Biology Unit 6 Chromosomes and Mitosis

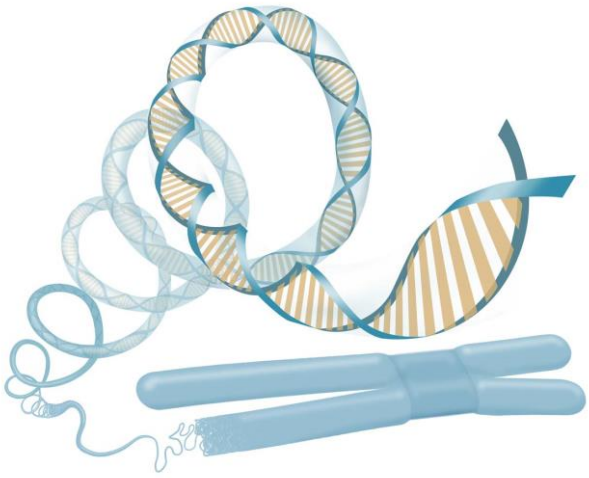
6:1 Chromosomes

DNA→GENES→CHROMATIN/CHROMOSOMES

CHROMOSOMES/CHROMATIN are made of units called GENES. GENES are made of a compound called deoxyribonucleic acid or DNA.

GENE: unit of heredity, enough DNA to instruct for the synthesis of one protein

CHROMATIN: genetic material in non-dividing cell's nucleus; DNA in thin, non-coiled strands.
DNA must be in chromatin form in order to be copied.

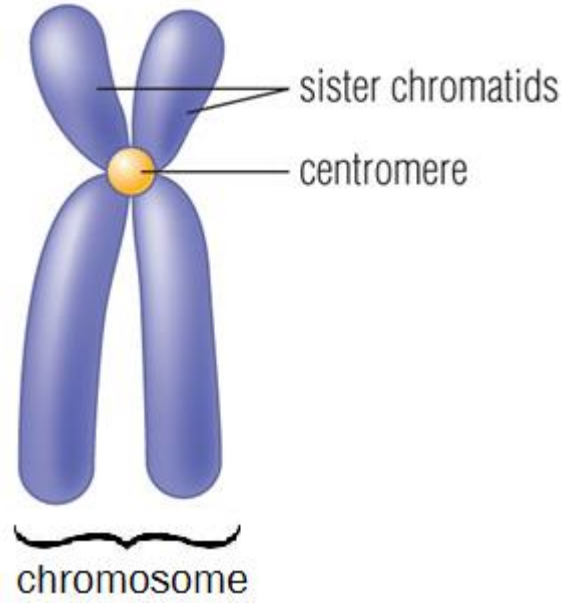


CHROMOSOME: genetic material in dividing cell's nucleus; DNA in coiled, rod-shaped form.
DNA must be in chromosome form in order for the cell to divide or reproduce.

DNA is replicated in chromatin form to make two copies for cell division. Chromatin then changes to chromosomes in order for the cell to divide. When chromatin forms a chromosome, the chromosome appears as TWO identical joined replicates.

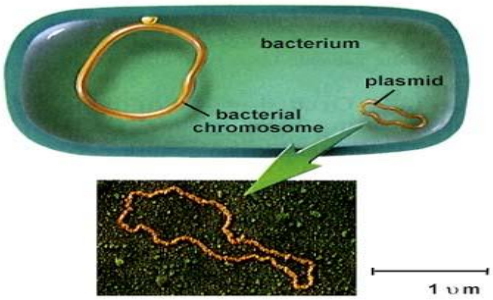
CHROMATID (SISTER CHROMATID): one of two duplicated, joined, identical parts of a chromosome; found after DNA replication but before cell division.

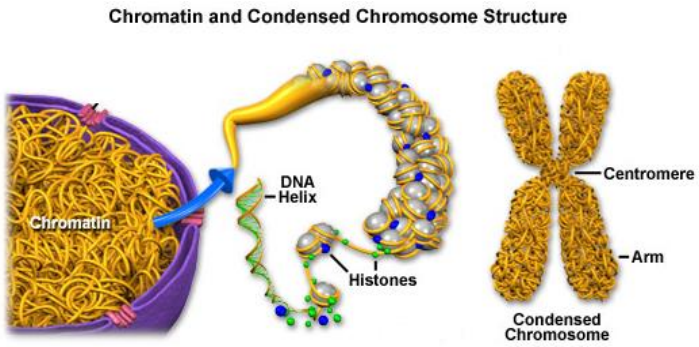
CENTROMERE: point at which sister chromatids are joined.



DNA in PROKARYOTES

- Bacterial DNA is circular
- Have 1 chromosome
- No nucleus, attached to cell membrane



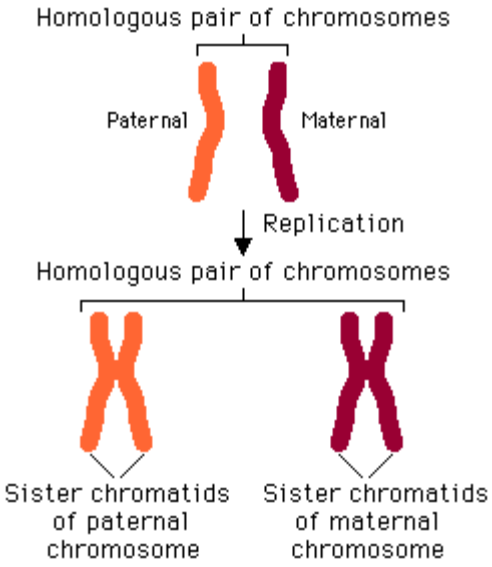


6:2 Chromosome Number

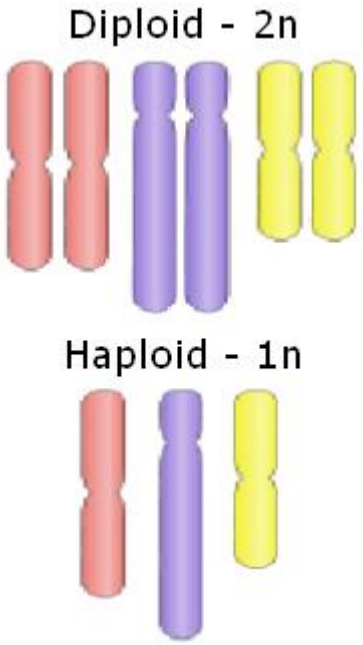
Every species has a characteristic number of chromosomes which is different from other species.

Example:	nematode worm	2 pairs
	protozoan	300 pairs
	human	23 pairs

Chromosomes occur in pairs in sexually reproducing organisms. One of the pair comes from the MOM and the other comes from the DAD.



HOMOLOGOUS CHROMOSOMES: two members of a pair of chromosomes that carry genes for the same traits, have the same size and shape, but not identical



DIPLOID (2N): total chromosome number in a body or somatic cell, having both chromosomes of a homologous pair. Diploid or 2N number in humans is 46 chromosomes.

HAPLOID (1N): chromosomes number in sex cell (egg or sperm), only one chromosome from each homologous pair. Haploid or 1N number in human egg or sperm is 23

SEX CHROMOSOMES: chromosomes that

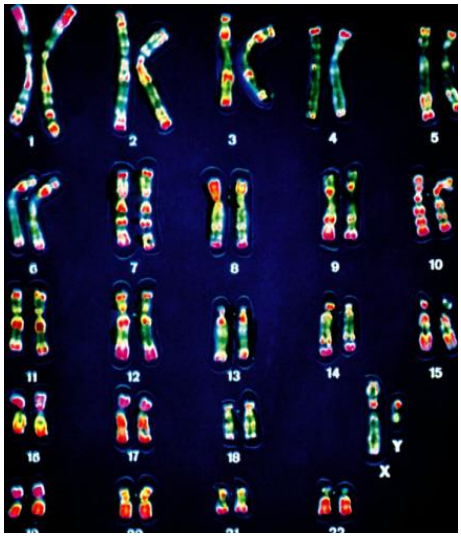
determine the sex of an organism, and carry the genes for other characteristics (X or Y), in humans there are 2

- Females have XX
- Males have XY

AUTOSOMES: non-sex chromosomes, in humans there are 44

KARYOTYPE: a pictorial display that shows an individual's chromosomes arranged in homologous pairs and in order of diminishing size

- First 22 are autosomes
- Last 2 are sex chromosomes

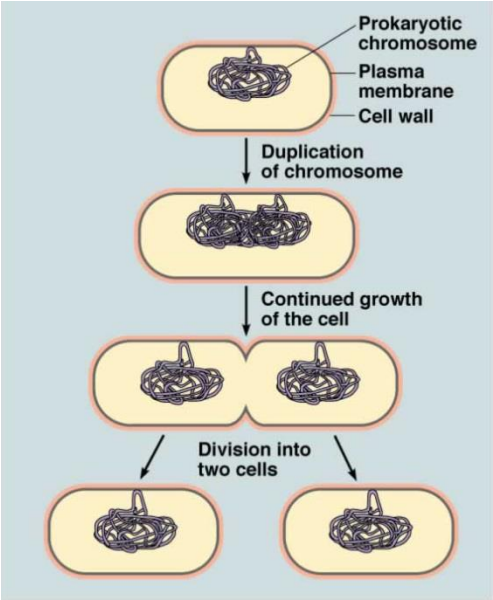


6:3 Cell Division in Prokaryotes

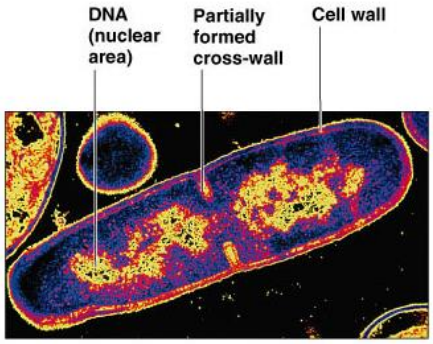
ASEXUAL REPRODUCTION: production of offspring from one parent

- Example:
  - BINARY FISSION: a form of asexual reproduction in single-celled organisms by which one cell divides into two cells of the same size, division of prokaryotes

1. The DNA is copied, resulting in two identical chromosomes attached to the inside of the cell membrane.



2. The cell grows until it reaches approximately twice the cell's original size.
3. The growing cell membrane pushes inward and the cell is constricted at the center.
4. A new cell wall forms around the new membrane.



(b) A thin section of a cell of *Bacillus licheniformis* starting to divide.

6:4 Cell Division in Eukaryotes

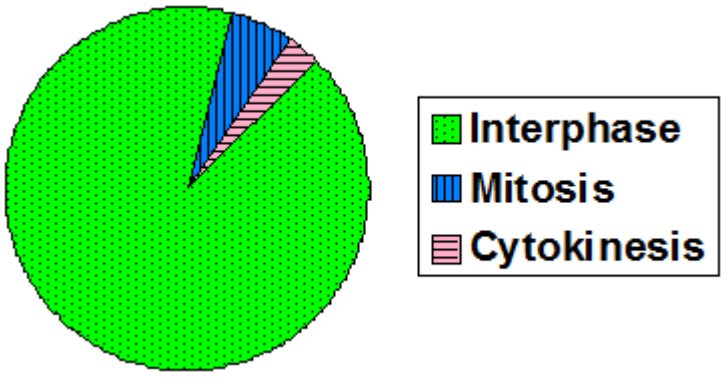
- ASEXUAL REPRODUCTION: production of offspring from one parent
  - Example:
    - MITOSIS: occurs in eukaryotic cells, a process of cell division that forms two new nuclei, each of which has the same number of chromosomes

- SEXUAL REPRODUCTION: reproduction in which sex cells from two parents unite
  - Examples:
    - MEIOSIS: a process in cell division during which the number of chromosomes decreases to half the original number by two divisions of the nucleus, which results in the production of sex cells

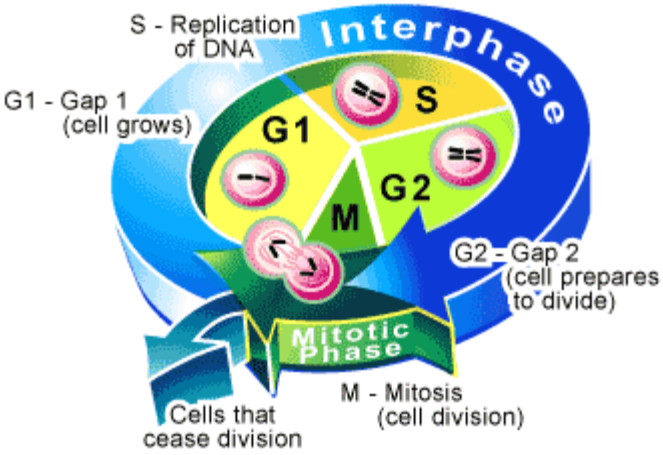
CELL CYCLE: sequence of events that occurs during the life of a cell from cell division to cell division.

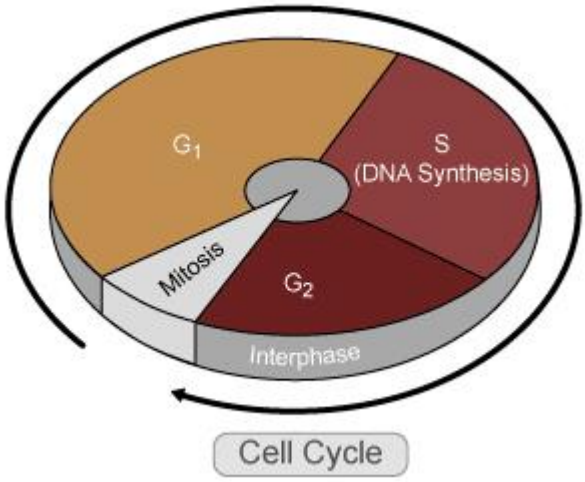
EVENTS OF THE CELL CYCLE:

1. Interphase
2. Mitosis
3. Cytokinesis



The Cell Cycle is a continuous process; cells are at some point in the cycle at all times.



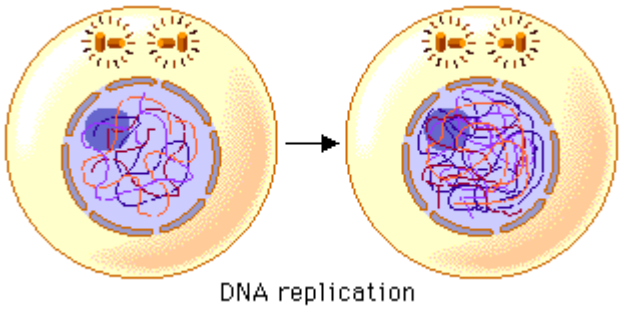


6:5 Interphase

INTERPHASE: the period of cell growth and development that precedes mitosis and follows cytokinesis.

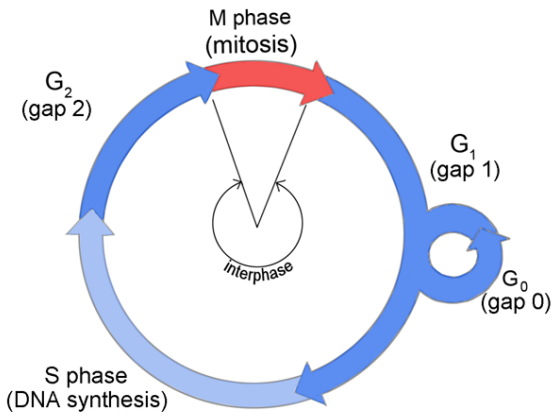
Events of Interphase:

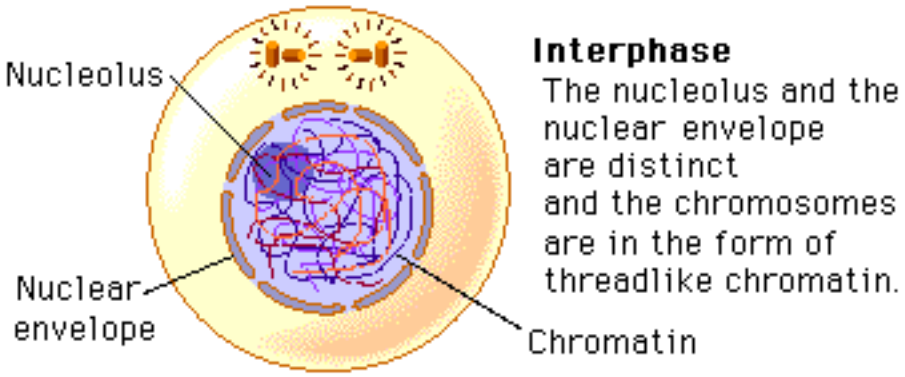
- The cell spends most of its life in interphase.
- 3 phases of Interphase:
  1. G_1 phase:
     a. Cells grow bigger
     b. DNA is in chromatin form, spread throughout the nucleus



2. S phase:
    a. Synthesize (make) DNA, cell will contain two exact copies of each chromosome
3. G_2 phase:
    a. Prepares for cell division
    b. Grows bigger
    c. Makes organelles needed for cell division

- Some cells enter G_0 phase:
    - Cells do not copy their DNA and do not prepare for cell division
    - Exit the cell cycle after G_1 phase
    - Examples: fully developed cells in the central nervous system, heart muscle cells





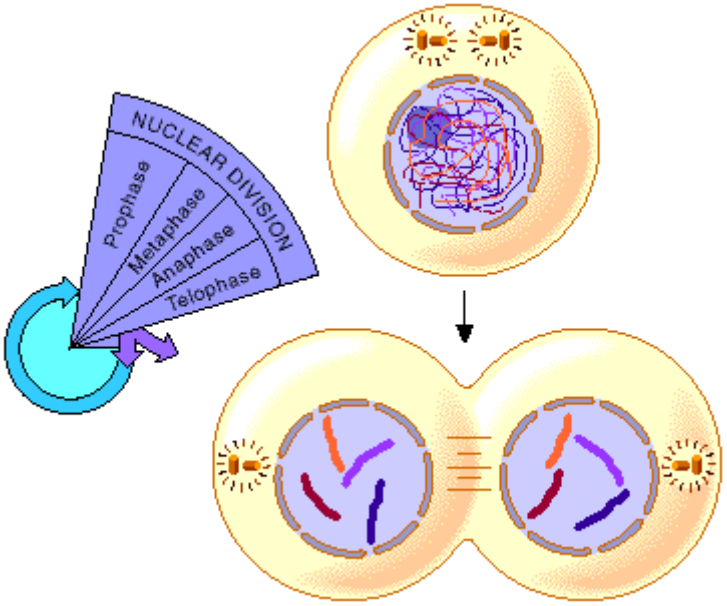
6:6 Mitosis

MITOSIS: the division of the cell nucleus in which the parent cell's chromosomes divide into two identical sets.

PARENT CELL: original cell that divides into two new cells.

DAUGHTER CELL: two identical cells that result from cell division of the parent cell.

Mitosis must be very orderly and organized to exactly divide the replicated chromosomes into two new cells.



FOUR PHASES OF MITOSIS

1. PROPHASE→

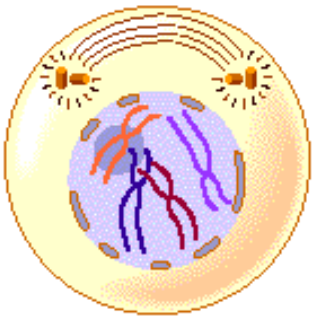
⇒1st dividing phase

⇒Centrioles move to opposite sides of cell.

⇒Chromatin coils into chromosomes.

⇒Nuclear membrane and nucleolus disappear.

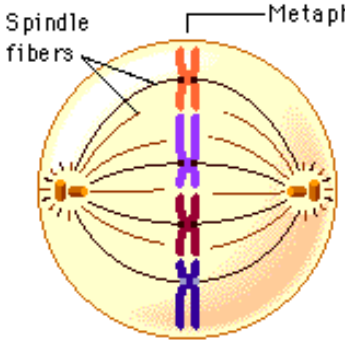
⇒Spindle fibers form from microtubules and attach to chromosomes



Prophase
The chromosomes appear condensed, and the nuclear envelope is not apparent.

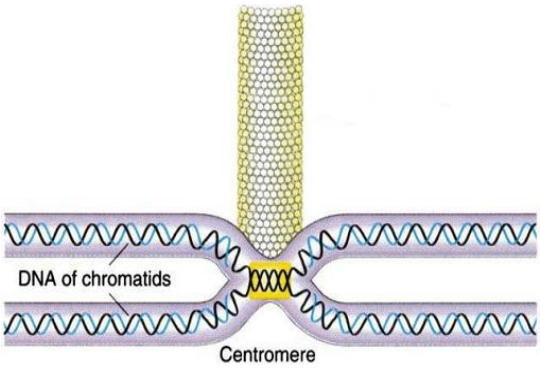
2. METAPHASE→

⇒Spindle fibers attach to paired sister chromatids



Metaphase
Thick, coiled chromosomes are lined up in the center of the cell on the metaphase plate. Spindle fibers are attached to the chromosomes.

⇒Chromosomes (both sister chromatids) move to the equator (middle of cell).

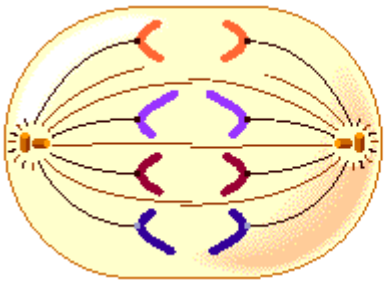


3. ANAPHASE

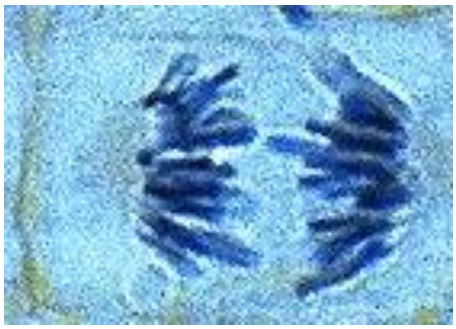
⇒Centromeres Split

⇒Chromatids are now considered to be individual chromosomes

⇒Spindle fibers shorten and pull the chromosomes AWAY to opposite poles of the cell.



Anaphase
The chromosomes have separated and are moving toward the poles.



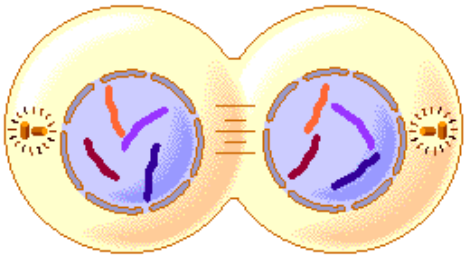
4. TELOPHASE→

⇒Centrioles and spindle fibers disappear.

⇒Chromosomes unwind into chromatin

⇒Nuclear membrane forms around TWO masses of chromatin.

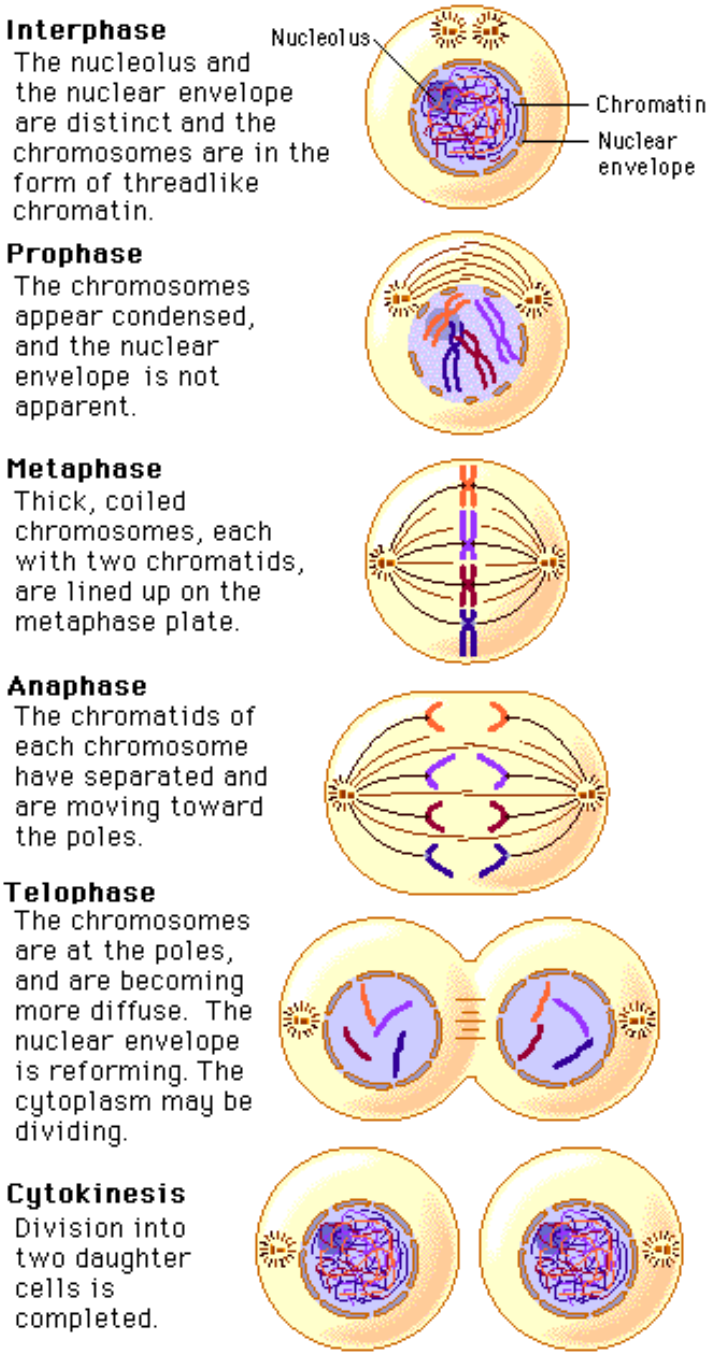
⇒Nucleolus re-appears.



Telophase
The chromosomes are at the poles, and are becoming more difuse. The nuclear envelope is reforming. The cytoplasm may be dividing.

MITOTIC PHASE CHROMOSOMES SPINDLE

Prophase	Condense from chromatin	Appears
Metaphase	Line up in the MIDDLE	Attaches to chromosomes
Anaphase	Moves AWAY to poles	Shortens
Telophase	Unwind into chromatin	Disappears



6:7 Cytokinesis

CYTOKINESIS: the division of the parent cell's cytoplasm into two daughter cells.

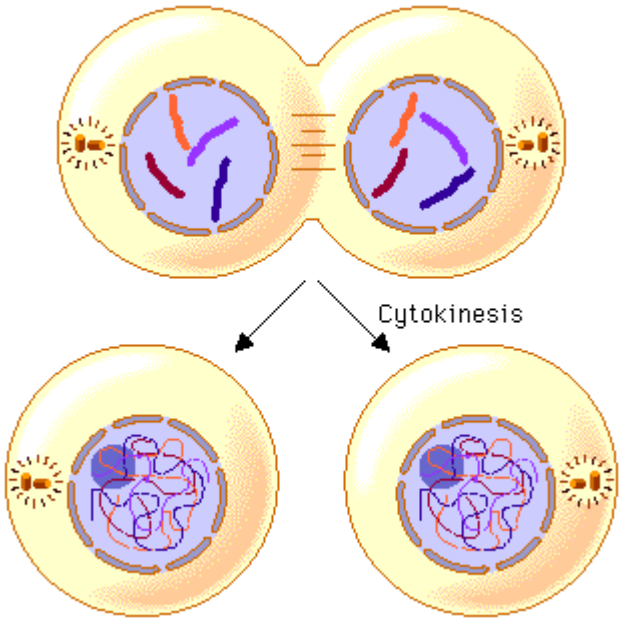
Events of Cytokinesis:

⇒Immediately follows mitosis.

⇒Cytoplasm from original parent cell splits to form two new cells.

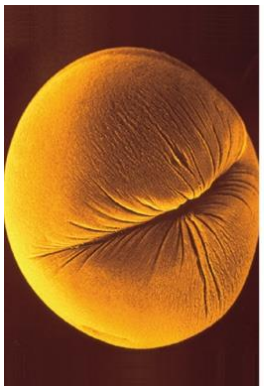
⇒Each new cell contains one of the nuclei formed by mitosis.

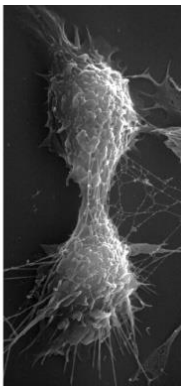
⇒Other cell structures are evenly distributed into two new, equally sized cells.



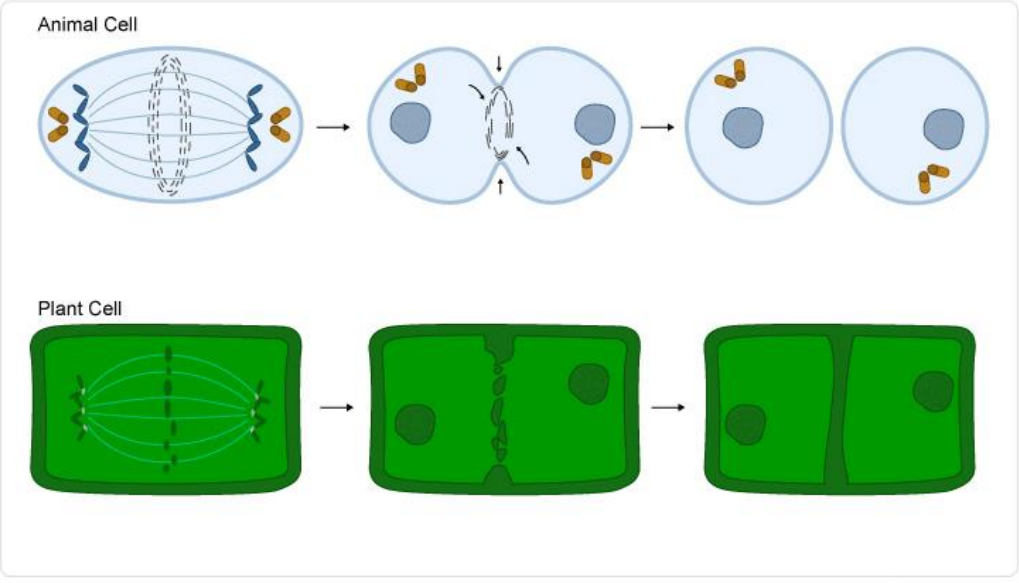
DIFFERENCES IN CYTOKINESIS - PLANT versus ANIMAL

ANIMAL → cell membrane pinches in dividing the cell with a cleavage furrow





PLANT → cell plate (which becomes cell wall) forms in the middle of the cell; cannot pinch because too rigid



Summary of Events in the Cell Cycle

1. _____
   a. _____
   b. _____
   c. _____
2. _____
   a. _____
   b. _____
   c. _____
   d. _____
3. _____

6:8 Meiosis

- SEXUAL REPRODUCTION: reproduction in which sex cells from two parents unite
  - Examples:
    - MEIOSIS: a process in cell division during which the number of chromosomes decreases to half the original number (haploid) by two divisions of the nucleus, which results in the production of sex cells

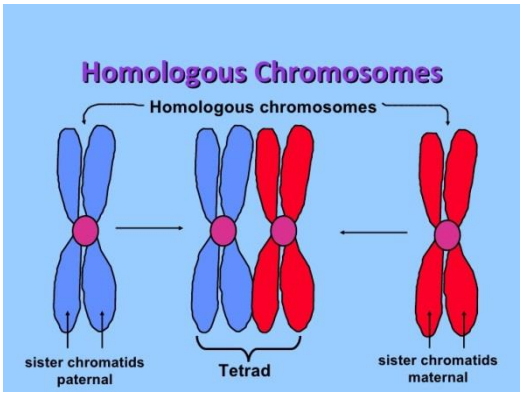
Advantages of Sexual Reproduction:

- Allows for variation in population
- Individuals can be different
- Provides foundation for evolution
- Allows species to adapt to changes in their environment

Steps of Meiosis

- *Meiosis I*
  - Prophase I:

- DNA coils tightly into chromosomes
- SYNAPSIS: pairing of homologous chromosomes during meiosis
- TETRAD: four chromatids in a pair of homologous chromosomes that come together in synapsis
- Chromatids twist around one another
- CROSSING-OVER: exchange of genetic material between homologous chromosomes that can result in genetic recombination



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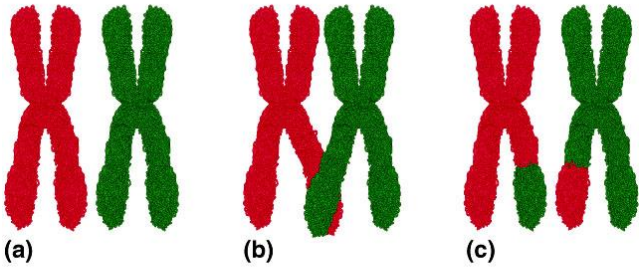
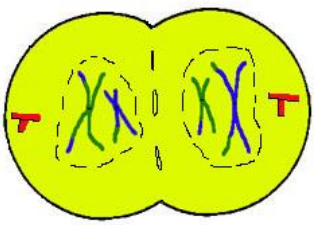
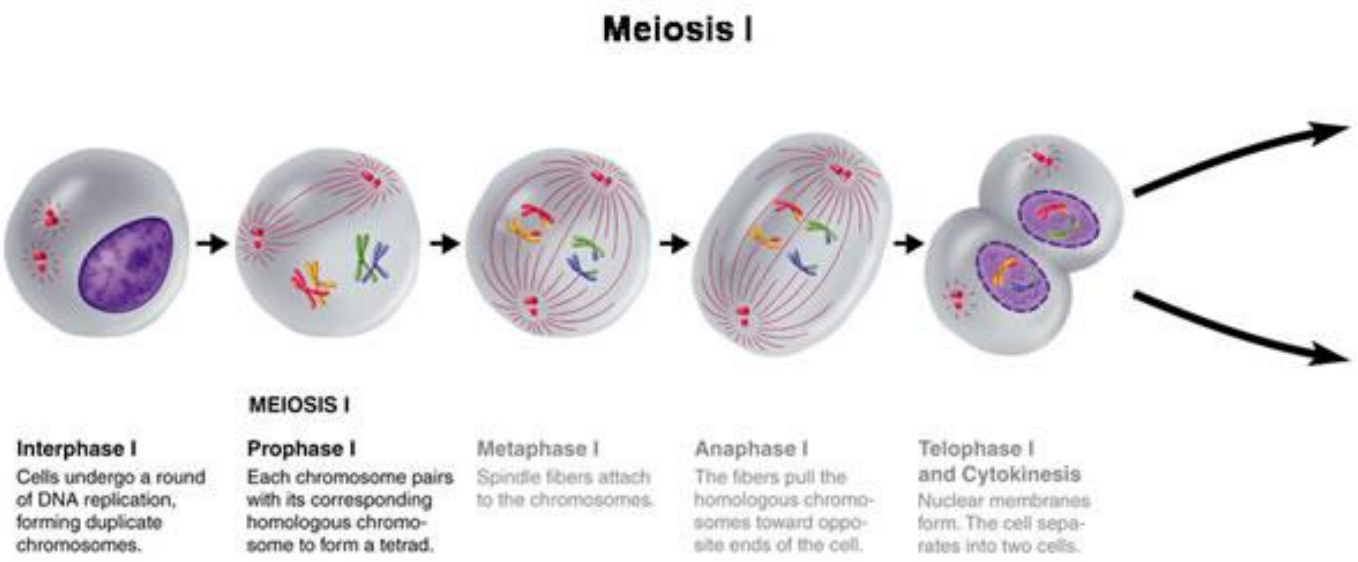
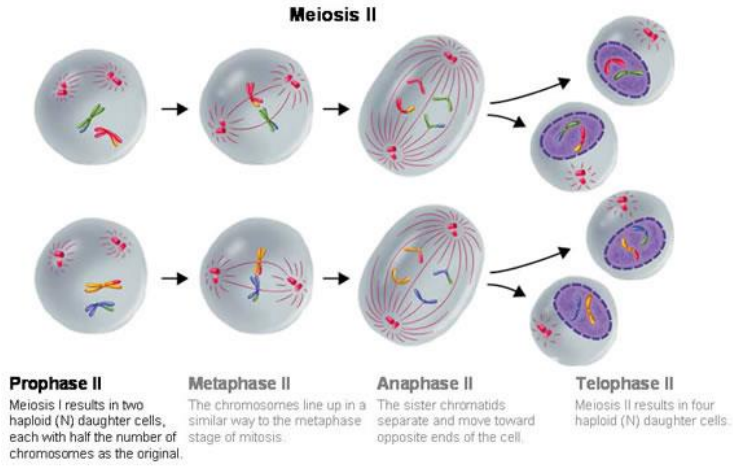


- Metaphase I:
  - Tetrads line up randomly along the center of the cell
  - Spindle fibers from one pole attach chromosomes
- Anaphase I:
  - Each homologous chromosome moves to an opposite pole of the dividing cell.
  - INDEPENDENT ASSORTMENT: random separation of homologous chromosomes
- Telophase I and Cytokinesis I
  - Nuclear membranes reform
  - The cell separates into 2 cells





- *Meiosis II*
  - Prophase II
    - 2 genetically different cells
    - Spindle fibers form
  - Metaphase II
    - Chromosomes move to the MIDDLE of the cell (similar to mitosis)
  - Anaphase II
    - Chromatids separate and move toward opposite poles of the cells
  - Telophase II and Cytokinesis II
    - Nuclear membrane forms around the chromosomes of the four new cells
    - Cytokinesis occurs, results in four haploid cells (1n)



Meiosis produces haploid (1n) egg cells and haploid (1n) sperm cells that fuse during fertilization to form a diploid (2n) zygote.

Differences between Mitosis and Meiosis:

	Meiosis	Mitosis
Type of Reproduction	Sexual	Asexual
Genetically	Different	Identical
Crossing Over	Yes	No
Pairing of Homologous Chromosomes	Yes	No
Function	Genetic diversity through sexual reproduction	Cellular reproduction and general growth and repair of the body
# of Divisions	2	1
# of Daughter Cells	4 Haploid Cells	2 Diploid Cells

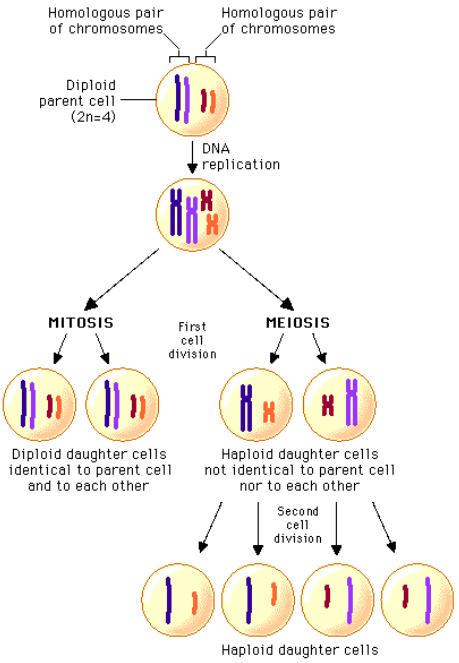
MITOSIS:

$G_1 \rightarrow S \rightarrow G_2 \rightarrow P \rightarrow M \rightarrow A \rightarrow T \rightarrow C$

MEIOSIS:

$G_1 \rightarrow S \rightarrow G_2 \rightarrow P \rightarrow M \rightarrow A \rightarrow T \rightarrow C$ (I)

$P \rightarrow M \rightarrow A \rightarrow T \rightarrow C$ (II)



6:9 The Development of Gametes

SPERMATOGENSIS: the process by which males gametes form

OOGENESIS: the production, growth, and maturation of an egg, or ovum

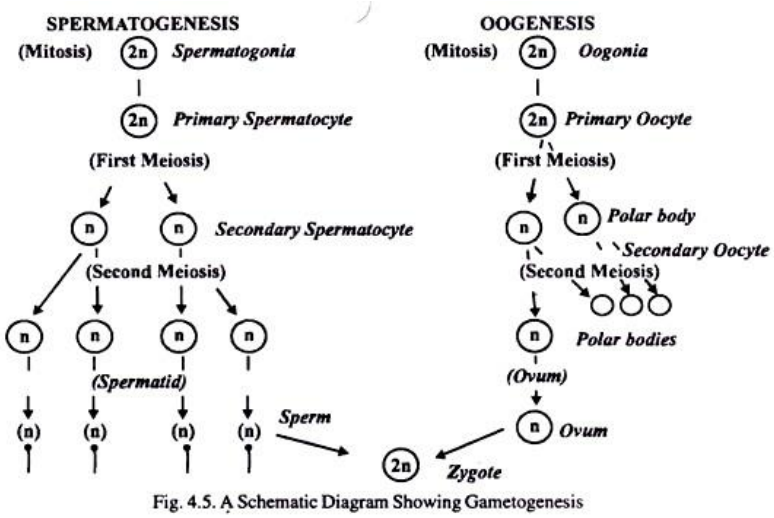


Fig. 4.5. A Schematic Diagram Showing Gametogenesis

POLAR BODY: a short-lived product of the formation of gametes by meiosis

Steps of Sexual Reproduction

1. Organisms produce GAMETES: haploid sex cells. Female gametes are eggs, male gametes are sperm.
2. Egg and sperm unite forming ZYGOTE: diploid fertilized egg resulting from fusion of gametes, capable of developing into new organism.
3. Zygote develops into mature organism by mitosis.