaphase I+II, and telophase I+II .	One, including : prophase, metaphase, anaphase, and telophase .
3.Synapsis of homologous chromosomes :	Occur during prophase I along with crossing-over between non sister chromatids , resulting	Doesn't occur .

	chiasmata hold pairs together due to sister chromatid cohesion .	
4.Number of daughter cells and genetic composition :	Four daughter cells, each one has haploid (n) containing half as many chromosomes as the parent cell, genetically different from the parent cell and from each other.	Two, each diploid (2n) and genetically identical to parent cell .
5.Chromosomes :	Meiosis is a specialized process that reduces the chromosomes number and occur only during the production of gametes .	Mitosis is a process that occurs during growth and repair of all tissue .

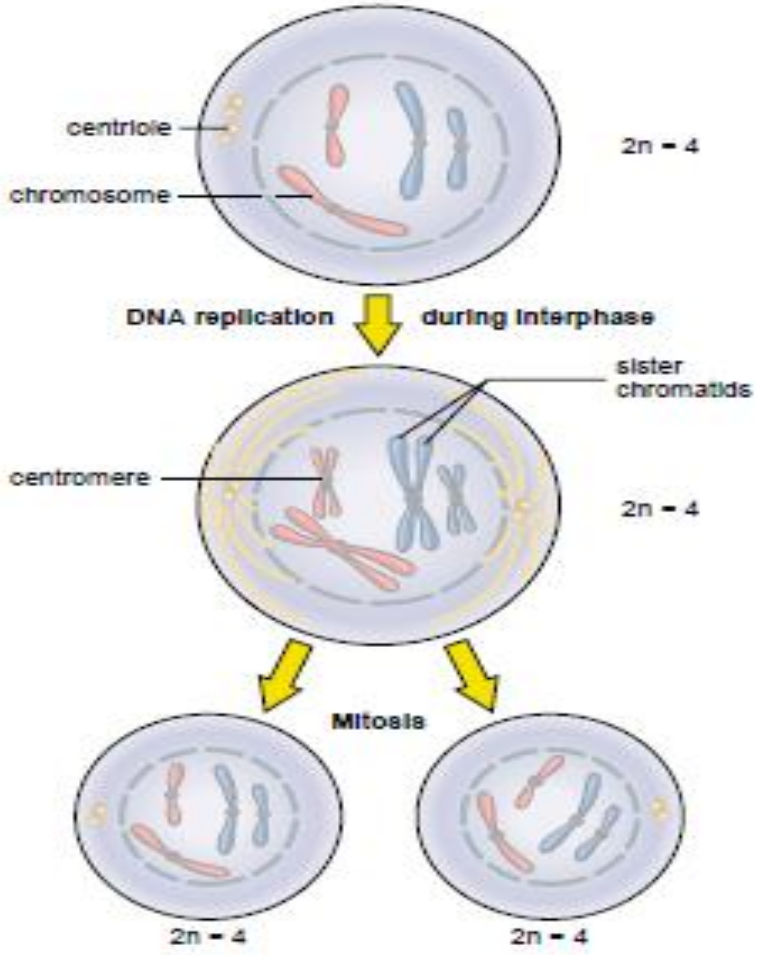


Synapsis and crossing-over.
During meiosis I, from left to right, duplicated homologous chromosomes undergo synapsis; nonsister chromatids break and then rejoin, so that two of the resulting daughter chromosomes have a different combination of genes.

The following are differences between meiosis and mitosis :

1. **DNA replication take place only once during both meiosis and mitosis.**
2. **There are two nuclear divisions during meiosis and only one nuclear division during mitosis .**
3. **Four daughter cells are produced by meiosis . mitosis results in two daughter cells .**
4. **The four daughter cells formed by meiosis are haploid . the daughter cells produced by mitosis have the same chromosome number as the parental cell.**
5. **The daughter cells from meiosis are not genetically identical to each other or to the parental cell .**

The daughter cells from mitosis are genetically identical to each other and to the parental cell .



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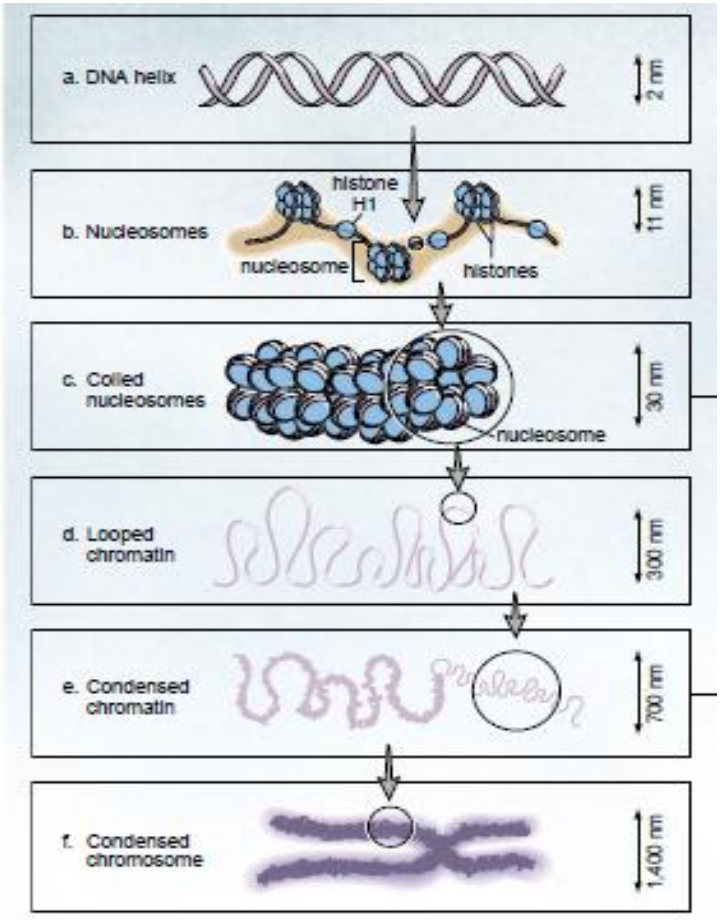

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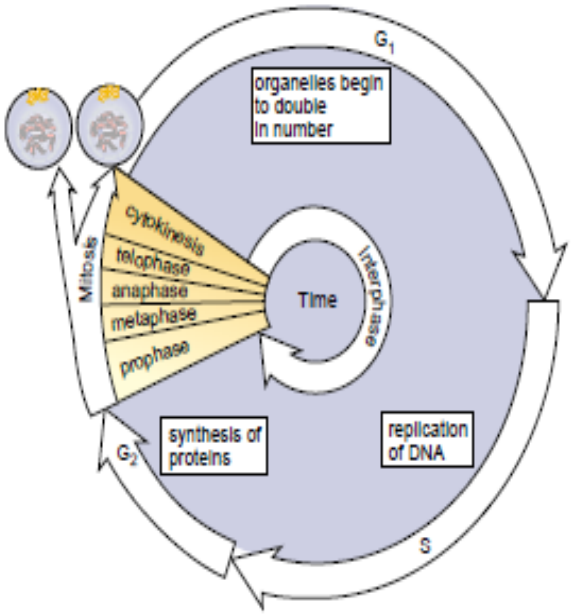

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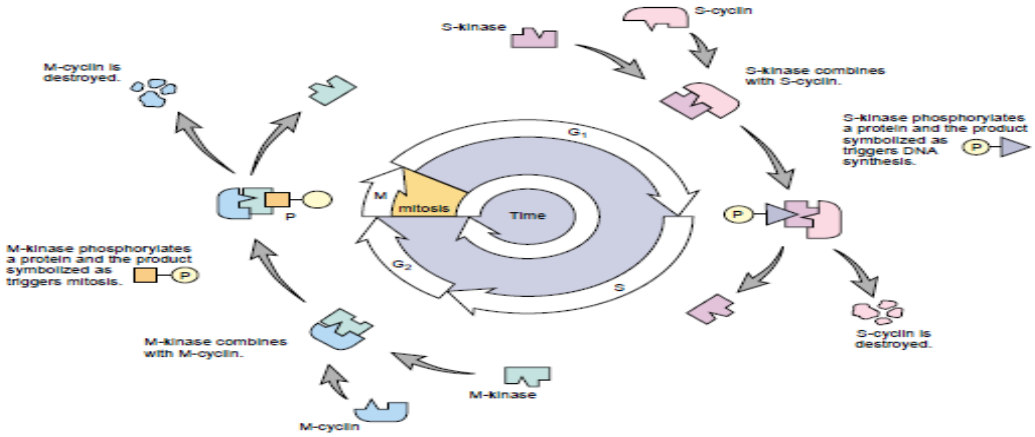
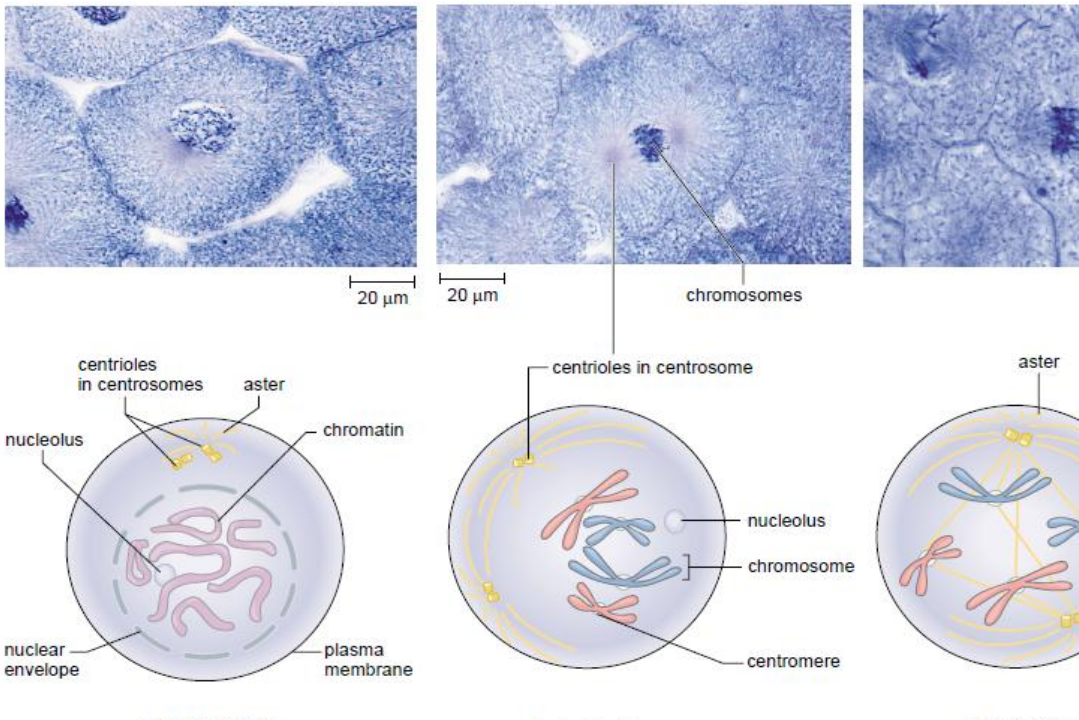
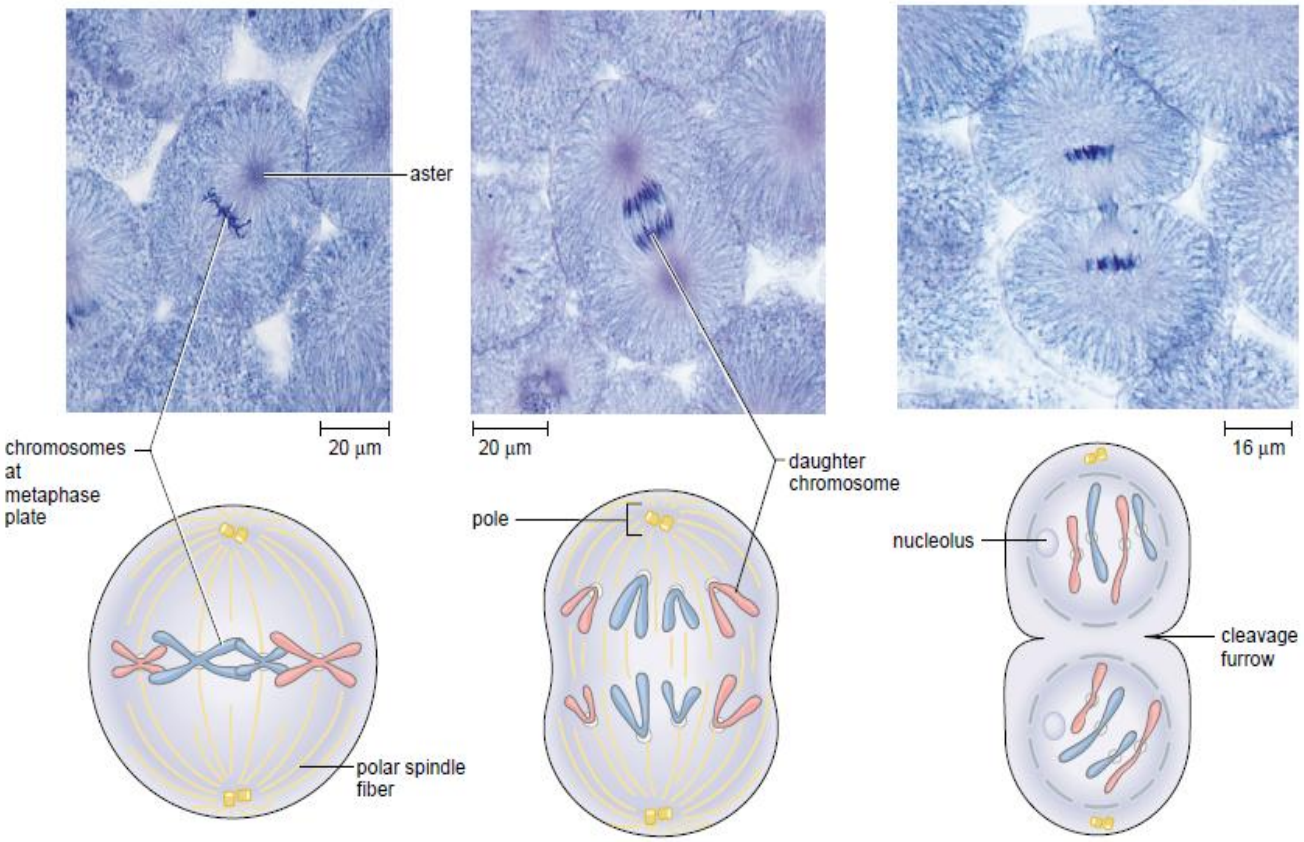
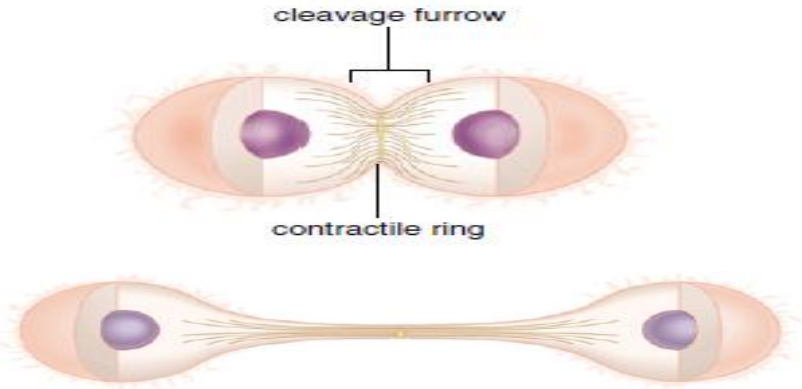


Control of the cell cycle.
At two critical checkpoints a kinase combines with a cyclin. Just before the S stage, S-kinase combines with S-cyclin and synthesis (replication) of DNA takes place. Just before the M stage, M-kinase combines with M-cyclin and mitosis takes place.



Late interphase.





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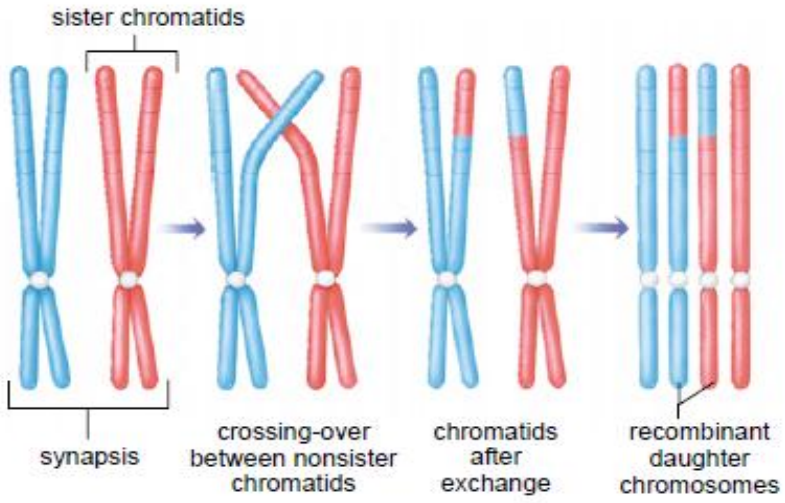

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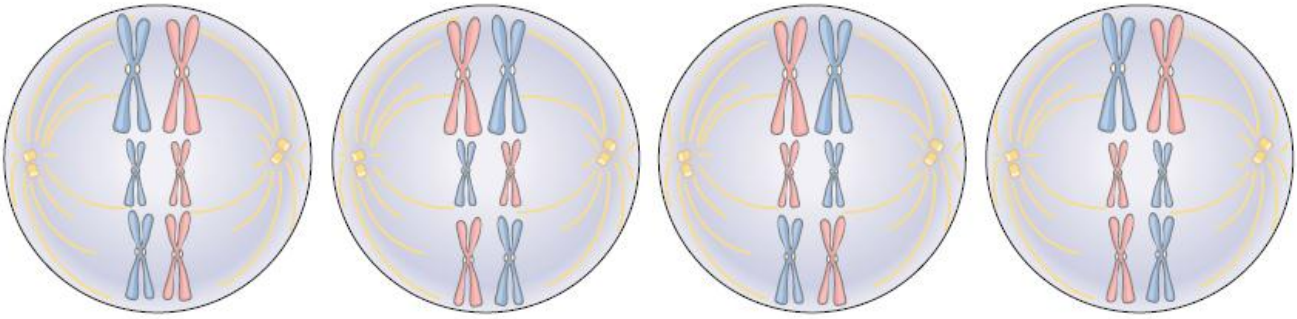

Independent assortment.
Four possible orientations of homologue pairs at the metaphase plate are shown. Each of these will result in daughter nuclei with a different combination of parental chromosomes. When a cell has three pairs of homologous chromosomes, there are 23 possible combinations of parental chromosomes in the daughter nuclei.

The End