BELLRINGER

1. What is DNA?
2. List anything you know about DNA (from readings, class, TV…?)

DNA Structure Simulation

- Before we begin, let's investigate the way DNA molecules are set up!

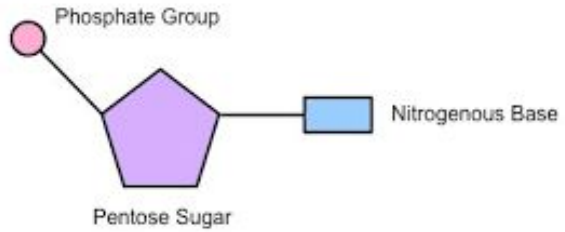
- http://learn.genetics.utah.edu/content/molecules/builddna/

The Structure of DNA

What is DNA?

A bit about DNA…

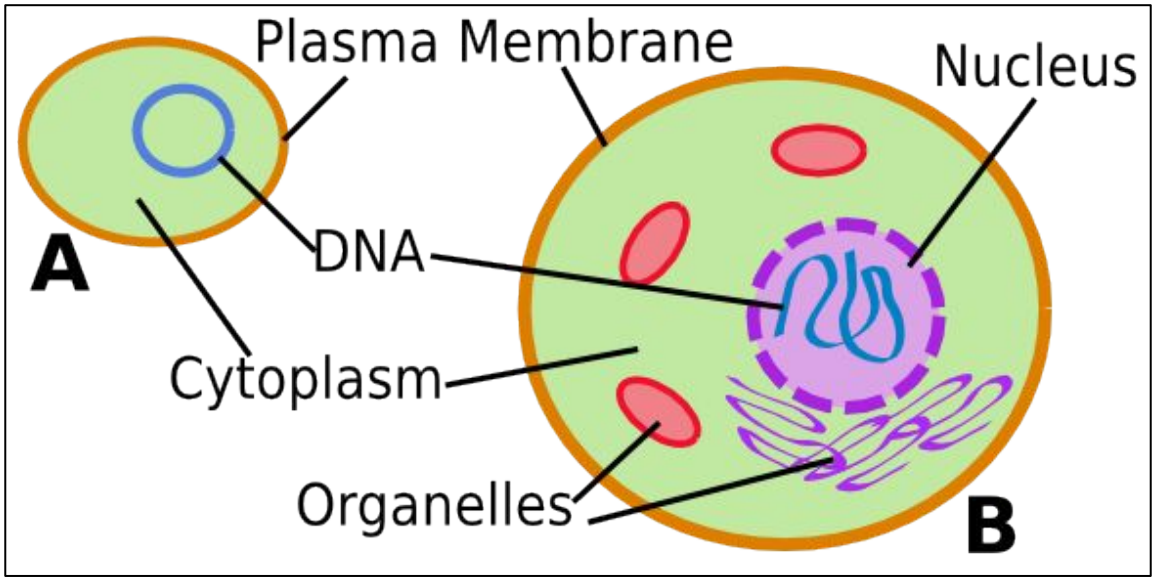
- DNA is the genetic material found in cells
- Stands for: "Deoxyribonucleic Acid"
- Is made up of repeating nucleic acids
  - *Nucleic Acid - made up of Nucleotides, one base and one of the 4 components (Adenine, Thymine, Cytosine, Guanine)*
- It's the "Unit of Heredity"



Nucleic Acid

Where is it found?

- DNA is found in the ***cytoplasm*** of prokaryotes and the ***nucleus*** of eukaryotes



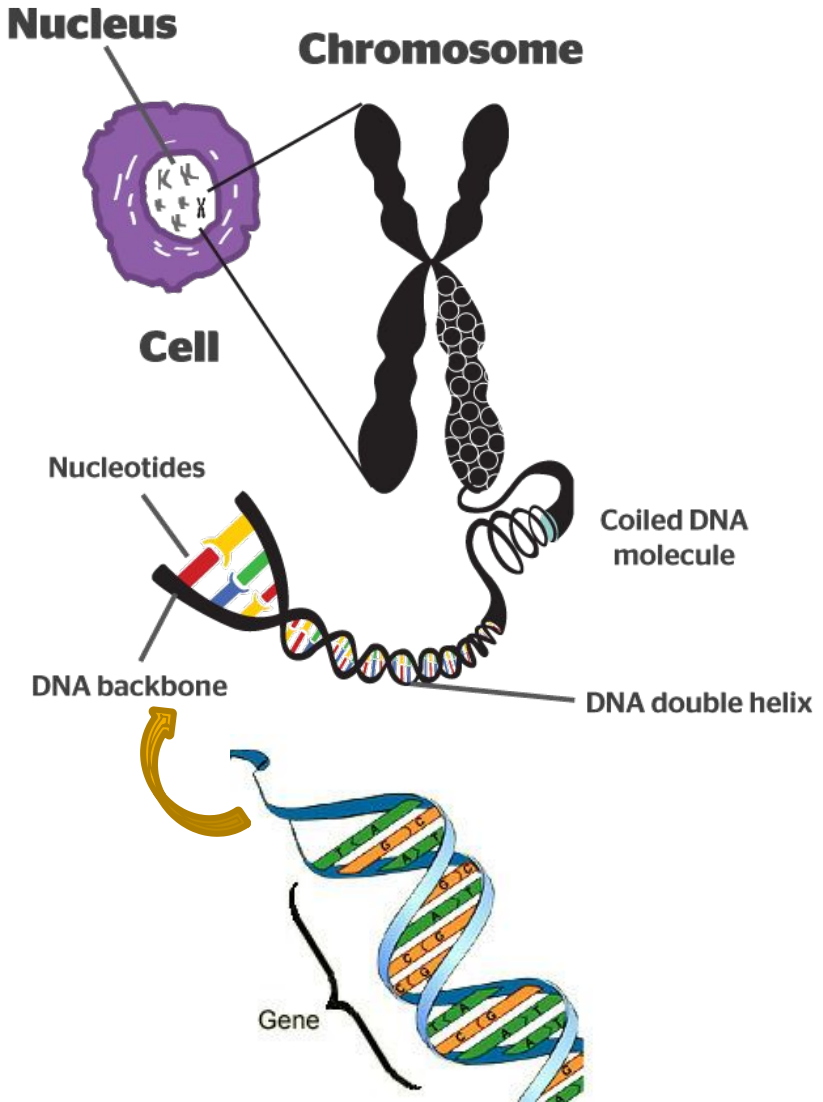
- The nucleus of a human cell contains 30,000 or more genes in the form of DNA called a ***genome*** (genetics)

Function of DNA

- Purpose: DNA controls the production of proteins in the cell
  - This is essential to life!
  - DNA $\rightarrow$ RNA $\rightarrow$ Proteins

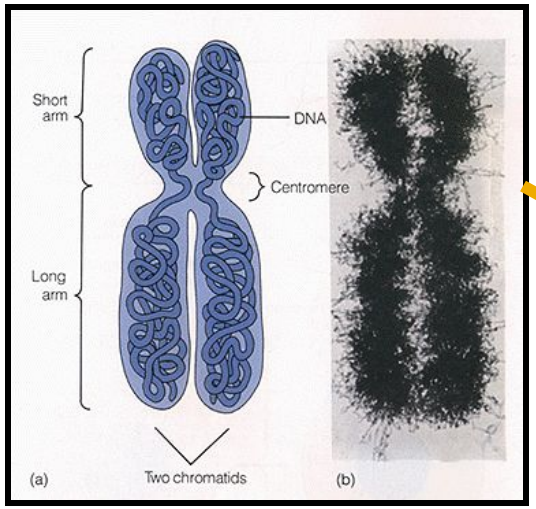
Structure of DNA

- DNA is packaged tightly into pieces called ***chromosomes*** that are visible during cell division
- Each *chromosome* includes several thousand ***genes***
- Each *gene* contains the directions to make one or more ***proteins***
  - Proteins are made of amino acids
- These proteins play a key role in the way we look and grow…ever hear someone say "it's in your genes?"

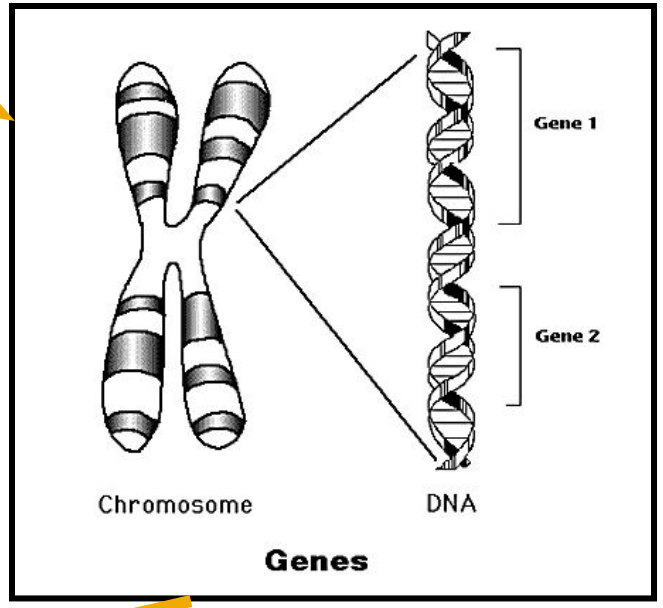


Structure of DNA

One Chromosome



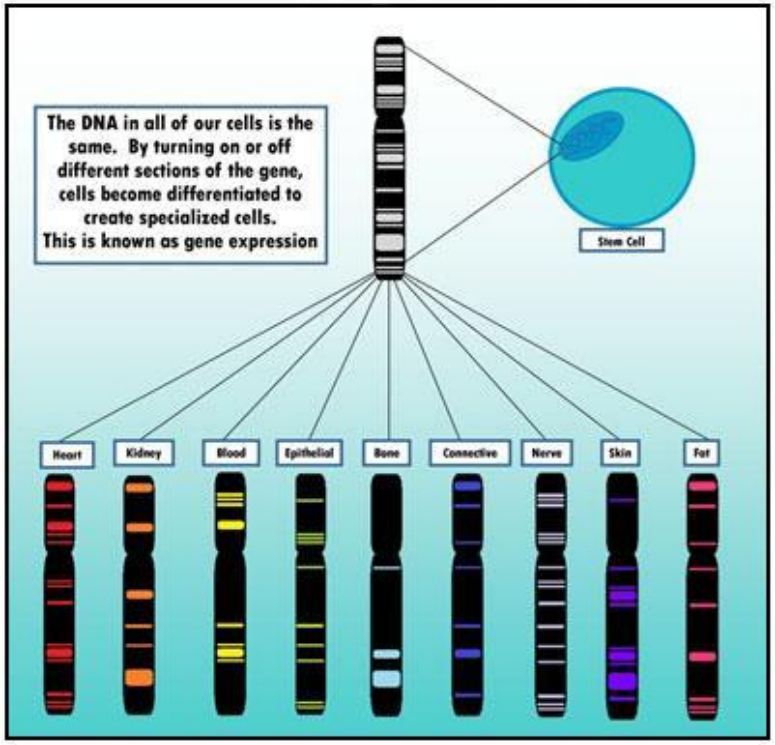
Contains many genes



Each gene codes for a protein
Ex. Keratin protein

Specialization

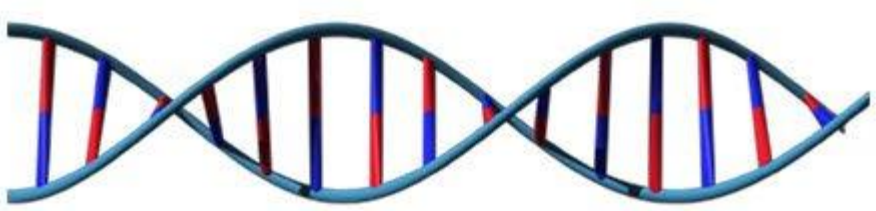
- Specialization
  - In embryo, all genes on the DNA are “on”. They are undifferentiated cells (stem cell) can develop into any type of cell.
  - Specialization occurs when certain genes are turned “off” and other genes remain “on” – making a particular type of cell
    - Ex. Muscle cells and Nerve cells in your body have the same DNA, but they have different genes activated.



But what does DNA look like?

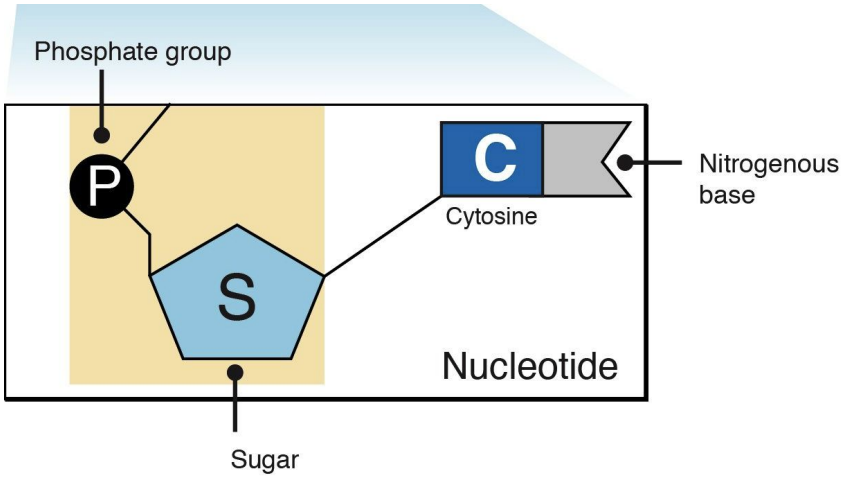
Think of DNA as a spiral staircase!

- DNA is comprised of two strands that twist around each other, called a ***double helix***
  - Discovered by *Watson and Crick* in 1953
- "Twisted ladder structure"



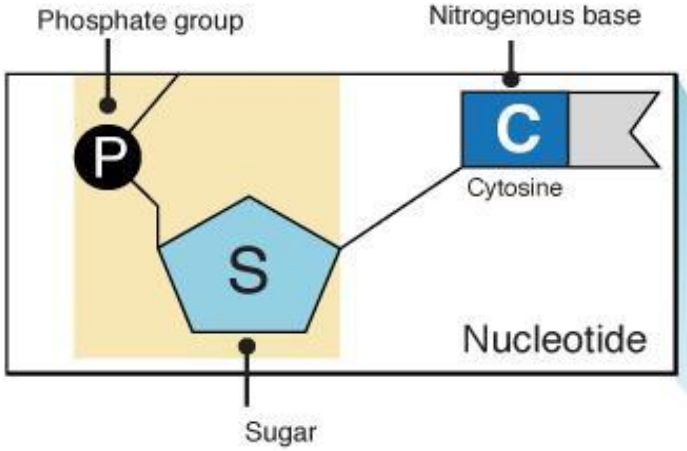
Structure of DNA

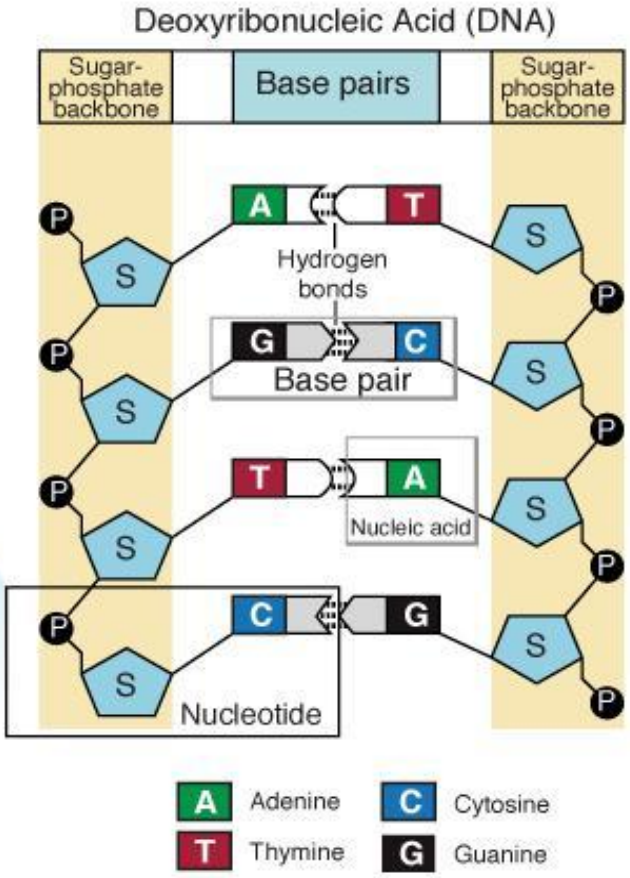
- DNA is a made of building blocks called ***nucleotides***
- A *nucleotide* is made of:
  - one phosphate
  - one 5-carbon sugar (called deoxyribose)
  - one nitrogen base
    - Adenine
    - Thymine
    - Guanine
    - Cytosine



Structure of DNA

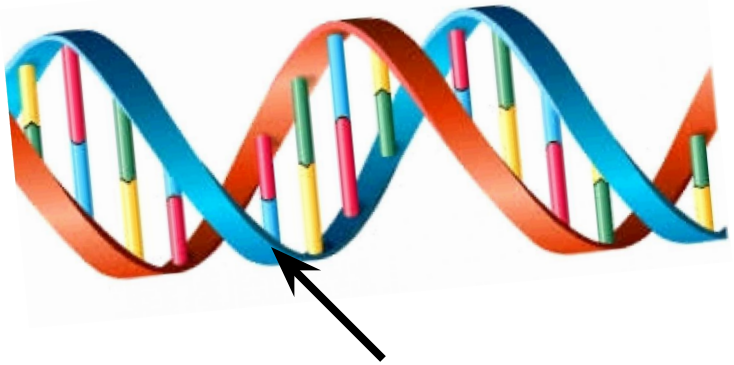
- Nucleotides put together make up the DNA strand!

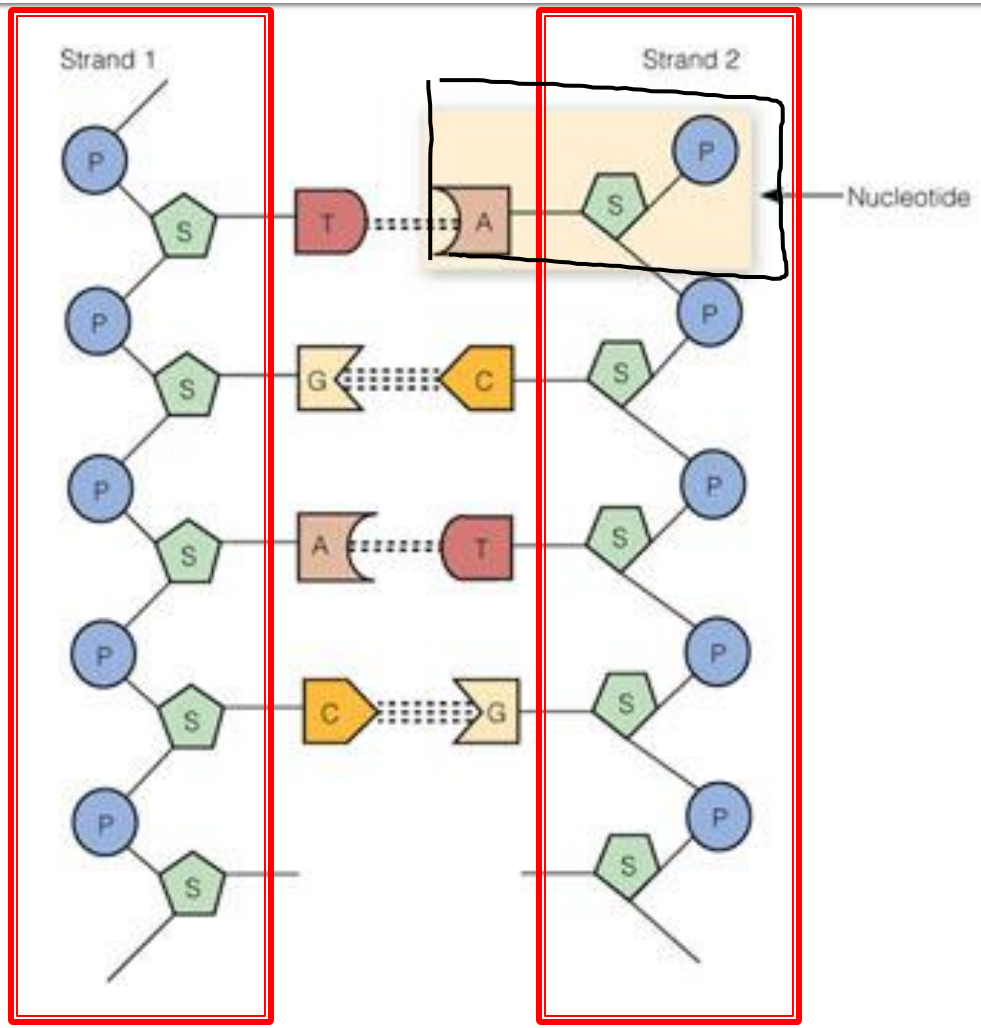




Parts of DNA: Sides

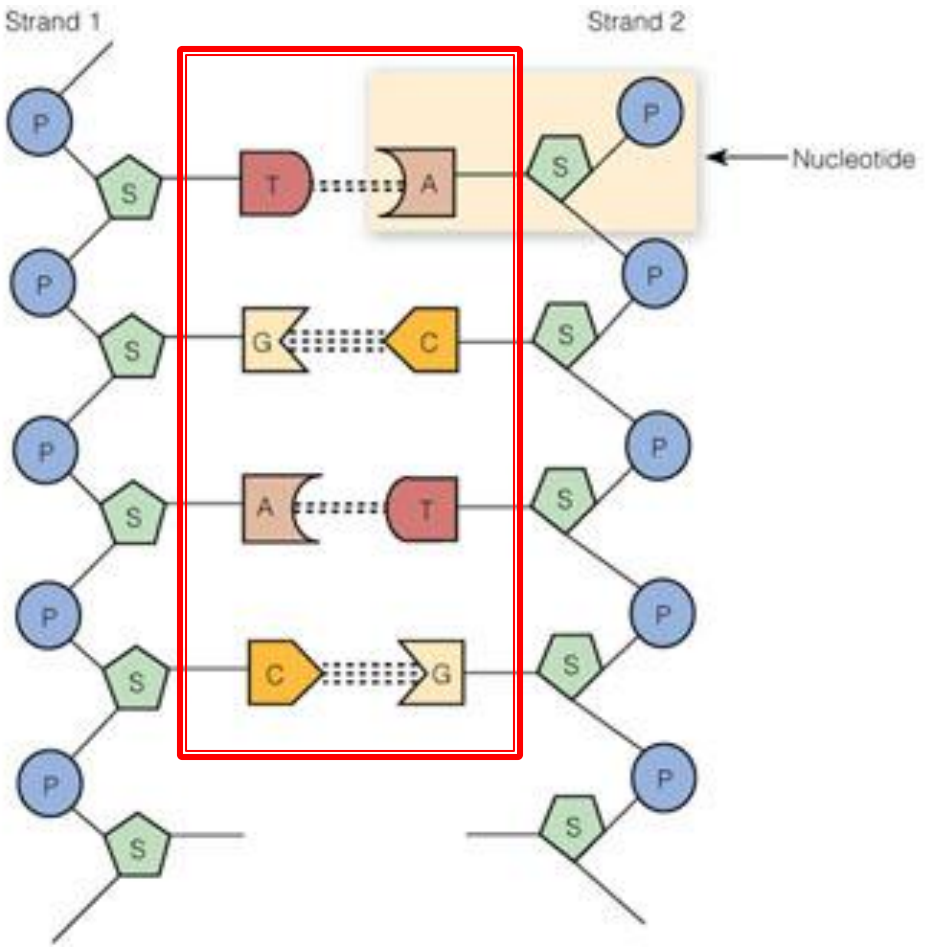
- The sides, or "backbone" of the DNA are composed of alternating phosphate-sugar groups





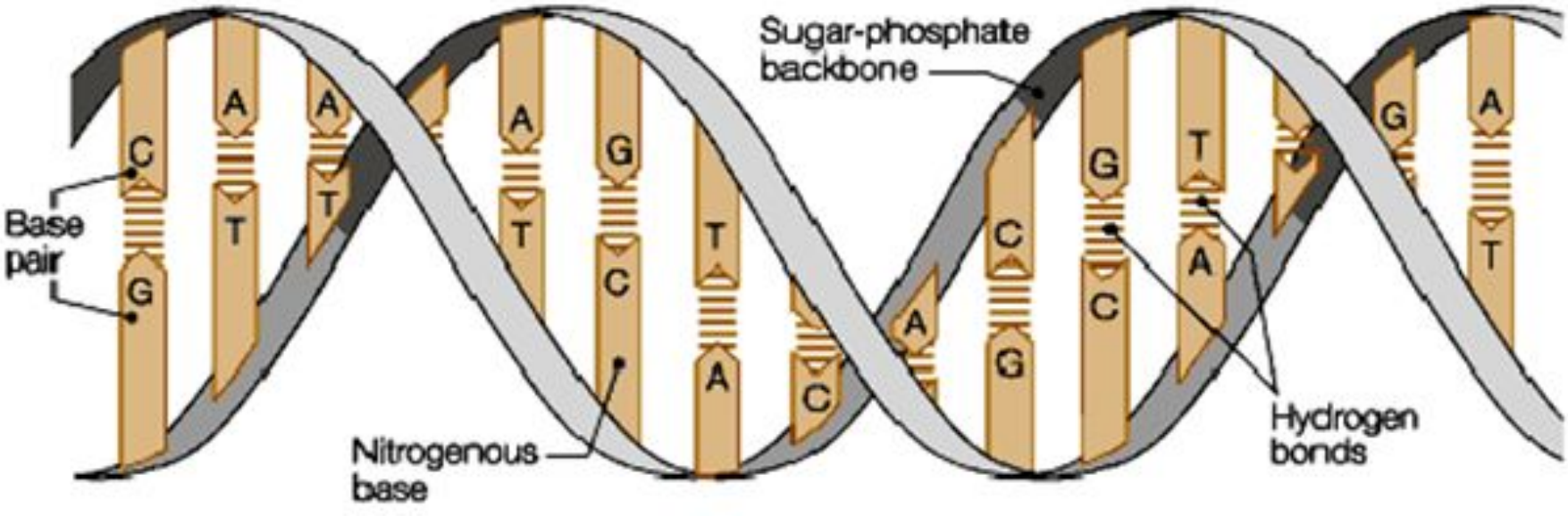
Parts of DNA: Bases

- Each “rung of the ladder” is made up of **complementary** nitrogenous base pairs
- The four bases *are A (adenine), T (thymine), G (guanine), and C (cytosine)*
  - **A pairs with T (2 H Bonds)**
  - **G pairs with C (3 H Bonds)**



Nitrogenous Base Pairs

- They form weak ***hydrogen bonds*** that hold the DNA strand together and are the reason DNA can be replicated
  - A::T forms 2 H-bonds, and C:::G forms 3 H-Bonds



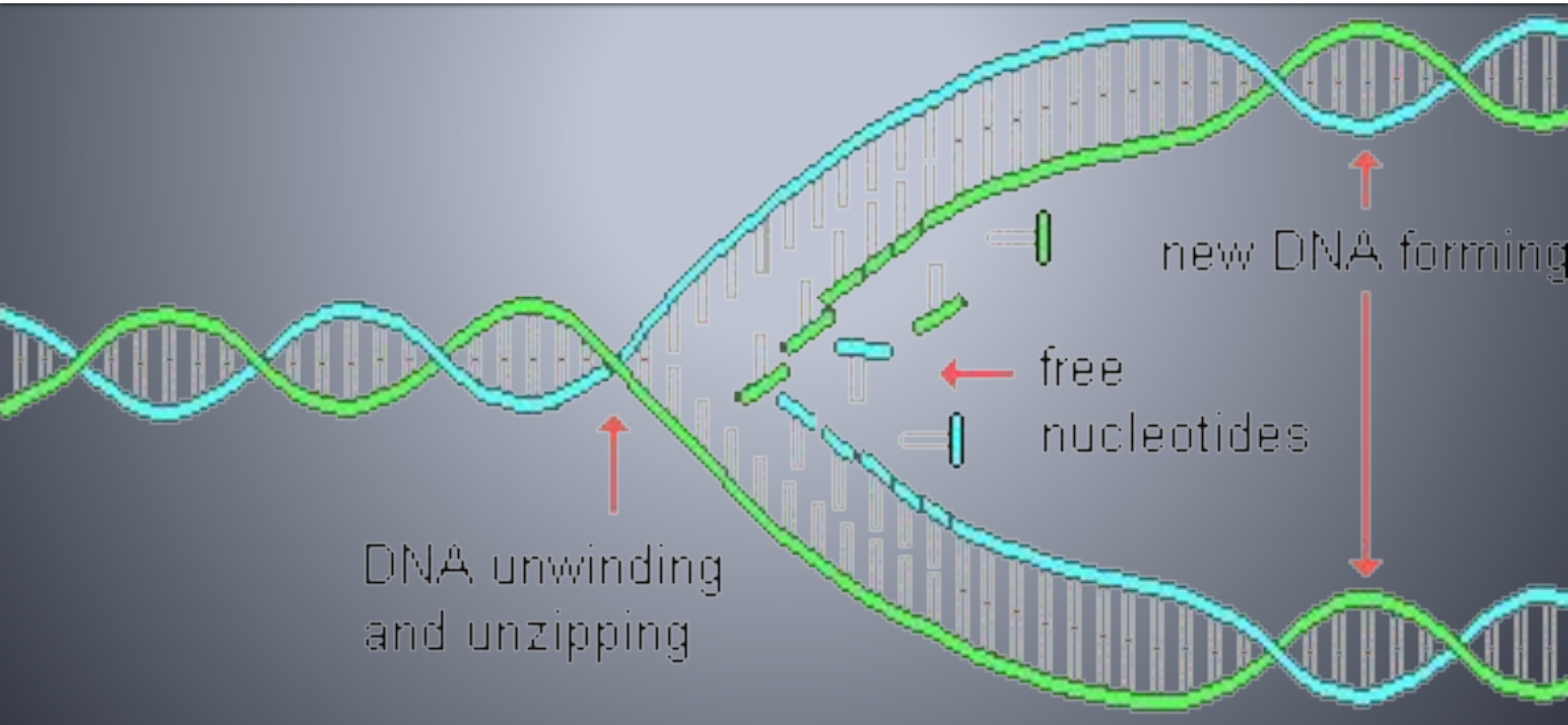
BELLRINGER-3/19/15

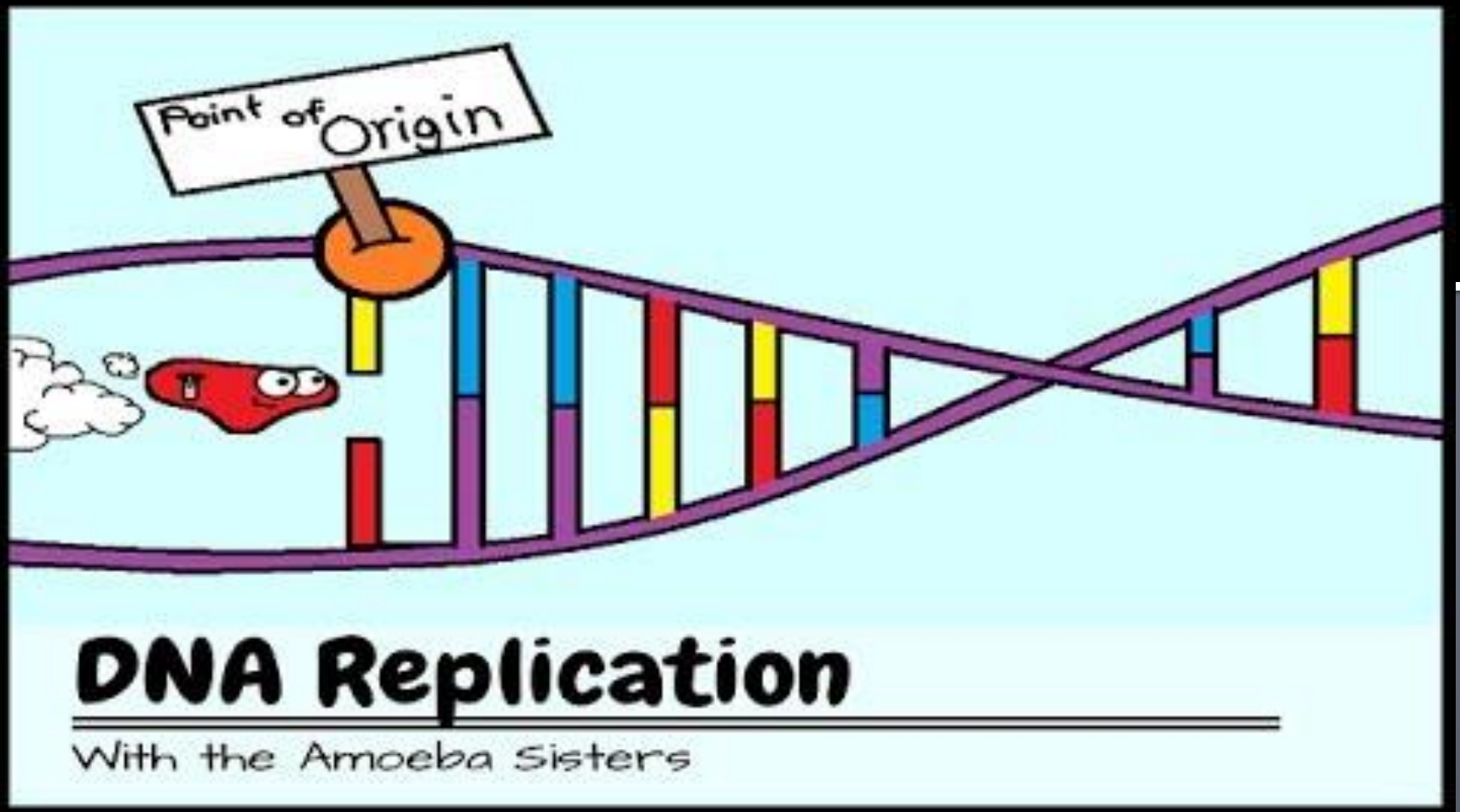
1. DNA is packaged into pieces. What are these pieces called?
2. There are thousands of genes on a chromosome. A single gene contains the directions to make what?
3. The base adenine (A) always pairs with _____, while the base guanine (G) always pairs with _____.


The
DNA
song
Jam campus

DNA REPLICATION

Making a new strand




Point of Origin
DNA Replication
With the Amoeba Sisters

DNA Replication

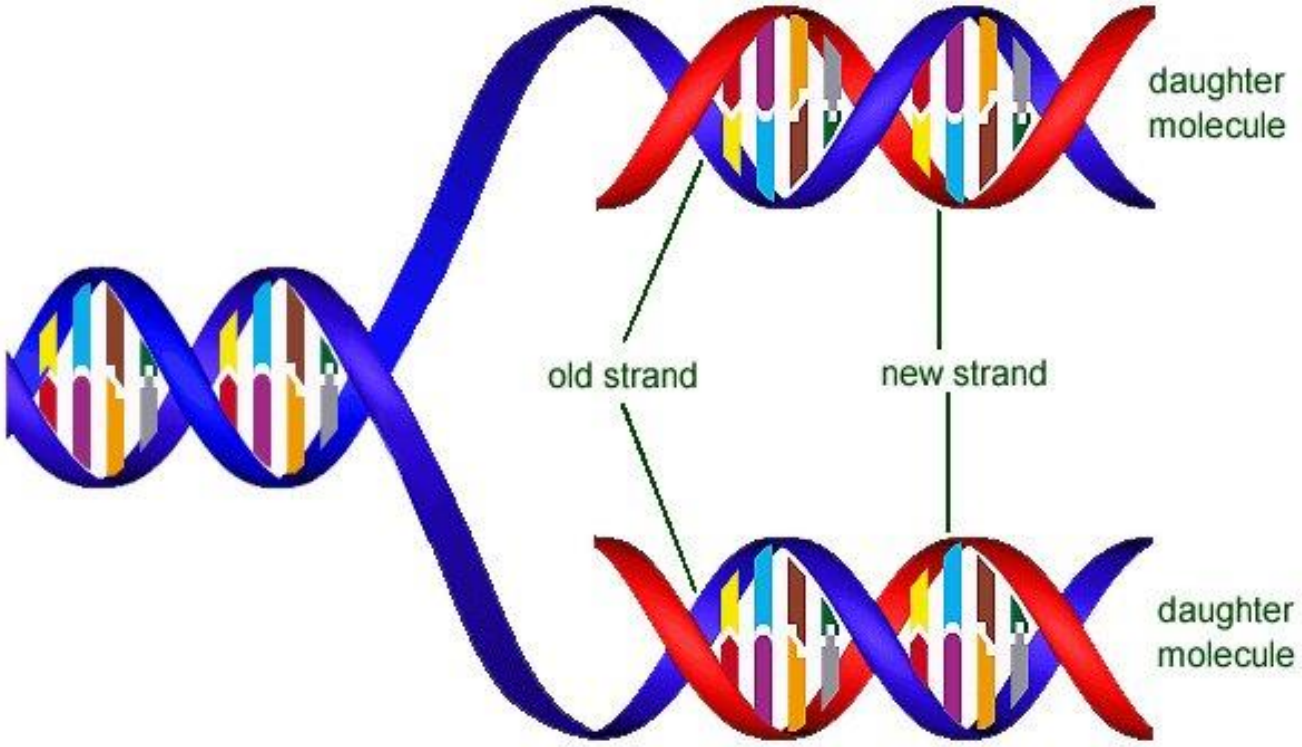
- ***DNA replication*** is the process of producing 2 identical replicas from one original DNA molecule
  - Replicate means “to copy”
- During replication, the DNA molecule separates into two strands, and builds two new ***complimentary*** *s*trands using the base pairing rules (A::T, C:::G)
- The molecule is unwound and “unzipped” with the help of ***helicase***, an enzyme!

Steps in DNA Replication

- Step 1: DNA unwinds, then "unzips," exposing the N-bases (remember, the bases are ATCG)
- Step 2: New DNA N-bases are added to each side of the molecule, making two separate strands
  - If the unzipped side reads ATCG, then TAGC would be added to that side. Now it is an independent strand!

DNA Replication

- Each new DNA strand (daughter chromosome) is made up of 1 strand from the original DNA (blue) and one new strand (red)



Complementary Base Pairs

- Given one strand, you can always find the other strand using base pairing rules!

- Let's practice!
- If the ***DNA sequence*** of bases on one strand was G C T A C A T, what would the complementary side be during replication?

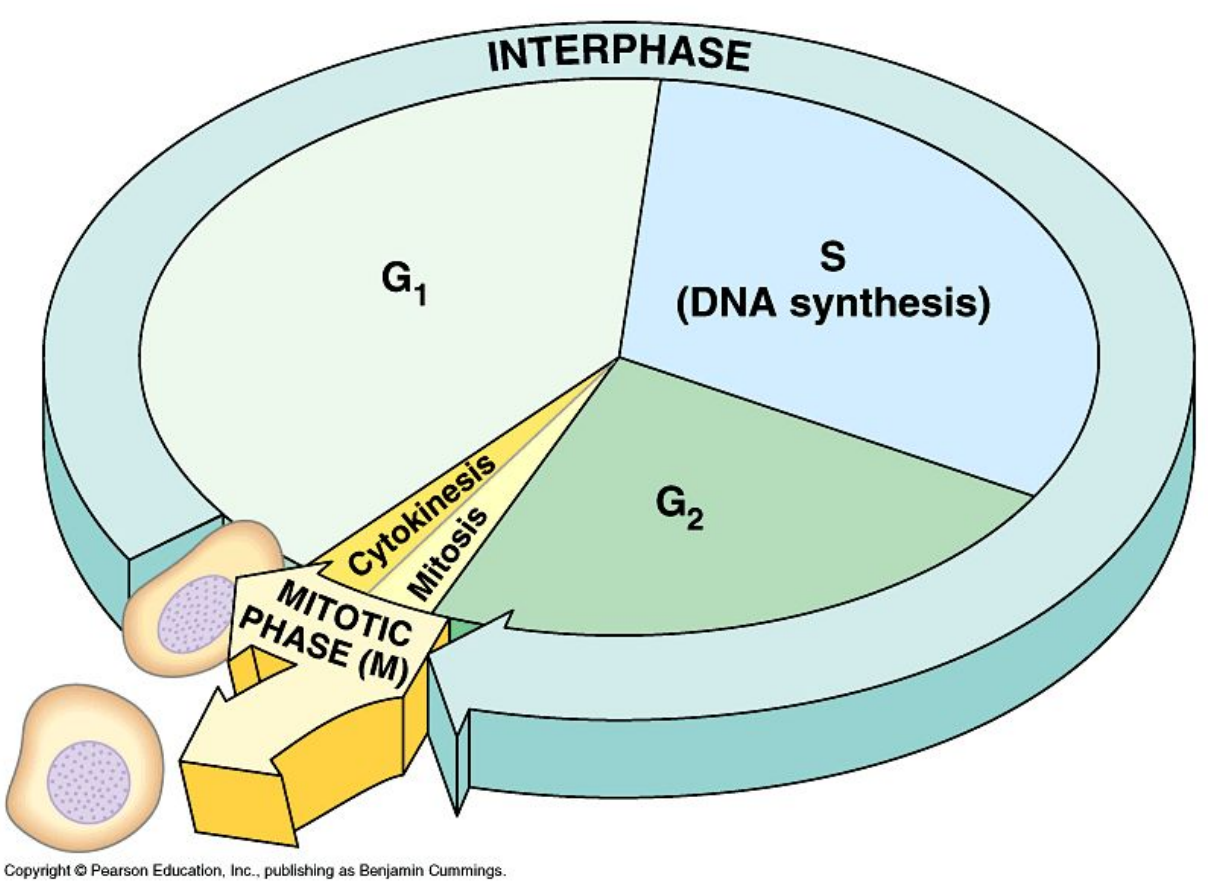
C G A T G T A

Bellringer

1. What are the steps in DNA replication?
2. Practice some replication:
    - CTG
    - AAT
    - CGA

The Cell Cycle

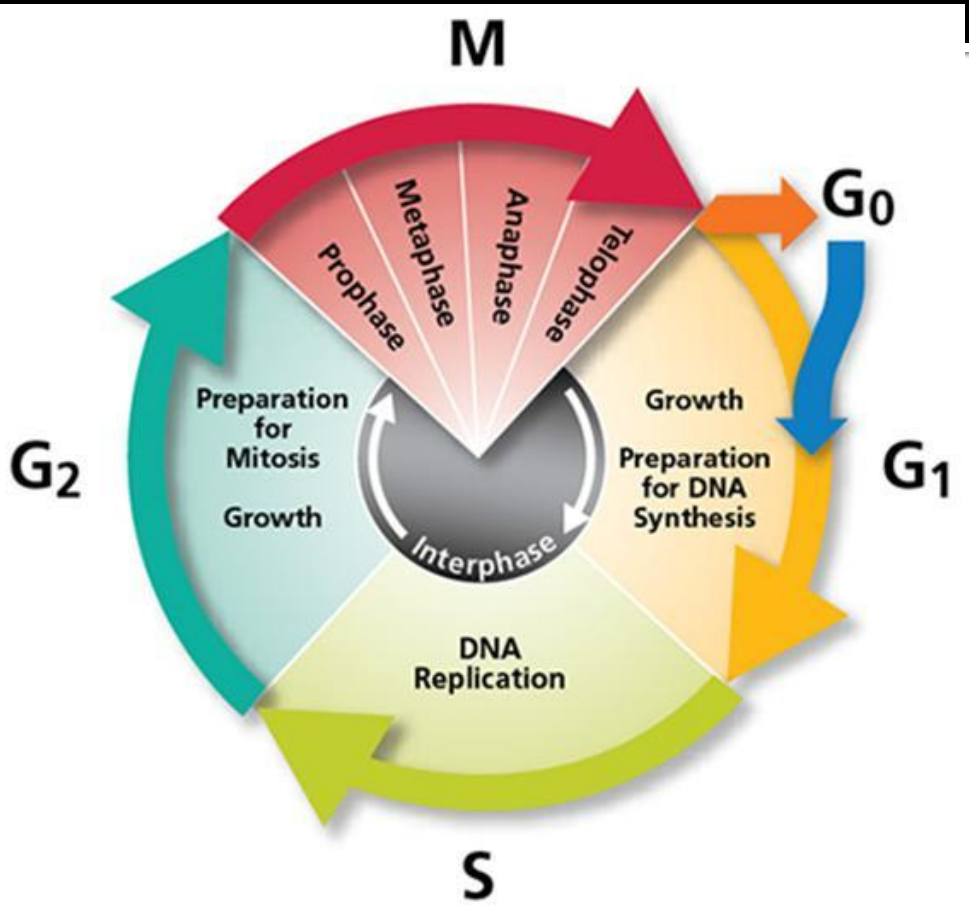
How does a cell grow and divide?



The Cell Cycle

- The ***Cell Cycle*** describes the life of a cell from birth to death
- There are three main parts of the cycle:
  - ***Interphase***-Normal cell activities; broken up into 3 parts
  - ***Mitosis***-The process of cell division (1 cell becomes 2!)
  - **Cytokinesis**-The division of the organelles and cytoplasm following mitosis

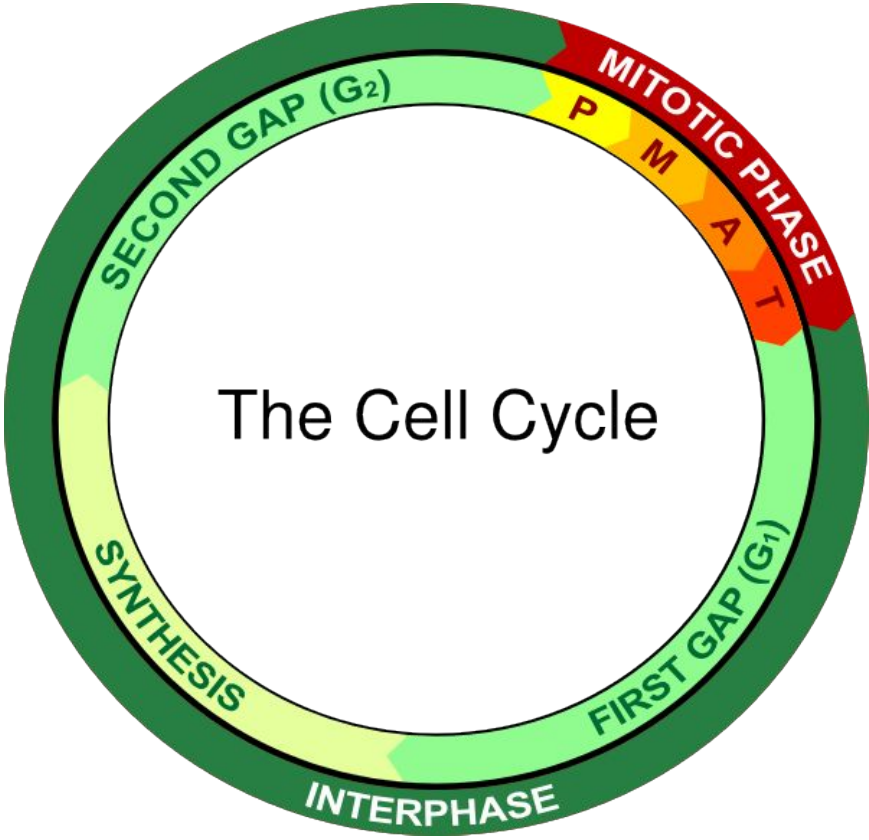
Cell Cycle Detailed



- Interphase is indicated in grey-it is the **longest** phase of the cycle, broken into 3 parts
- Mitosis is indicated in pink-we will discuss the stages of mitosis later!

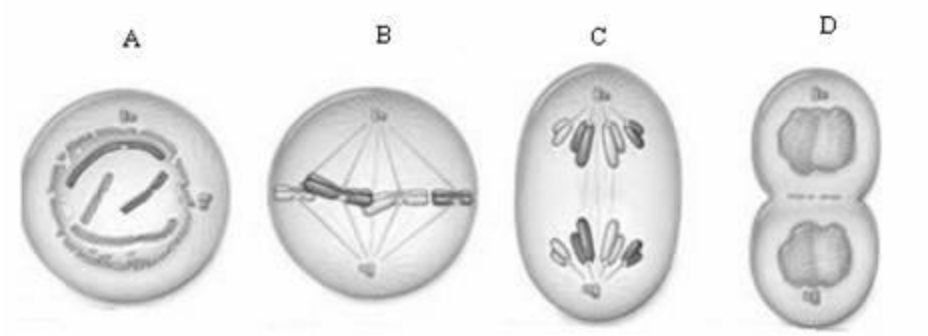
The Cell Cycle: Interphase

- ***G1 phase*** (Gap 1)-Period of cell growth
  - Cells can remain in the G1 phase indefinitely
  - Called G0
- ***S phase*** (Synthesis)-Period when DNA replication occurs
  - Once a cell copies its DNA, it must divide
- ***G2 phase*** (Gap 2)-Cell growth and preparation for Mitosis



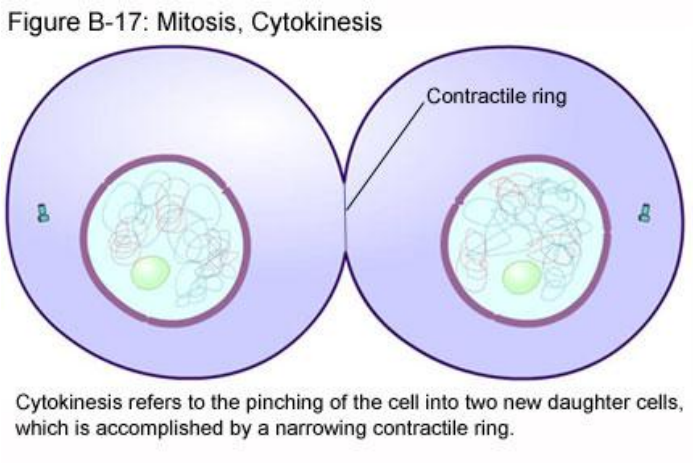
The Cell Cycle: Mitosis

- ***Mitosis*** is a form of asexual reproduction-means only 1 organism required
- Occurs in response to the body's need for growth and repair
- 4 stages of mitosis: Prophase, Metaphase, Anaphase, Telophase
  - We'll talk more about this in a bit!



Cytokinesis

- The cell cycle ends with ***cytokinesis***→ the division of the cytoplasm
  - Accompanies *mitosis*
- This means one cell has divided into two cells, and those two cells can continue with their own independent cell cycles!

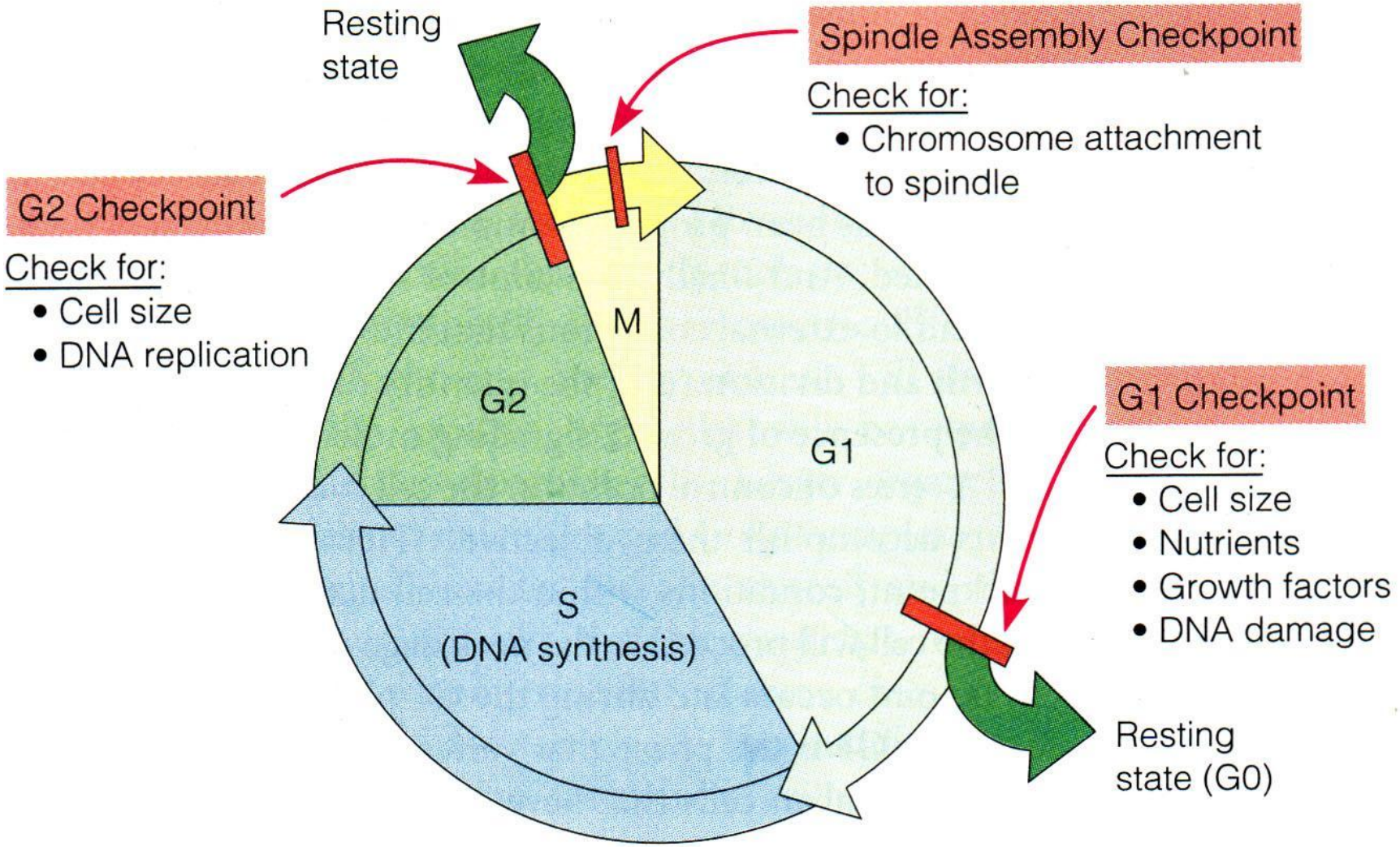


Regulation of the Cell Cycle

- ***Cyclins***-Proteins that regulate the rate of the cycle
  - Internal regulation-cell cycle can't proceed until certain levels of these proteins are reached (ex. Poor nutrition→ cell stays in G1)
  - External regulation-cycle can speed up or slow down
  -

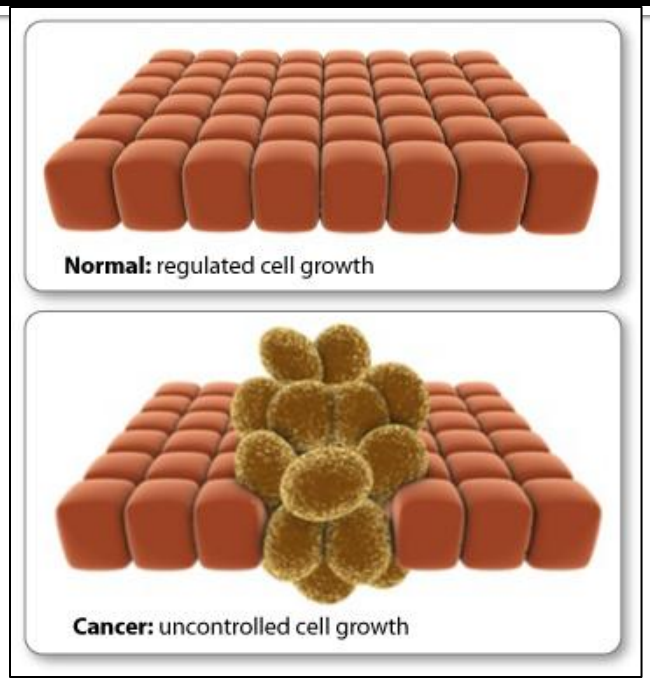
*Do you think a paper cut on your finger would cause the cell cycle to speed up or slow down?

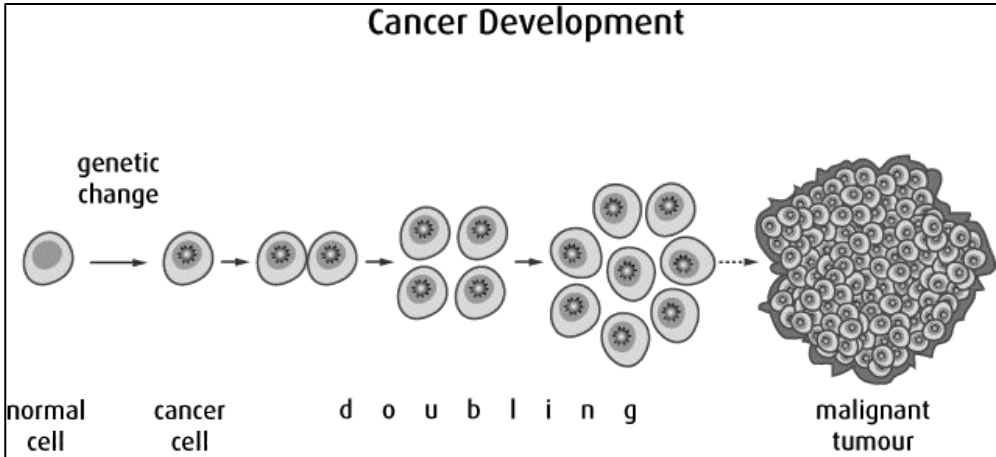
Cell Cycle Checkpoints



Case Study: Cancer

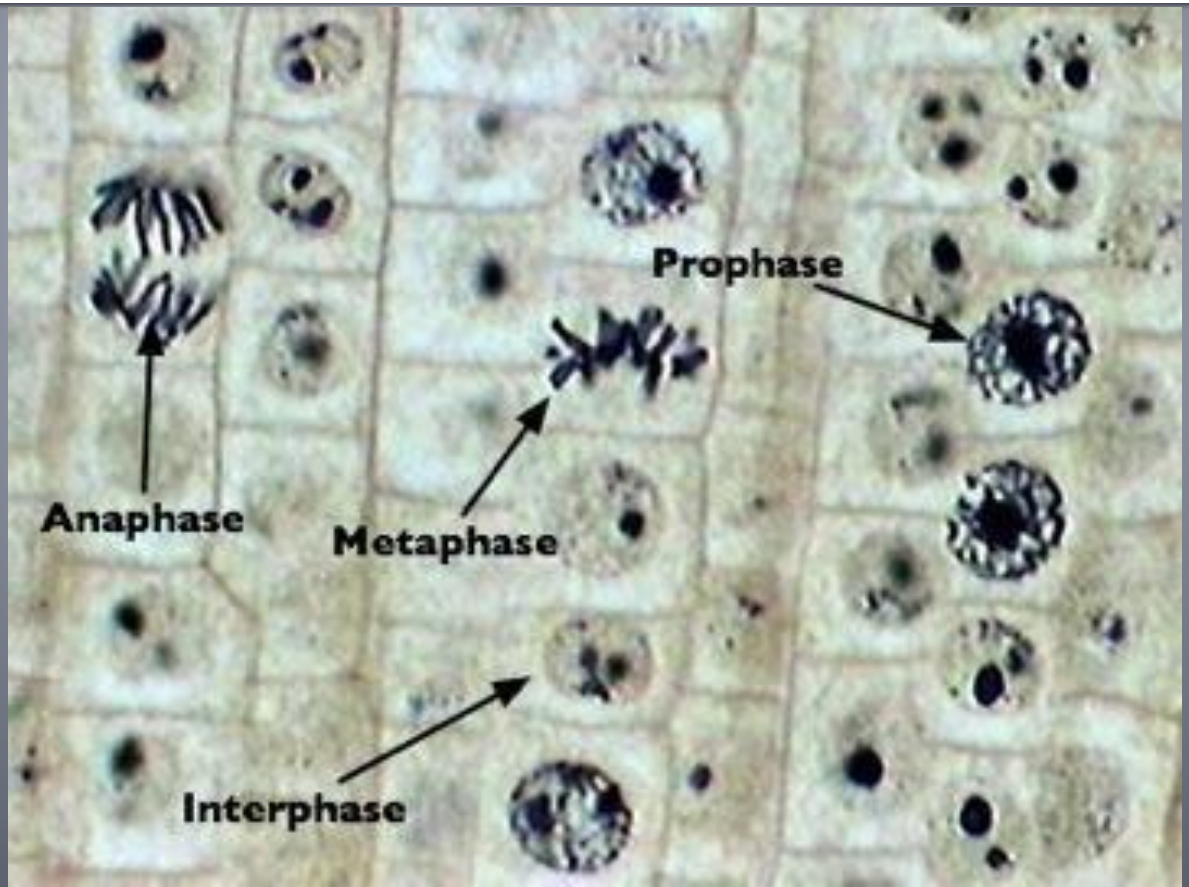
- Sometimes errors in the cell cycle can lead to cancer-
  - Errors can be genetic or due to an environmental toxin
- Internal regulation error followed by external; cells cannot “feel” their neighbors, and thus begin uncontrolled division
  - Lack density dependence (tumor) and anchorage dependence (metastasized cancer cells)





Mitosis

Stages of Asexual Cell Division

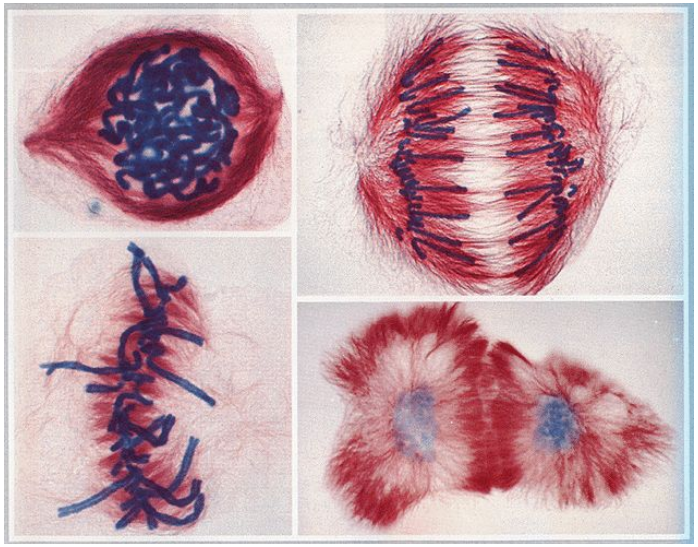


The Cell Cycle

- Recall that the cell cycle is made up of three main parts
  - Interphase (G1, S, and G2)
  - Mitosis
  - Cytokinesis
- ***Mitosis*** refers to the division of the cell
  - Asexual reproduction for unicellular eukaryotes
  - Occurs in response to the bodies need for growth and repair

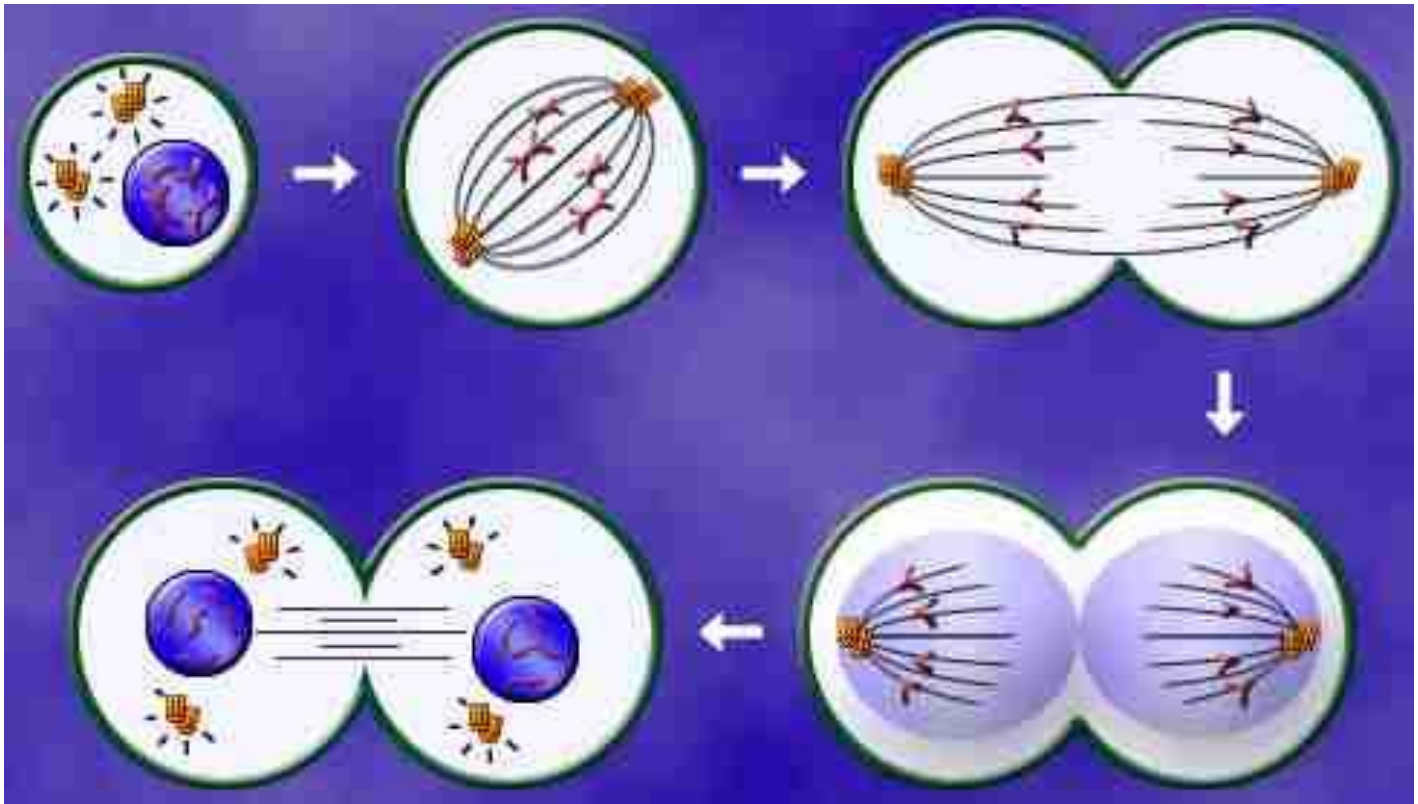
More About Mitosis

- Occurs in eukaryotes
- 1 cell divides to produce 2 daughter cells
- These cells are identical to the original cell→ same number of chromosomes!



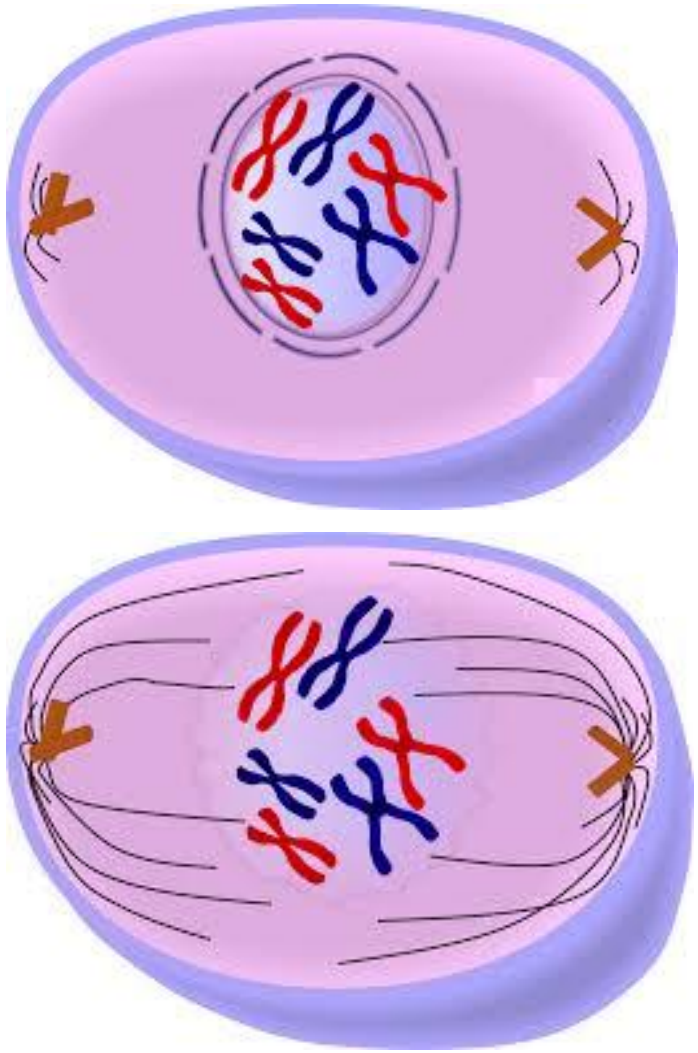
The Stages of Mitosis

- What happens when the cell leaves interphase and is ready to begin division…?



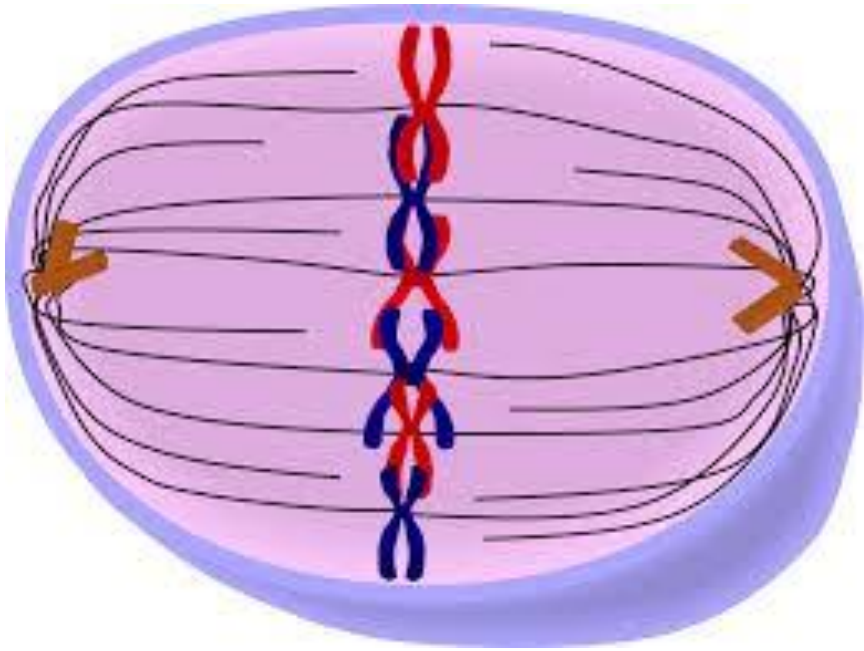
Stage 1: Prophase

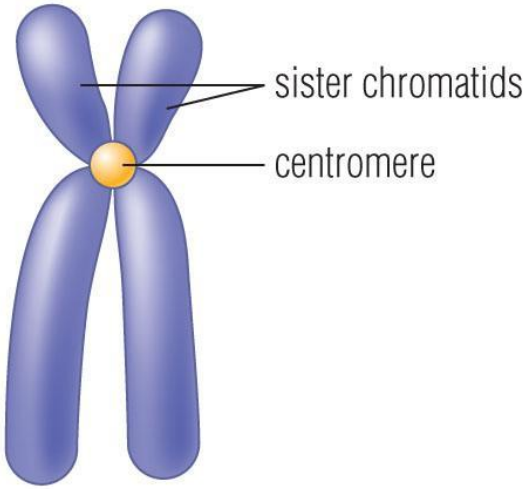
- What Happens?
  - Nuclear membrane dissolves
  - Chromatin condenses into chromosomes
    - Chromatin: uncondensed DNA (looks like spaghetti)
    - Chromosome: condensed DNA (looks like X's)
  - Centrioles move to opposite ends of the cell
  - Spindle forms and spindle fibers extend from one side to the other



Stage 2: Metaphase

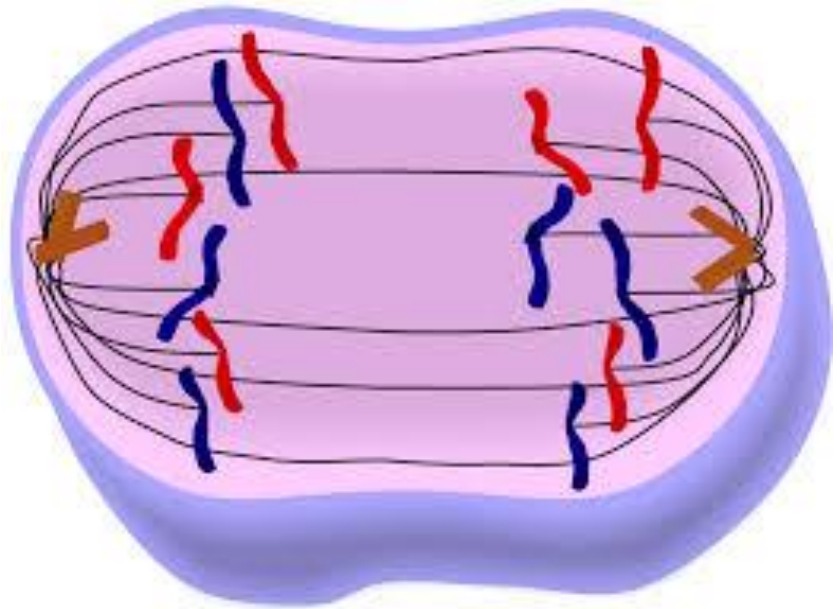
- What Happens?
  - Centromeres (middle of chromosome) attach to spindle fibers
  - Chromosomes are pulled to the middle of the cell





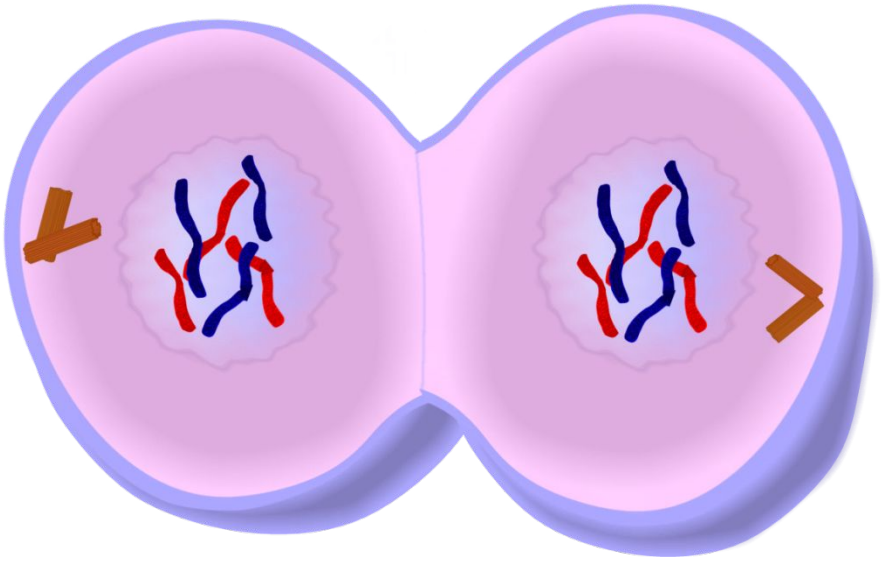
Stage 3: Anaphase

- What Happens?
  - Spindle fibers pull chromosomes apart
  - Each sister chromatid moves toward opposite end of the cell



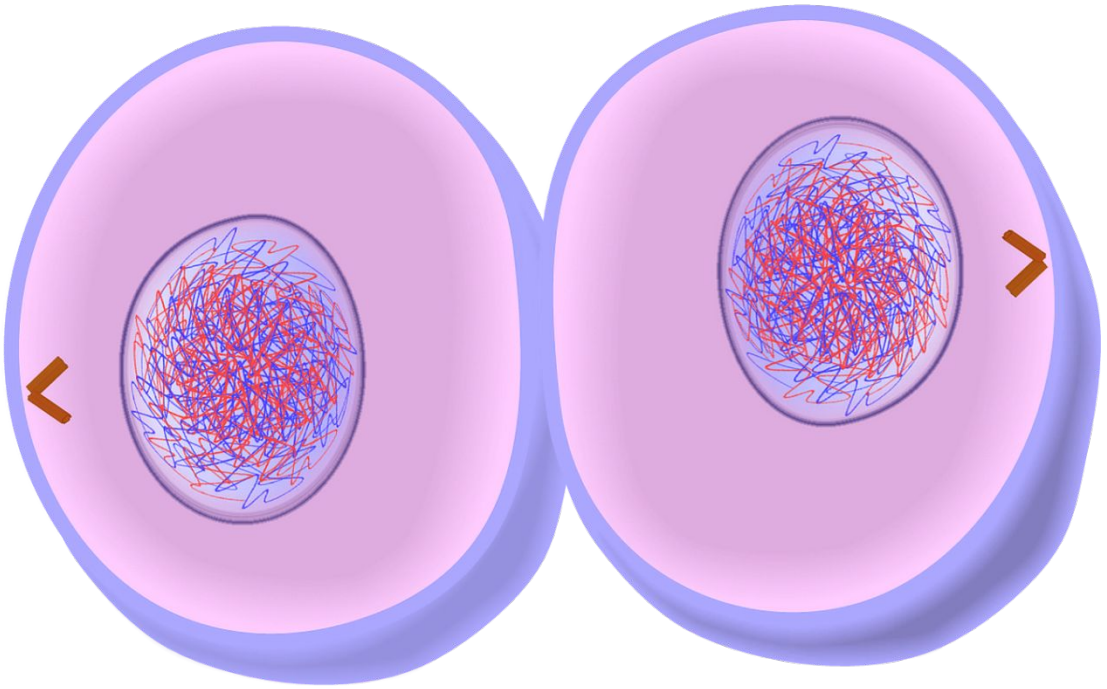
Stage 4: Telophase

- What Happens?
  - Nuclear membrane reforms
  - Spindle fibers disappear
  - Animal Cells:
    - Cell membrane pinches
  - Plant Cells:
    - New cell wall begins to form

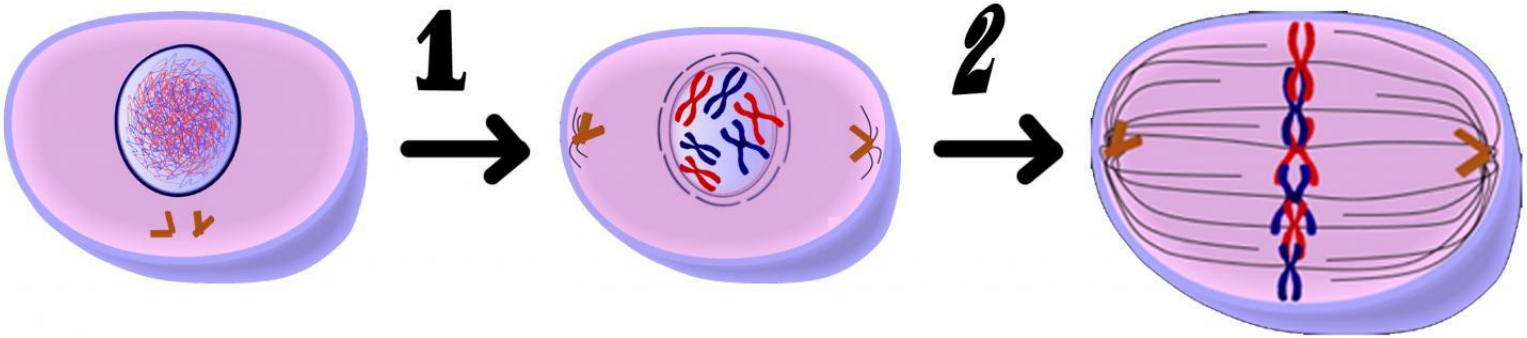


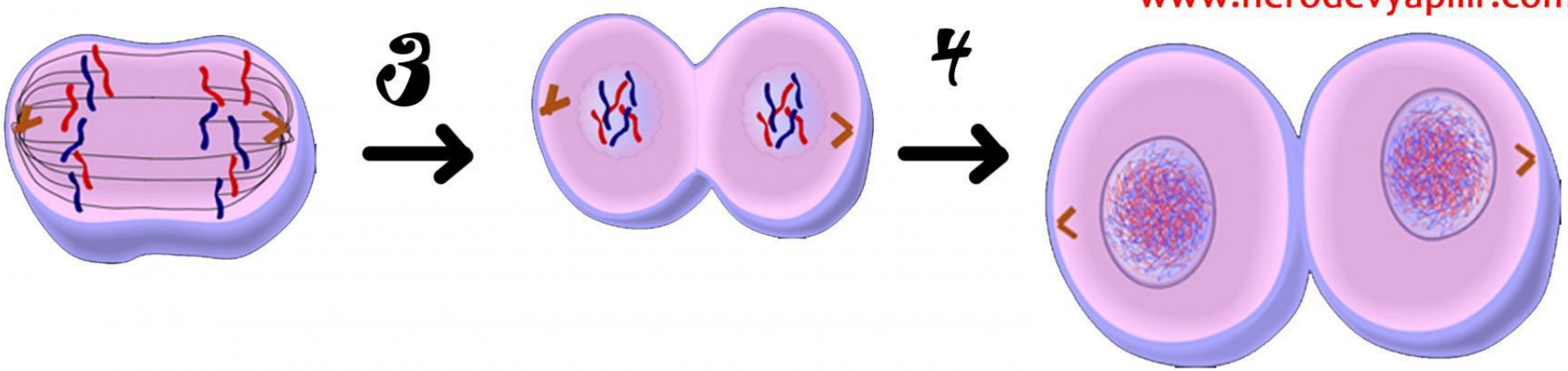
Cytokinesis

- What happens?
  - Division of the cytoplasm and organelles
  - 1 cell is now 2 identical cells!

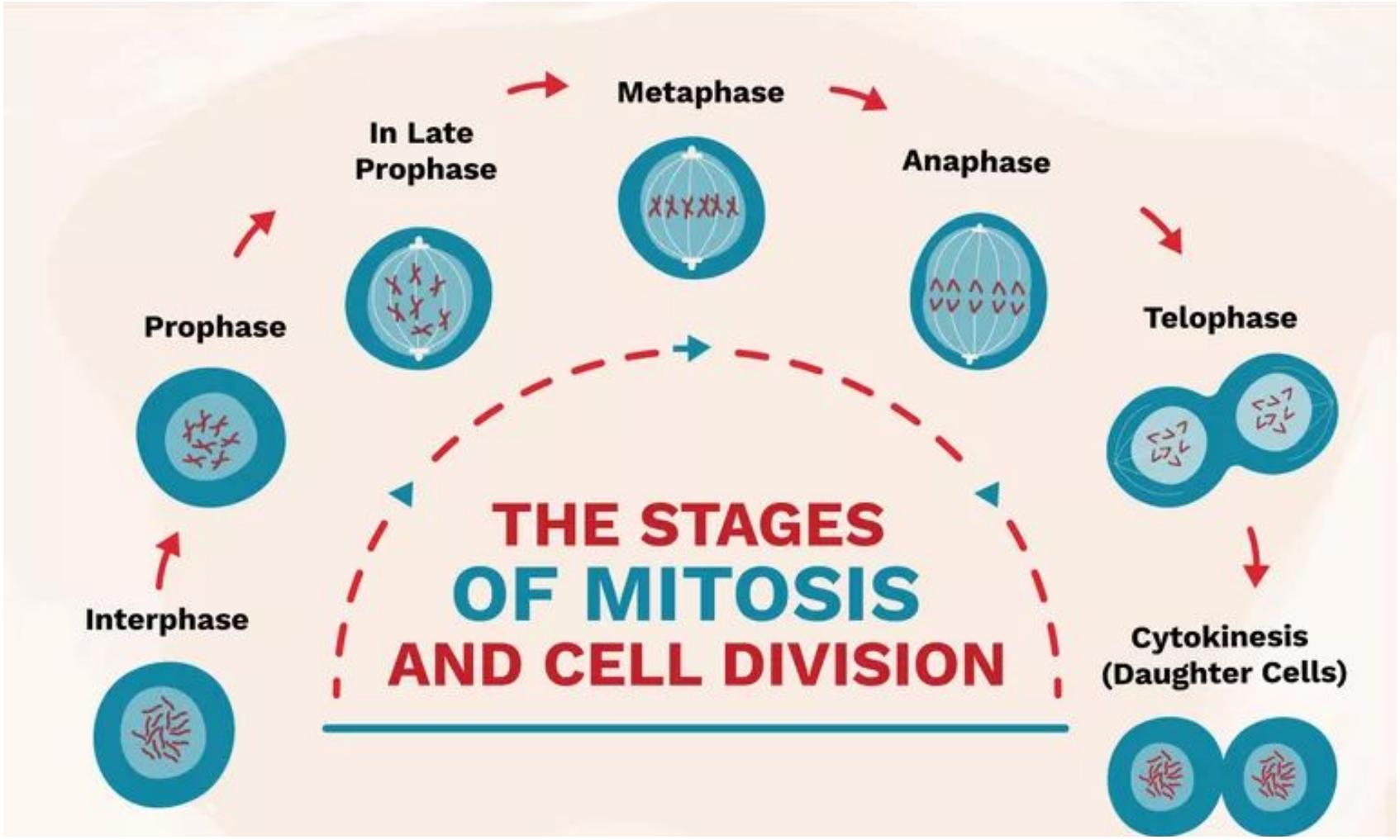


Stages of Mitosis

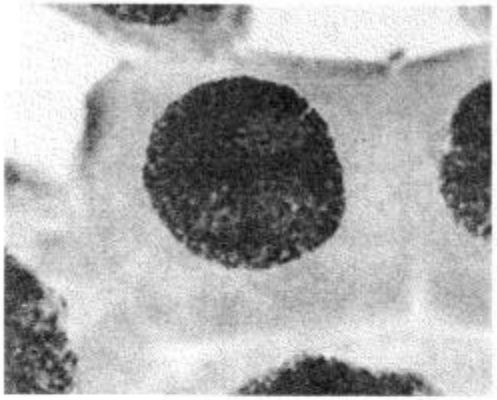




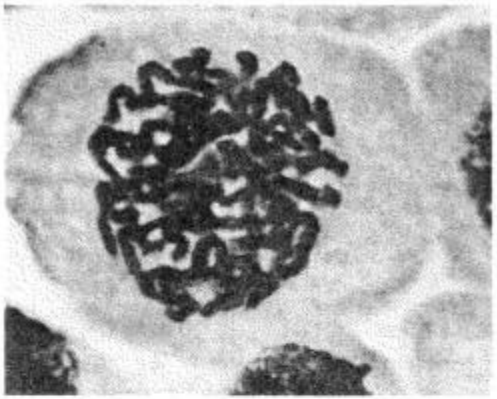
Stages of Mitosis



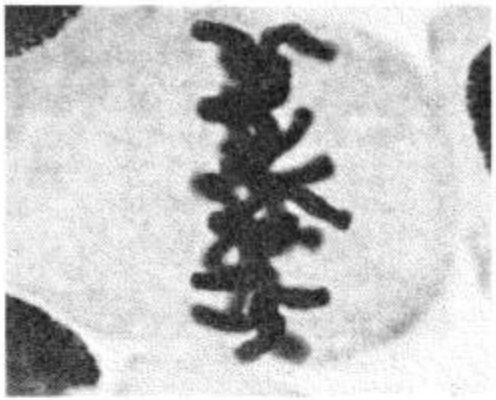
Stages of Mitosis



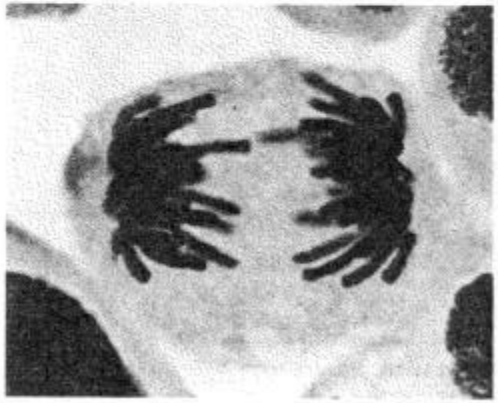
Interphase. DNA molecules of chromosomes (chromatin) replicating; chromosomes dispersed in nucleus as chromatin.



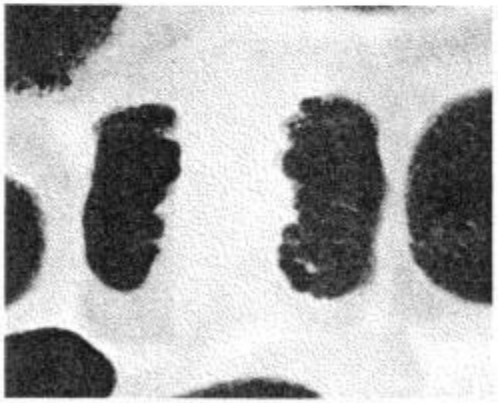
Prophase. Chromatin condenses into chromosomes.



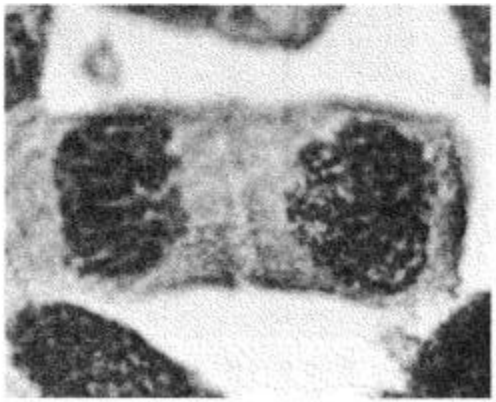
Metaphase. Chromosomes line up on equator of cell; centromeres attach to spindle fibers; longitudinal separation of chromatids (now chromosomes) occurs; chromatids remain joined at centromere.



Anaphase. Centromeres divide; each set of chromosomes moves towards the opposite end of the cell.



Telophase. Spindle fibers disappear; chromosomes become diffuse; nuclear membrane and nucleolus reappear; cytokinesis (cytoplasmic division) occurs.



Daughter Cells. Mitosis and cytokinesis complete; two new cells in interphase result.