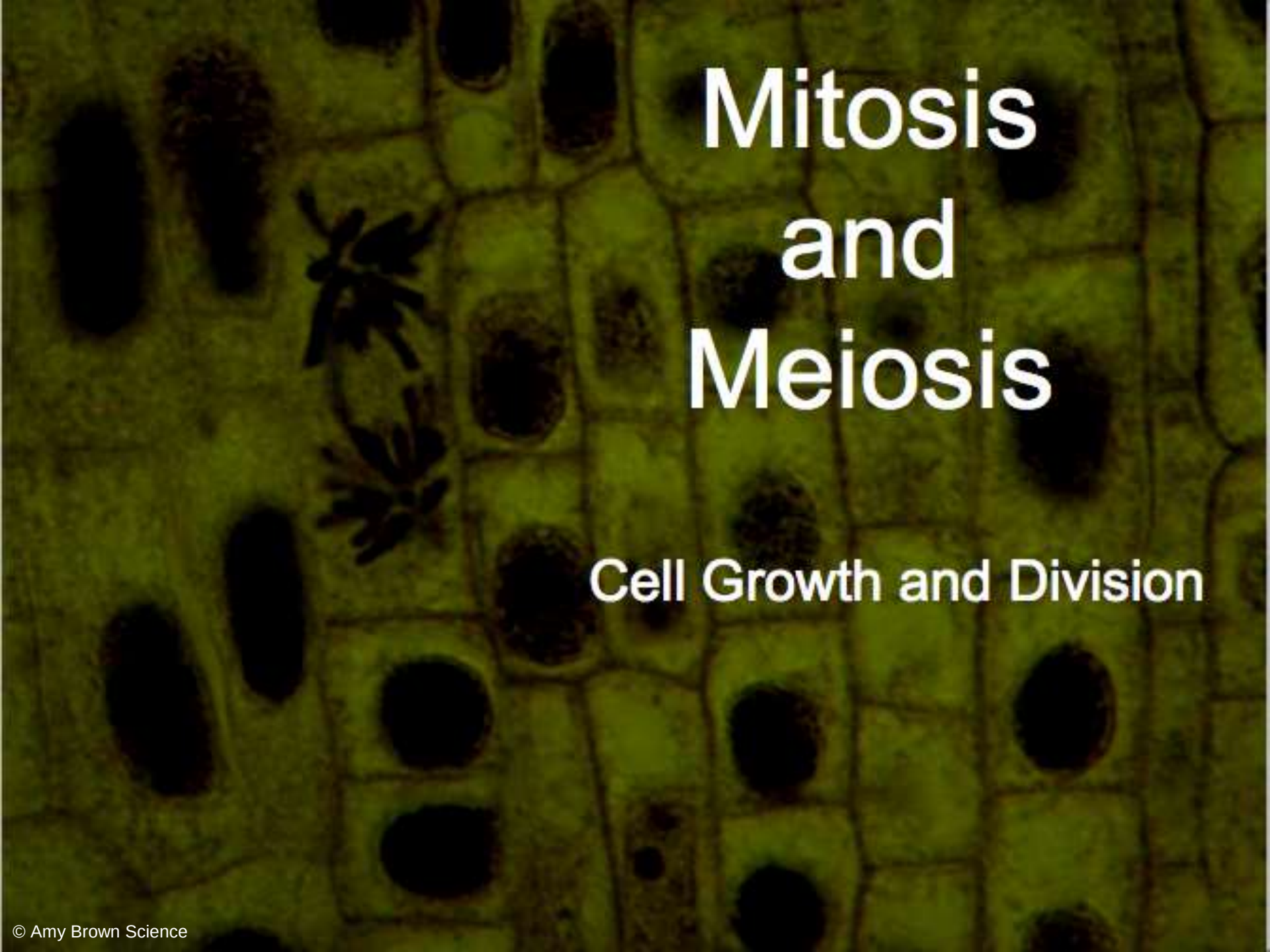


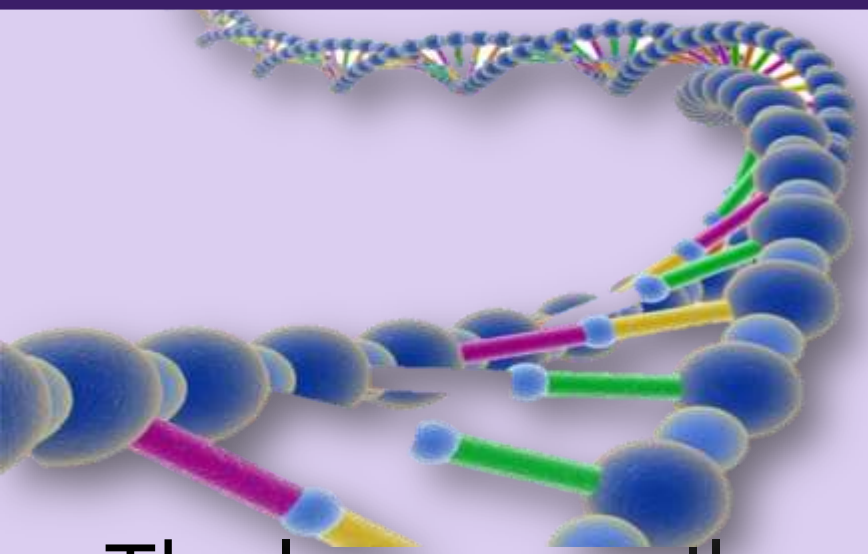
Update Notes ToC

Limits to Cell Growth

Why do cells divide?

Instead of dividing, why don't cells just grow larger and larger?

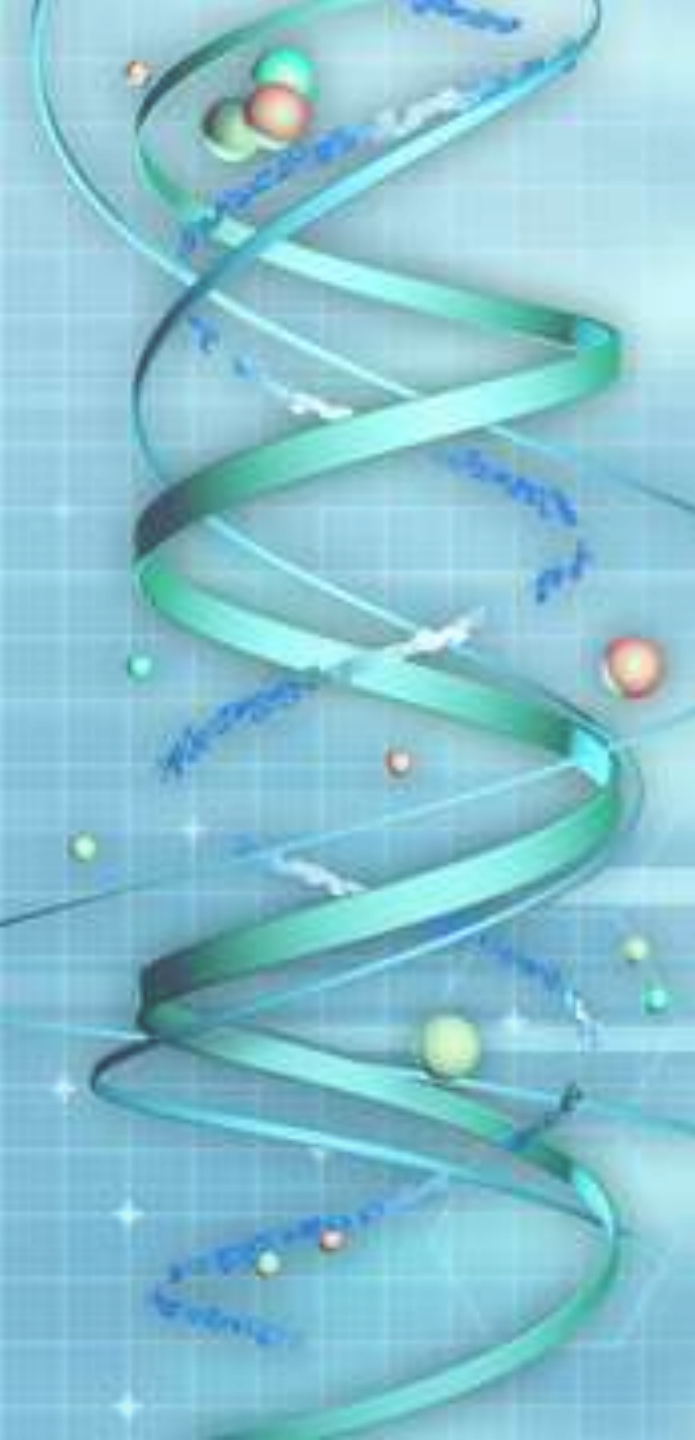
There are two main reasons why cells divide rather than continuing to grow larger and larger:



If the cell grows too large, it will have trouble moving enough nutrients and wastes across the cell membrane.

The larger a cell becomes, the …….

…. more demands the cell places on its DNA.

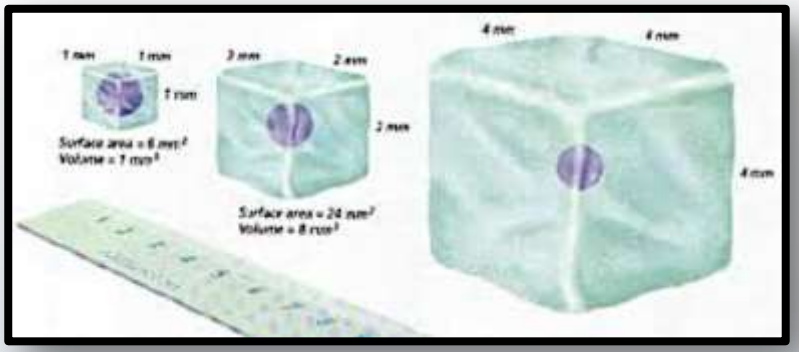


Problem #1: Our DNA has its limits!

- All of the information that a cell needs to function is stored in the DNA of the cell.
- DNA is packaged into chromosomes. A chromosome consists of one very long linear DNA molecule consisting of 1000's of genes.
- Each gene is the instructions for making a particular protein that the cell needs.
- The cell is constantly making copies of these genes and sending the copies (in the form of RNA) out to the ribosomes.
- When the cell is small, the information stored in the cell's DNA is adequate to meet the needs of the cell.
- As the cell grows too large, there is an "information crisis". The DNA cannot keep up with the demands of running a larger cell.

Problem #2:

A Growing Cell Needs More Food!



A cell must take in a constant inflow of food, oxygen and water across the membrane.

Waste products must constantly be crossing the membrane in order to leave the cell.

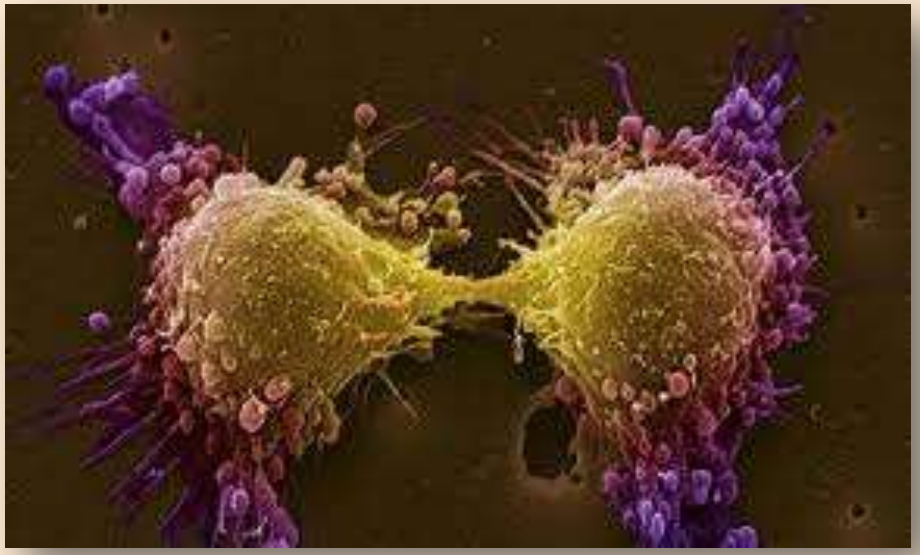
A larger cell will require much more food, oxygen and water. A larger cell will generate much more waste.

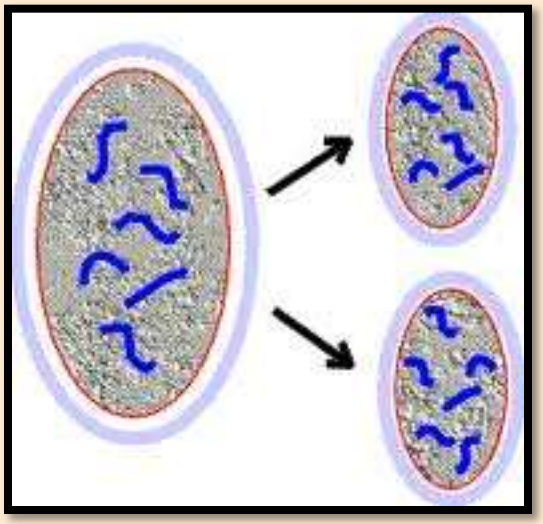
As the cell grows, the volume of the cell increases much more rapidly than the surface area of the cell membrane.

When the cell gets too large, the membrane surface area is not adequate enough to transport the large quantities of food and water in and waste products out.

Cell Division

Cell division is the process by which cellular material is divided between two new daughter cells.





1 Mother Cell → 2 Daughter cells.

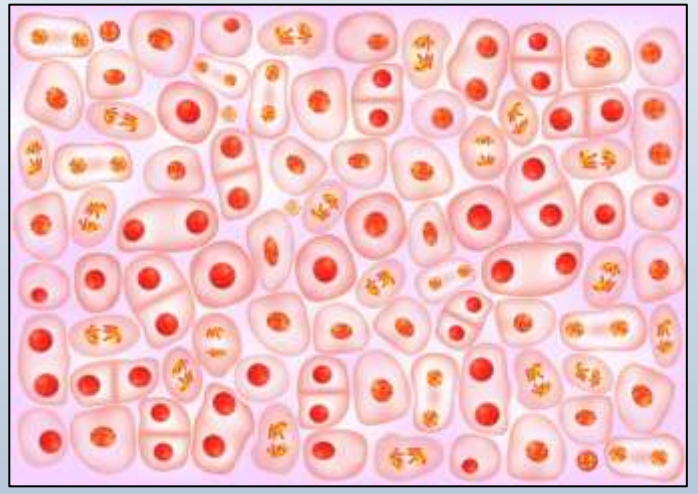
The two daughter cells will be….

…identical to each other and to the mother cell.

Each daughter is half the size of the parent cell, but immediately begins growing.

A typical human cell has about 2 meters of DNA. Before the cell can divide, all of this DNA must be copied and then the two copies separated so that each daughter cell ends up with a complete set of DNA.

Each species has a characteristic number of chromosomes in each cell nucleus; humans have 23 pairs or 46.



Chromosomes During Eukaryotic Cell Division

Each cell must first copy its chromosomes before cell division occurs.

Each daughter cell gets a complete copy of that information.

Cell division occurs in two main stages:

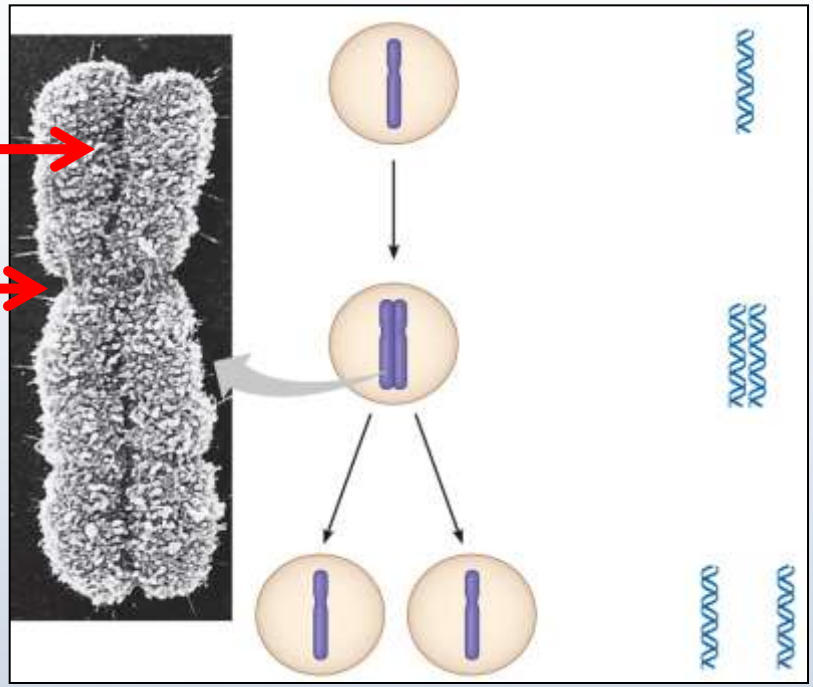
Mitosis – The division of the nucleus

Cytokinesis – The division of the cytoplasm

The chromosomes are not visible except during cell division. At the beginning of cell division, the chromosomes condense into compact, visible structures that are easily seen with a microscope.

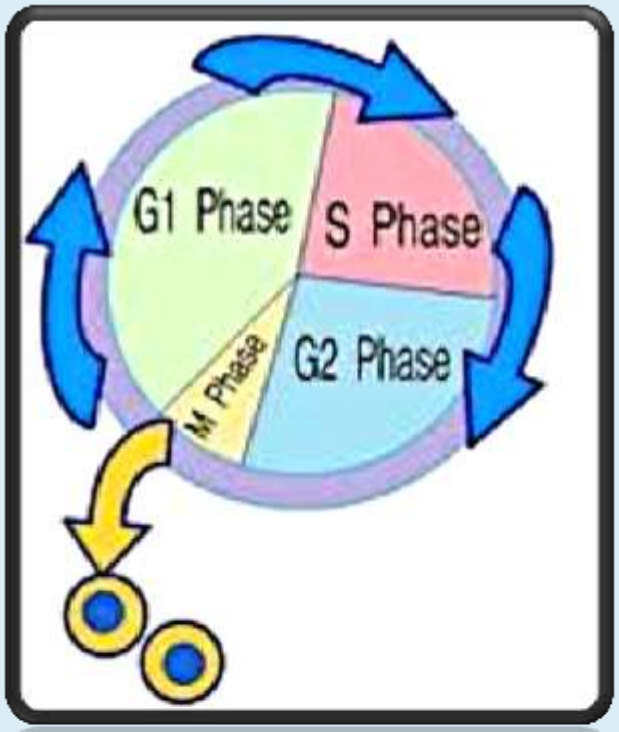
Replicated chromosome consisting of 2 sister chromatids.

centromere



Well before cell division takes place, each chromosome is replicated or copied.

At the beginning of cell division, each chromosome consists of two identical " sister chromatids ". These chromatids are connected at an area called a **centromere** .



The Cell Cycle

The cell cycle is:

The series of events that cells go through as they grow and divide.

The cell cycle is the life of the cell from the time it is first formed from a dividing parent cell until its own division into two cells.

During the cell cycle:

1. A cell grows.
2. The cell prepares for division.
3. The cell divides to form two daughter cells.

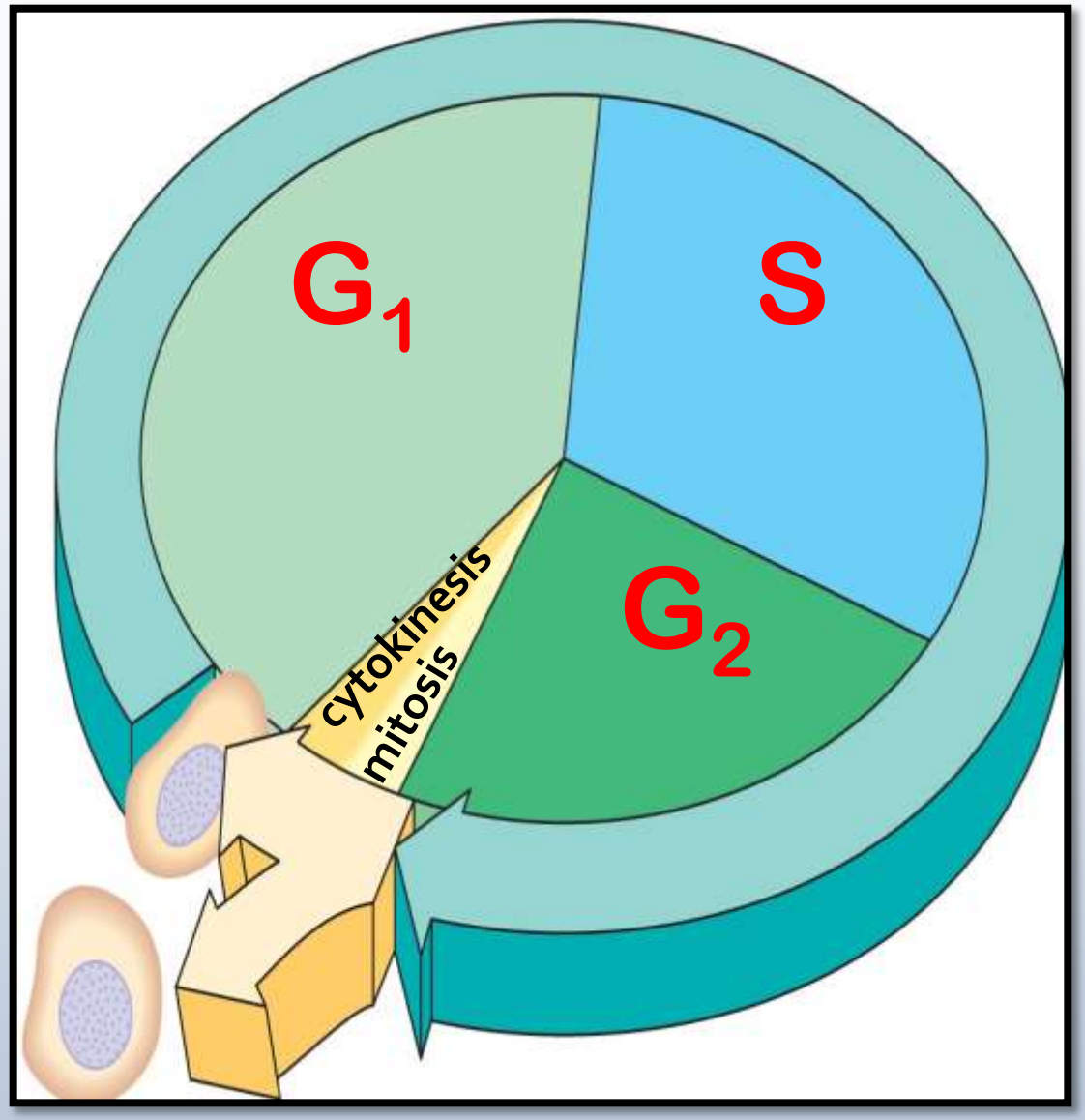
The cell cycle consists of five major phases:

- **G_1 (first gap)**
- **S (synthesis)**
- **G_2 (second gap)**
- **Mitosis**
- **Cytokinesis**

Mitosis is the division of the nucleus.

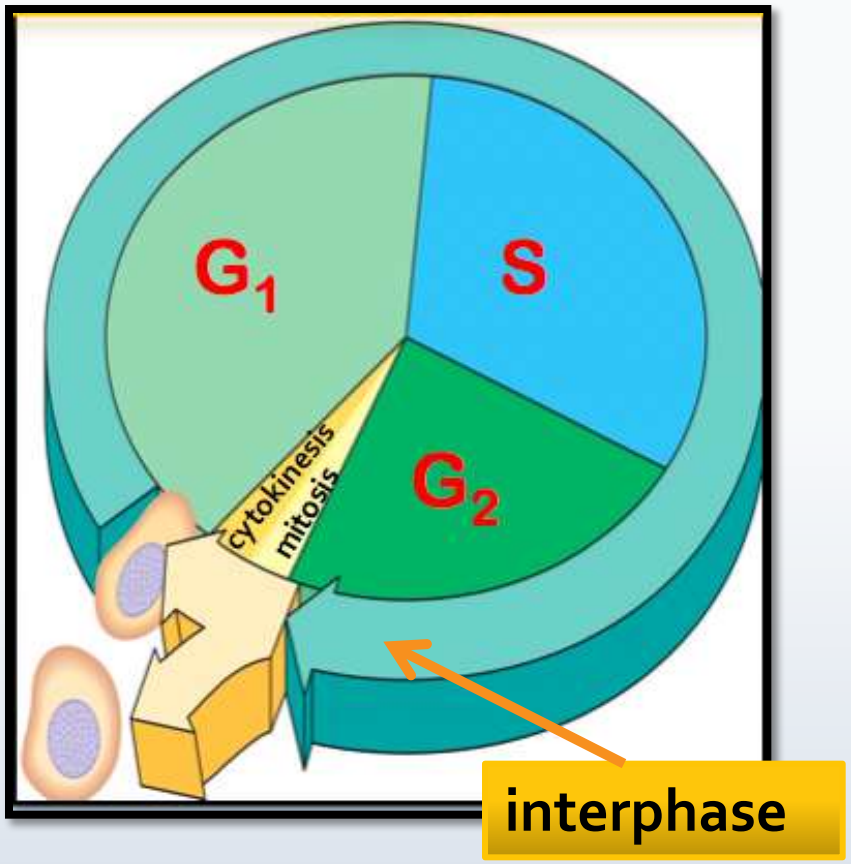
Cytokinesis is the division of the cytoplasm.

Two new cells are produced.



Before a cell can begin mitosis and actually divide, it must do two things:

a) It must form duplicates of its chromosomes.
b) It must produce a supply of organelles for the two daughter cells.



These preparations occur during the G_1, S, and G_2 phases of the cell cycle.

These three (G_1, S, and G_2) are collectively known as interphase.

G_1 phase

a) The cell doubles in size.
b) The enzymes, cytoplasmic organelles and other molecules double in number.

S phase

Replication of DNA occurs.

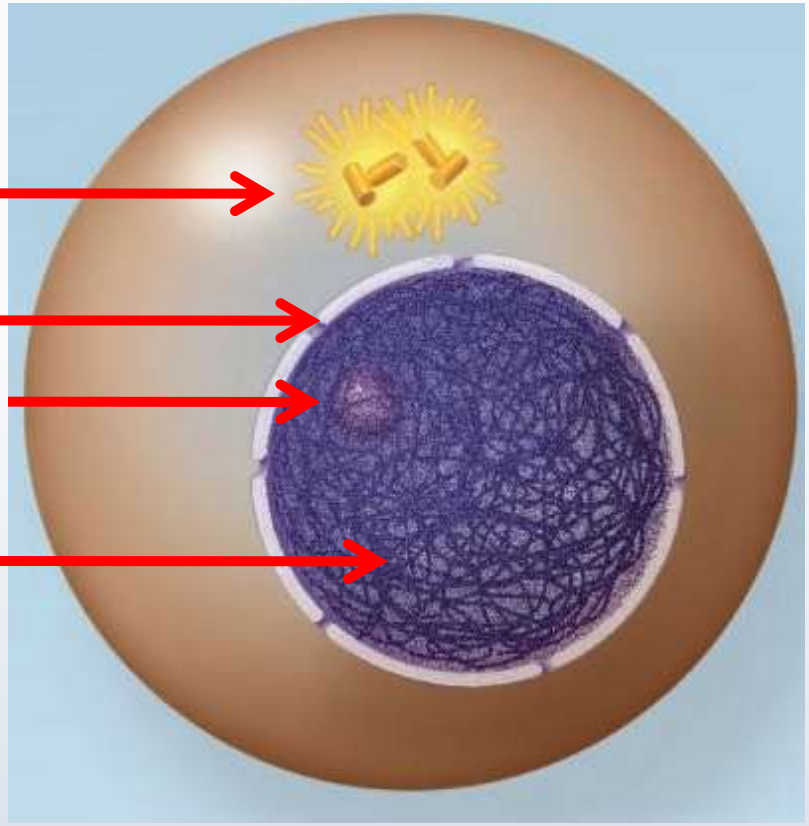
G_2 Phase

The cell assembles the special structures needed for cell division

When interphase (G_1, S, G_2) is complete, the cell is ready to begin the process of cell division.

“Let’s break mitosis down into its individual stages and see what is going on in each stage.”

Interphase



Of the cell cycle, interphase accounts for 90% of the time.

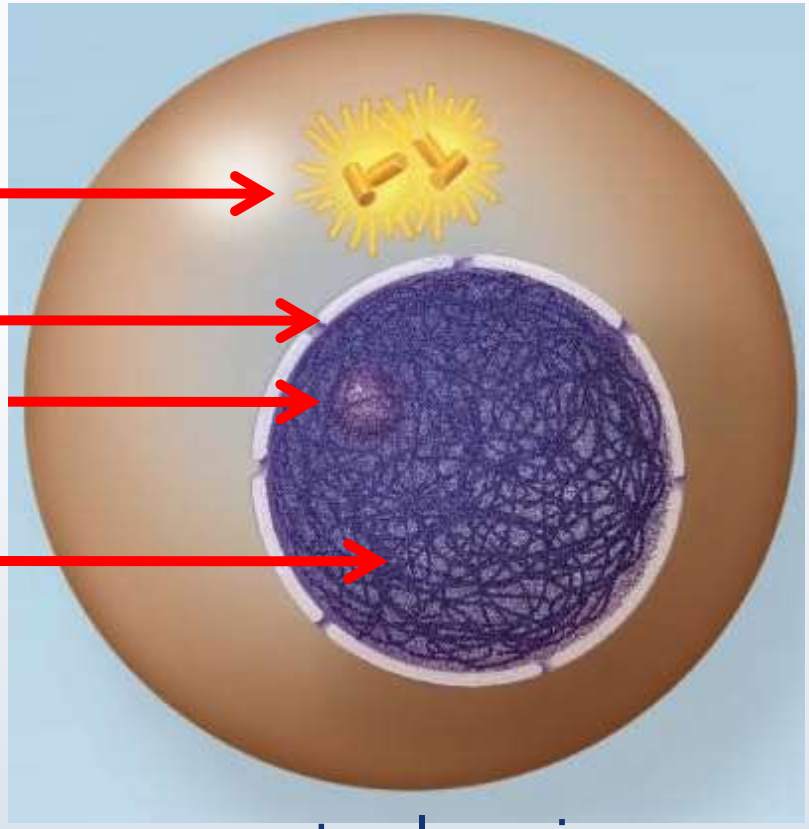
Nucleus is well defined and bounded by the nuclear membrane.

Outside of the nucleus are two centrioles. Their function is to:

organize the microtubules into a spindle.

They will begin to move apart as spindle microtubules grow out of them.

Interphase

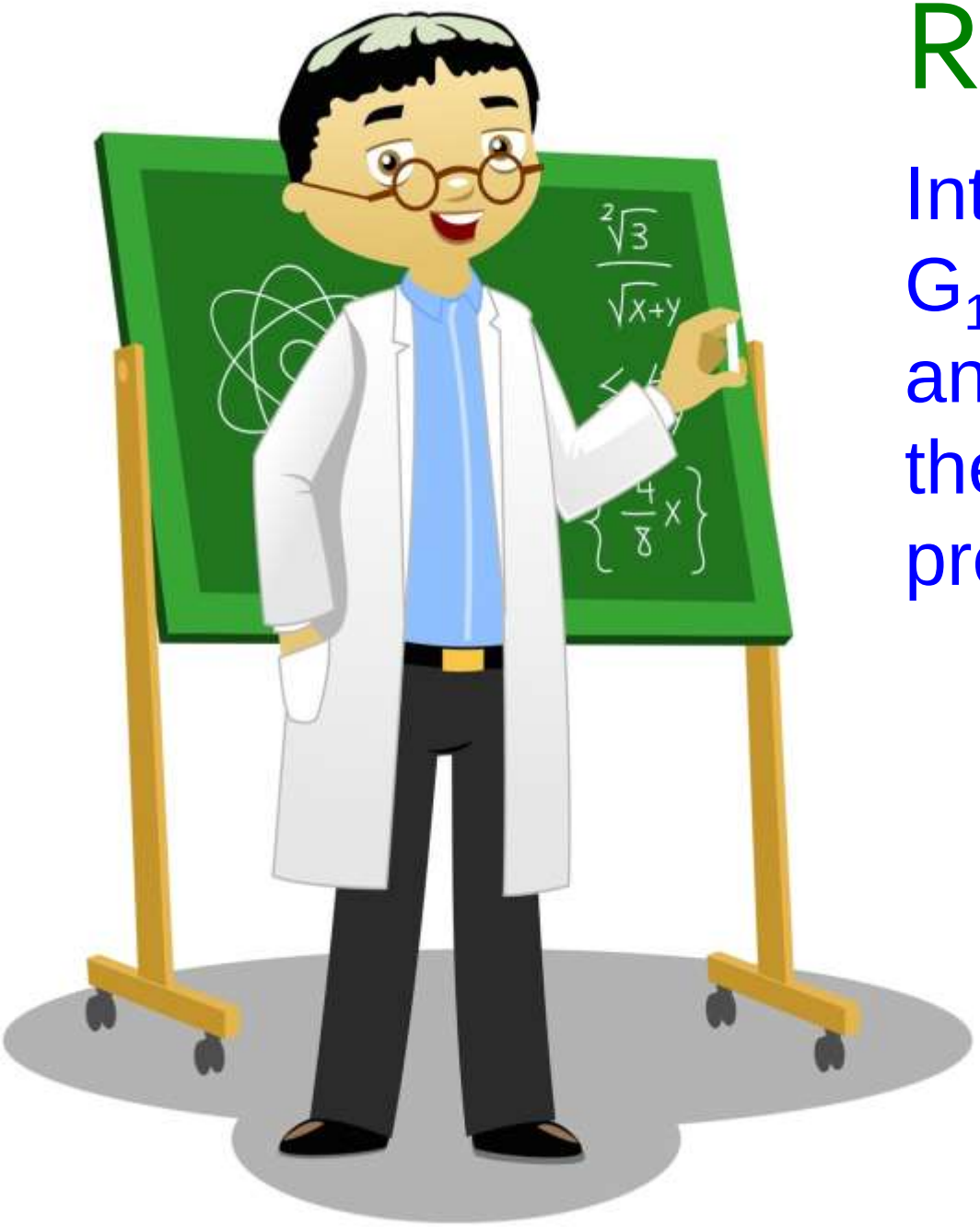


G_1 phase is a period of intense biochemical activity:

The cell doubles in size and the enzymes, cytoplasmic organelles and other molecules double in number.

The chromosomes have duplicated during the S phase and they appear as a jumbled mass of fibers. They have not yet condensed.

G_2 Phase: The cell assembles the special structures needed for cell division



Remember!

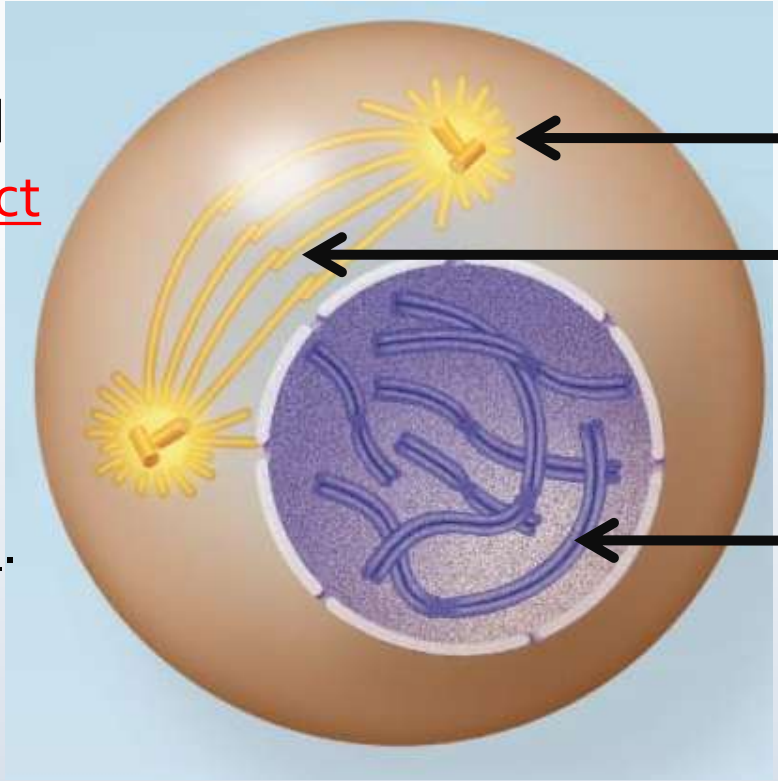
Interphase includes the G_1 phase, the S phase, and the G_2 phase. It is the period of time preceding mitosis.

Mitosis has 4 stages:

1. Prophase
2. Metaphase
3. Anaphase
4. Telophase

Prophase

Early prophase



The chromosomes coil and thicken and become distinct from one another. The chromosomes are now visible.

The nucleolus disappears.

The chromosomes are doubled throughout their length.

Each half of the double chromosome is a chromatid.

The chromatids are connected by a centromere.

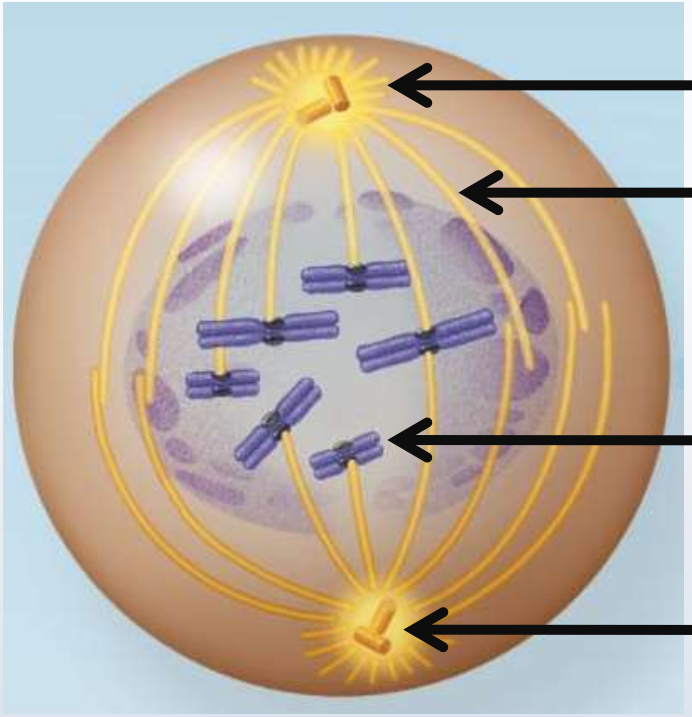
The centrioles separate and start moving to opposite ends of the cell. A spindle made of microtubules begins to form.

Prophase

The nuclear membrane fragments and the microtubules invade the nuclear area. The spindle is completely formed.

The spindle is a structure that will help to separate the chromosomes. During prophase the pairs of chromatids become attached to the fibers of the spindle.

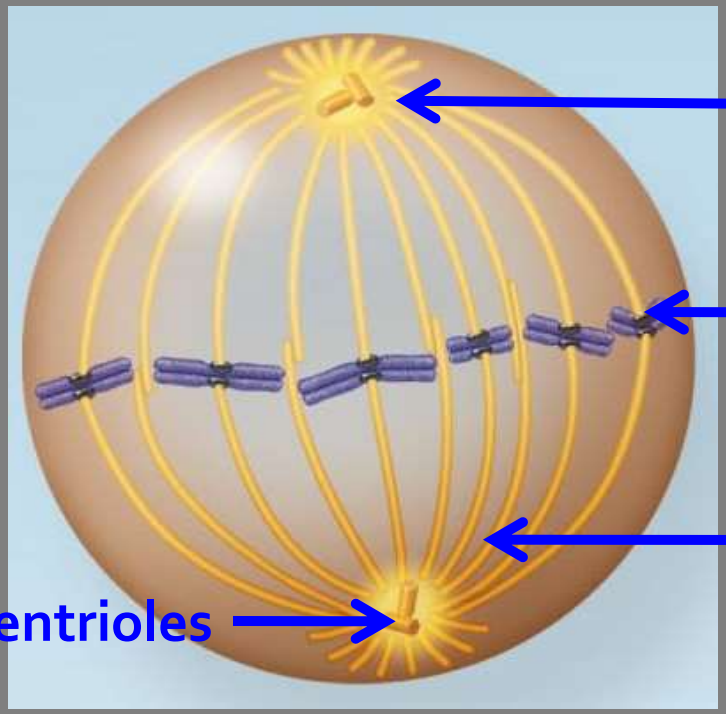
Late prophase



The centrioles have moved to the opposite poles, forming the spindle as they go.

Metaphase

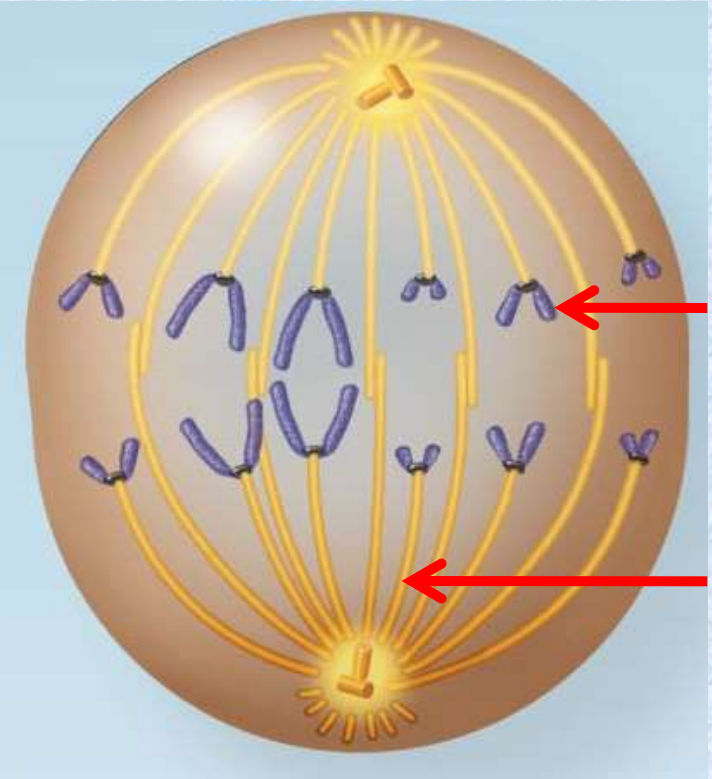
- The centrioles are now at opposite sides of the cell.
- The spindle fibers will push and pull the chromosomes.
- The chromosomes line up at the center of the cell.



Each chromosome is connected to a spindle fiber at its centromere.

Anaphase

The centromeres divide and the chromatids move to opposite sides of the cell.



Chromatids are being pulled to opposite sides of the cell.

Shortening of the microtubules

The microtubules begin to shorten and this pulls the chromatids apart to opposite sides of the cell.

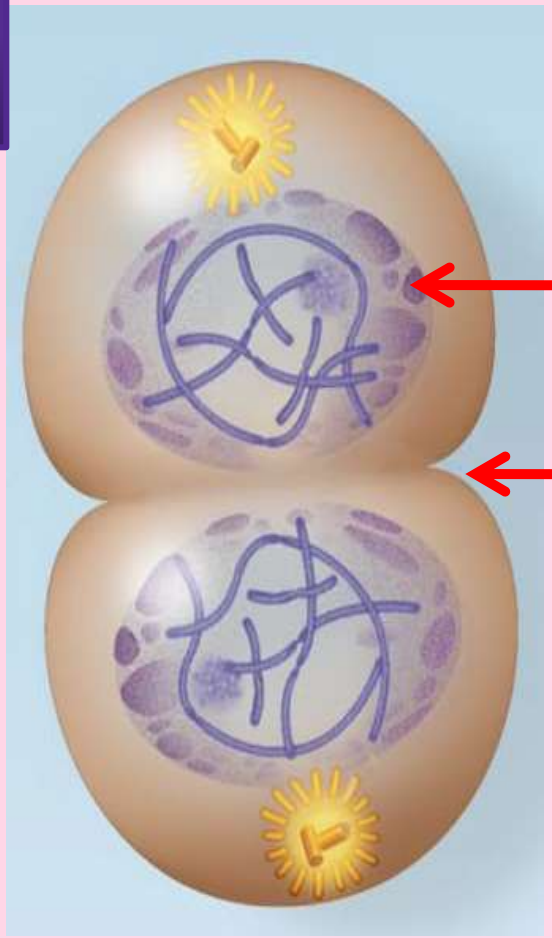
By the end of anaphase, the two ends of the cell have equivalent and complete sets of chromosomes.

Telophase

Nuclear membrane begins to form.

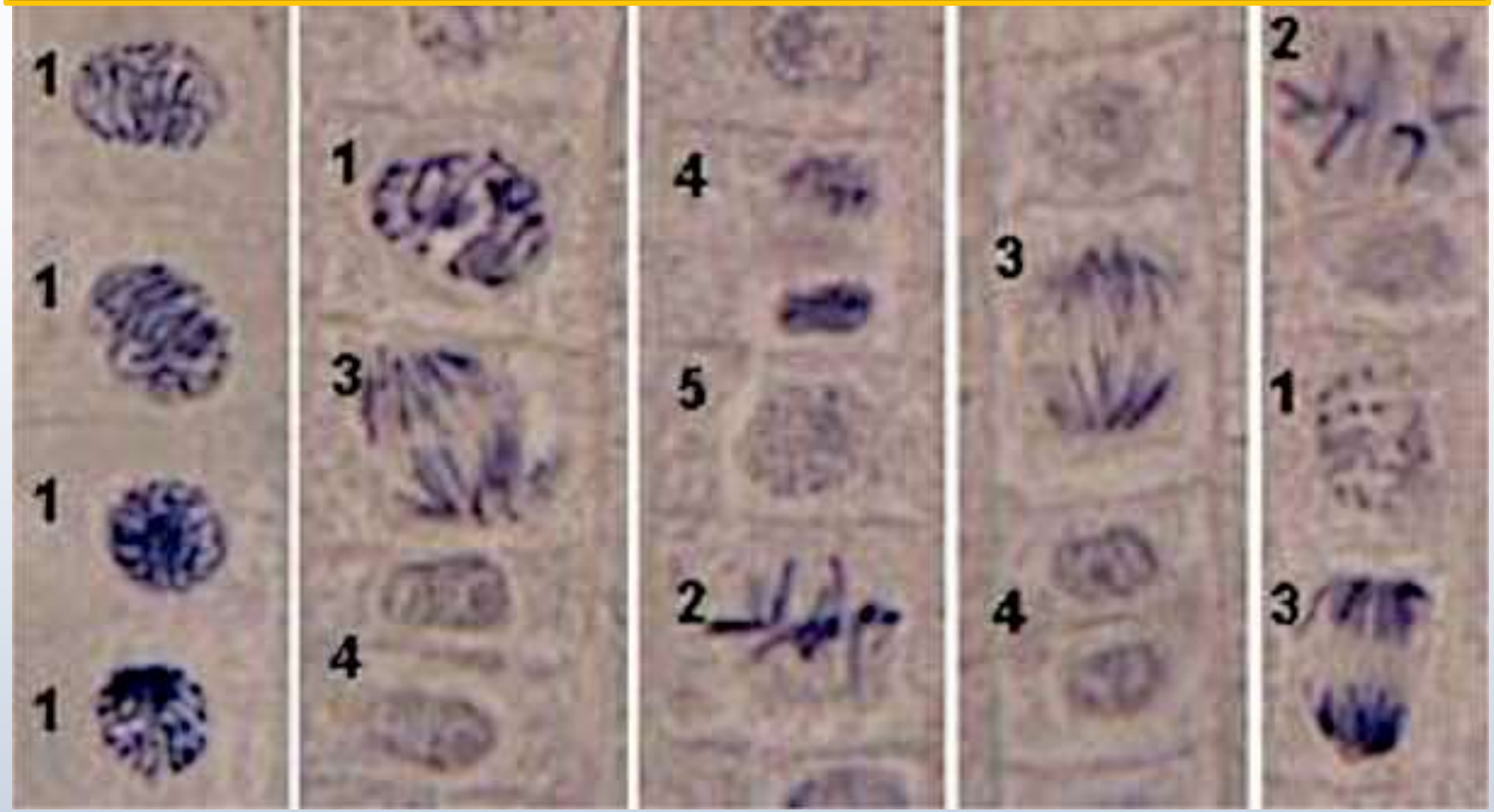
Nucleolus returns.

The cell begins to pinch in. This is called a cleavage furrow.



The end result is two cells that are exact copies of each other.

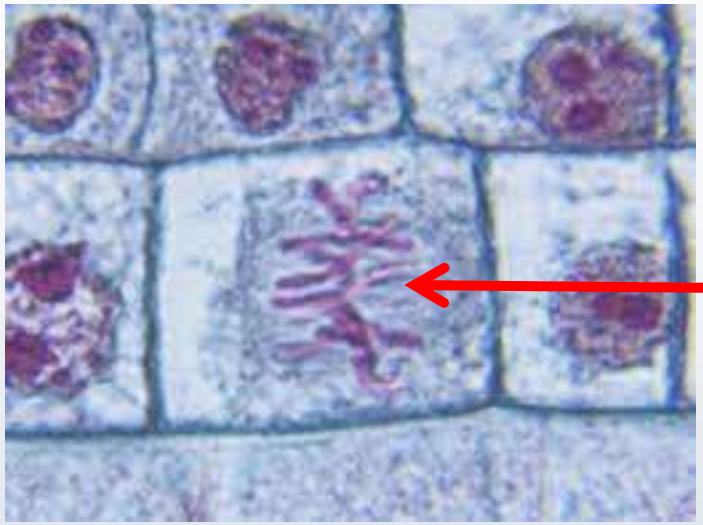
Can you name these phases?



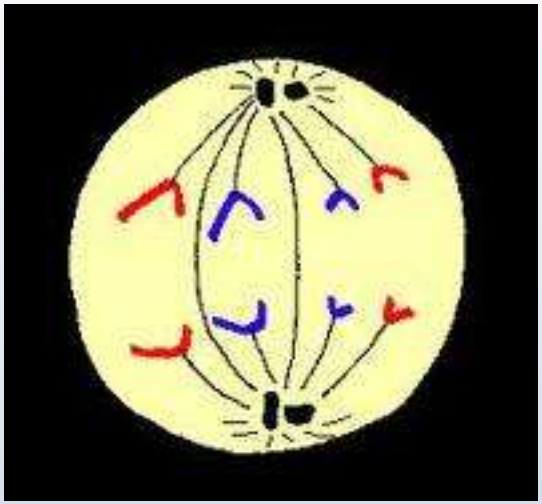
1 - Prophase **2 - Metaphase** **3 - Anaphase**

4 - Telophase **5 - Interphase**

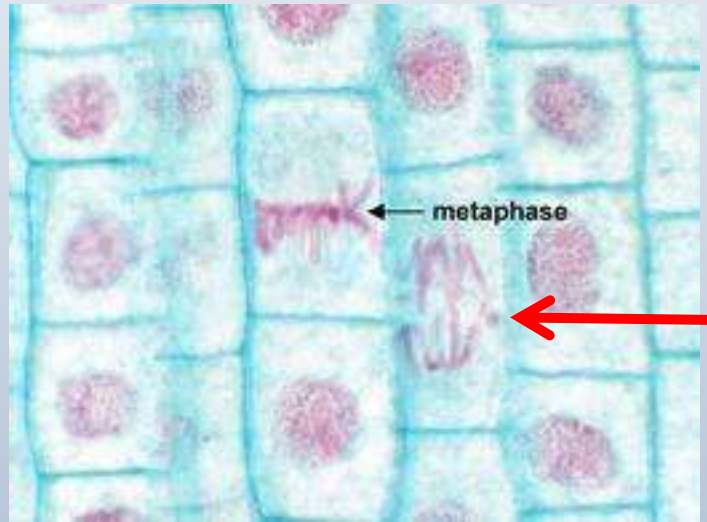
Let's practice identifying the phases!



metaphase

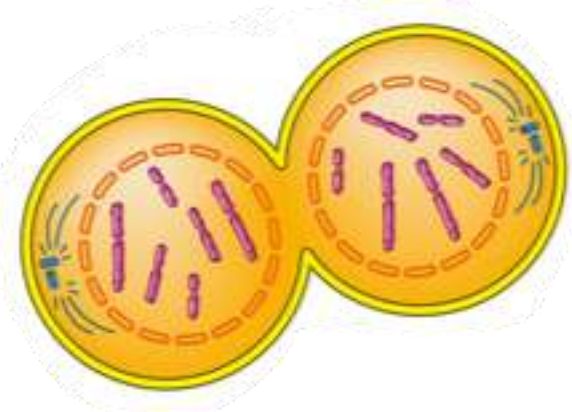


anaphase

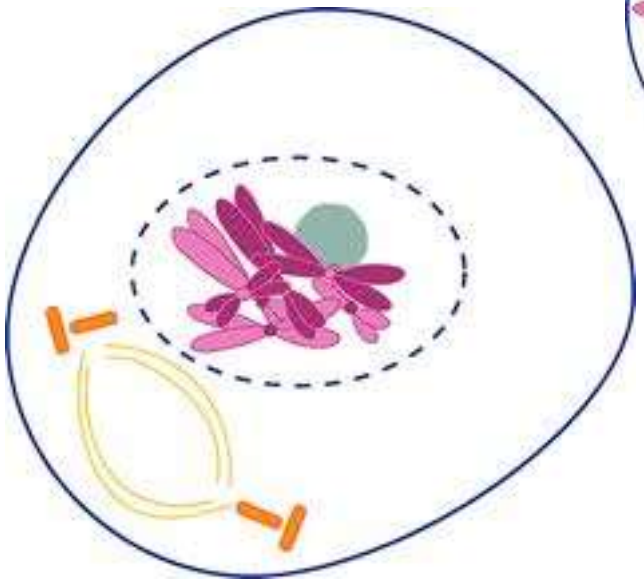


anaphase

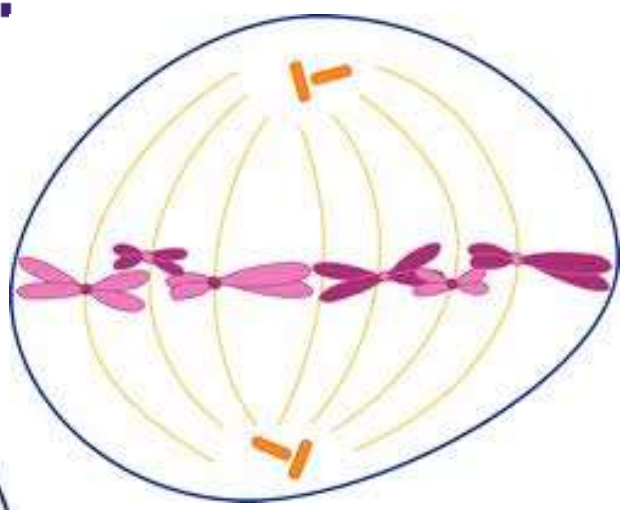
Let's practice identifying the phases!



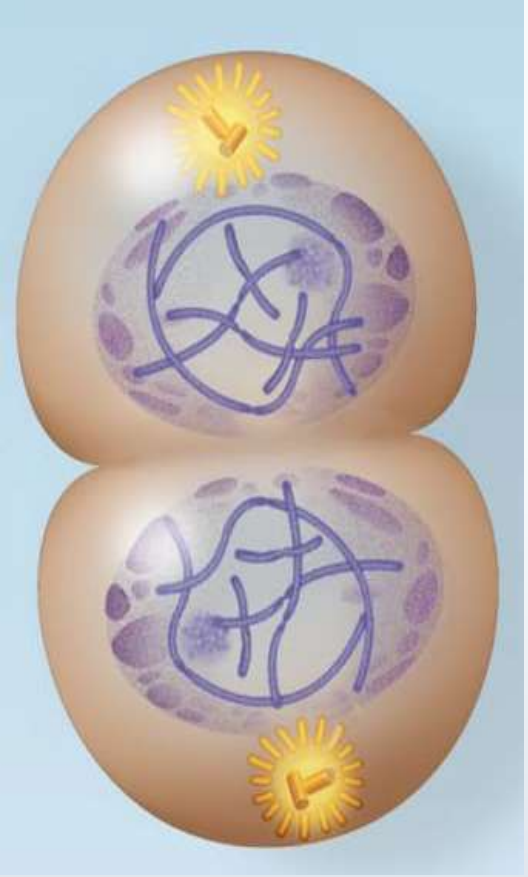
Telophase



Prophase



Metaphase

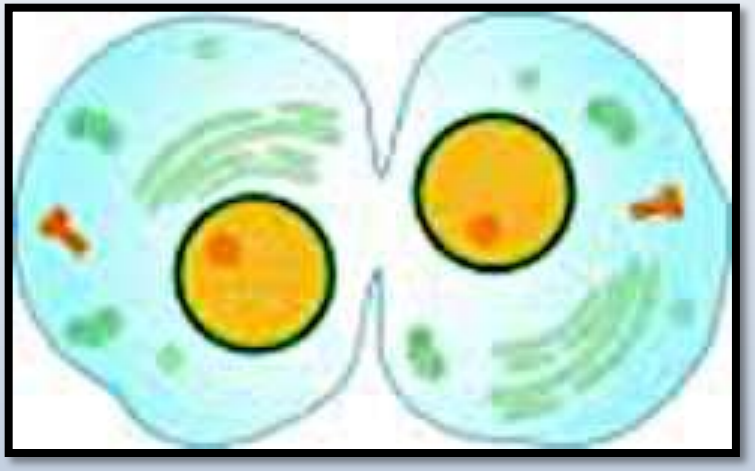


Cytokinesis

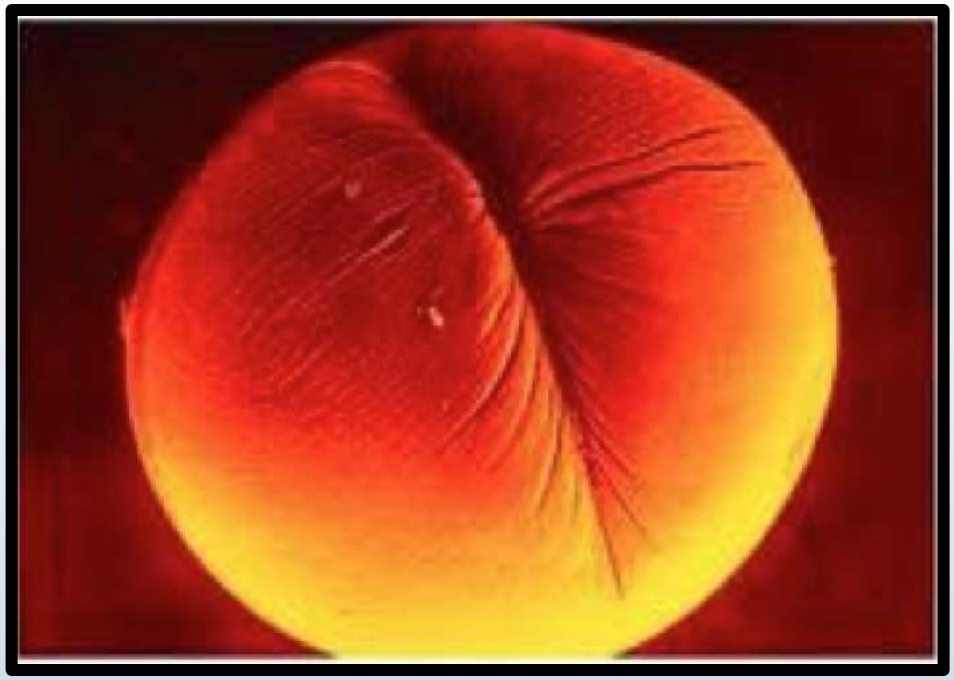
At the end of mitosis, two nuclei have been formed. Each nucleus has an identical set of chromosomes.

Cytokinesis is: the division of the cytoplasm.

Cytokinesis usually occurs at the same time as telophase.

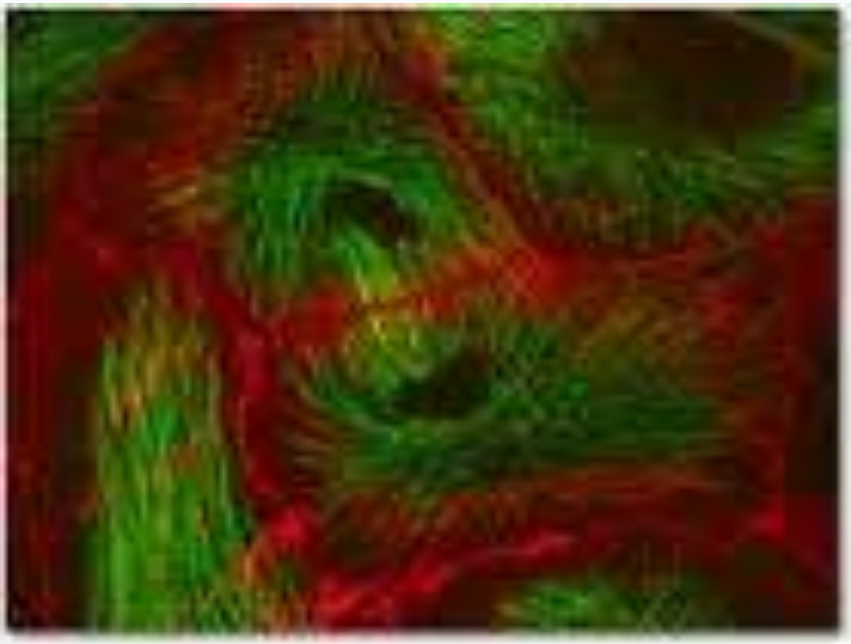


Cytokinesis in Animal Cells

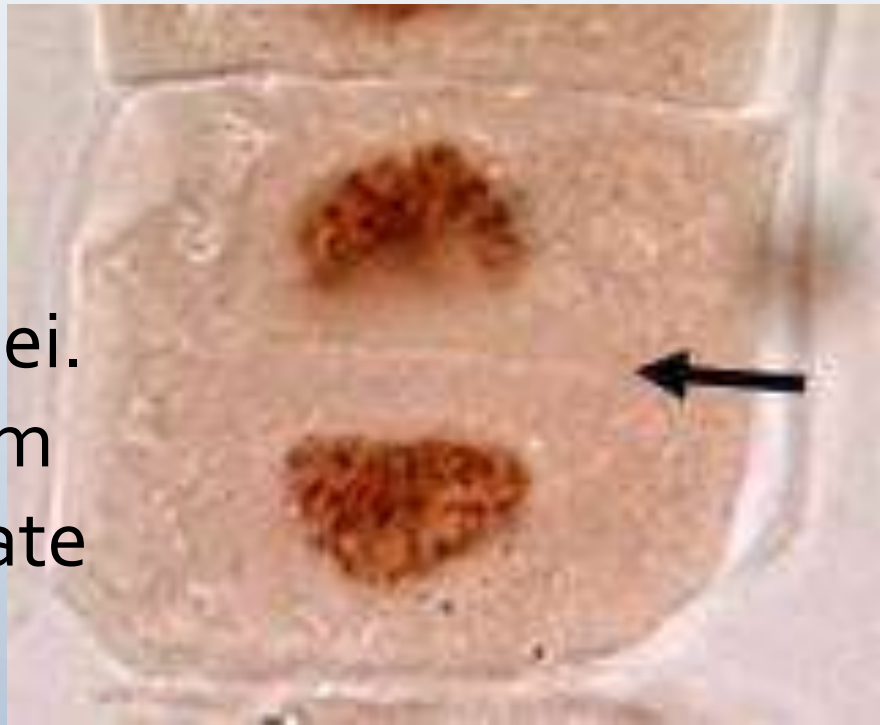


In animal cells, a cleavage furrow pinches the cell membrane inward until the cell is pinched into two separate cells. Each new cell contains its own nucleus, cytoplasm, and organelles.

Cytokinesis in Plant Cells

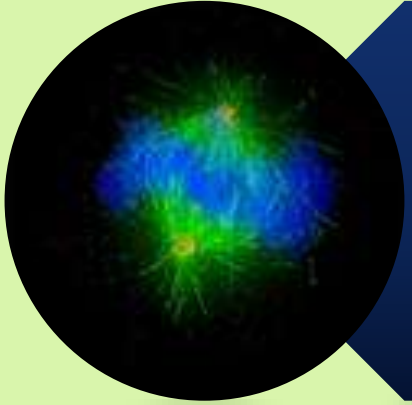


In plants, it is not possible for the cell to pinch inward because of the rigid cell wall.

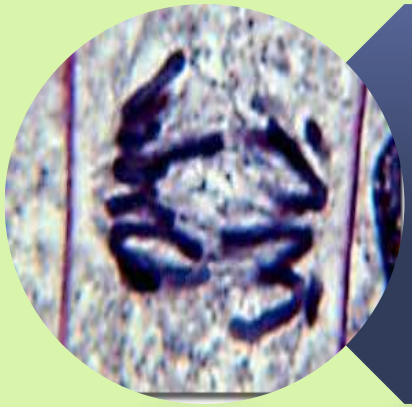


In plants, a cell plate forms midway between the two nuclei. The cell plate continues to form across the cell until two separate cells have been formed.

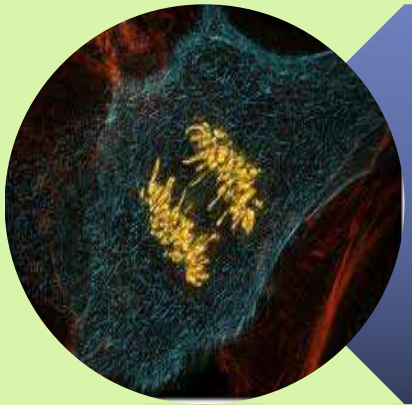
MITOSIS



Takes between 30 minutes and 2 hours.



One Mother Cell = Two Daughter cells.



The two daughter cells are identical to the mother cell.

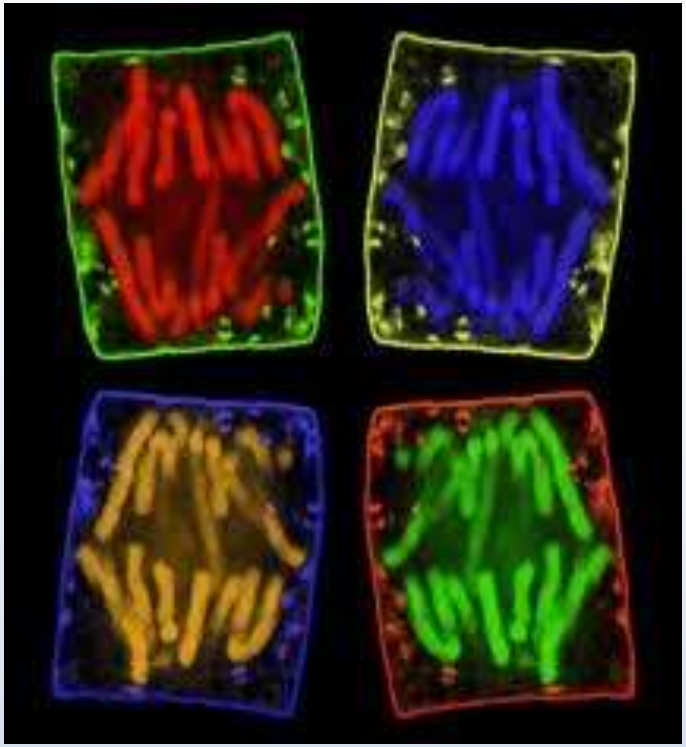
Results of Mitosis

- In unicellular plants and animals, it results in new offspring by asexual reproduction.
- In multicellular organisms, it results in the growth and repair of the organism.

Importance of Mitosis

- The two new cells are exact duplicates.
- Insures that the new cells will be able to carry on the same functions as the mother cell.

Regulation of the Cell Cycle



The frequency of cell division varies with the type of cell.

Skin cells divide frequently throughout our lives.

Liver cells maintain the ability to divide but only do so on rare occasion - say to repair a wound.

The most specialized cells, such as muscle cells and nerve cells, do not divide at all.

Controls on Cell Division

When cells come into contact with other cells, they respond by not growing.

When an injury, like a cut in the skin occurs, the cells at the edge of the injury begin to divide rapidly.

When the healing process nears completion, the rate of cell division slows down.

Cell Cycle Regulators

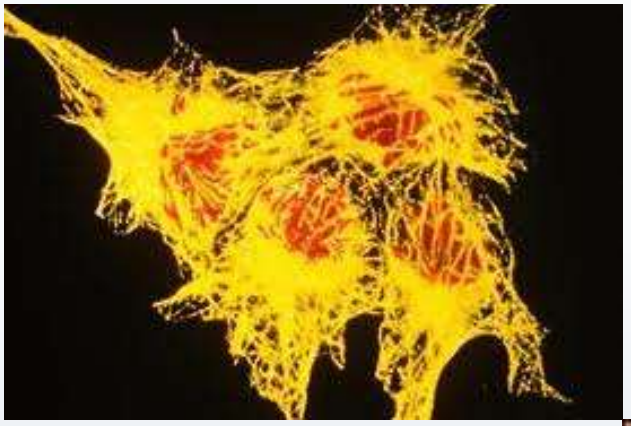
There are many proteins found on the inside and the outside of the cell that regulate cell division.

Some of these proteins are responsible for starting and stopping cell division.

Other proteins seem to speed up or slow down the cell division process.

These proteins send out signals that prevent excessive cell growth. This keeps the tissues of the body from disrupting one another.

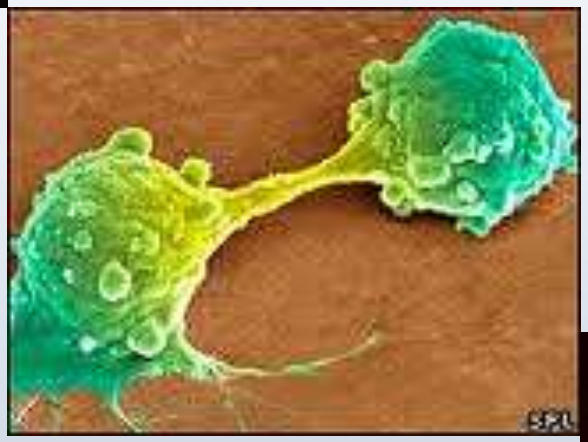
Uncontrolled Cell Growth



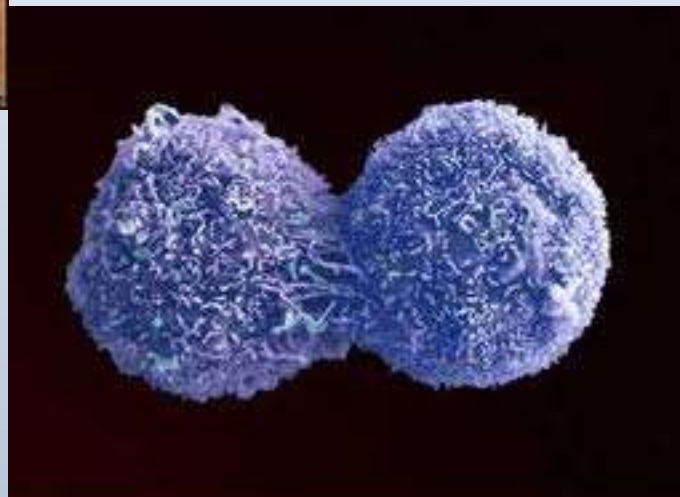
Cancer cells do not respond to the signals that regulate the growth of cells.

Cancer cells divide uncontrollably and form masses of cells called tumors.

If the cells in a tissue grow uncontrollably, the consequences may be severe.



These tumors can damage the surrounding healthy tissues.



All cancers have one thing in common:

The protein regulators that control the cell cycle have failed to do their job.