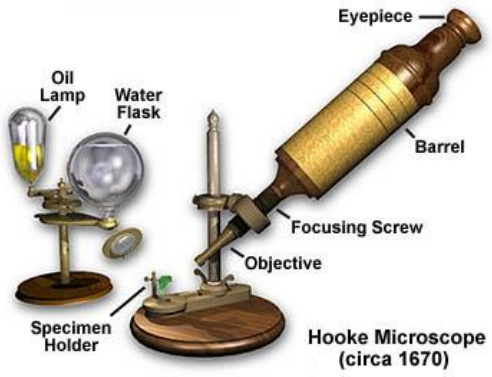
Cytology

Definition – the study of cells

History

1660	Leeuwenhoek - microscope
1665	Hooke - viewed cork cells
1831	Brown - nucleus
1838	Schleider & Schwan - cell theory
1846	Purkenje & Mohl - protoplasm
1888	Schneider - chromosomes
1898	Golgi - golgi bodies
1931	Knoll & Ruska - electron microscope



Cell Theory

Until the 1600's, scientists only saw living systems as whole units. Only after the microscope was invented did they see that all living organisms are composed of cells. Robert Hooke coined the term "cell" when he observed cork under a microscope. The little compartments he observed reminded him of the monk's cells in a monastery.

Schleider & Schwan

There are 3 main points in Cell Theory

1. Cells are the basic unit of **structure** in all living organisms.
   (All living things are made up of cells)
2. Cells are the basic unit of **function** in all living organisms.
   (Life occurs because of chemical reactions in cells – CELLS ARE ALIVE)
3. All cells come from pre-existing cells.

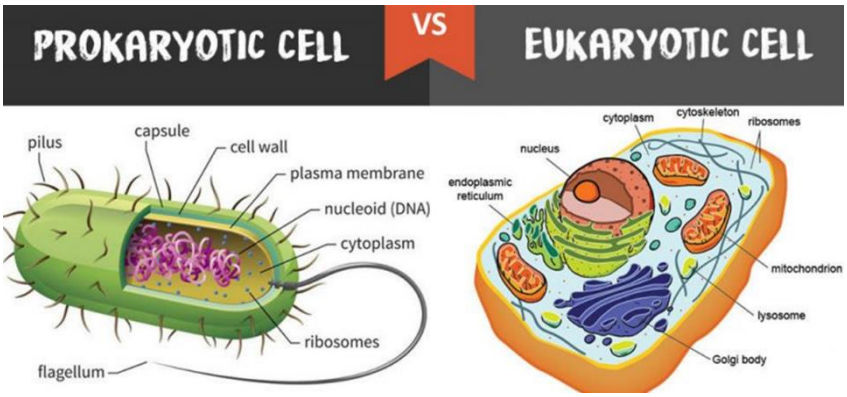
Cell Structure and Function

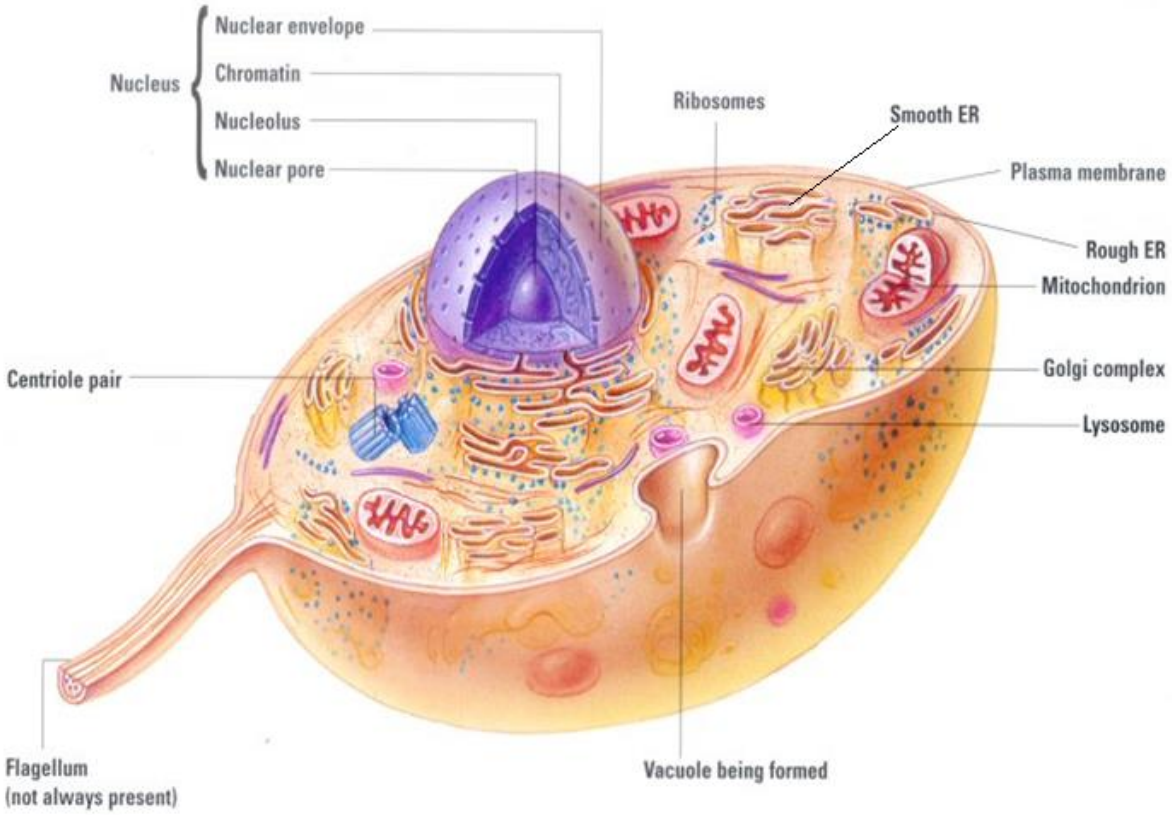
A living cell is like a miniature factory. There are many different parts that do many different jobs.

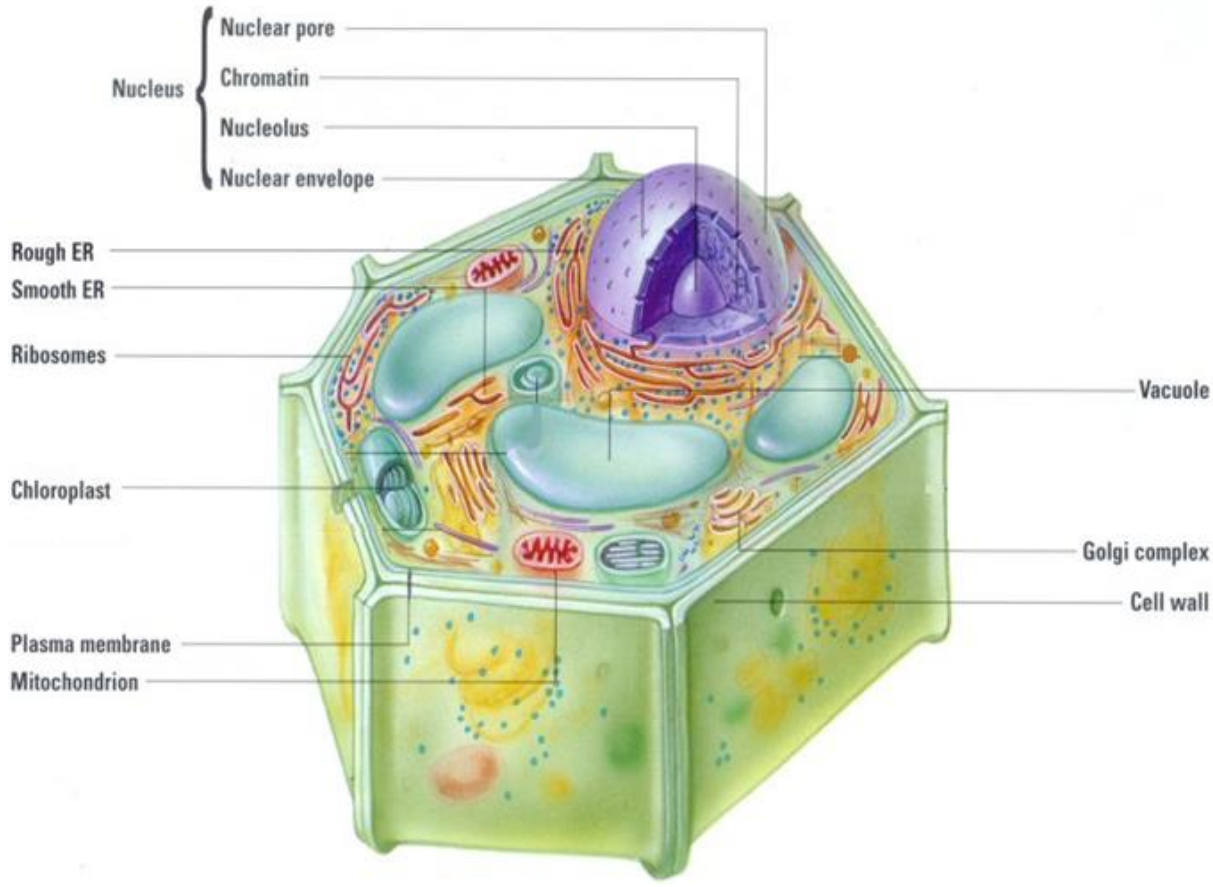
These small parts, or **organelles**, are for the most part very similar in all types of cells, but differences do occur

Scientists generally divide cells into 2 main groups.

1. **Eukaryotes** – contain a membrane bound nucleus e.g plant cells, animal cells
2. **Prokaryotes** – do not have a "true" nucleus e.g. bacteria




Nucleus
Nuclear envelope
Chromatin
Nucleolus
Nuclear pore
Ribosomes
Smooth ER
Plasma membrane
Rough ER
Mitochondrion
Centriole pair
Golgi complex
Lysosome
Flagellum
(not always present)
Vacuole being formed


Nucleus
Nuclear pore
Chromatin
Nucleolus
Nuclear envelope
Rough ER
Smooth ER
Ribosomes
Vacuole
Chloroplast
Golgi complex
Cell wall
Plasma membrane
Mitochondrion

Cell Organelle Functions .

1. Cell memebrane – controls movement of materials in and out of the cell.
2. Cell Wall – protects and supports plant cells. (plants only)
3. Chloroplast – responsible for photosynthesis. (plants only)
4. Cytoplasm – all material in the cell except the nucleus (main functioning area of cell)
5. Endoplasmic reticulum – responsible for the making and transporting of cell products
6. Golgi apparatus – storing, packing and transporting materials
7. Lysosome – contains enzymes for digesting food or cell parts (animal cells only)
8. Mitochondrion – energy conversion/power house of the cell
9. Nucleus – general control area of the cell
10. Nucleolus – makes ribosomes and helps with protein synthesis
11. Nuclear membrane – controls movement of materials in and out of the nucleus
12. Ribosomes – make protein
13. Vacuole – storage for food, water, waste etc. (large ones in plants only)
14. Centrosome – helps with cell division (animal cells only)
15. Chromatin (chromosomes) threadlike structures that contain all the information about the cell (DNA)
16. Flagellum – helps move the cell

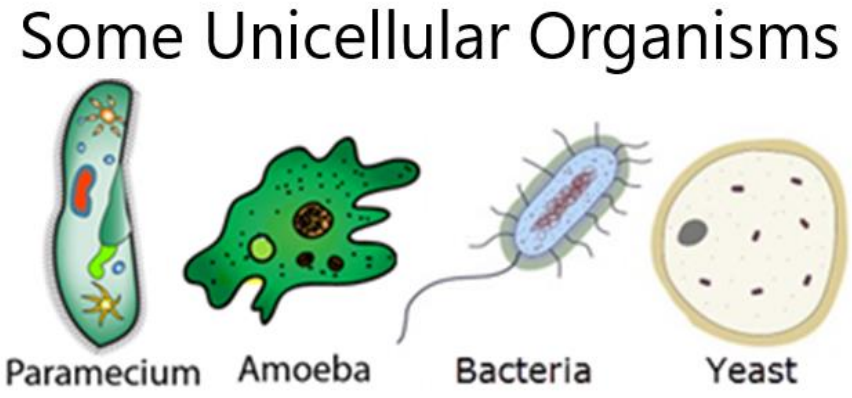
Diversity and Unity in Cells

All living organisms are variations on a basic cell structure. All cells and living organisms must:

a) absorb nutrients to survive and grow
b) convert nutrients to usable energy
c) be able to reproduce
d) eliminate wastes

Organisms may be

1) **unicellular organisms** (only one cell) – these cells must perform all the above functions
2) **multicellular organisms** (multiple cells) – these organisms often have specialized cells to carry out certain functions. These cells cooperate with each other to carry on life.

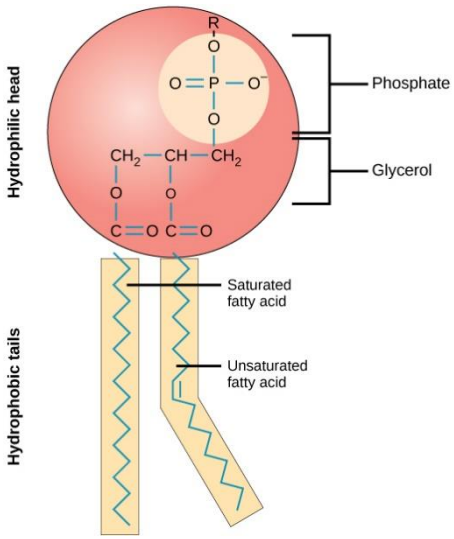


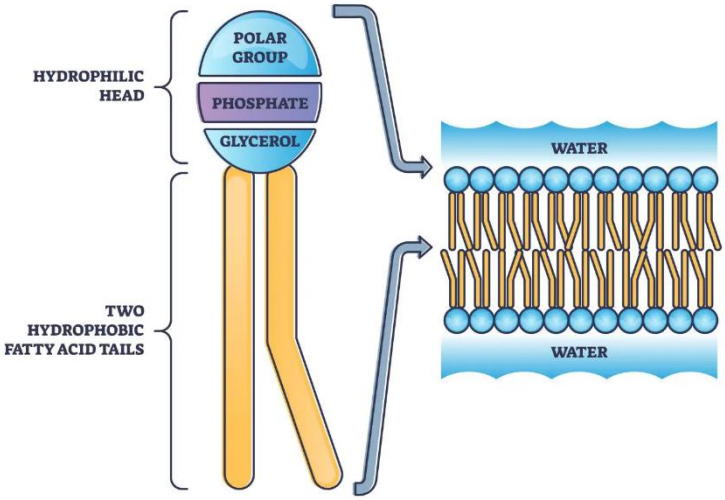
Cell Transport

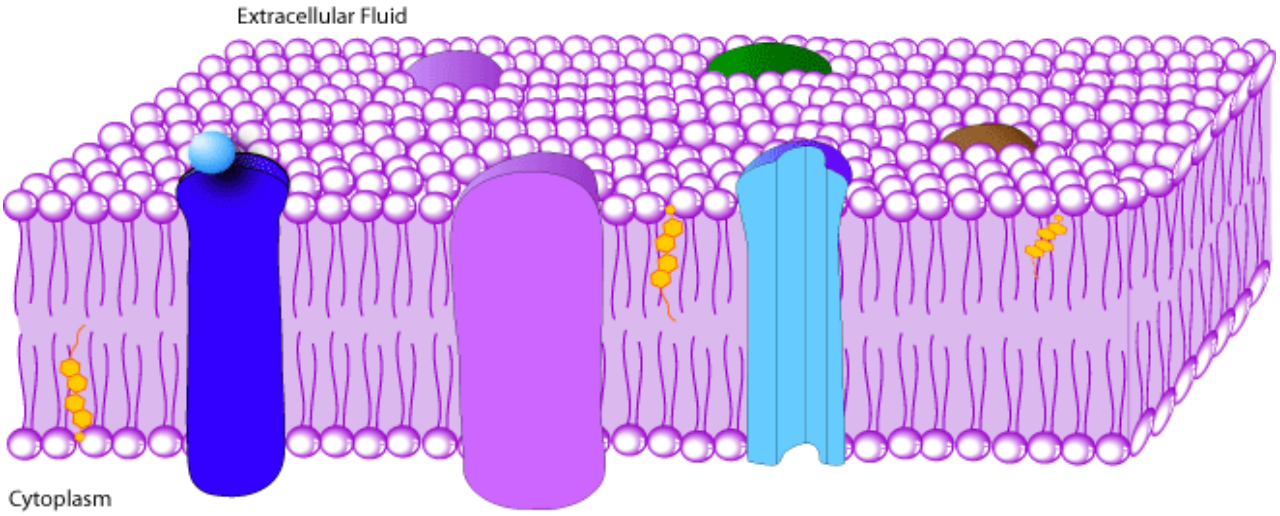
In order to survive, cells must move materials in and out of themselves. Movement of materials in and out of the cell can occur by a number of different methods.

Cell Membrane

Surrounds the cell. Comprised of **phospholipids**. The cell membrane is a bilipid layer (2 fat layers thick) and is described as a fluid mosaic surface. Fluid because it can bend and flex, mosaic because it contains many different bodies (proteins) embedded in it. Some particles are able to pass through the cell membrane and others are not. Because of this, we say the cell membrane is **semi-permeable**.



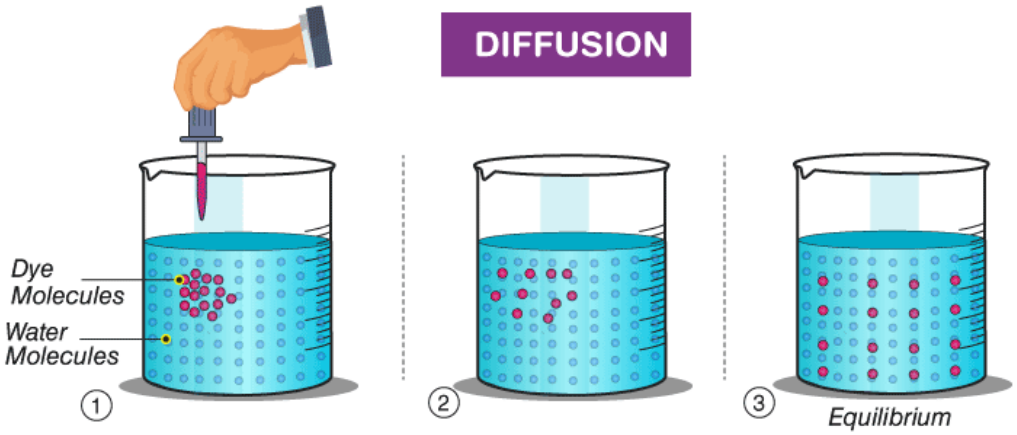


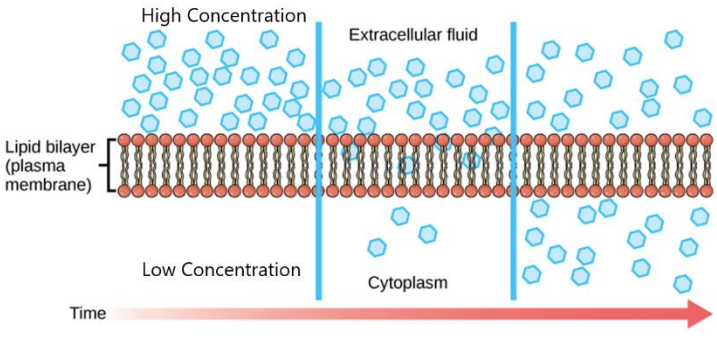


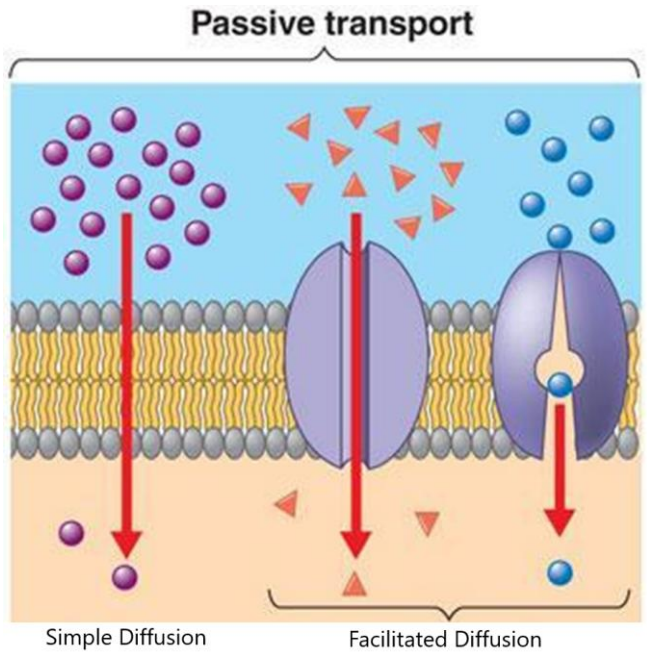
A. Passive Transport

The transport of molecules in and out of the cell **NOT requiring energy** from the cell. Particles are generally smaller and uncharged (neutral) and move from **high** to **low** concentration.

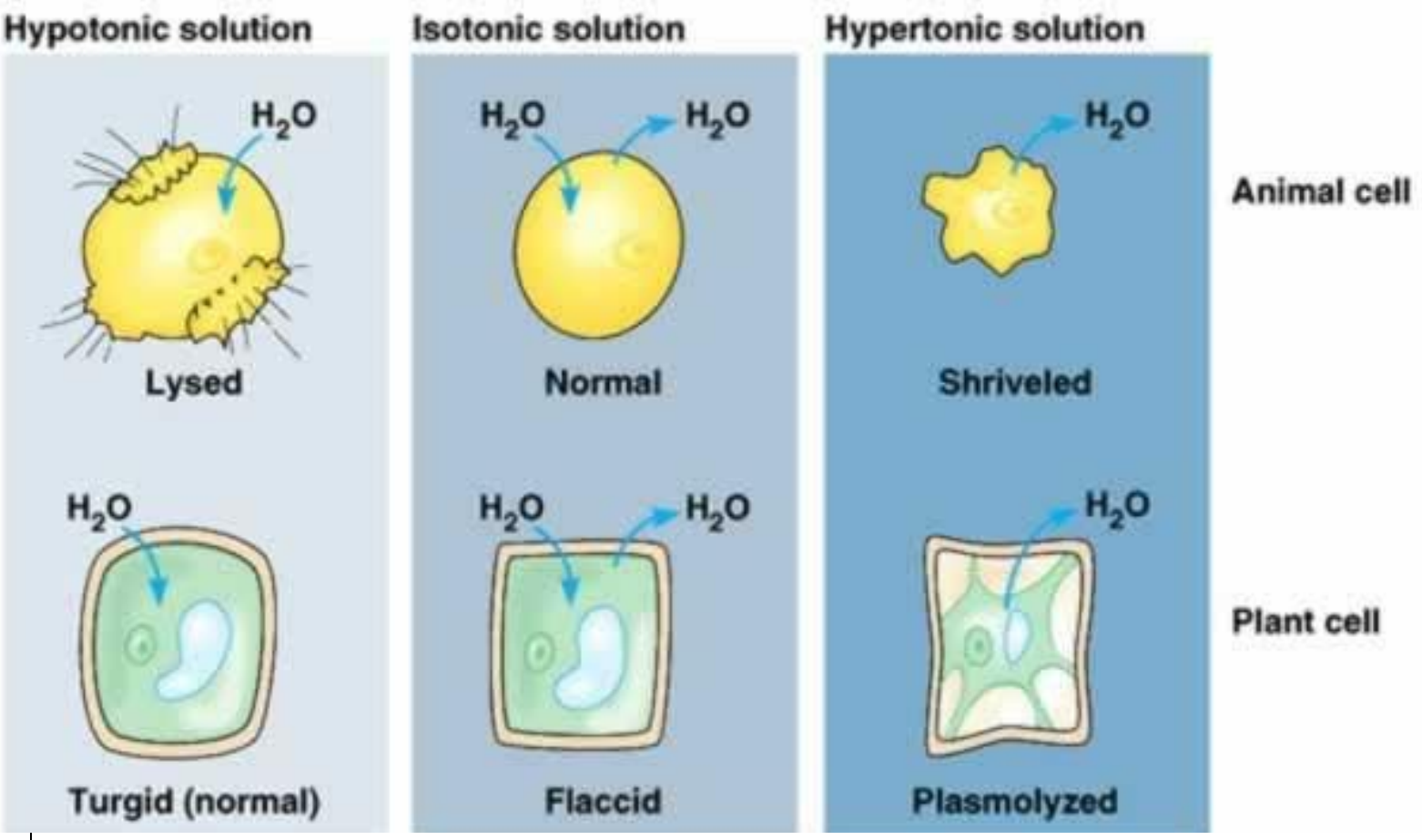
1. **Simple Diffusion** – the movement of materials from an area of higher concentration to an area of lower concentration (CO_2, O_2 can diffuse through cell membrane between the fat molecules or through a non-specific protein channel).
2. **Facilitated Diffusion** – particles that are too large to pass through the cell membrane are moved through a specific protein "carrier molecule" imbedded in the cell membrane.
3. **Osmosis** – the diffusion of **water** across the cell membrane. If some particles (often ions) cannot pass through the cell membrane, then water may pass in or out of the cell to balance the concentrations.







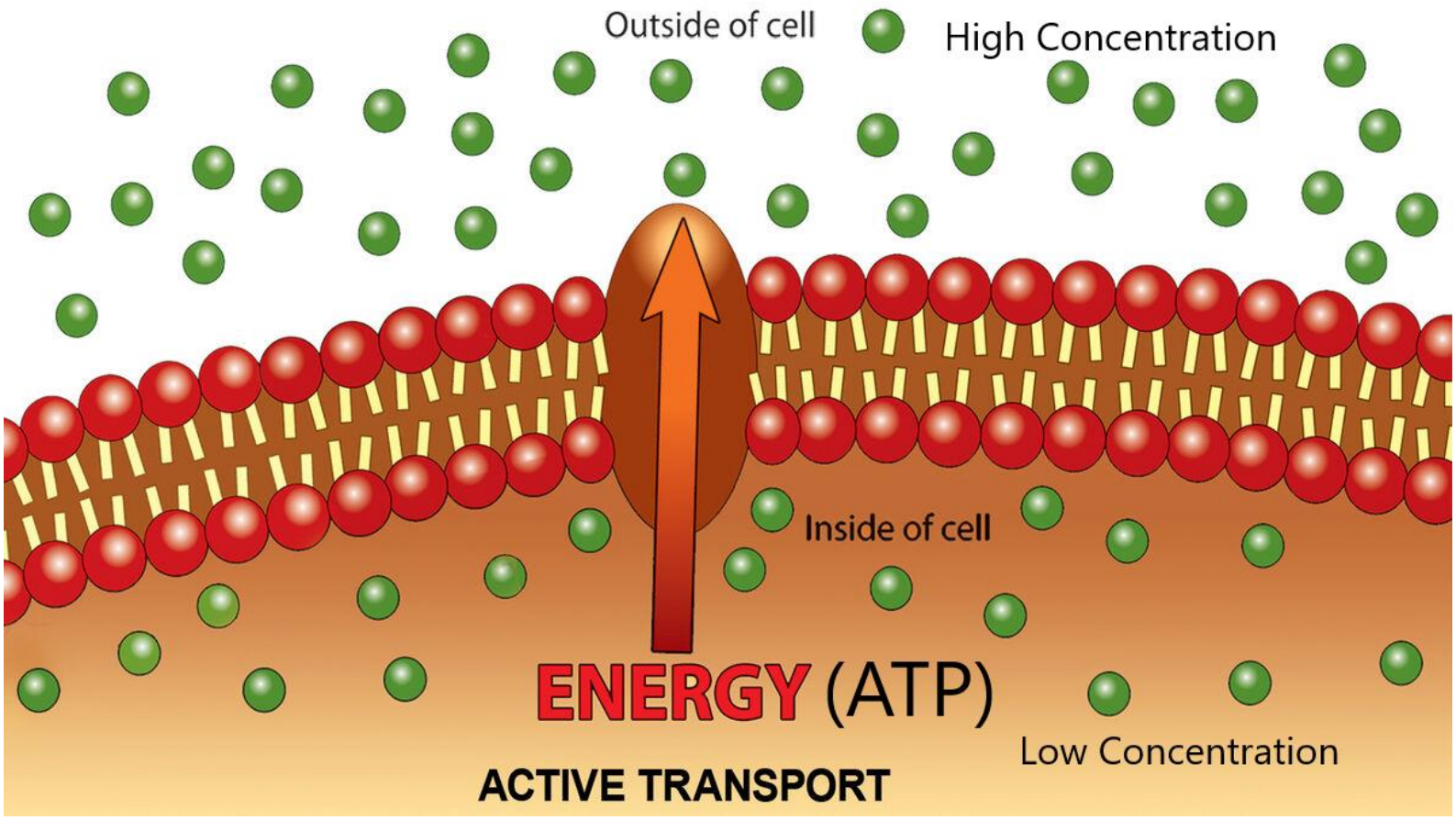
Tonicity refers to the concentration of ions (salt for example) inside a cell relative to the concentration of ions outside the cell in the surrounding solution. Three situations can exist.
1) Hypertonic - a cell is placed in a salt solution stronger in concentration than itself.
2) Hypotonic - a cell is placed in a salt solution weaker in concentration than itself.
3) Isotonic - a cell is placed in a salt solution equal in concentration to itself.



<u>Plasmolysis</u> – when a plant cells vacuole and cytoplasm shrivel up when the cell is immersed in a hypertonic solution (see diagram above).

B. Active Transport

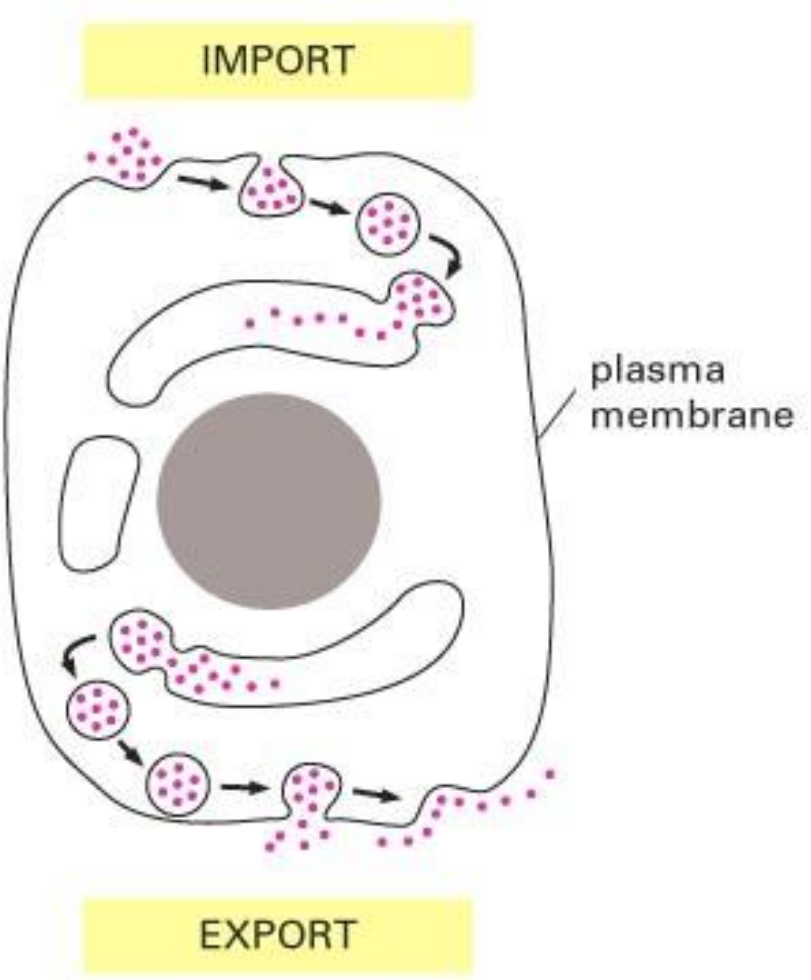
The transport of molecules in and out of the cell **requiring energy** from the cell. This usually occurs when moving particles from an area of **low concentration** to an area of **higher concentration**. Larger charged particles (ions) are moved. In this case a transport protein spins or changes shape and transports substances across the membrane.

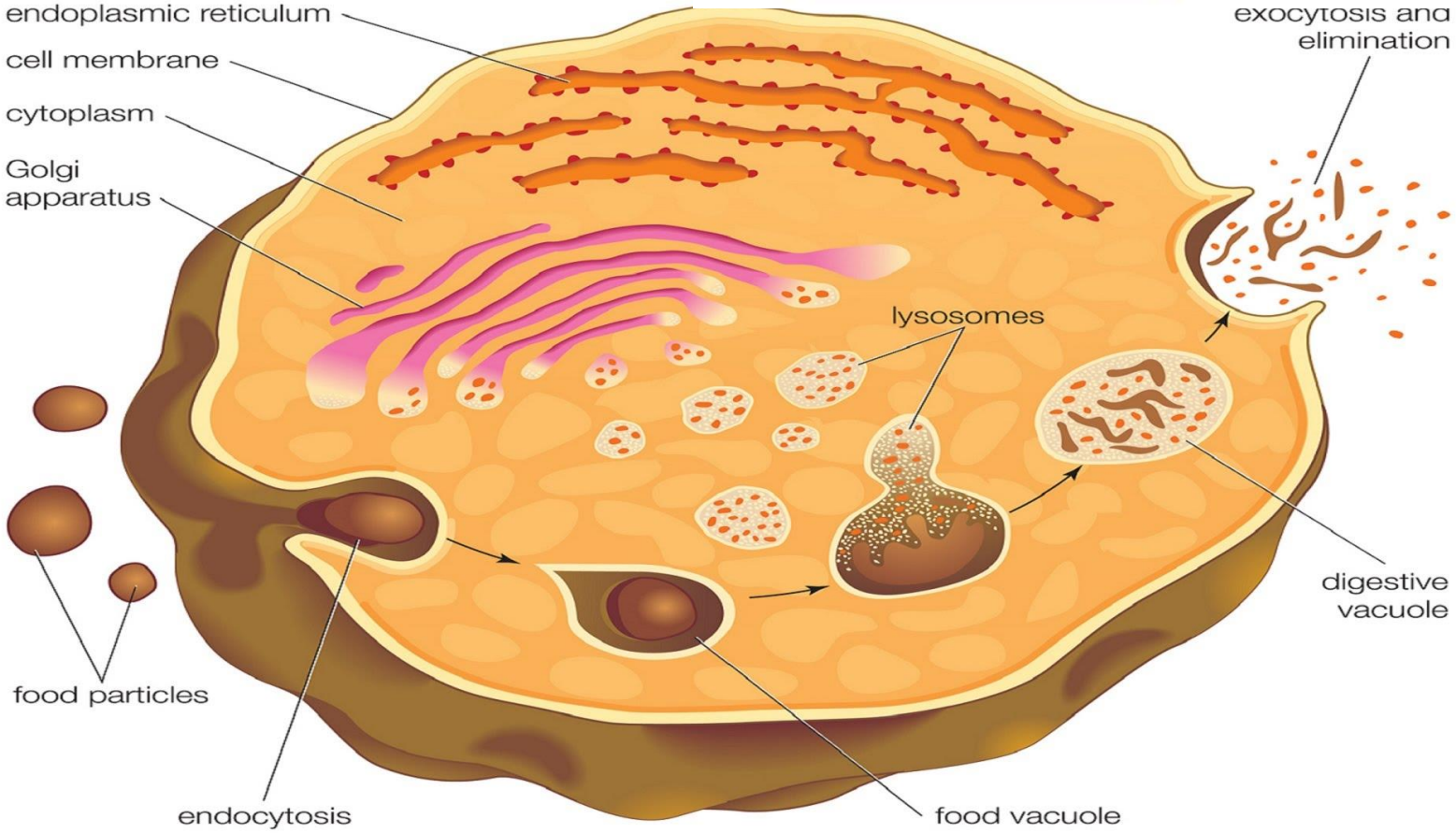


Endocytosis.
The movement of large amounts of materials into a cell (usually nutrients) by the membrane wrapping around the material and "pinching off".
Pinocytosis – tiny chunks (drinking)
Phagocytosis – larger chunks

Exocytosis
The movement of large amounts of materials (usually wastes) out of the cell by a vacuole moving to the cell membrane. (Opposite of endocytosis)

Cyclosis
Also known as **cytoplasmic streaming**, cyclosis is the passive movement of the cytoplasm and its contents (various organelles) around in the cell. Cyclosis aids with diffusion of particles within the cell.





Cell Cycle

The life cycle of a cell is often represented by a circular diagram. See below.
It is important to note, that in order for a cell to compete the cycle and divide into two cells, first the DNA must be copied.
Also note, not every cell completes the cell cycle. In fact, most cells in your body differentiate and become one of the 210 different cell types in your body (skin cell, muscle cell etc). Once the cell differentiates, it can no longer divide. It remains in a functional phase of Interphase often referred to as G_0. Only special cells called stem cells complete the cell cycle and divide to replace the old worn-out cells.

There are 2 main stages to the cells cycle.

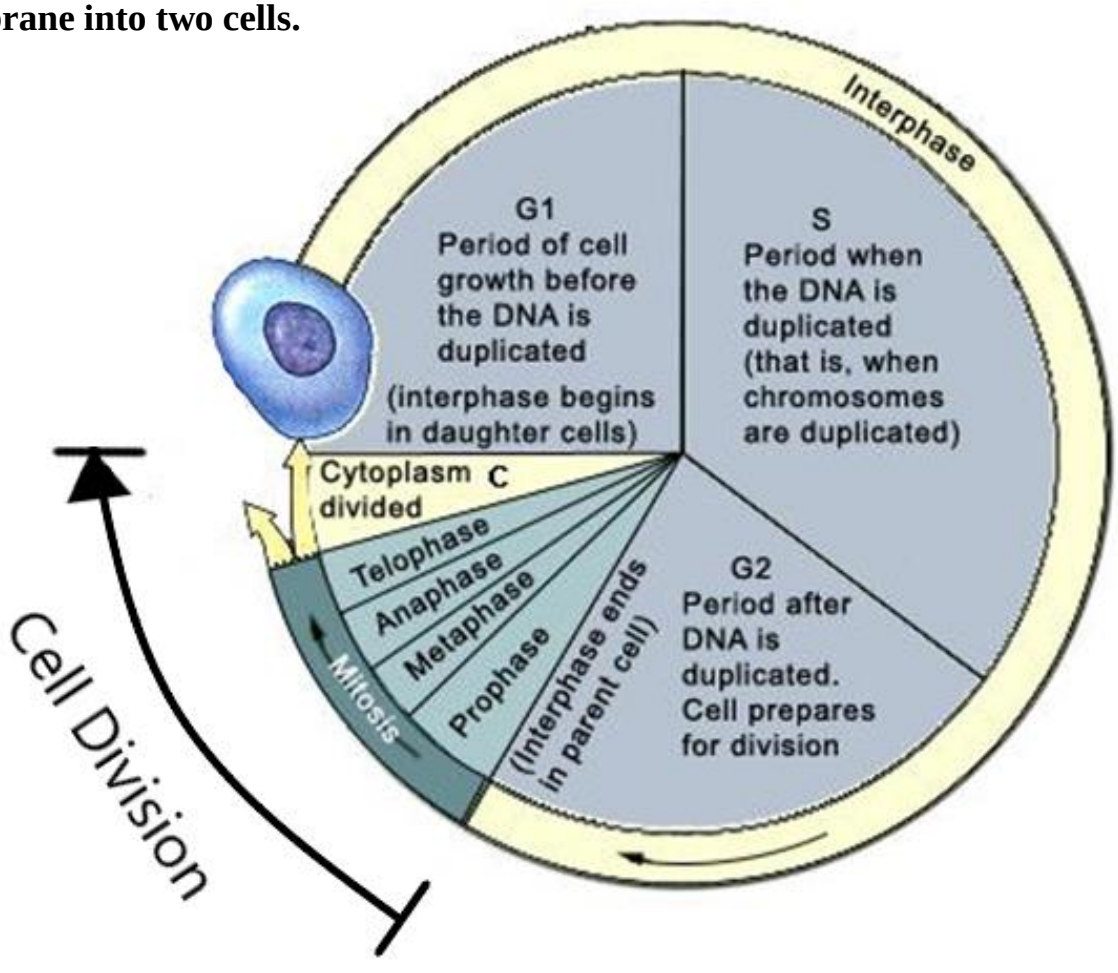
1. **Interphase**
2. **Cell Division**

Interphase is subdivided into 3 stages.

1. G_1 – cell growth
2. S – DNA is replicated
3. G_2 – cell grows again and prepares for cell division

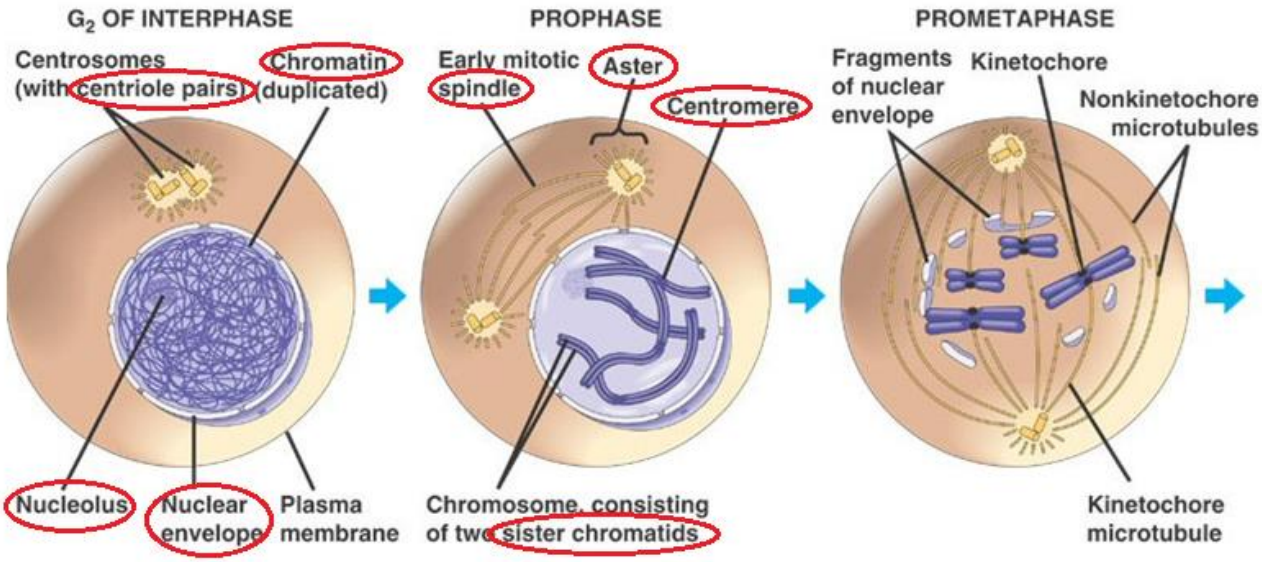
Cell Division is subdivided into 2 stages.

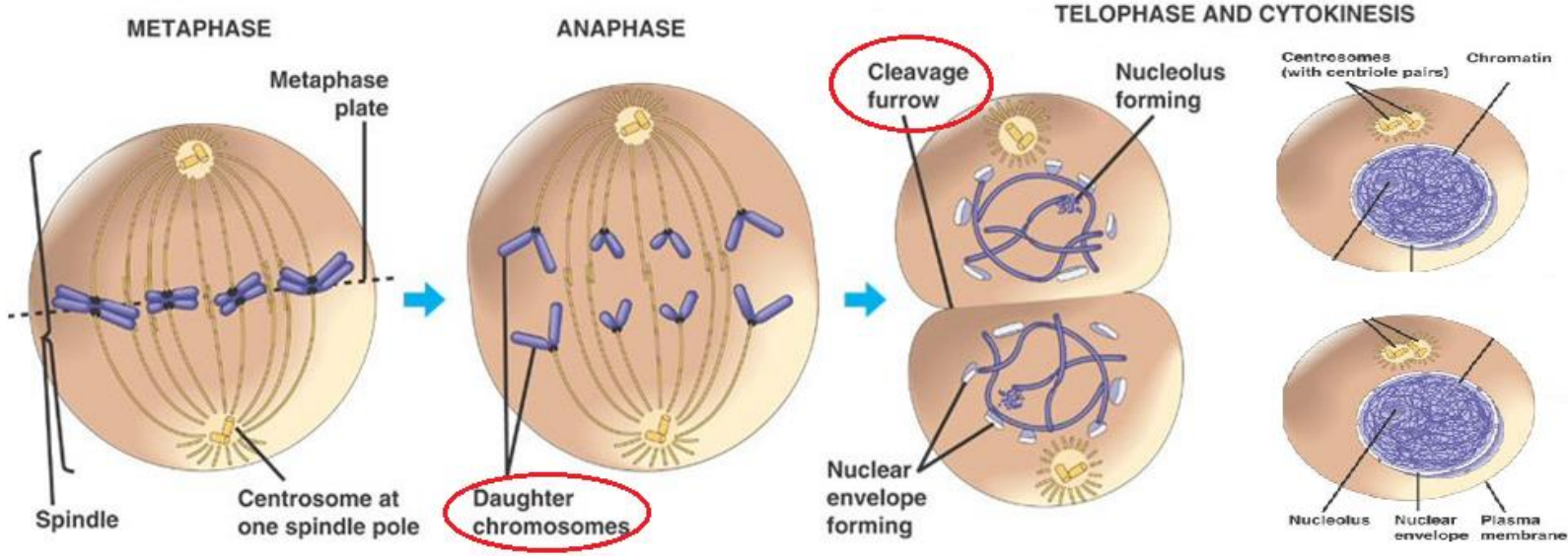
1. Mitosis (which is nuclear division)
2. Cytokinesis (which is the actual division of the cytoplasm and pinching of the cell membrane into two cells.



Cell Division (I P P M A T C)

Interphase – the stage before cell division where chromatin (DNA) replicate.
Prophase – the first stage of mitosis – chromatin condense into chromosomes.
Prometaphase - the nuclear membrane breaks down and the spindle fibers attach to the chromosomes.
Metaphase – (M=meta M=middle) chromosomes align along the **middle** of the cell (equatorial plate).
Anaphase – (A=ana A=apart) sister chromatids separate and are pulled **apart** to opposite poles.
Telophase – (T=telo T=two new nuclei) chromosomes reach the poles and **two new nuclei** form. Mitosis is now complete.
Cytokinesis – the cytoplasm and its contents (organelles) are divided in half as the cell membrane pinches together (cleavage furrowing) resulting in two cells.





Cancer

Normal cells in the body follow an orderly path of cell growth, division, and death. Cancer is a class of diseases characterized by out-of-control cell division. There are over 100 different types of cancer, and each is classified by the type of cell that is initially affected.

Cancer occurs when cells divide uncontrollably to form lumps or masses of tissue called tumors. Unlike regular cells, cancer cells do not experience programed cell death (apoptosis) and instead continue to grow and divide.

Malignant tumors grow rapidly and interfere with normal cell function in the region in which they grow and are thus referred to as cancerous.

Benign tumors stay in one spot and demonstrate limited growth, are generally considered to be less harmful and are thus not referred to as cancerous.

When a malignant tumor spreads to other parts of the body, invading and destroying other healthy tissues, it is said to have metastasized.

Physicians and researchers who specialize in the study, diagnosis, treatment, and prevention of cancer are called oncologists.

There are many different causes of cancer. Some forms of cancer are caused by damage or mutations to the DNA, particularly to the genes involved in regulating cell division. Four key types of genes are responsible for regulating cell division:

1. **Oncogenes** - tell cells when to start dividing “ON SWITCH”.
2. **Tumor Suppressor Genes** - tell cells when to stop dividing “OFF SWITCH”.
3. **Apoptosis Genes** - programed cell death to remove unwanted or damaged cells.
4. **DNA Repair and Proofreading Genes** - repair damage and errors in DNA.