CHAPTER 10 OUTLINE

**Image Bank**

**Preview**

**Binary Fission**

**The Cell Cycle**

**Prophase**

**Metaphase**

**Anaphase**

**Telophase**

**Checkpoints**

**Binary Fission**

**The Cell Cycle**

**Prophase**

**Metaphase**

**Anaphase**

**Telophase**

**Checkpoints**

* Section 1: Cell Reproduction

Preview

* Bellringer
* Key Ideas
* Why Cells Reproduce
* Chromosomes
* Preparing for Cell Division
* Summary
* Bellringer

Each time a cell reproduces, it divides into two new cells. When each of the new cells divide, the result is four new cells. If this continues, how many cells will be present after the cells reproduce 6 times?

* Key Ideas
* Why do cells divide?
* How is DNA packaged into the nucleus?
* How do cells prepare for division?
* Why Cells Reproduce
* As the body of a multicellular organism grows larger, its cells do not also grow large. Instead, the body grows by producing more cells.
* New cells are needed to help tissues and organs grow.
* As old cells die and new cells take their place.
* New cells also replace damaged cells.
* Why Cells Reproduce, *continued*

Cell Size

* A cell grows larger by building more cell products. To do this, the cell must take in more nutrients, process them, and get rid of wastes.
* A cell’s ability to exchange substances is limited by its surface area–to-volume ratio. As a cell gets larger, substances must travel farther to reach where they are needed.
* Why Cells Reproduce, *continued*

Cell Maintenance

* The work of cells is done by proteins. As a cell gets larger, more proteins are required to maintain its function.
* If the cell gets too large, DNA instructions cannot be copied quickly enough to make the proteins that the cell needs to support itself.
* Cell size is also limited by the cell’s DNA.
* Why Cells Reproduce, *continued*

Making New Cells

* Each “daughter” cell has a higher surface area–to-volume ratio than its parent does.
* Each new cell also gets an entire copy of the cell’s DNA.
* Because larger cells are more difficult to maintain, cells divide when they grow to a certain size.
* Chromosomes
* The large molecule of DNA is organized into hereditary units called **genes.**
* A gene is a segment of DNA that codes for RNA and protein.
* Each cell has a large amount of DNA that must be condensed into a very small volume.
* DNA is organized and packaged into structures called **chromosomes.**
* Visual Concept: Chromosomes
* Chromosomes, *continued*

Prokaryotic Chromosomes

* A prokaryotic cell has a single circular molecule of DNA.
* This loop of DNA contains thousands of genes.
* A prokaryotic chromosome is condensed through repeated twisting or winding, like a rubber band twisted upon itself many times.
* Chromosomes, *continued*

Eukaryotic Chromosomes

* Eukaryotic cells contain many more genes arranged on several linear DNA molecules.
* Eukaryotic DNA into highly condensed chromosome structures with the help of many proteins.
* The DNA and proteins make up a substance called **chromatin.**
* Chromosomes, *continued*

Eukaryotic Chromosomes

* The first level of packaging is done by a class of proteins called **histones.** A group of eight histones come together to form a disc-shaped histone core.
* The long DNA molecule is wound around a series of histone cores in a regular manner and is called a **nucleosome.** Under an electron microscope, this level of packaging resembles beads on a string.
* The string of nucleosomes line up in a spiral to form a cord that is 30 nm in diameter.
* Chromosomes, *continued*

Eukaryotic Chromosomes

* During most of a cell’s life, its chromosomes exist as coiled or uncoiled nucleosomes.
* As the cell prepares to divide, the chromosomes condense even further ensuring that the extremely long DNA molecules do not get tangled up during cell division.
* Chromosomes, *continued*

Eukaryotic Chromosomes

* The nucleosome cord forms loops that are attached to a protein scaffold. These looped domains then coil into the final, most highly condensed form of the chromosome.
* Many dense loops of chromatin form the rod-shaped structures that can be seen in regular light microscopes.
* Chromosomes, *continued*

Eukaryotic Chromosomes

* Each of the two thick strands of a fully condensed, duplicated chromosome are called a **chromatid.**
* Each chromatid is made of a single, long molecule of DNA.
* Chromosomes, *continued*

Eukaryotic Chromosomes

* Identical pairs, called *sister chromatids,* are held together at a region called the **centromere.**
* During cell division, the sister chromatids are separated at the centromere, and one ends up in each daughter cell.
* Each new cell has the same genetic information as the parent cell.
* Preparing for Cell Division
* All new cells are produced by the division of preexisting cells.
* The process of cell division involves more than cutting a cell into two pieces. Each new cell must have all of the equipment needed to stay alive.
* All newly-formed cells require DNA, so before a cell divides, a copy of DNA is made for each daughter cell.
* Each new cells will function in the same way as the cells that they replace.
* Preparing for Cell Division, *continued*

Prokaryotes

* In prokaryotic cells, the circular DNA molecule is attached to the inner cell membrane.
* The cytoplasm is divided when a new cell membrane forms between the two DNA copies. Meanwhile the cell continues to grow until it nearly doubles in size.
* Preparing for Cell Division, *continued*

Prokaryotes

* The cell is constricted in the middle, like a long balloon being squeezed near the center.
* Eventually the dividing prokaryote is pinched into two independent daughter cells, each of which has its own circular DNA molecule.
* Binary Fission
* Preparing for Cell Division, *continued*

Eukaryotes

* The reproduction eukaryotic cells is more complex than that of prokaryotic cells.
* Eukaryotic cells have many organelles. In order to form two living cells, each daughter cell must contain enough of each organelle to carry out its functions.
* The DNA within the nucleus must also be copied, sorted, and separated.
* Visual Concept: Comparing Cell Division in Prokaryotes and Eukaryotes
* Summary
* Because larger cells are more difficult to maintain, cells divide when they grow to a certain size.
* Many proteins help package eukaryotic DNA into highly condensed chromosome structures.
* All newly-formed cells require DNA, so before a cell divides, a copy of its DNA is made for each daughter cell.
* Section 2: Mitosis

Preview

* Bellringer
* Key Ideas
* Eukaryotic Cell Cycle
* Stages of Mitosis
* Cytokinesis
* Summary
* Bellringer

Using the diagram of a football field, write a short paragraph describing how the players, the midfield line, and the goal posts compare to the structures of a cell involved in mitosis and cell division.

* Key Ideas
* What are the phases of the eukaryotic cell cycle?
* What are the four stages of mitosis?
* How does cytokinesis occur?
* Eukaryotic Cell Cycle
* The **cell cycle** is a repeating sequence of cellular growth and division during the life of a cell.
* The life of a eukaryotic cell cycles through phases of growth, DNA replication, preparation for cell division, and division of the nucleus and cytoplasm.
* The cell cycle is made up of five phases. The first three phases together are known as **interphase.** The remaining two phases make up cell division.
* The Cell Cycle
* Eukaryotic Cell Cycle, *continued*

Interphase

* During interphase, the cell is not dividing. It is growing and preparing to divide.
* Different types of cells spend different amounts of time in interphase.
* Cells that divide often, such as skin cells, spend less time in interphase. Cells that divide seldom, such as nerve cells, spend most of their time in interphase.
* Eukaryotic Cell Cycle, *continued*

Interphase

* During the *first gap phase* (G1), a cell grows rapidly as the cell builds more organelles. For most organisms, this phase occupies the major portion of the cell’s life.
* During the *synthesis phase* (S), a cell’s DNA is copied. At the end of the S phase, the cell’s nucleus has twice as much DNA as it did in the G1 phase.
* During the *second gap phase* (G2), the cell continues to grow and prepares to divide. Hollow protein fibers called *microtubules* are organized in the cytoplasm during G2.
* Visual Concept: Cell Cycle—G1 Phase
* Visual Concept: Cell Cycle—S Phase
* Visual Concept: Cell Cycle—G2 Phase
* Visual Concept: Cell Cycle—M Phase
* Eukaryotic Cell Cycle, *continued*

Cell Division

* Each new cell requires a complete set of organelles, including a nucleus.
* The process of dividing the nucleus into two daughter nuclei is called **mitosis.**
* The process of separating the organelles and the cytoplasm is called **cytokinesis.**
* Visual Concept: Mitosis
* Eukaryotic Cell Cycle, *continued*

Cell Division

* During mitosis, the nucleus divides to form two nuclei. Each nucleus contains a complete set of the cell’s chromosomes.
* The nuclear membrane breaks down briefly. The two sister chromatids of each chromosome are pulled to the opposite sides of the dividing cell.
* Eukaryotic Cell Cycle, *continued*

Cell Division

* As the nucleus divides, the cytoplasm also begins to divide.
* Each daughter cell receives about half of the original cell’s organelles.
* During cytokinesis, the two daughter cells are physically separated.
* Stages of Mitosis
* Although mitosis is a continuous process, biologists traditionally divide it into four stages.
* Mitosis is a continuous process that can be observed in four stages: prophase, metaphase, anaphase, and telophase.
* Stages of Mitosis, *continued*

Stage 1 Prophase

* Within the nucleus, chromosomes begin to condense and become visible under a light microscope.
* The nuclear membrane breaks down. Outside the nucleus, a special structure called the **spindle** forms. The spindle is made up of several spindle fibers.
* Each spindle fiber in turn is made up of an individual microtubule—a hollow tube of protein. Microtubules organize into a spindle that runs at a right angle to the cell’s equator.
* Stages of Mitosis, *continued*

Stage 1 Prophase

* Cells have an organelle called the **centrosome,** which helps assemble the spindle.
* In animal cells, the centrosome includes a pair of centrioles. Each centriole is made up of nine triplets of microtubules arranged as a short, hollow tube.
* Before mitosis, the cell’s centrosome is duplicated. During prophase, the centrosomes move to opposite poles of the cell.
* Prophase
* Stages of Mitosis, *continued*

Stage 2 Metaphase

* During metaphase, the chromosomes are packaged into their most condensed form.
* The nuclear membrane is fully dissolved, and the condensed chromosomes move to the center of the cell and line up along the cell’s equator.
* Spindle fibers form a link between the poles and the centromere of each chromosome.
* Metaphase
* Stages of Mitosis, *continued*

Stage 3 Anaphase

* Once all of the chromosomes are lined up, the spindle fibers shorten. The spindle fibers shorten by breaking down the microtubules bit by bit.
* Sister chromatids move toward opposite poles as the spindle fibers that are attached continue to shorten.
* Each pole now has a full set of chromosomes.
* Anaphase
* Stages of Mitosis, *continued*

Stage 4 Telophase

* A nuclear envelope forms around the chromosomes at each pole of the cell.
* Chromosomes, now at opposite poles, uncoil and change back to their original chromatin form.
* The spindle dissolves and the spindle fibers break down and disappear.
* Mitosis is complete.
* Telophase
* Visual Concept: Snapshot of Mitotic Structures
* Cytokinesis
* As mitosis ends, cytokinesis begins. The cytoplasm is separated, and two cells are formed.
* During cytokinesis, the cell membrane grows into the center of the cell and divides it into two daughter cells of equal size.
* Each daughter cell has about half of the parent’s cytoplasm and organelles.
* The end result of mitosis and cytokinesis is two genetically identical cells in place of the original cell.
* Cytokinesis, *continued*

Separating the Cytoplasm

* In animal cells and other cells that lack cell walls, the cell is pinched in half by a belt of protein threads.
* In plant cells and other cells that have rigid cell walls, the cytoplasm is divided in a different way.
* Cytokinesis, *continued*

Separating the Cytoplasm

* Vesicles holding cell wall material line up across the middle of the cell.
* These vesicles fuse to form a large, membrane-bound cell wall called the *cell plate*.
* When it is completely formed, the cell plate separates the plant cell into two new plant cells.
* Visual Concept: Comparing Cell Division in Plants and Animals
* Cytokinesis, *continued*

Continuing the Cell Cycle

* After cytokinesis is complete, each cell enters the G1 stage of interphase.
* The daughter cells are about equal in size—about half the size of the original cell.
* The activity of each cell continues because each has its own DNA and organelles. The cell cycle continues for each new cell.
* Summary
* The life of a eukaryotic cell cycles through phases of growth, DNA replication, preparation for cell division, and division of the nucleus and cytoplasm.
* Mitosis is a continuous process that can be observed in four stages: prophase, metaphase, anaphase, and telophase.
* During cytokinesis, the cell membrane grows into the center of the cell and divides it into two daughter cells of equal size. Each daughter cell has about half of the parent’s cytoplasm and organelles.
* Section 3: Regulation

Preview

* Bellringer
* Key Ideas
* Controls
* Checkpoints
* Cancer
* Summary
* Bellringer

You have learned how cells divide. One cell divides into two daughter cells. Each of those daughter cells divide into two more daughter cells. Make a graph that shows how the number of cells increases.

* Key Ideas
* What are some factors that control cell growth and division?
* How do feedback signals affect the cell cycle?
* How does cancer relate to the cell cycle?
* Controls
* Cell division is highly controlled.
* Cell growth and division depend on protein signals and other environmental signals. Many proteins within the cell control the phases of the cell cycle.
* Signals from surrounding cells or even from other organs can also regulate cell growth and division.
* Environmental conditions, including the availability of nutrients, also affect the cell cycle.
* Visual Concept: Control of the Cell Cycle
* Checkpoints
* During the cell cycle, a cell undergoes an inspection process to ensure that the cell is ready for the next phase in the cell cycle.
* Feedback signals at key checkpoints in the cell cycle can delay or trigger the next phase of the cell cycle.
* There are three main checkpoints in the cell cycle—G1 Checkpoint, G2 checkpoint, mitosis checkpoint.
* Checkpoints
* Checkpoints, *continued*

G1 Checkpoint

* Before the cell copies its DNA, the cell checks its surroundings. If conditions are favorable and the cell is healthy and large enough, the cell enters the synthesis phase.
* If conditions are not favorable, the cell goes into a resting period.
* Certain cells, such as some nerve and muscle cells, remain in this resting period for a long time. They do not divide very often.
* Checkpoints, *continued*

G2 Checkpoint

* Before mitosis begins, the cell checks for any mistakes in the copied DNA. Enzymes correct any mistakes.
* This checkpoint ensures that the DNA of the daughter cells will be identical to the DNA of the original cell.
* Proteins also double-check that the cell is large enough to divide.
* If the cell passes the G2 checkpoint, then the cell may begin to divide. Once past this checkpoint, proteins help to trigger mitosis.
* Checkpoints, *continued*

Mitosis Checkpoint

* During the metaphase stage of mitosis, chromosomes line up at the equator. At this point, the cell checks that the chromosomes are properly attached to the spindle fibers.
* Without this point, the sister chromatids of one or more chromosomes may not separate properly.
* This checkpoint ensures that the genetic material is distributed equally between the daughter cells.
* Cancer
* Each year, more than 1 million Americans are diagnosed with cancer.
* **Cancer** is a group of severe and sometimes fatal diseases that are caused by uncontrolled cell growth.
* Uncontrolled cell growth and division can result in masses of cells that invade and destroy healthy tissues.
* Preventing or curing cancer requires an understanding of how a healthy person’s cells can become cancerous.
* Cancer, *continued*

Loss of Control

* Normally, a cell responds properly to signals and controls.
* However, damage to a cell’s DNA can cause the cell to respond improperly or to stop responding leaving the cell cycle uncontrolled.
* The defective cell divides and produces more defective cells. Eventually, these cells can form a mass called a **tumor.**
* Cancer, *continued*

Development

* A *benign tumor* does not spread to other parts of the body and can often be removed by surgery.
* A *malignant tumor* invades and destroys nearby healthy tissues and organs.
* Malignant tumors, or cancers, can break loose from their tissue of origin and grow throughout the body. This process is called *metastasis*. Once a cancer has metastasized, it becomes difficult to treat.
* Cancer, *continued*

Treatment

* Some cancers can be treated by using drugs that kill the fast-growing cancer cells.
* Because drugs are chemicals, this method of treatment is called *chemotherapy,* or “chemo” for short.
* Some cancers can be treated by surgery to remove of the affected organ.
* In radiation therapy, high-energy rays are focused on an area in order to destroy cancerous cells.
* Cancer, *continued*

Prevention

* The best way to prevent cancer is to avoid things that can cause cancer.
* Ultraviolet radiation in sunlight can damage genes that control the cell cycle.
* Chemicals in cigarette smoke also affect how cell growth and division is regulated.
* Summary
* Cell growth and division depend on protein signals and other environmental signals.
* Feedback signals at key checkpoints in the cell cycle can delay or trigger the next phase of the cell cycle.
* Uncontrolled cell growth and division results in tumors, which can invade surrounding tissues and cause cancer.