CELL DIVISION

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Cell Division

- Cell division is the process that results in the multiplication of cells and involves both nuclear and cytoplasmic division. Two types of nuclear, or chromosomal, division are mitosis and meiosis.

Homologous Chromosomes

- Human body cells, or somatic cells, contain 23 pairs of homologous chromosomes (or 46 total chromosomes). One member of each homologous pair was inherited from each parent.
- The two chromosomes of each pair are called **homologous chromosomes** (or homologs) because they carry the same genes in the same order (mostly).

Fig. 6.1

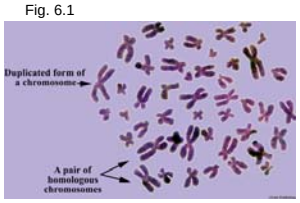

Fig. 6.2

Designation of Number of Chromosomes

- If a cell contains both of each of the homologous chromosomes, the cell is referred to as **diploid, or 2n**.
- If a cell contains only one of each of the homologous chromosomes, the cell is referred to as **haploid, or n**. Thus, haploid cells contain only the chromosomes that are different.

Mitosis

- Mitosis is a cell division process described as nuclear division.
- Mitosis results in the formation two daughter nuclei, **each having the same number of chromosomes**.
- Usually, the process of **cytokinesis** accompanies mitosis. Cytokinesis is the process of cytoplasmic division.

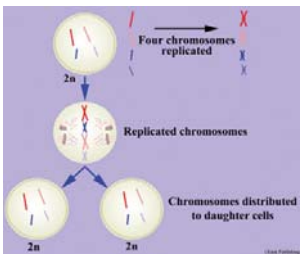

Fig. 6.3

Meiosis

- Meiosis is a process of nuclear division that results in a reduction in the number of chromosomes.
- Meiosis takes place in nuclei of gamete producing cells (diploid) and results in gametes, the sperm and an egg.
- Gametes have nuclei that contain one of each of the homologous chromosomes (haploid).

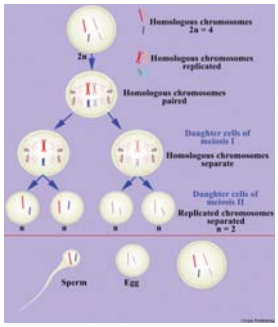

Fig. 6.4

CELL LIFE CYCLE

The life of a cell can be divided into two major parts: (1) interphase and (2) division.
Interphase is the time interval between a cell's divisions.
Cell division may include mitosis and/or meiosis.

Life Cycle of Mitotic Cells

- MITOSIS
  - Mitosis is the division process that occurs in the nucleus of a cell and when accompanied by the division of the cytoplasm (cytokinesis) results in daughter cells that have the same number of chromosomes.
- INTERPHASE
  - In interphase, the cell is undergoing growth and development; it is not dividing. Many preparations for division are underway.

Life Cycle of Mitotic Cells

The life cycle of a mitotic cell can be divided into four phases, G1, S, G2, and M. A fifth phase, G0, is given to cells that differentiated into amitotic cells.

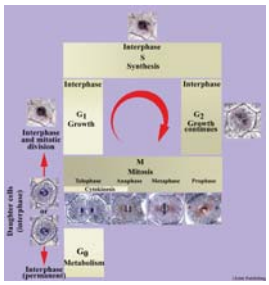

Fig. 6.5

DNA REPLICATION

- The DNA of the cell is replicated in the S phase of interphase. After DNA replication the process of mitosis (nuclear division) distributes identical copies of DNA to each of the daughter cells.
- A molecule of DNA is structured from nucleotides. A DNA nucleotide is formed from three building blocks: (1) a phosphate group, (2) deoxyribose (a pentose sugar), and (3) one of four nitrogen bases - adenine (A), thymine (T), cytosine (C), or guanine (G). Since there are four nitrogen bases, there are four different nucleotides.

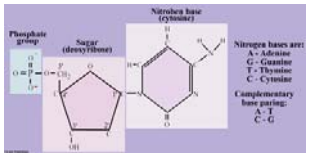

Fig. 6.6

Nitrogen Base Pairing

- In the hydrogen bonding of the nucleotide nitrogen bases, complementary bases are always paired, adenine (A) bonds with thymine (T) and cytosine (C) bonds with guanine (G).
-

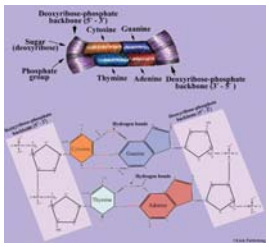

Fig. 6.7

Organization of DNA

- Two linear polynucleotide strands of DNA are hydrogen bonded together to form the double helix **DNA molecule**.
- DNA molecules become associated with proteins called histones and are organized into a form called **chromatin**. Chromatin is the form of DNA that is found in interphase.
- In cell division, chromatin is further condensed into **chromosomes**.

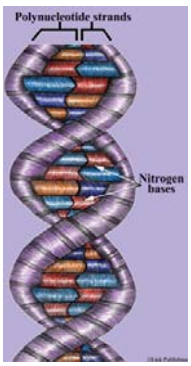

Fig. 6.8

Replication of DNA

- A molecule of DNA is replicated. The DNA molecule is enzymatically separated to expose the nitrogen bases of each polynucleotide strand.
- Nucleotides are enzymatically added by complementary base pairing to each exposed nucleotide strand.
- Replication results in two identical DNA molecules called **chromatids**. The chromatids are attached at a site called the **centromere**.

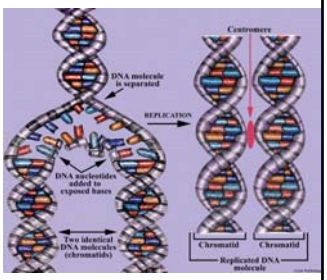

Fig. 6.9

Replicated Chromosomes

- A cell with two replicated DNA molecules (chromosomes). Each replicated chromosome consists of two chromatids attached at the centromere.
- In mitosis when the chromatids separate, they are called chromosomes.
- Each daughter cell receives one of the replicated chromosomes. Thus, the original genetic information is maintained.

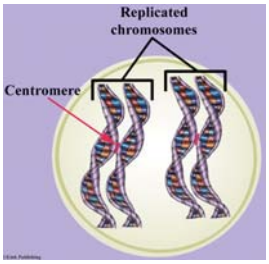

Fig. 6.10

INTERPHASE and MITOSIS

Interphase and the four stages of mitosis are studied by observation of animal and plant cells. The mitotic event in both plants and animal cells is similar. However, the spindle fibers and poles are usually not stained in preparations of plant cell mitosis.

Lab Activity 1
Whitefish Blastula

- Whitefish blastula sections on a prepared slide. Each section consists of many cells that are either in interphase or mitosis.
- The microscopic appearance of each cell will depend upon the cell's position when it was sectioned.

Fig. 6.11

Interphase

- A cell directly from mitosis (a daughter cell) enters interphase and makes preparations for the next mitotic division.
- The daughter cell shown contains one pair of centrioles, a nucleus with two chromosomes (unreplicated) and two nucleoli.

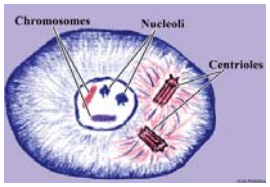

Fig. 6.12

Interphase (Late)

- A cell in late interphase (G2). The cell has made preparations for the next mitotic division.
- The cell contains two pairs of **centrioles**, a **nucleus** with two replicated chromosomes, and two **nucleoli**.
- Each replicated chromosome consists of two sister **chromatids** attached at the **centromere**.

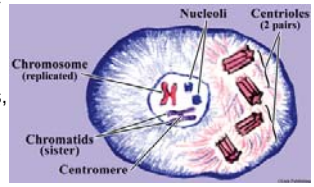

Fig. 6.13

Interphase

- A whitefish blastula cell observed in interphase (430X) .
- What are the events of interphase?

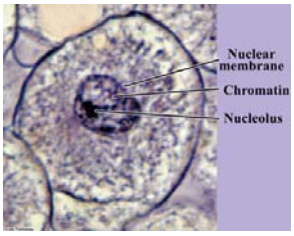

Fig. 6.15

Mitosis - Whitefish Blastula Microscopic Study

Mitosis is nuclear division. It results in the equal division of a cell's replicated chromosomes for distribution into two daughter cells. For the convenience of study, mitosis is divided into four sequential stages:

(1) prophase,
(2) metaphase,
(3) anaphase, and
(4) telophase.

PROPHASE

- Prophase is characterized by the following events:
  - The nuclear membrane fragments and disappears.
  - Chromosomes (replicated) appear randomly dispersed within the fragmenting nuclear region. Each chromosome consists of two sister chromatids attached at a centromere.
  - The nucleoli disappear.
  - One of each of the two pairs of centrioles (a pair of centrioles and the surrounding cytoplasm is called the centrosome) moves to form the poles of the mitotic apparatus (spindle).
  - Fibers begin to appear from the cytoplasm surrounding each pair of centrioles. The fibers (microtubules) can be classified as spindle fibers and aster fibers.

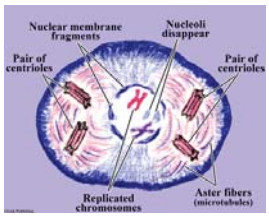

Fig. 6.16

PROPHASE- Whitefish Blastula

- Prophase as seen in a whitefish blastula cell (430X).

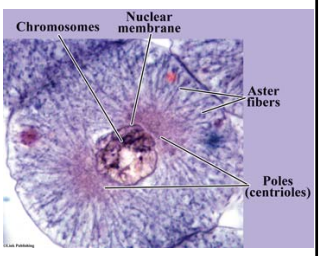

Fig. 6.18

METAPHASE

- Metaphase is the second stage of mitosis. Metaphase is relatively short in duration.
- Metaphase is characterized by the following event:
  - the chromosomes (replicated) align along the equator of the mitotic spindle.

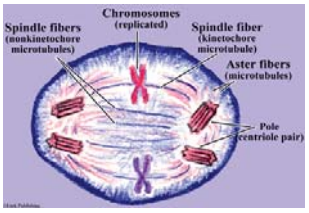

Fig. 6.19

METAPHASE – Whitefish Blastula

- Metaphase as seen in a whitefish blastula cell (430X).

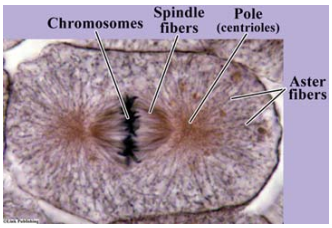

Fig. 6.21

ANAPHASE

Anaphase is the third stage of mitosis.

- Anaphase is characterized by the following events:
  - Anaphase begins with the splitting of the centromeres and the separation of the sister chromatids. (The separated sister chromatids are now called sister chromosomes.)
  - Each sister chromosome begins movement toward an opposite pole.
  - Anaphase ends when chromosomes reach the poles and their movement stops.

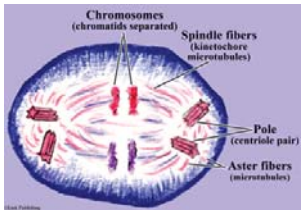

Fig. 6.22

ANAPHASE – Whitefish Blastula

- Anaphase as seen in a whitefish blastula cell (430X).

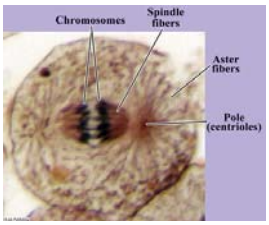

Fig. 6.24

TELOPHASE

- Telophase is the last (fourth) stage of mitosis.
- Telophase is characterized by the following events:
  - Telophase begins after the chromosomes have stopped movement and are located at the poles.
  - The nuclear membrane reforms.
  - The chromosomes become organized into chromatin
  - The nucleoli reappear within the nucleus (in late telophase).
  - The mitotic spindle (spindle fibers) and aster fibers disappear.

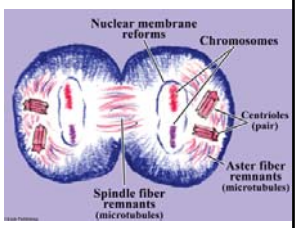

Fig. 6.25

TELOPHASE – Whitefish Blastula

- Telophase as seen in a whitefish blastula cell (430X).

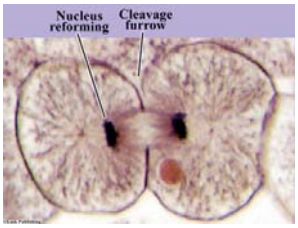

Fig. 6.27

DAUGHTER CELLS

The descriptive term “daughter cells” is used to identify the two interphase cells that originated from a parent cell by division of the cytoplasm.

Cytokinesis

- Cytokinesis is defined as the division of the cytoplasm of animal cells. It usually begins when the cell is in either late anaphase or early telophase. Cytokinesis begins with the formation of a cleavage furrow at the center of the cell and ends when the cell is pinched into two daughter cells. If cytokinesis did not occur, the cell would be binucleate.

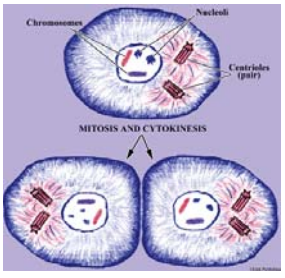

Fig. 6.29

Lab Activity 2
Plant Cell Mitosis

- Plant cell studies typically use the growing tip of an onion root.
- Onion (Allium) root tip sections on a prepared slide. Each section consists of many cells that are either in interphase or mitosis. The microscopic appearance of each cell will depend upon the cell's position when it was sectioned.

Fig. 6.31

Interphase Cells - Allium Root Tip

- The chromosomes are not visible as distinctive entities. Instead, the chromosomes are in a dispersed arrangement called **chromatin**. In late interphase and in the stages of mitosis chromosomes are visible as distinctive strands.
- Identify the following:
- (1) nucleus,
- (2) nucleoli, and
- (3) chromatin

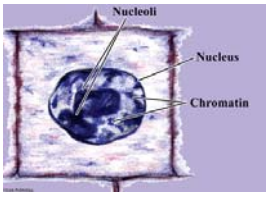

Fig. 6.32

Prophase Cells - Allium Root Tip

- In plant cells, the poles (centrosomes) and microtubules are usually not as visible as in the animal cells.
- Identify the following:
  - (1) replicated chromosomes,
  - (2) nuclear membrane (fragments and disappears by late prophase) and
  - (3) nucleoli, or singular nucleolus (will disappear by late prophase).

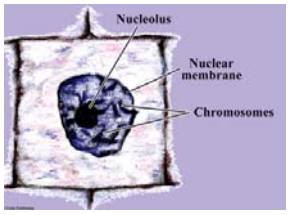

Fig. 6.33

Prophase Cells - Allium Root Tip

- Prophase as seen in an Allium (onion) root tip cell (430X).

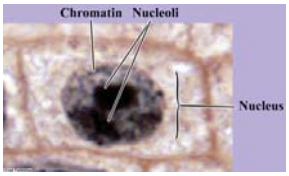

Fig. 6.34

Metaphase Cells - Allium Root Tip

Identify the following:

- (1) chromosomes (replicated) aligned along the equator of the cell.

Fig. 6.35

Metaphase Cells - Allium Root Tip

- Metaphase as seen in an Allium (onion) root tip cell (430X).

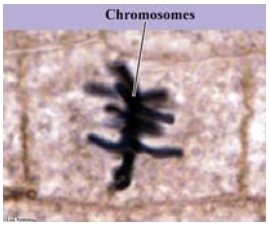

Fig. 6.36

Anaphase Cells - Allium Root Tip

- Identify the following:
  - (1) chromosomes (sister) separating
- The chromosomes can be in any position from early splitting of chromatids to a position near the poles.

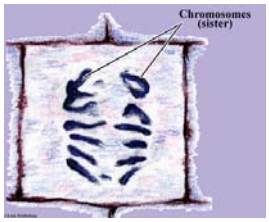

Fig. 6.37

Anaphase Cells - Allium Root Tip

- Anaphase as seen in an Allium (onion) root tip cell (430X).

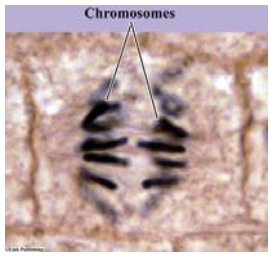

Fig. 6.38

Telophase Cells - Allium Root Tip

Locate several cells in telophase.

- Identify the following:
  - (1) nuclei (reforming nuclear membranes)
  - (2) cell plate (forming)
- Telophase is accompanied by the formation of a cell plate, the beginning of a cell wall that separates the two daughter cells.

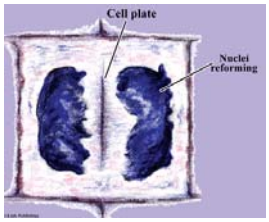

Fig. 6.39

Telophase Cells - Allium Root Tip

- Telophase as seen in an Allium (onion) root tip cell (430X).

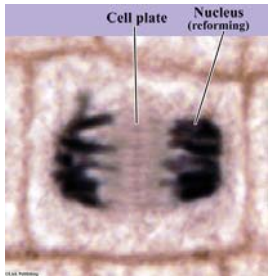

Fig. 6.40

Daughter Cells - Allium Root Tip

- Cell plate
- Cytoplasmic division in plant cells begins with the production of a cell plate. Cytoplasmic division begins either in late anaphase or early telophase by the deposition of cell wall components (cell plate) at the center of the dividing plant cell.
- Newly produced daughter cells will be half the size of the parent cell and will show nearly identical structural detail. Identify the following:
  - (1) nucleus of each cell
  - (2) cell wall

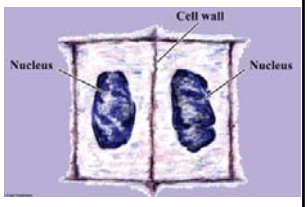

Fig. 6.41

Daughter Cells - Allium Root Tip

- Daughter cells as seen in Allium (onion) root tip (430x).

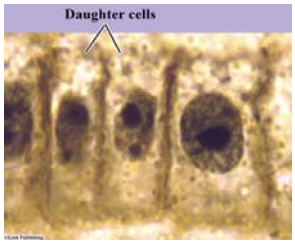

Fig. 6.42

MEIOSIS
and Gamete Production

Overview of Meiosis

- Meiosis is nuclear division in gamete producing cells that results in a reduction in the number of chromosomes from diploid (2n) to haploid (n). In meiosis, one of each pair of homologous chromosomes is distributed to a daughter cell. Haploid daughter cells function as gametes, sperm and eggs.

Summary of Meiosis

A cell with a diploid number (2n) of four chromosomes undergoes meiosis to produce four haploid (n) cells (gametes).

- Each gamete contains only one of each of the homologous chromosomes.
- Thus, the gametes contain only the chromosomes that are different. Nuclear fusion at fertilization produces a zygote (2n) with the same chromosome number as the parent.

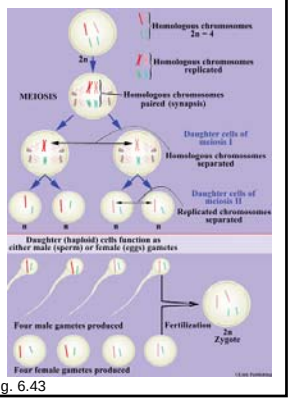

Fig. 6.43

Spermatogenesis

Spermatogenesis is the process of male gamete production. Meiosis reduces the diploid human chromosome number of 46 to the haploid number of 23.

- Meiosis assures that each of the gametes contains only half of the homologous chromosomes.

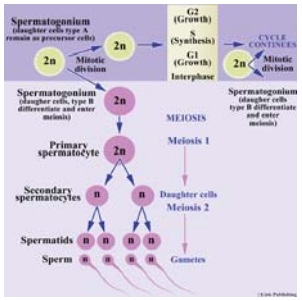

Fig. 6.45

Lab Activity 3
Spermatogenesis

- Spermatogenesis - Microscopic Study
- Testis
  - Observe a microscope slide preparation labeled “Testis.”
  - The testis consists of numerous seminiferous tubules

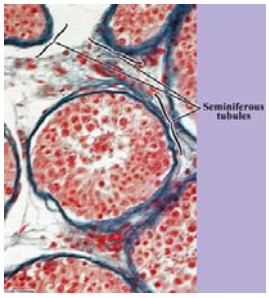

Fig. 6.46

Spermatogenesis

High power photograph of a seminiferous tubule (rat) showing cell division. Dividing cells are not always observed in testis preparations.

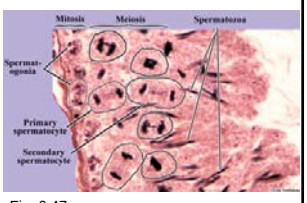

Fig. 6.47

Spermatogenesis

- High power photograph of a seminiferous tubule (rat) showing sustentacular cells and spermatogenic cells. The cells are mostly identified by the location and shape of their nuclei. Interstitial cells are located around the seminiferous tubule.

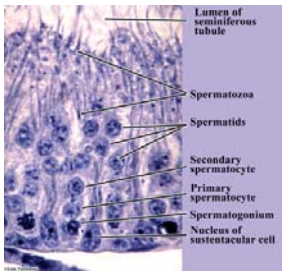

Fig. 6.49

Meiosis - Oogenesis

Oogenesis is the process of production and maturation of the egg (ovum).

Oogenesis - Overview

- Meiosis - oogenesis
- Oogenesis begins in early fetal development with the mitotic production of oogonia (2n), the precursor (stem) cells to the ova. The oogonia develop into primary oocytes as they become surrounded by a single layer of follicular cells, forming a primordial follicle.

Oogenesis - Overview

- Meiosis reduces the diploid human chromosome number of 46 to the haploid number of 23. Meiosis assures that the ovum contains only half of the homologous chromosomes.

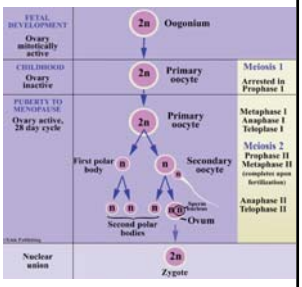

Fig. 6.50

Primary Oocytes

- Ovary (human) of a infant. Primary oocytes are produced early in fetal development and their meiotic activity stops in prophase I. The primary oocytes are surrounded by a single layer of follicular cells. A primary oocyte and its follicular cells are called a primordial follicle. Primordial follicles remain inactive until the onset of puberty.

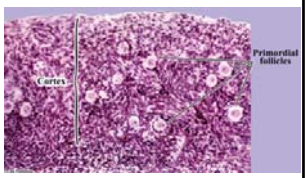

Fig. 6.51

Stages of Oocyte and Follicular Development

- Ovary (monkey) showing various stages of oocyte and follicular development.

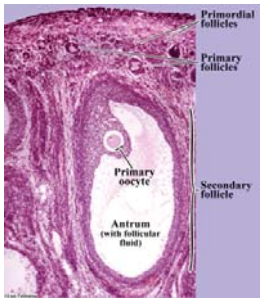

Fig. 6.52