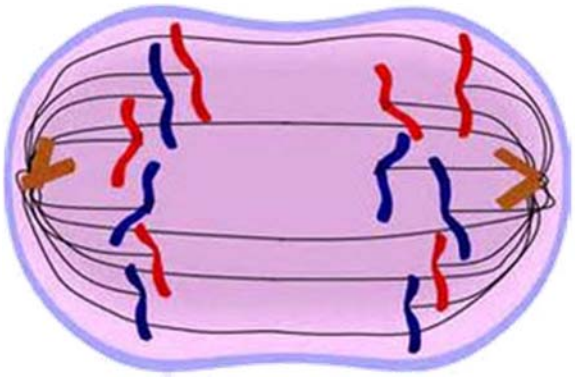
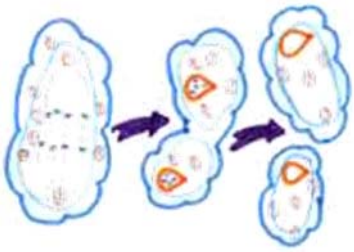


MITOSIS

Through our work with previous lessons, you have now learned about the different types of cells, the parts of a cell, the membranes of a cell, how substances move in and out of a cell, and some of the most important metabolic processes in cells. In this unit you will learn how a cell divides or reproduces. There are two ways that cells, or more specifically a nucleus, can divide or reproduce: mitosis or meiosis. This unit will examine mitosis while the next unit will look into meiosis. As the human body grows larger, the cells do not necessarily become larger. Instead, the cells become more numerous. Of the over 25 trillion cells that make up the adult human body, about two trillion replacement cells are produced every day. The new body cells are exact copies of the cells they replace.

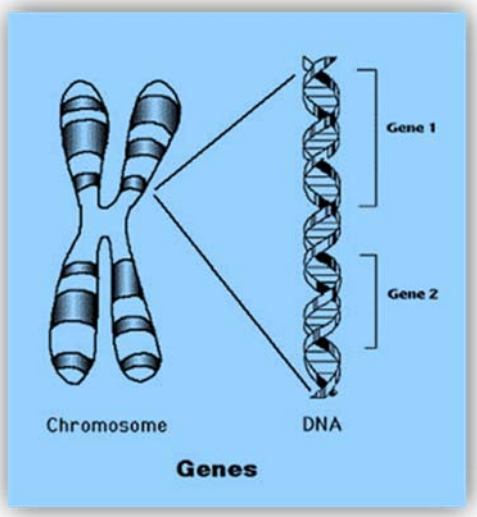


*To review the surface area-to-volume ratio, in terms of a cell, go back to **Unit 6 – Cells** under Cell Size and Shape.*

New cells are small in size and therefore have a higher surface area-to-volume ratio. As the cell grows it produces more material and substances inside of itself making it larger. As the cell grows larger and the surface area-to-volume ratio becomes smaller the cell must divide or reproduce to survive.

The need for cell division of new cells is not only necessary for growth but also for replacement and repair. For example, the skin cells of the human body are constantly lost from the outermost layer and need to be replaced. In addition, when you have a cut in the skin of your finger, you need new cells to repair or heal the damaged skin.

Chromosomes

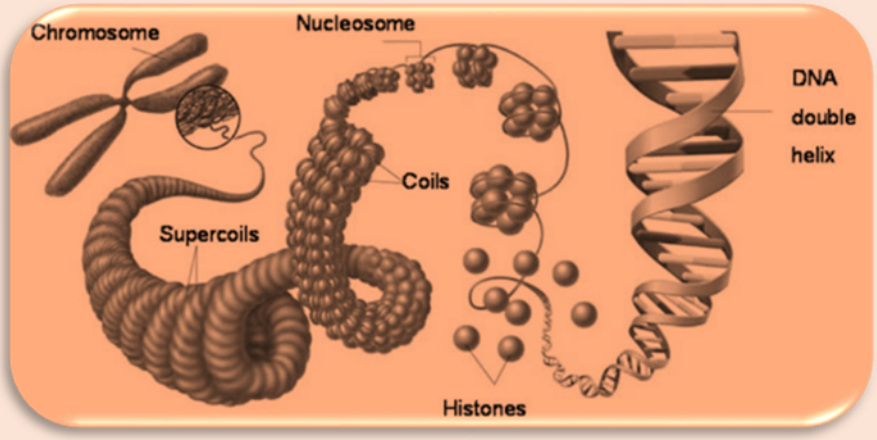


Before we look at mitosis, you need to understand the different ways DNA can be organized. Remember that **DNA** controls all of the activities within a cell and, in eukaryotes, DNA is found in the *nucleus*. DNA is divided into units of differing lengths to code for RNA which in turn will code for a protein (to be discussed in detail later). These units of DNA are called **genes**. DNA is made of thousands of genes. In order for this long DNA molecule to fit inside the nucleus it must be condensed as much as possible. The DNA coils and is packaged into a structure called a **chromosome**.

PROKARYOTIC CHROMOSOME

Recall that prokaryotes do not have a nucleus. The DNA of prokaryotes is found in the form of a circular loop floating in the cytoplasm. This chromosome consists of DNA that has been twisted several times within its loop.

EUKARYOTIC CHROMOSOME



As was already mentioned, the DNA of a eukaryote is packed in the nucleus. Eukaryotic cells contain more genes than prokaryotic cells so the DNA needs to be greatly condensed. When the DNA and proteins associated with it are found scattered throughout the nucleus it is called **chromatin**. Even though the DNA is found scattered it is still coiled or condensed to allow all of it to fit within the nucleus. This coiling involves proteins called **histones**. Eight histones create a center core for the DNA to wrap or coil around. There will be many histones in succession for the DNA to wrap around. The term **nucleosome** is used for one set of histones

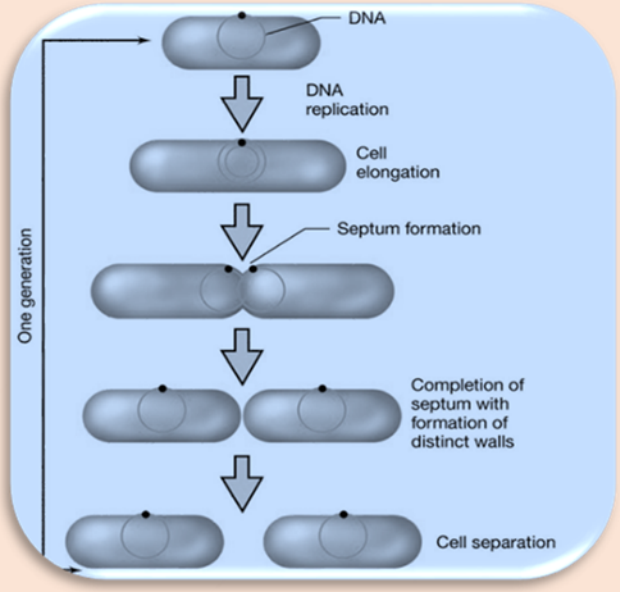
with the DNA wrapped around it. The nucleosome is like taking thread and wrapping it

around a group of eight beads.

When the cell is preparing to divide or is dividing the DNA will coil further into a rod-shaped

structure called a chromosome. A fully condensed or coiled chromosome will actually be made up of the original DNA material and a copy of that DNA attached to it. The original DNA and copied DNA attached are collectively called a **chromosome** while each rod-shaped strand of coiled DNA individually is called a **chromatid**. The two strands or chromatids are held together by a structure called a **centromere**. The two chromatids held together by a centromere are called **sister chromatids**, remember they are identical strands.

PROKARYOTIC CELL DIVISION



Prokaryotes, having no organelles or nucleus to deal with, makes prokaryotic cell division simpler than eukaryotic cell division. The circular DNA of the prokaryote will attach to the inner cell membrane. Once attached, the DNA loop will be copied with the copied loop also being attached to the inner cell membrane. The cell membrane then begins to divide or pinch in between the two DNA attachment points. The cell will continue to grow to provide enough material for the two daughter cells. The cell wall will also form around the membrane that is dividing the cell in half between the DNA attachment points. When the cell membrane and cell wall finish separating the cell in half, two new prokaryotic cells have now been produced each with its own DNA. This process of cell division in a prokaryote is known as **Binary Fission**.

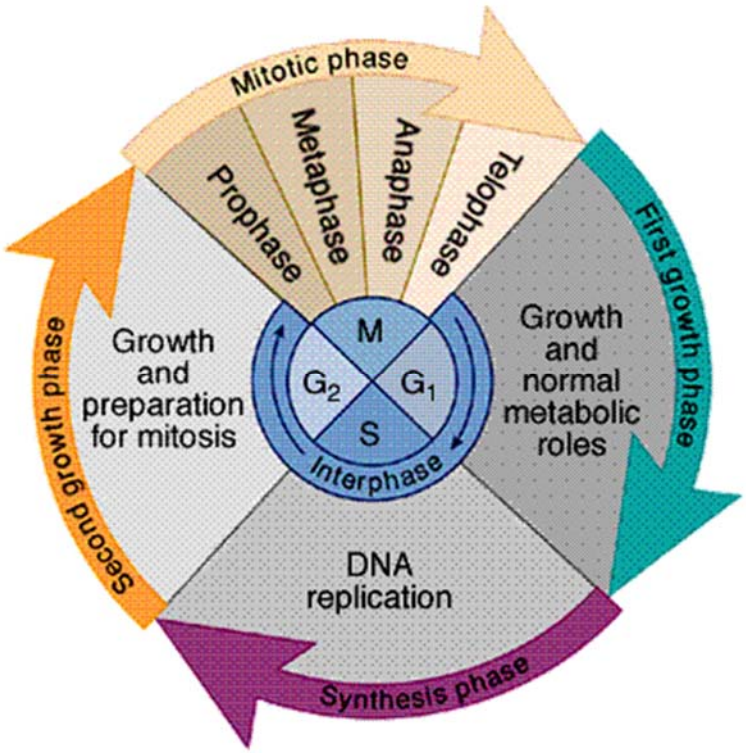
Parent Cell: Cell that begins cell division.
Daughter Cell: Cell that is produced after cell

EUKARYOTIC CELL DIVISION

Eukaryotic cell division is more complicated than prokaryotic cell division. In eukaryotic cell division, enough organelles must be available for the two daughter cells, along with having a nucleus containing an identical copy of DNA.

Cell Cycle

The life cycle of a cell is called the Cell Cycle. The cell cycle involves the sequence of growth and division of a cell. The cell cycle involves three overall stages: interphase, mitosis, and cytokinesis.



STAGE 1: Interphase

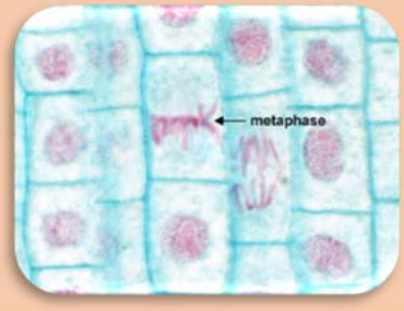
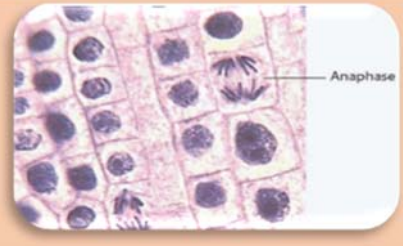
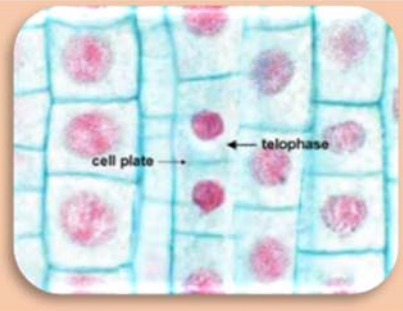
Much of a cell's lifetime is spent undergoing cell growth, making proteins, sugars, and fats, and assembling genetic material. This time in a cell cycle is called interphase. Interphase consists of three phases: G_1, S, and G2.

PHASES OF INTERPHASE		
G_1	***First Gap Phase***	This is the phase when the cell grows or increases in mass. The cell is producing proteins from the instructions found in

		DNA and it is functioning as it is meant to. Cells that will not divide stay in this phase (sometimes called G_0 phase) and do not move on.
S	***Synthesis Phase***	Synthesis refers to making or producing. This is the phase when DNA is copied. The DNA is still in the form of chromatin, but remember that this DNA with its copy attached will make up a chromosome consisting of two chromatids held together by a centromere as it continues to condense.
G_2	***Second Gap Phase***	This is the phase when the cell continues to grow and prepares for cell division by producing organelles, molecules, and structures called centrioles (which will be discussed in a moment) to help with cell division.
Visit Cells *alive!* To see an animation of the cell cycle. http://www.cellsalive.com/cell_cycle.htm		

STAGE 2: Mitosis

STAGES OF MITOSIS			
Order	**Stage**	**Events**	**Figure of Stage** *(onion root tip)*
#1	**Prophase**	• Chromosomes begin to condense and become visible. • The mitotic spindle forms. • Centrioles move to opposite poles. • Nuclear envelope dissolves.	
In prophase, the chromosomes begin to condense and become visible under a microscope. Remember the DNA made a copy of itself in the S phase of interphase and had the copy attach to the original by the centromere, but it still needed to condense more. The mitotic spindle forms. The spindle is responsible for moving the chromosomes around the inside of the cell. The spindle, when fully formed, is described as being football-shaped when considering a three-dimensional cell. **Centrioles**, structures made of microtubules, will anchor the mitotic spindle. The centrioles are constructed in G_2 of interphase. Lastly, in prophase the nuclear envelope dissolves. So, for a short time there is no nucleus.			

#2	**Metaphase**	• Centromeres line up on the equator of the cell.	
In metaphase, the centromeres line up on the equator of the cell. The **equator** is the middle of the cell. Sometimes the equator is called the *metaphase plate*. The kinetochore fibers are responsible for dragging the centromeres, which hold the two sister chromatids together, to the equator.			
#3	**Anaphase**	• Centromeres separate pulling daughter chromosomes to opposite poles.	
In anaphase, the kinetochore fibers split the centromere. By splitting the centromere the two sister chromatids are now separated. The moment the sister chromatids are separated in anaphase their name changes to **daughter chromosomes**. It is just a name change. The daughter chromosomes are still identical copies of DNA, just not connected by the centromere any more. The daughter chromosomes tend to take on a V-shape because they are being dragged to opposite poles of the cell through the cytoplasm. Sort of like dragging a straight piece of thread through jelly from the middle of the thread.			
#4	**Telophase**	• Chromosomes transition back to chromatin. • The mitotic spindle dissolves. • Centrioles dissolve • Nuclear envelope reappears.	
Telophase is practically the opposite of prophase. The daughter chromosomes uncoil to become chromatin again. The mitotic spindle dissolves and will not be visible again until the next mitotic division. Along with the spindle, the centrioles are gone. The nuclear envelope reappears, therefore the nucleus is now present and will be until the next mitotic division.			

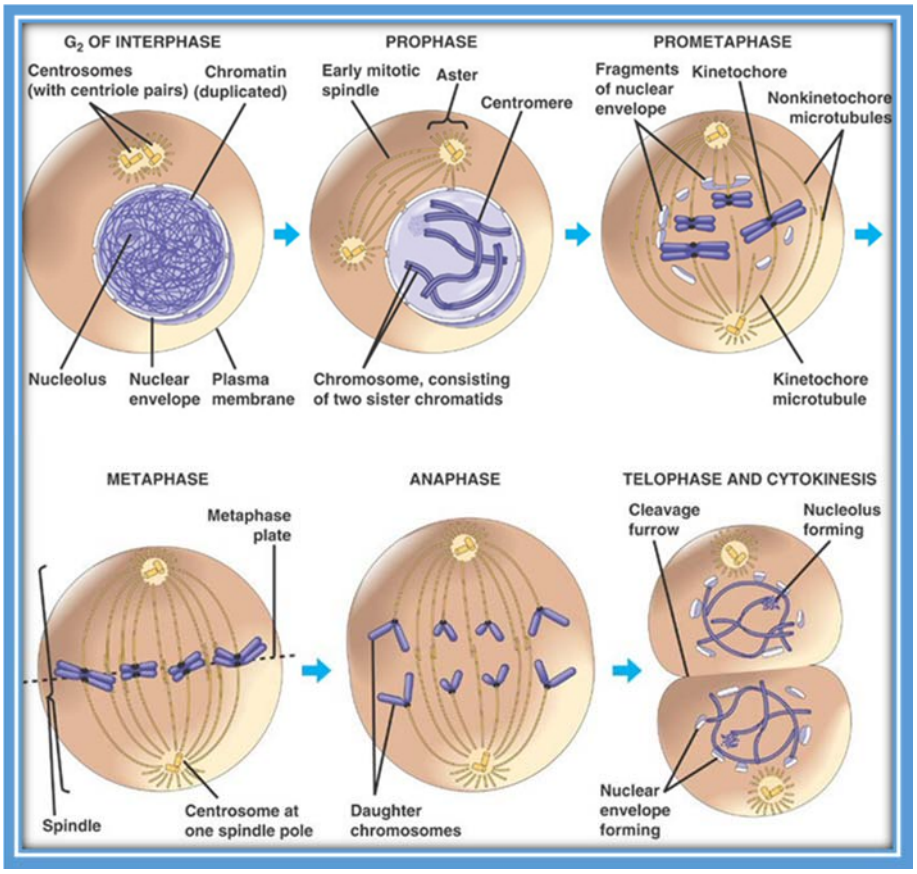


Figure of Mitosis in an Animal Cell

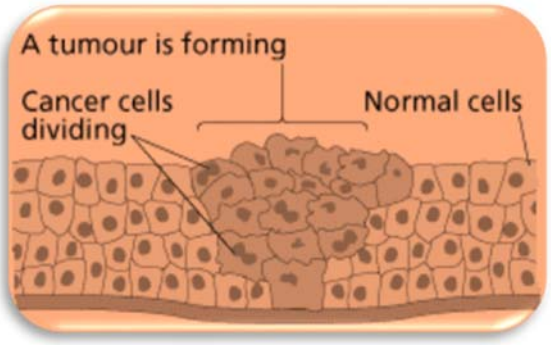
STAGE 3: Cytokinesis

Mitosis and its four stages mostly involved the DNA of the cell splitting into two new nuclei. So the best way to define mitosis, which was mentioned in the beginning of this unit, is to say *mitosis is nuclear division* or division of the nucleus. Cytokinesis is concerned with splitting everything else in the cell. Remember that everything else outside the nucleus is cytoplasm, so, ***cytokinesis*** *can best be defined as cytoplasmic division* or division of the cytoplasm.

The process of cytokinesis overlaps the end of mitosis. While mitosis finishes dividing the nucleus, cytokinesis begins separating the cytoplasm. When cytokinesis begins a cleavage furrow becomes present. A **cleavage furrow** is the indentation in the middle of the cell membrane which is attempting to pinch the cell in half. Animal cells and other eukaryotes without a cell wall conduct cytokinesis in this fashion. Eukaryotes with a cell wall cannot form a cleavage furrow so instead they have vesicles which will deposit materials across the equator of the cell and form a new cell wall and cell membrane. This new forming cell wall is called a **cell plate**. When cytokinesis finishes two new daughter cells have formed and they will each enter their own G_1 of interphase. It is very important to remember that each daughter cell is identical to each other and to the parent cell they came from.

The Cell Cycle and Mitosis

CANCER



Cancer is essentially uncontrolled cell division. It is a situation where cells are growing uncontrollably and sometimes spreading. A growth of cancer cells is known as a **tumor**. A tumor is a growth caused by cells with an abnormal rate of cell division and structure, and cells that lack a function. Cancer is mainly due to some change in the DNA that controls the cell cycle making the cycle now uncontrollable. There are two types of growth, or tumor, possible with cancer cells. A **benign tumor** does not spread to other parts of the body. Benign tumors can often be surgically removed from the body. **Malignant tumors** spread and destroy nearby healthy tissues and organs. The spreading of these cancer cells is called *metastasis*. Once cancer cells begin to spread it is very difficult to treat. Some tumors can be treated by removing the affected organ, others require treatments to try to control the cells. Many treatments, such as chemotherapy, aim to kill the fast-growing cancer cells which also unfortunately affects healthy cells in the process. Click on the image on the left to view an animation of cancer cells.

Unit 11 Worksheet Mitosis

UNIT VOCABULARY REVIEW

Click on the **Quizlet link** below to access the quizlet.com vocabulary flash cards. Review the vocabulary before completing your assessment.

Quizlet

Now answer questions 1 through 20.