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Unit 4 Student Notes

Cell Cycle

B-2.6 Summarize the characteristics of the cell cycle: interphase (called G1, S, G2); the phases of mitosis (called prophase, metaphase, anaphase, and telophase); and plant and animal cytokinesis.

Key Concepts:

Cell cycle

Interphase: gap 1 phase (G1); synthesis phase (S), chromatid, centromere; gap 2 phase (G2)

Mitosis: prophase, metaphase, anaphase, telophase

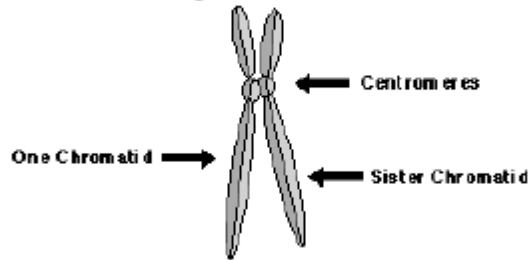
Cytokinesis: cleavage furrow, cell plate

The *cell cycle* is a repeated pattern of growth and division that occurs in eukaryotic cells. This cycle consists of three phases. The first phase represents cell growth while the last two phases represent cell division.

Interphase

- ✓ Cells spend the majority of their cell cycle in interphase. The purpose of interphase is for cell growth. By the end of interphase a cell has two full sets of DNA (chromosomes) and is large enough to begin the division process.
- ✓ Interphase is divided into three phases. Each phase is characterized by specific processes involving different structures.
- ✓ During the *G1 (gap 1) phase*, the cell grows and synthesizes proteins.
- ✓ During the *S (synthesis) phase*, chromosomes replicate and divide to form identical sister *chromatids* held together by a *centromere*.
- ✓ During the *G2 (gap 2) phase*, cells continue to grow and produce the proteins necessary for cell division.

Chromosome composed of two sister chromatids



Mitosis

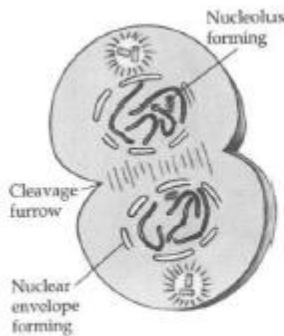
The purpose of mitosis is cell division: making two cells out of one. Each cell has to have its own cytoplasm and DNA. The DNA that replicated in Interphase when two chromosome strands became four strands (two strands per chromatid). In mitosis the four strands (two sister chromatids) have to break apart so that each new cell only has one double-stranded chromosome.

- ✓ Mitosis, which follows Interphase, is divided into four phases. Each phase is characterized by specific processes involving different structures.
- ✓ **Prophase** is characterized by four events:
 - Chromosomes condense and are more visible.
 - The nuclear membrane (envelope) disappears.
 - By the end of prophase the centrioles (cell organelles that produce spindle fibers) have separated and taken positions on the opposite poles of the cell.
 - Spindle fibers form and radiate toward the center of the cell.
- ✓ **Metaphase** (the shortest phase of mitosis) is characterized by two events:
 - Chromosomes line up across the middle of the cell.
 - Spindle fibers connect the centromere of each sister chromatid to the poles of the cell.
- **Anaphase** is characterized by three events:
 - Centromeres that join the sister chromatids split.
 - Sister chromatids separate becoming individual chromosomes.
 - Separated chromatids move to opposite poles of the cell.
- ✓ **Telophase** (the last phase of mitosis) consists of four events:
 - Chromosomes (each consisting of a single chromatid) uncoil.
 - A nuclear envelope forms around the chromosomes at each pole of the cell.
 - Spindle fibers break down and dissolve.
 - Cytokinesis begins.

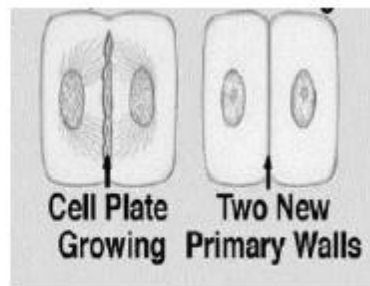
Cytokinesis

Cytokinesis is the division of the cytoplasm into two individual cells. The process of cytokinesis differs somewhat in plant and animal cells.

- ✓ In animal cells the cell membrane forms a *cleavage furrow* that eventually pinches the cell into two nearly equal parts, each part containing its own nucleus and cytoplasmic organelles.
- ✓ In plant cells a structure known as a *cell plate* forms midway between the divided nuclei, which gradually develops into a separating membrane. The cell wall forms in the cell plate.



Animal Cell Telophase/Cytokinesis



Plant Cell Telophase/Cytokinesis

B-2.7 Summarize how cell regulation controls and coordinates cell growth and division and allows cells to respond to the environment, and recognize the consequences of uncontrolled cell division.

Key Concepts:

Chemical control system: internal signal, external signal, checkpoint

Cancer cells: malignant tumor, benign tumor

The cell cycle is driven by a *chemical control system* that both triggers and coordinates key events in the cell cycle. The cell cycle control system is regulated at certain checkpoints.

- ✓ Signals from inside the cell (internal signals) and from outside the cell (external signals) are involved in turning the process of cell division off and on.

- ✓ An **internal signal** involves the cell sensing the presence of chemicals, called enzymes, which are produced inside the cell
- ✓ An **external signal** involves the cell sensing the presence of a chemical (such as a growth factor) which was produced in other specialized cells.
- ✓ Cells can also respond to physical signals from their environment.
- ✓ Cells sense when they are too closely packed and cell division is turned off.
- ✓ Cells sense when they are not in contact with a surface and cell division is turned on.
- ✓ A **checkpoint** in the cell cycle is a critical control point where stop and go signals can regulate the cycle. The cell division mechanism in most animal cells is in the "off" position when there is no stimulus present. Specific stimuli are required to start the processes.

Sometimes cells do not respond normally to the body's control mechanisms and divide excessively.

- ✓ **Cancer cells** are an example of cells that do not heed the normal signals which shut down the cell division process; they continue to divide even when they are very densely packed and/or there is no growth factor present.
 - ✓ Cancer begins when a single cell is transformed into a cancer cell, one that does not heed the regulation mechanism.
 - ✓ Normally the body's immune system will recognize that the cell is damaged and destroy it, but if it evades destruction, it will continue to divide and each daughter cell will be a cancer cell.
 - ✓ A mass of these cells that invades and impairs the functions of one or more organs is called a *malignant tumor*.
- A **benign tumor** is a mass of abnormal cells that remains at the original site.
- ✓ Cancer cells may also separate from the original tumor, enter the blood and lymph vessels of the circulatory system, and invade other parts of the body, where they grow to form new tumors.

B-2.4 Explain the process of cell differentiation as the basis for the hierarchical organization of organisms (including cells, tissues, organs, and organ systems).

Key Concepts:

Cell division: differentiation

Stem cells

In the development of most multicellular organisms, a single cell (fertilized egg) gives rise to many different types of cells, each with a different structure and corresponding function.

- ✓ The fertilized egg gives rise to a large number of cells through *cell division*, but the process of cell division alone could only lead to increasing numbers of identical cells.
- ✓ As cell division proceeds, the cells not only increase in number but also undergo *differentiation* becoming specialized in structure and function. (Cell division is covered in B- 2.6.)
- ✓ The various types of cells (such as blood, muscle, or epithelial cells) arrange into tissues which are organized into organs, and, ultimately, into organ systems.
- ✓ Nearly all of the cells of a multicellular organism have exactly the same chromosomes and DNA.
- ✓ During the process of differentiation, only specific parts of the DNA are activated; the parts of the DNA that are activated determine the function and specialized structure of a cell.
- ✓ Because all cells contain the same DNA, all cells initially have the potential to become any type of cell.
- ✓ Once a cell differentiates, the process can not be reversed.
- ✓ **Stem cells** are unspecialized cells that continually reproduce themselves and have, under appropriate conditions, the ability to differentiate into one or more types of specialized cells.
- ✓ Embryonic cells, which have not yet differentiated into various cell types, are called embryonic stem cells.
- ✓ Stem cells found in adult organisms, for instance in bone marrow, are called adult stem cells.
- ✓ Scientists have recently demonstrated that stem cells, both embryonic and adult, with the right laboratory culture conditions, differentiate into specialized cells.