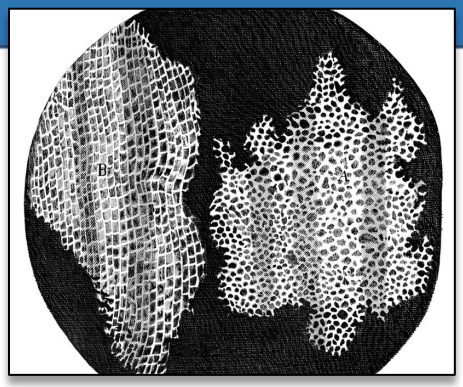
Introduction to Cells

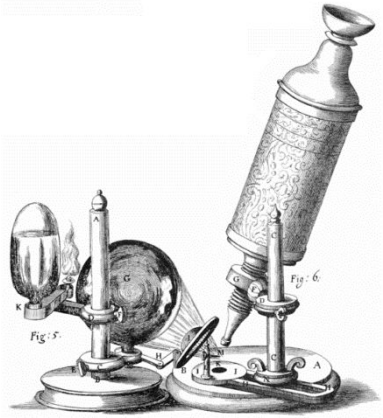
Cell Structure & Function

What is a cell?

Robert Hooke's "cells"



- Cells are the basic **units** that make up every **living thing.**
- Scientist **Robert Hooke** first named "cells" because when he looked at cork under one of the first compound microscopes, the little boxes reminded him of monastery cells/rooms.
- The **study of cells is called cytology**.



Hooke's microscope. A compound microscope uses more than one lens to increase magnification.

What is the cell theory?

- After Hooke's discovery, two German scientists built upon it.

- Botanist Matthias Schleiden determined that all plants were made of cells.

- Biologist Theodor Schwann determined all animals were made of cells.

- A few years later, two Polish physicians carried the study of cells even further.

- Robert Remak studied the development of chicken embryos and tadpoles.

- Rudolf Virchow published Remak's work as his own and concluded that all cells come from the division of other cells.

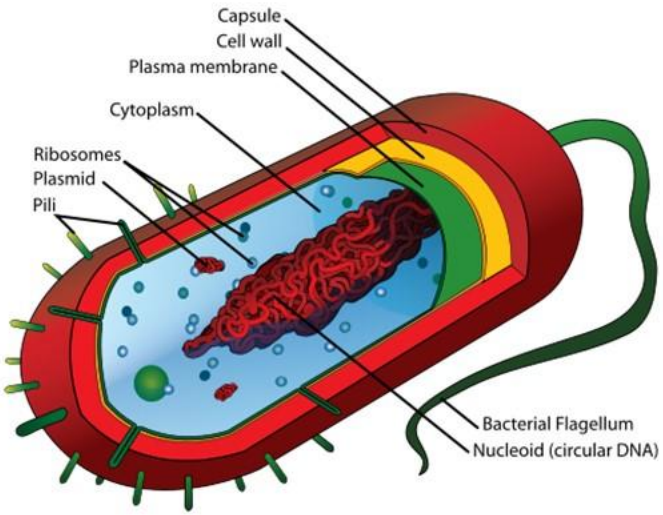
- These observations led to the formation of 3 major principles, now called the cell theory:
  - **The cell is the basic unit of all living things.**
  - **Cells perform all the functions of living things.**
  - **Cells come from the reproduction of existing cells.**

How do prokaryotic & eukaryotic cells differ?

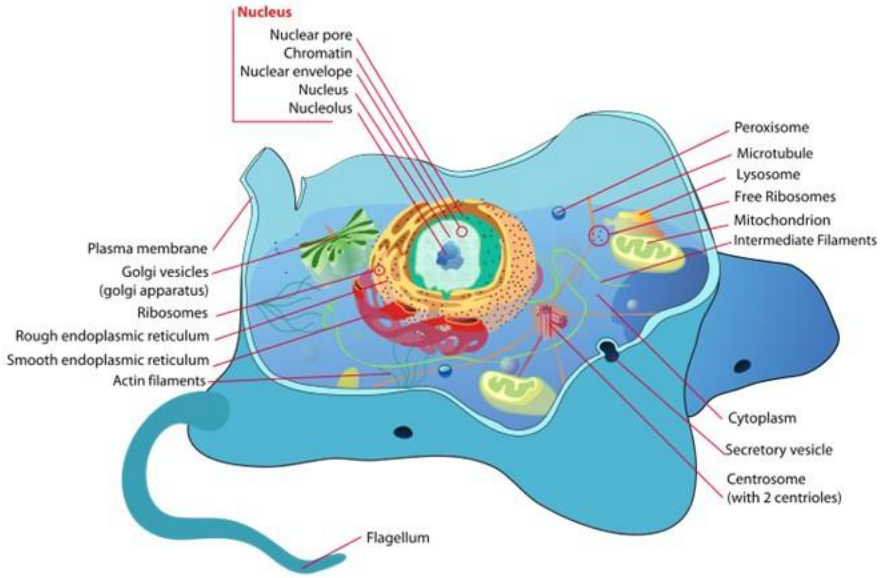
- All cells have **DNA**, which carries their **genetic code**, and a **cell membrane**, which acts as a **barrier** between the cell and its environment.

- This is a microscopic amoeba. It has a very flexible cell membrane that allows it to extend in many directions.

- There are 2 major types of cells:
  - Eukaryotic cells have **organelles** bound by membranes. Each organelle performs a specific **function** in the cell.
  - Prokaryotic cells do not have membrane-bound **organelles**.
    - Plant and animal cells are examples of eukaryotic cells, while bacteria are prokaryotic.
  - The DNA of **prokaryotic** cells is circular and loosely packed, while eukaryotic cells have **DNA** tightly packed into a **nucleus** to protect it.



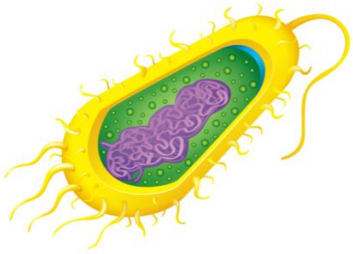
Prokaryotic cell



Eukaryotic cell

Cell Theory

– **Two types**:



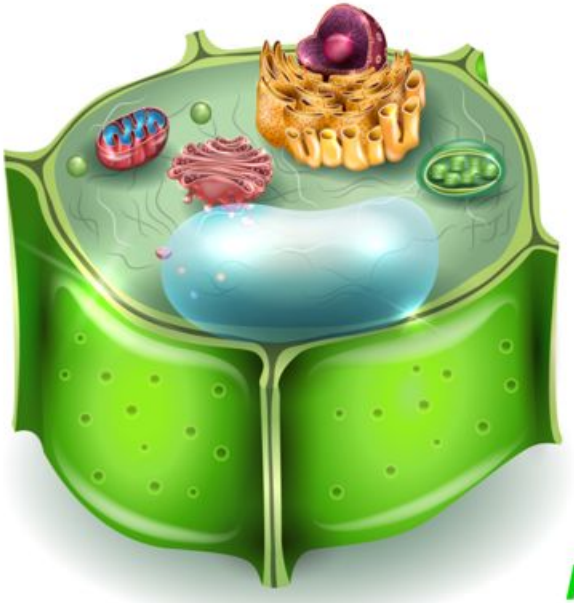
	Prokaryotic	Eukaryotic
Nucleus?	no	yes
Membrane-bound organelles?	no	yes
Division?	binary fission	mitosis
Size of organisms?	unicellular	uni- or multicellular
Cell walls?	Yes, made of peptidoglycan	Only fungi and plants, made of chitin or cellulose
Ex. of organisms with this type of cell?	bacteria	animals, plants, fungi, protists

Organelles

- *All cells have these four structures, but **eukaryotic cells** also have membrane-bound organelles.*
- **Organelles** = specialized structures within the cell that work together to help the cell function
  - *Think of them as "mini organs" within the cell working together for one main purpose → TO MAKE PROTEINS!*

Animal cell

Remember, eukaryotes include animals, plants, protists, and fungi, but we will focus mainly on plants and animals



Plant cell

Cell Organelle

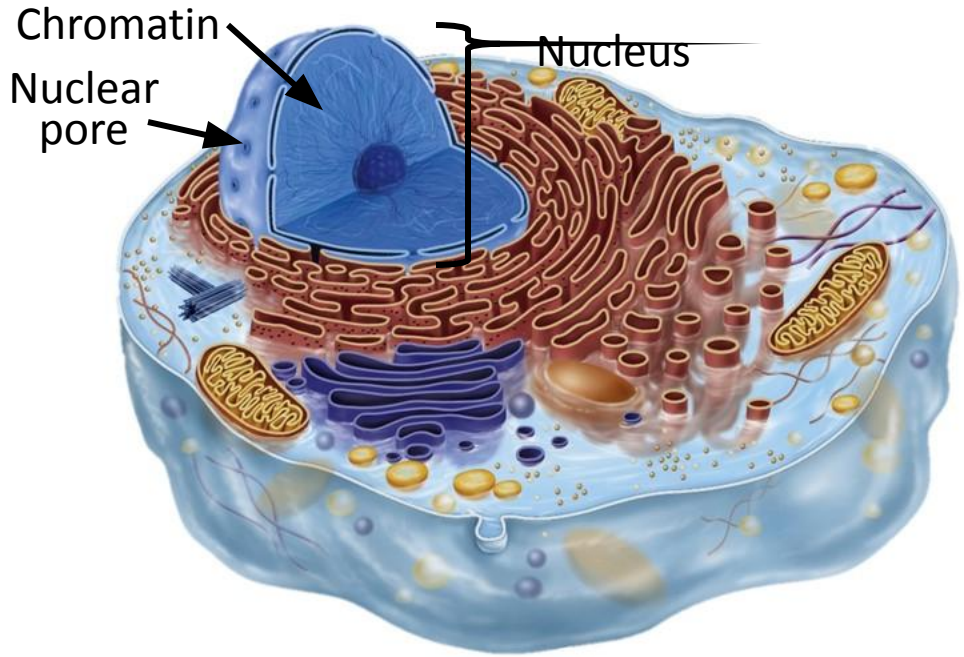
Stations Activity

after – complete pg 9 & 10

summary

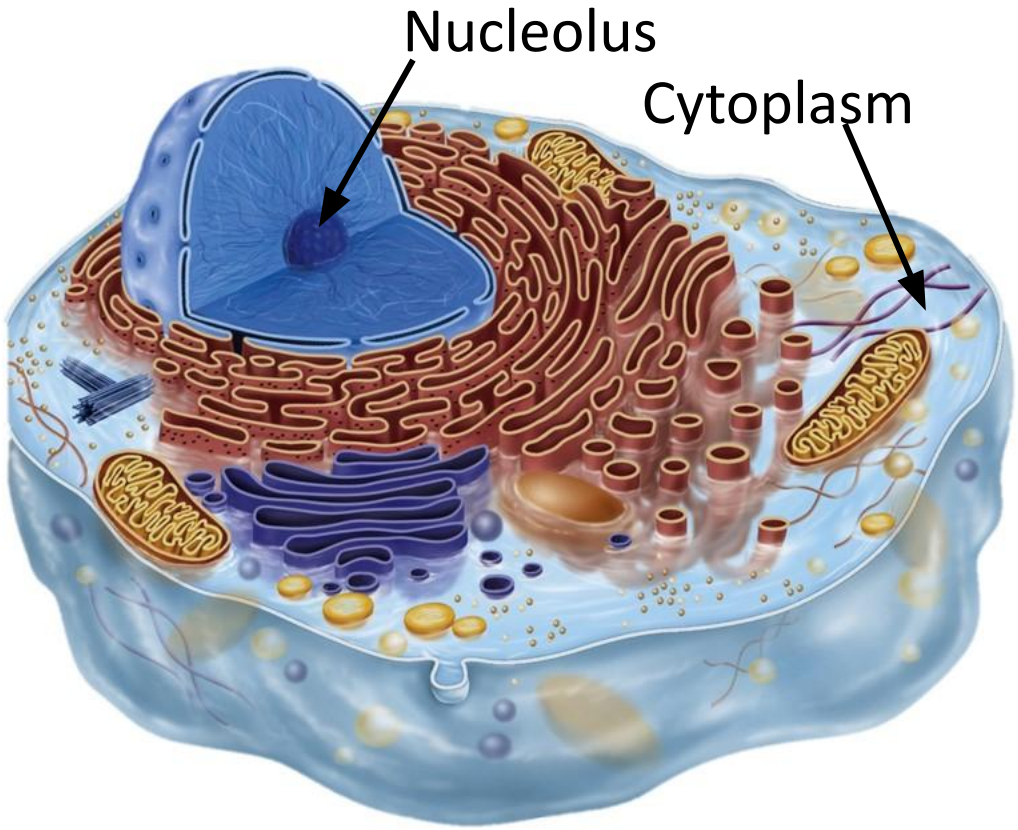
How does a cell store its genetic information?

- Most of the **DNA** of eukaryotic cells is **housed** in the nucleus.
- Unless the cell is **dividing**, the DNA is wound around **proteins** in long strings called **chromatin**.



- The nucleus is surrounded by a **nuclear envelope** with small **pores** to let materials in and out.

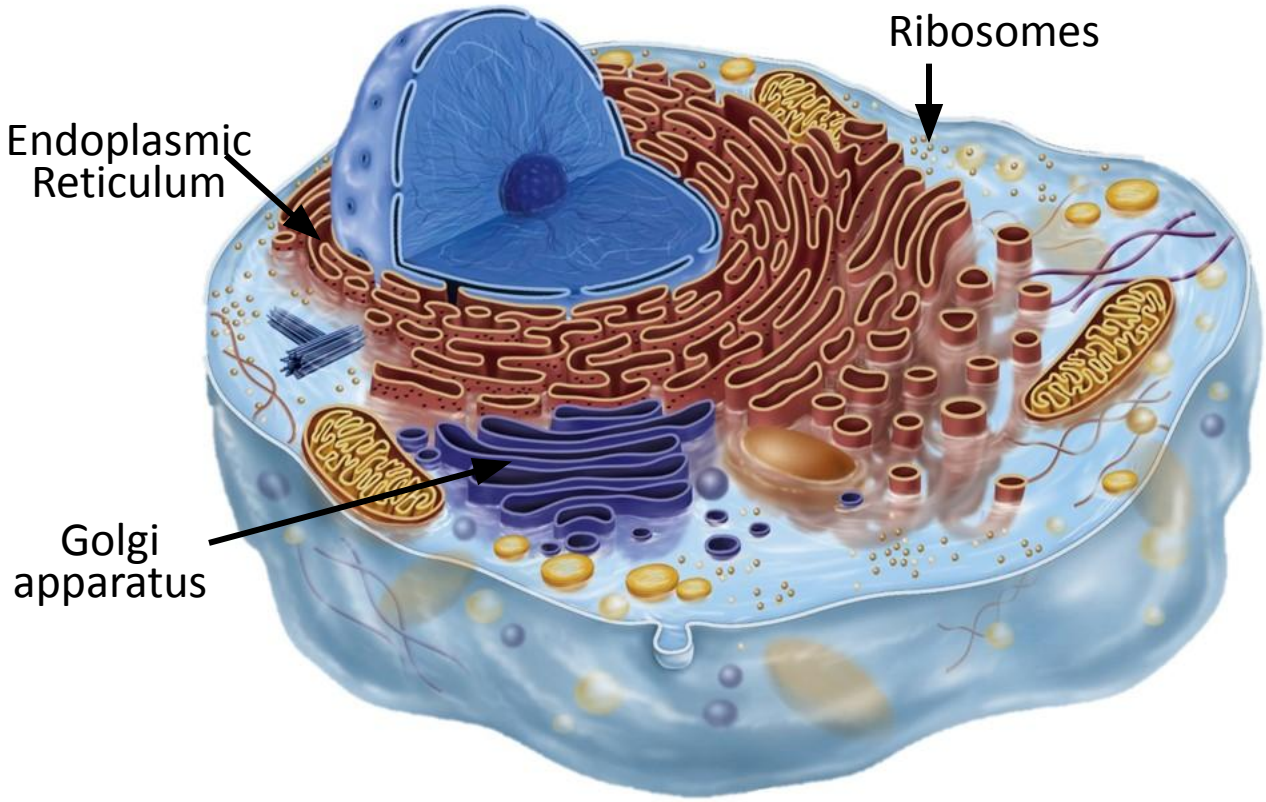
- The **nucleolus** is a smaller, dense portion of the nucleus that **manufactures ribosomes**.



- The **empty space** in the cell is filled with a jelly-like substance called **cytoplasm**.
- Both prokaryotic & eukaryotic cells are filled with cytoplasm.

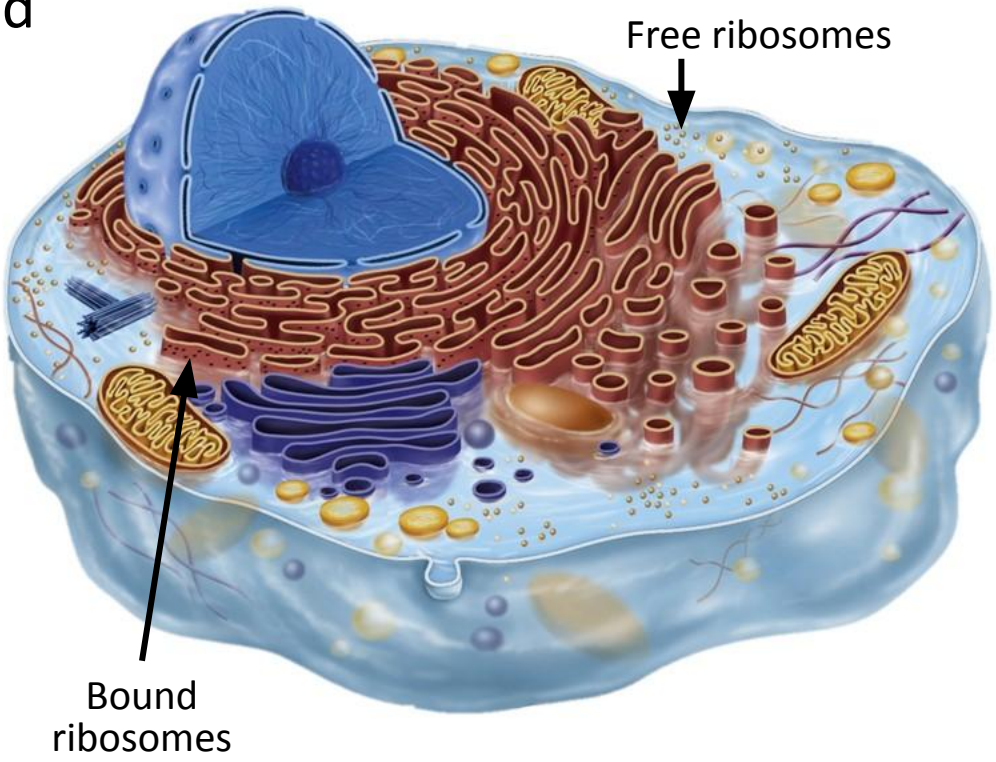
How does a cell make proteins?

- 3 organelles are involved in producing and distributing proteins: ribosomes, endoplasmic reticulum, and Golgi apparatus.



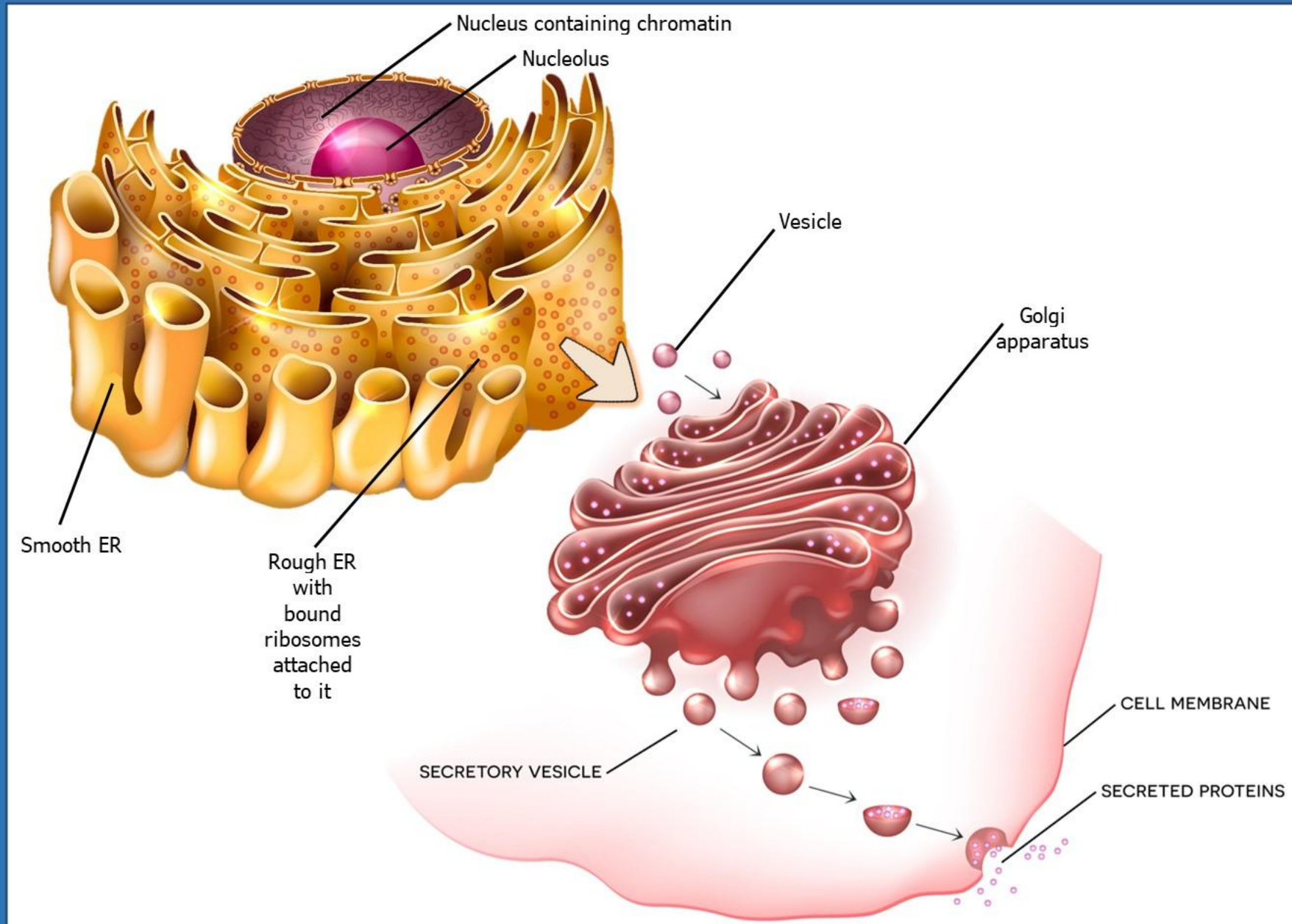
Ribosomes

- Ribosomes produce **proteins** from the **DNA code**.
  *More on this later in the course!
- They are found in both **prokaryotes** and **eukaryotes**.
- Ribosomes can be found in two places within a eukaryotic cell:
  - **Freely floating in the cytoplasm** (free ribosomes)
  - **Attached to the endoplasmic reticulum** (bound ribosomes)
- Ribosomes frequently **move between** the 2 locations.



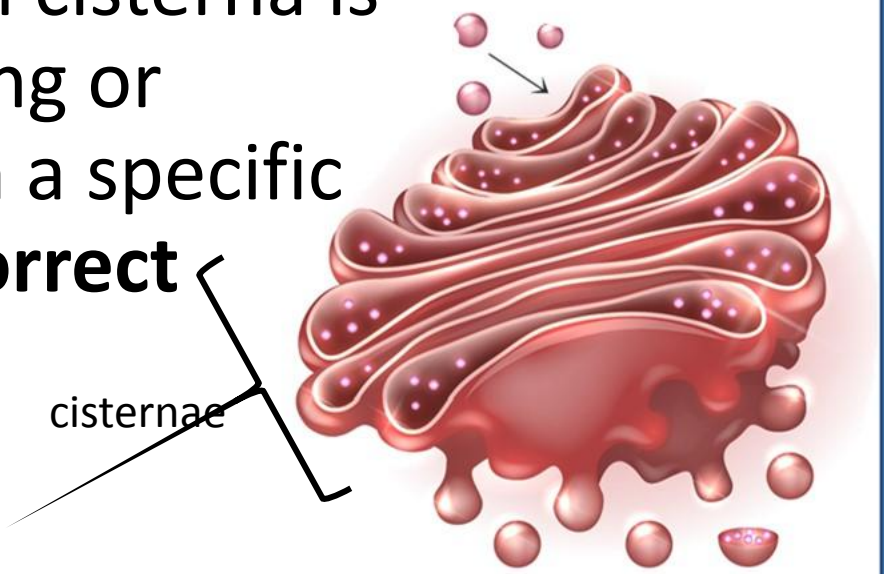
Endoplasmic Reticulum

- The endoplasmic reticulum (ER) is attached to the **nuclear envelope**.
- There are two kinds of ER:
  - 1. **Smooth** ER- contains **enzymes** for making **lipids** and **carbohydrates**.
  - 2. **Rough** ER- has **ribosomes** attached to its surface. After proteins are made in the ribosomes, they are **modified** by the rough ER and **transported** in **vesicles** to the Golgi apparatus.



Golgi Apparatus

- The Golgi apparatus **modifies** and **ships** the proteins to their final destinations, either **inside** or **outside** of the cell.
- The Golgi apparatus is a flattened stack of **cisternae**. Each cisterna is responsible for modifying or "**tagging**" the protein in a specific way so it reaches the **correct destination**.

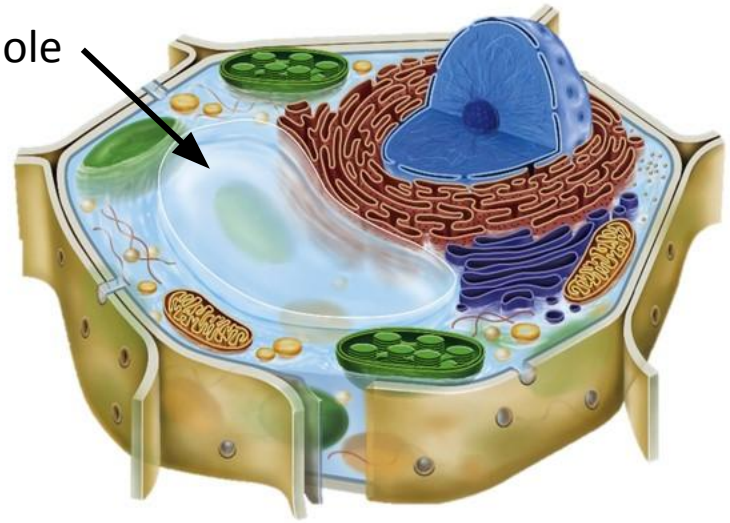


Summary

- DNA is stored in the cell's **nucleus**. Its code is used to produce **proteins** in the **ribosomes**, which are then sorted by the **endoplasmic reticulum** and modified by the **Golgi apparatus** before reaching their final destination.

How are substances stored within a cell?

- Vacuoles store **water** and **nutrients** for the cell.
- Animal cells have **several small** vacuoles and plant cells have **one central** vacuole.
- The vacuole in plant cells makes the cells **rigid**, which **allows plants to stand upright**.

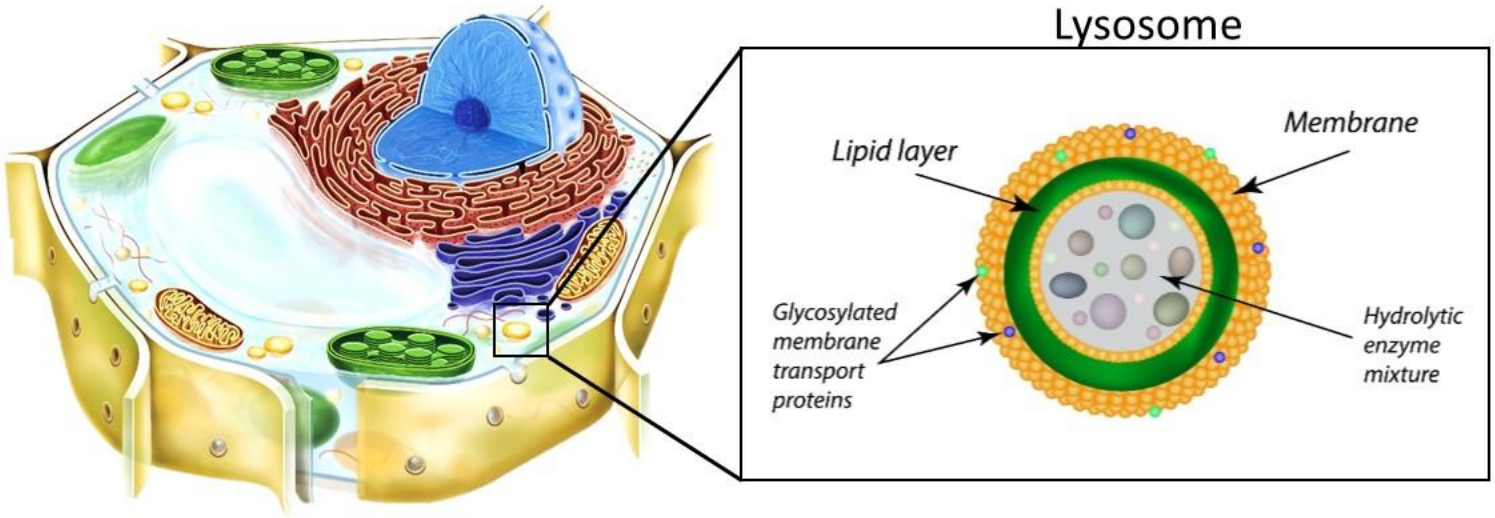


Plant cell

- Some specialized animal cell vacuoles can **pump water** out of the cell.

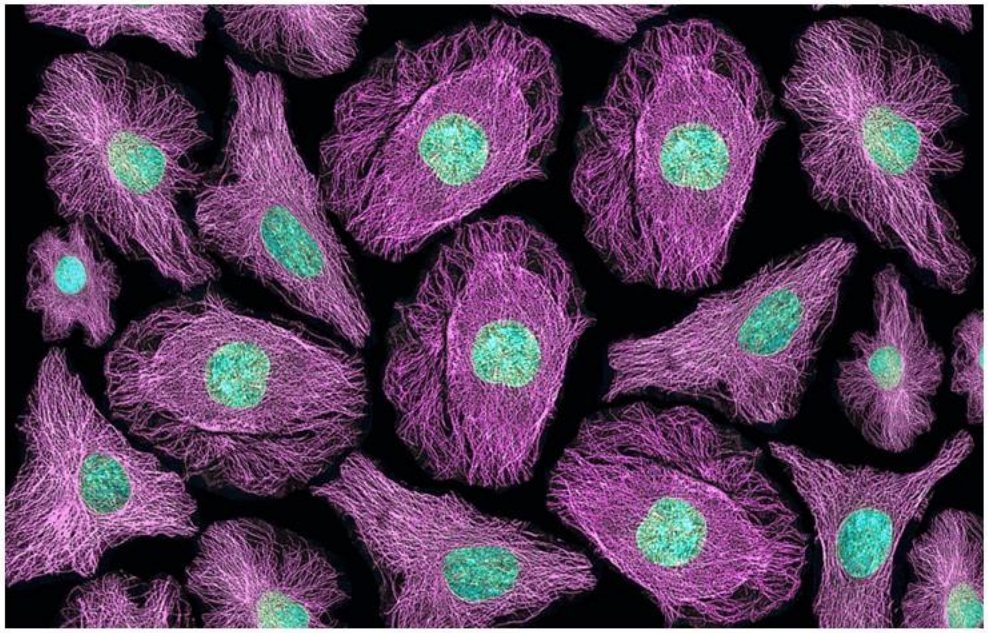
How does a cell digest materials?

- Lysosomes are small sacs of **enzymes** that can break down **macromolecules**.
- Lysosomes can break down old **cell parts** and **recycle** the **monomers** in them. They can also be used to **digest** large cells and particles **engulfed** by the cell.



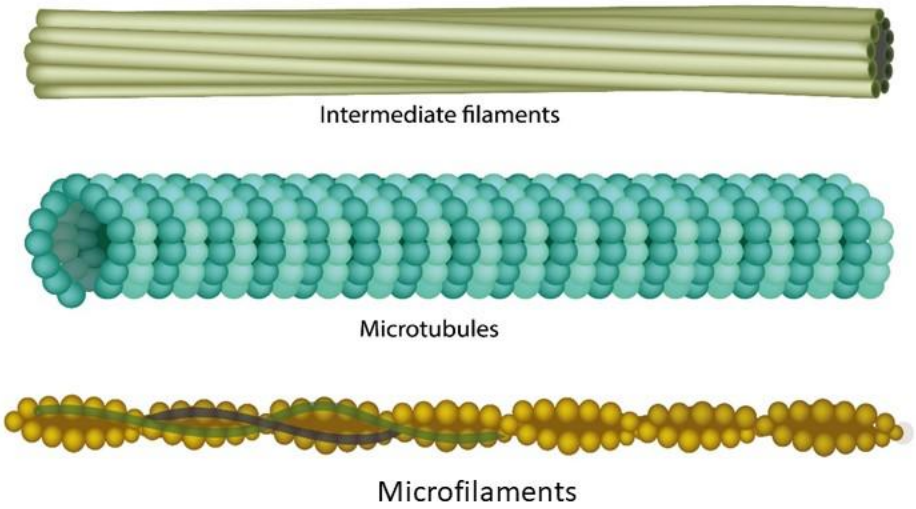
How are organelles supported within a cell?

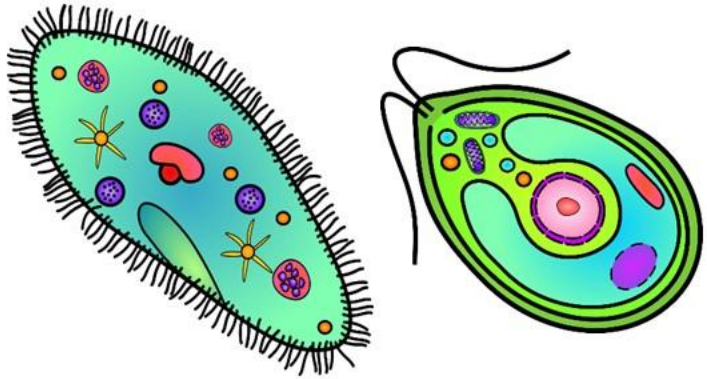
- Organelles do not **float freely** in the cell.
- The **cytoskeleton** provides an internal **support** and helps to **move materials** around the cell like a conveyor belt.



The cytoskeleton in these cells was stained with fluorescent purple dye.

- The cytoskeleton is made of three types of fibers:
  - Microtubules- **hollow fibers that can grow and shrink to change the shape of the cell**. Microtubules also serve as **tracks to move organelles** and **form cilia and flagella**, which cause cell movement.
  - Microfilaments- **thin fibers that maintain the cell shape**.
  - Intermediate filaments- **anchor the organelles in place**





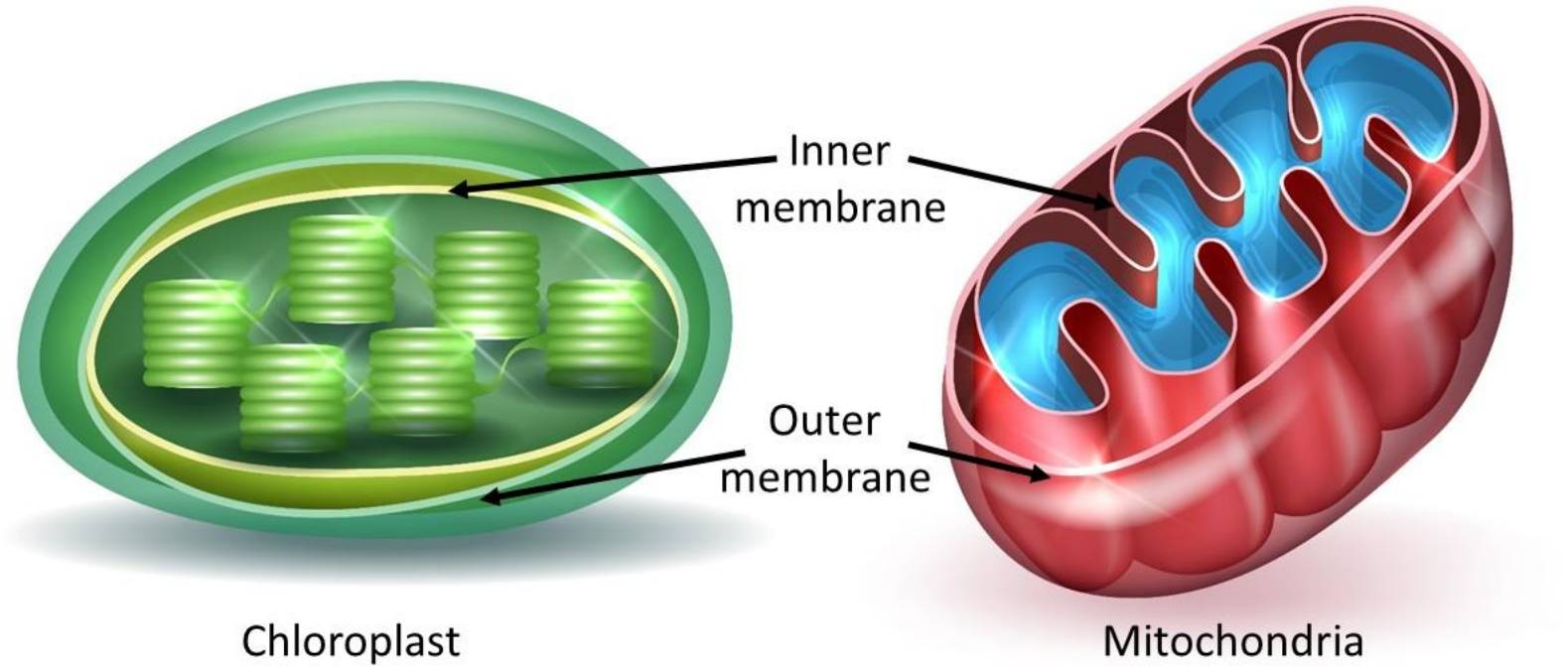
These cells have microtubules modified for movement. The cell on the left has short, hair-like cilia and the one on the right has 2 long flagella.

Summary

- **Vacuoles** store materials in a cell and **lysosomes** break down materials using **enzymes**. The cell has an internal **cytoskeleton** to provide **support** and movement.

How do cells get and use energy?

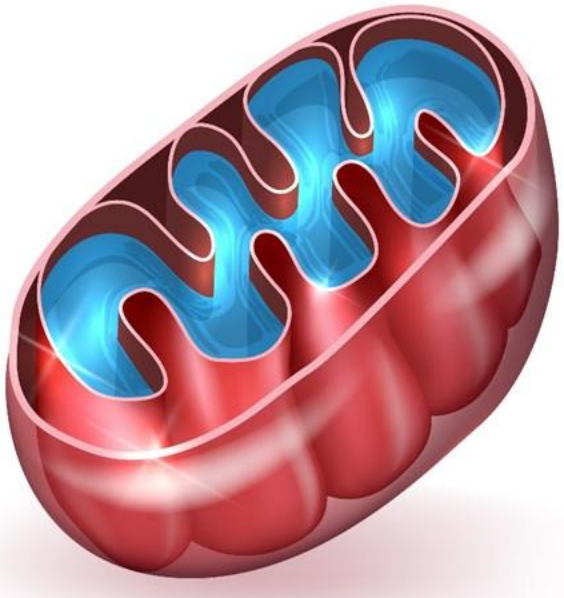
- Two organelles maintain energy resources for the cell: **chloroplasts** and **mitochondria**.
- Both of these organelles have **double** membranes.



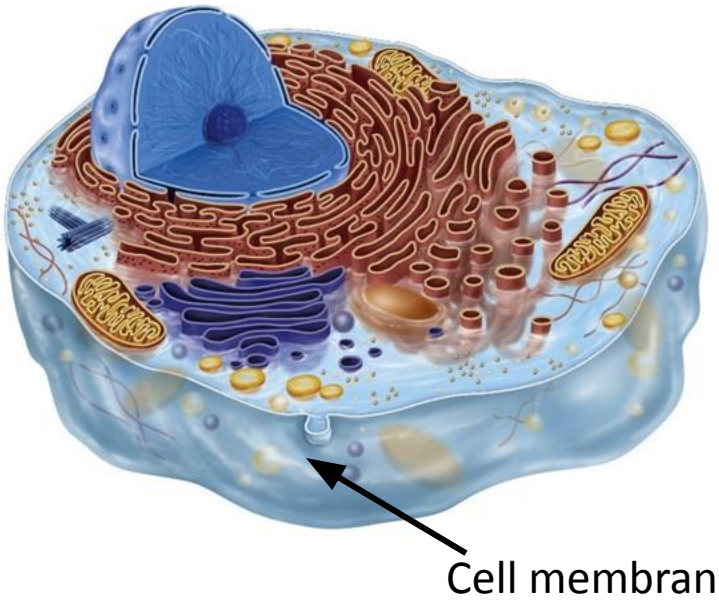
- Only **plants** and a few other organisms have chloroplasts.
- Chloroplasts contain **stacks** of flat disks that contain **chlorophyll**.
- Chlorophyll is the **pigment** responsible for capturing energy from **sunlight** and storing it as sugars in the cell (**photosynthesis**).

Chloroplast

- All **eukaryotic** cells have mitochondria.
- Mitochondria convert **food** molecules into usable **energy** for the cell (**cellular respiration**).
- The inner membrane is **folded**, which provides a large **surface area** for molecules to be moved in and out.

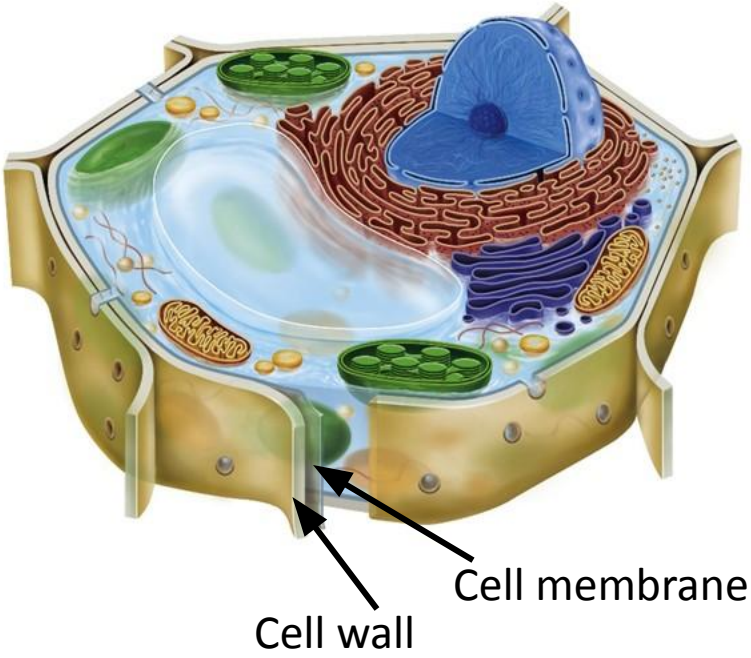


Mitochondria



What are the boundaries of the cell?

- All cells have **flexible** cell membranes that **regulate** substances **entering** and **leaving** the cell.
- The cell membrane is **selectively permeable** because it allows some **molecules** to cross, but not others.



- **Plant** cells (along with fungi and prokaryotes) also have more **rigid** cell walls that provide **structure** and **support**.

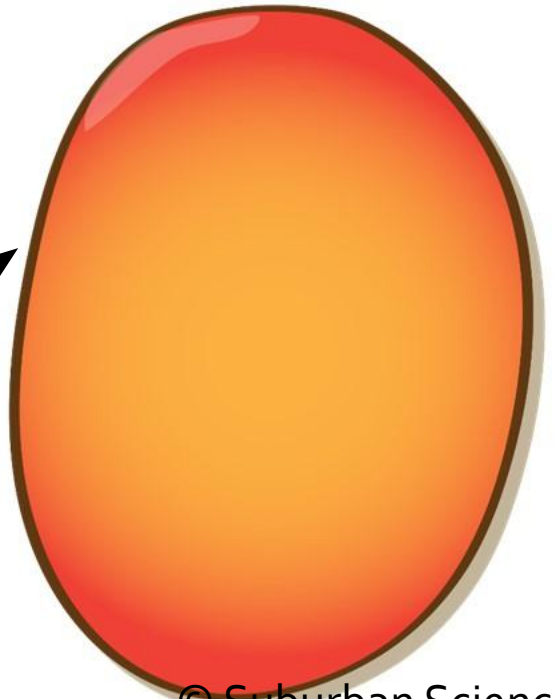
Summary

- Plant cells have specialized structures like **chloroplasts** and **cell walls**, but all eukaryotic cells have **mitochondria** to convert food into usable **energy** and cell **membranes** to regulate materials coming in and out.

What is the structure of the cell membrane?

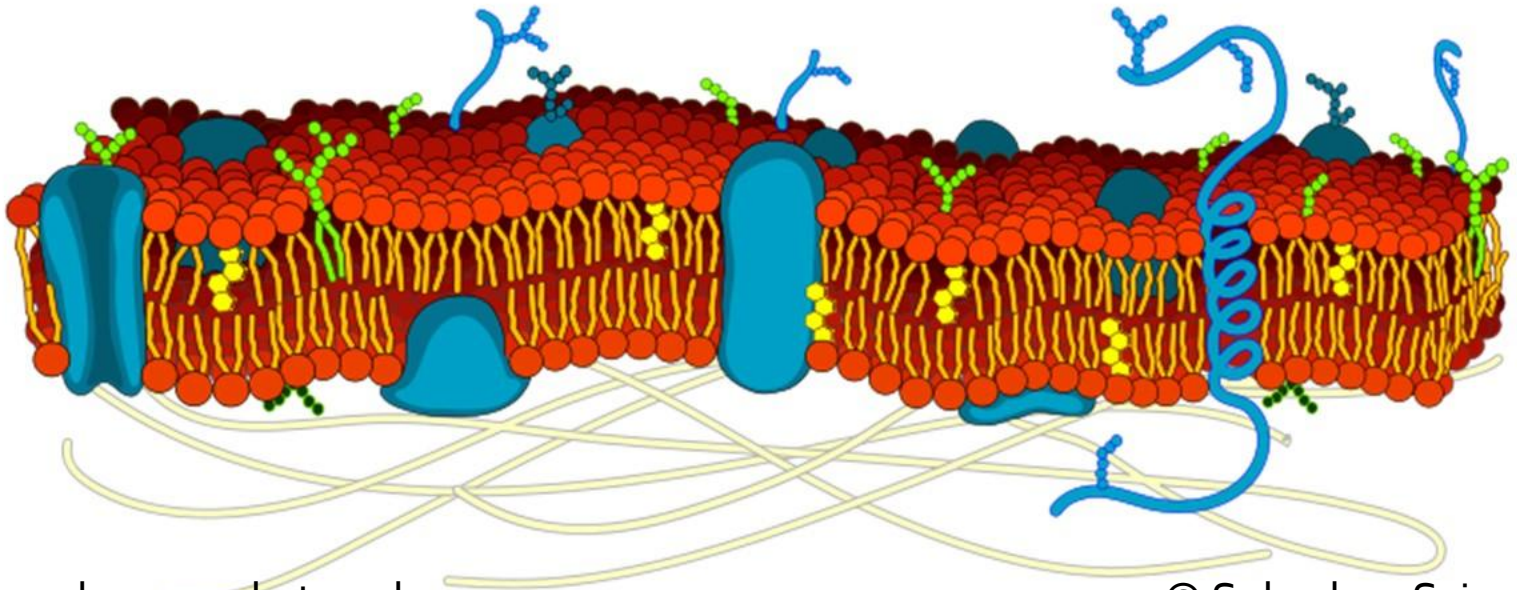
- Cells need to move materials in and out.
- Substances can move through the cell membrane.

Cell membrane surrounds the cell



Apalone has a rocket pack.

- The cell membrane is comprised of **2** layers of **phospholipids**, which have 2 fatty acid chains and one **phosphate** group.
- Therefore, the cell membrane is also known as a **phospholipid bilayer**.



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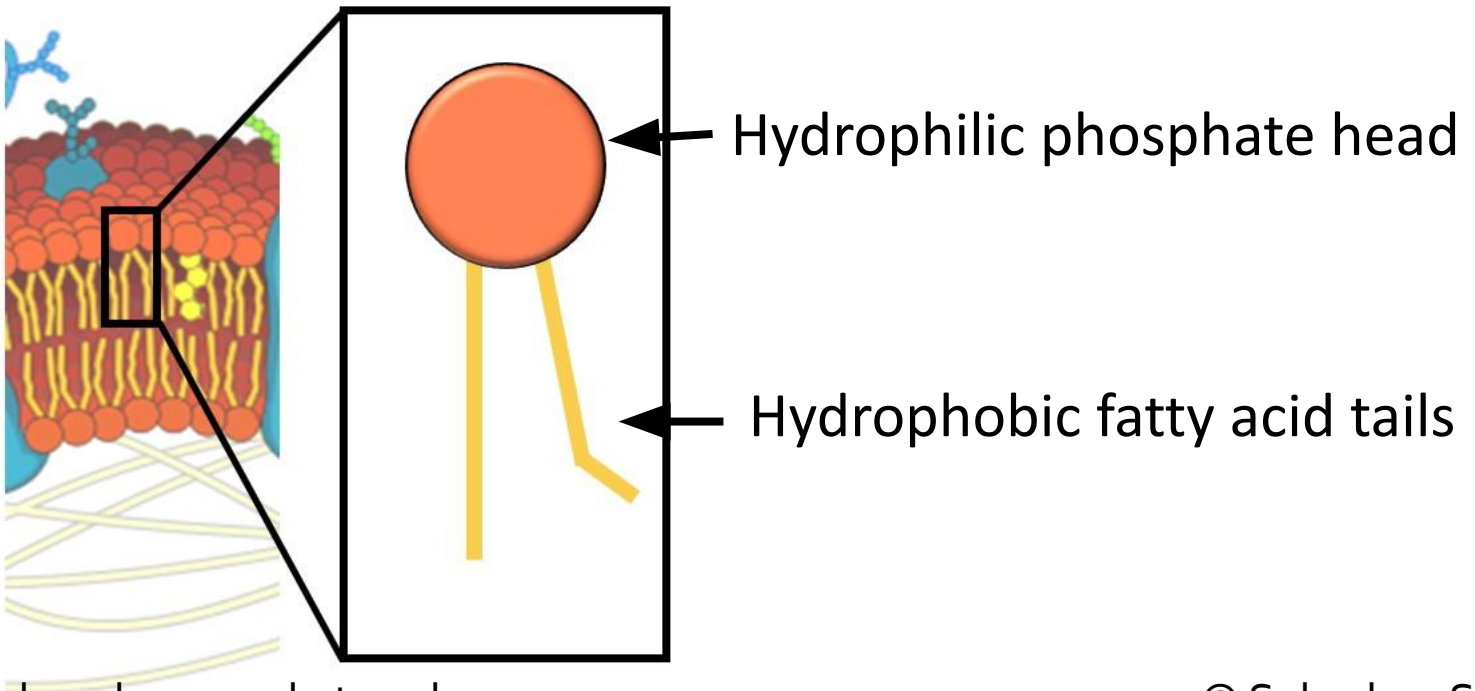
- The phosphate side of the phospholipid is **hydrophilic** (water-loving) while the fatty acid side is **hydrophobic** (water-fearing).



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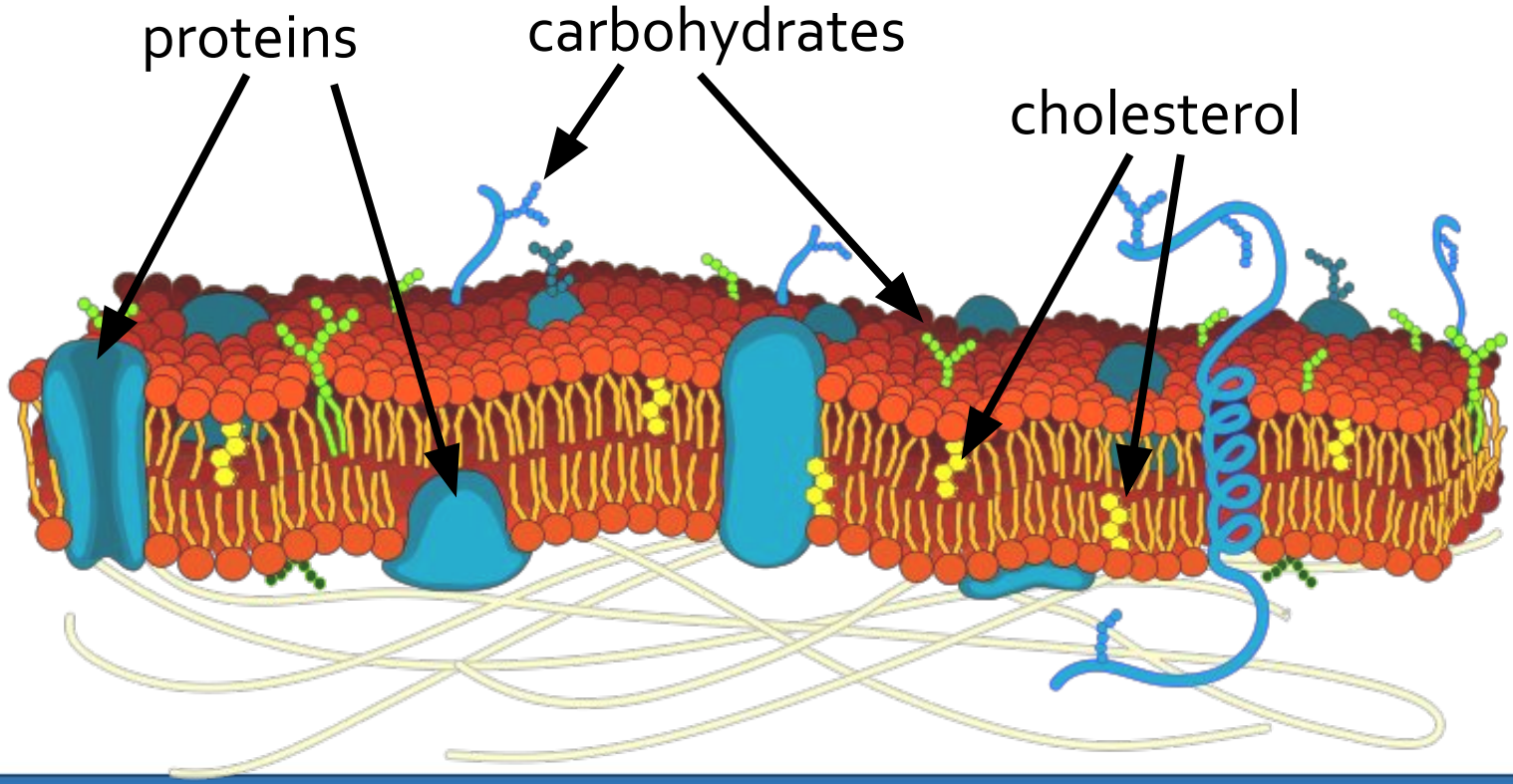
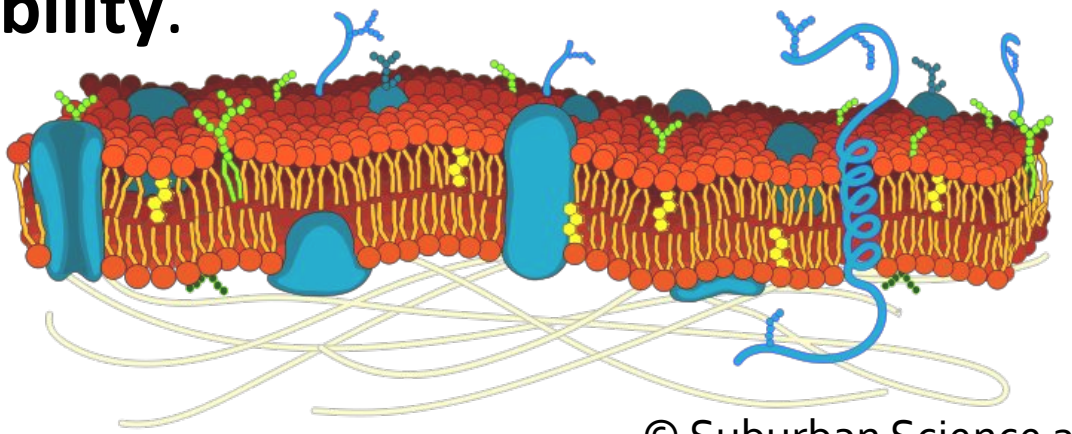
- Other molecules are also found in the cell membrane.
- **Carbohydrates- help mark the cell**
- **Proteins- channels for large substances**
- **Cholesterol- provides membrane stability**



How does the structure of the cell membrane contribute to its function?

- Because the interior of the cell membrane is **hydrophobic**, some **charged** molecules will not pass through it.
- The **carbohydrates** and **proteins** in the membrane also **regulate** what can pass in and out of the cell.
- These all contribute to the membrane's **selective permeability**.



How can substances move through the membrane?

- There are two basic ways substances move through the membrane:

1. **Active transport-** requires **energy**

   Examples: diffusion, facilitated diffusion, osmosis

2. **Passive transport-** does not require **energy**

   Examples: exocytosis, endocytosis, molecular transport, bulk transport

Summary

- The cell membrane is made of **2** layers of **phospholipids**, proteins and other molecules that contribute to its **selective permeability**. Substances can pass across this membrane using **passive** or **active** transport**.**

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Words to Know

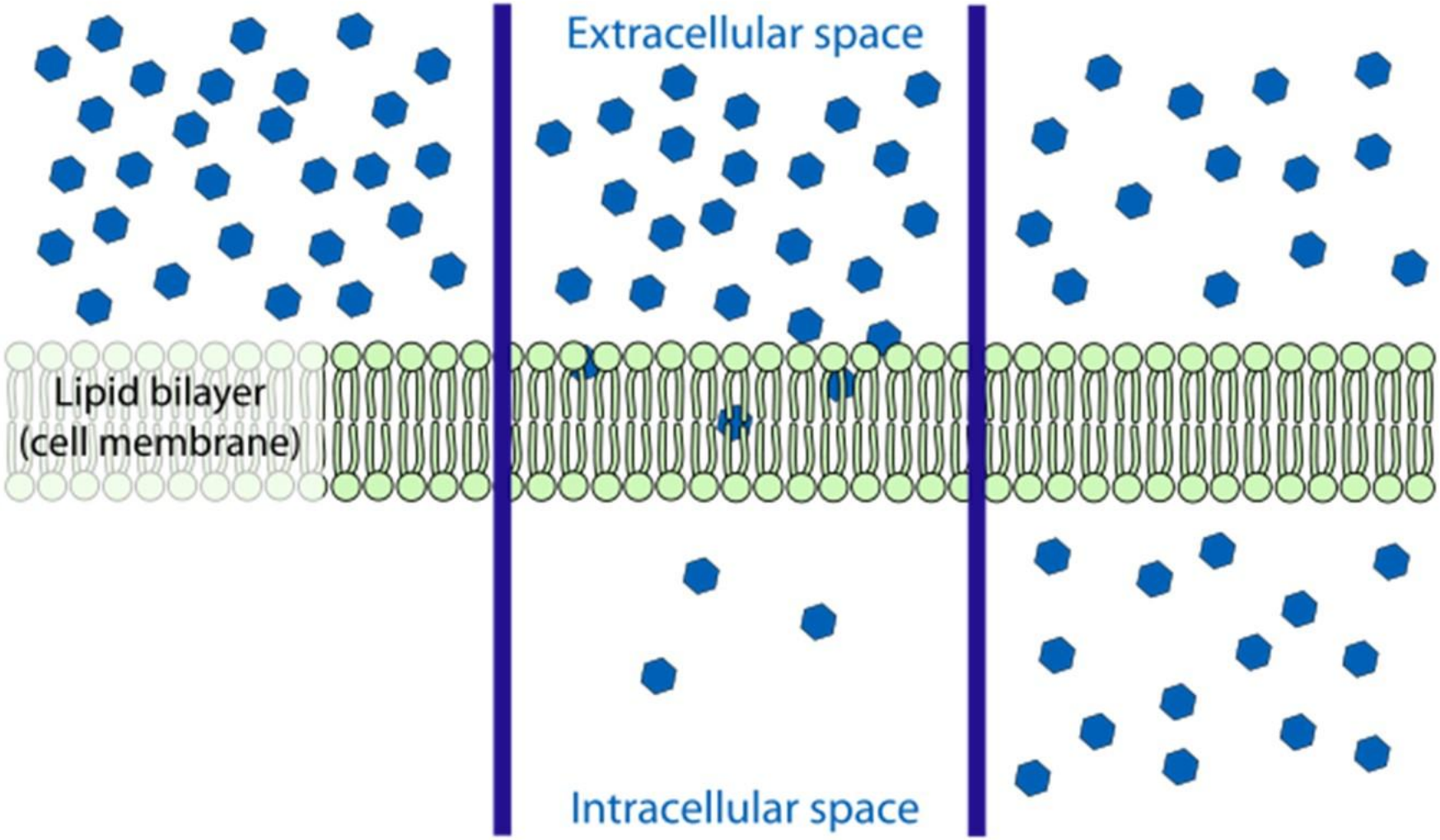
- **Solute** – what gets dissolved *(Ex. Lemonade powder)*
- **Solvent** – does the dissolving *(Ex. Water)*
- **Solution** – uniform mixture of two or more substances *(Ex. Lemonade)*
- **Concentration** – amount of solute dissolved in solvent
  - Symbol for abbreviation = [ ]

What is diffusion?

- Diffusion- **the random motion of molecules from an area of high concentration to an area of lower concentration.**
- For example: When perfume is sprayed in one corner of a room, it is first noticed by students near that corner. Eventually, the whole room can smell the perfume because the molecules have moved from high concentration (in the corner) to low concentration (in other parts of the room).
- Video example

Ink molecules diffusing throughout a glass of water

- Diffusion will continue until the molecules are equally spread out. This is called a state of equilibrium.
- **Equilibrium- the state at which the concentration of solute is the same throughout the solution**

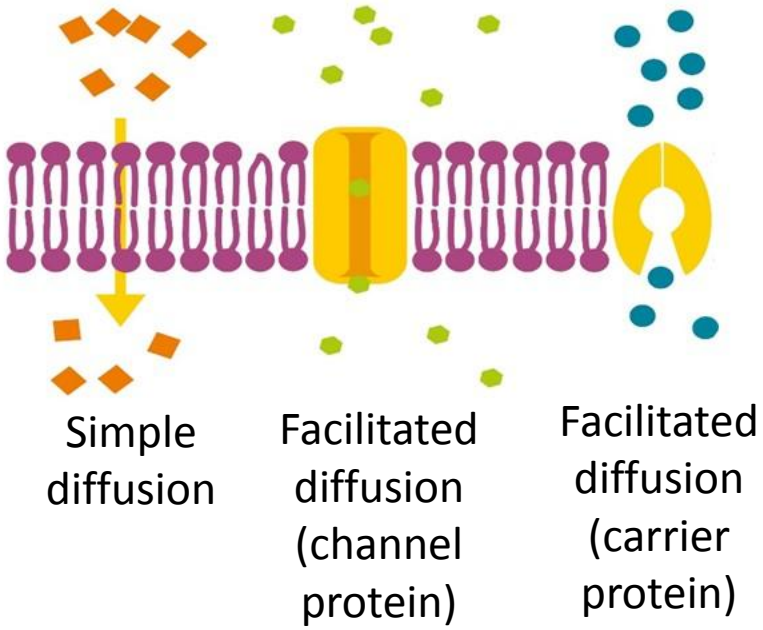


Over time, substances move from high concentration on one side of the membrane to lower concentration on the other side. The molecules will bounce into each other and spread out until the substance is equally spread, which means it is in equilibrium.

Abalone has a rocket pack.

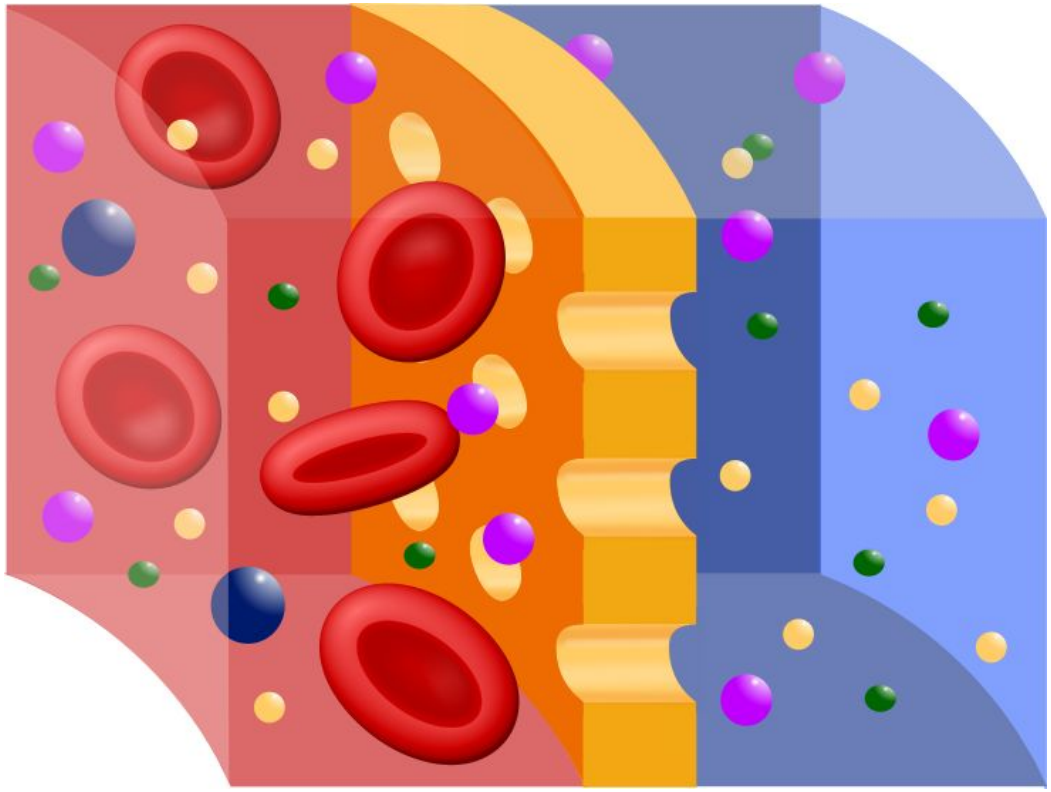
What is facilitated diffusion?

- Facilitated diffusion is **passive transport** with the help of **proteins**.
- 2 types of proteins:
  1. **Channel proteins-** allow charged or larger molecules to flow through the membrane
  2. **Carrier proteins-** change shape to transport specific molecules across the membrane

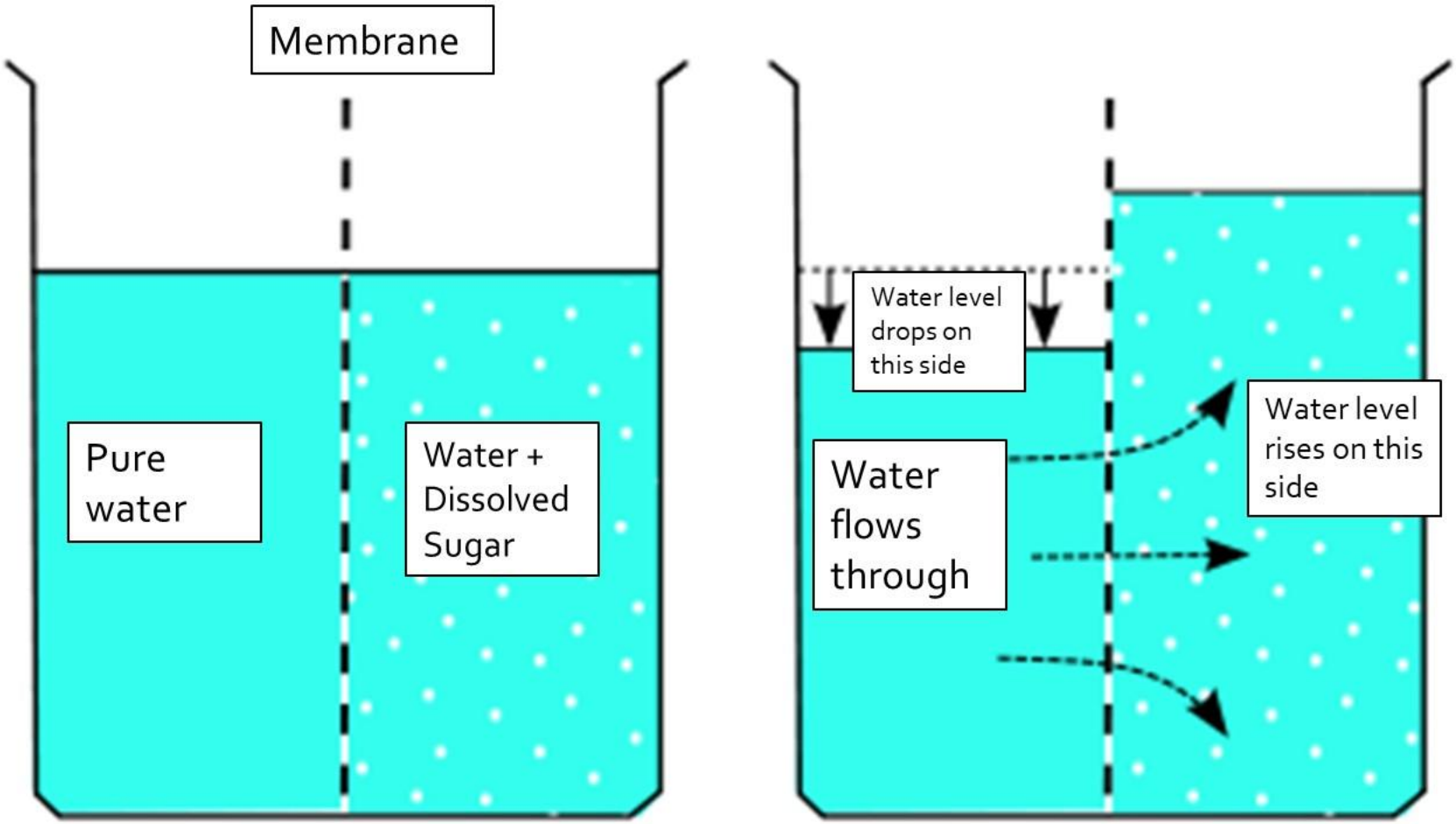


How does osmosis differ from diffusion?

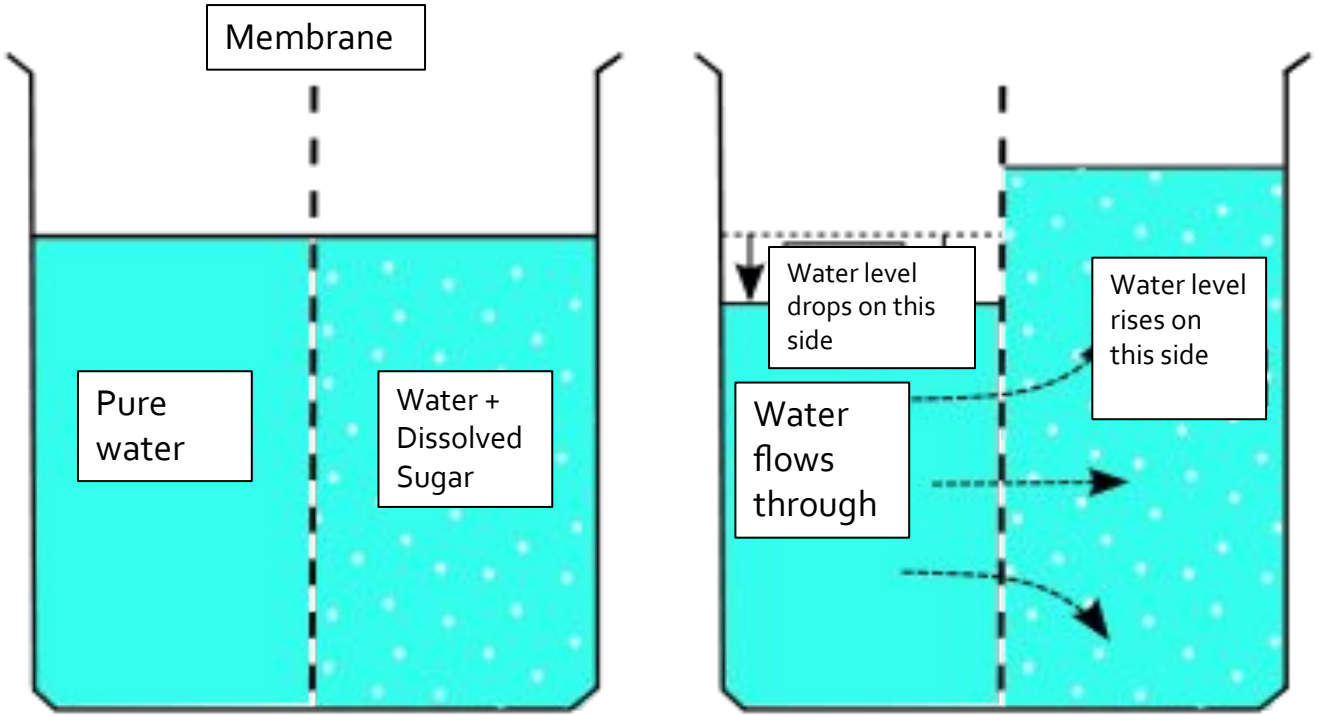
- Osmosis is the diffusion of **water** through a **semipermeable membrane.** How is this different from the previous definition of diffusion?
  - **Diffusion is the movement of any type of molecule and does not require a membrane.**



Small molecules can pass through the yellow membrane, but the larger molecules can not. This is why the membrane is said to be SEMI-permeable, rather than just permeable to all substances.



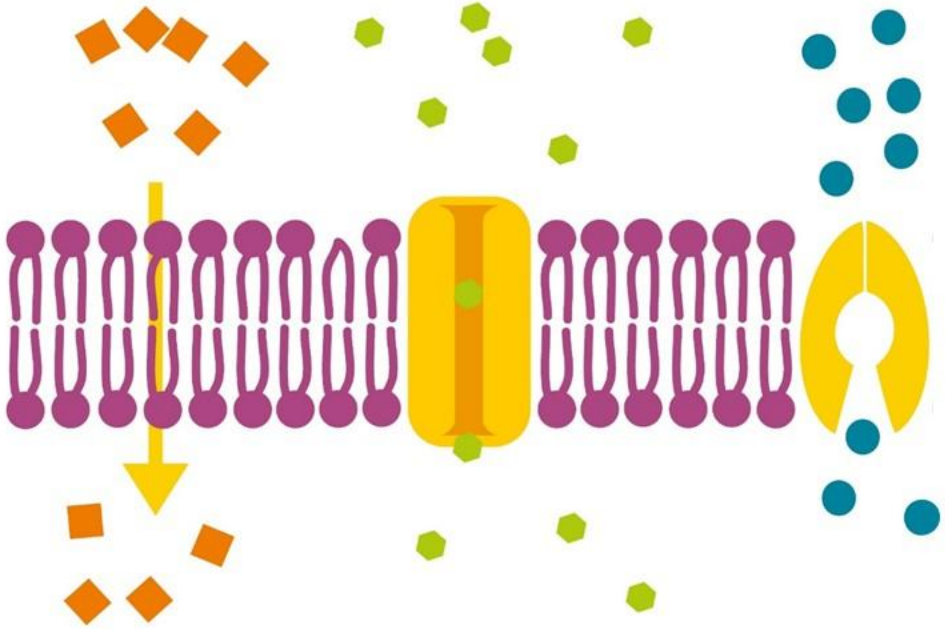
In this diagram, the sugar is too big to pass through the semi-permeable membrane, but the water can pass through. The water will move towards the high solute concentration in order to equalize the solution again.



Way to Remember: **SOLUTE SUCKS!**

Wherever there is more of solute, the water will be “sucked” to that area.

- In a cell, **channel proteins** called **aquaporins** move **water** across the cell membrane.



- Which image shows an aquaporin?
- **Answer: the second (channel protein)**

Summary

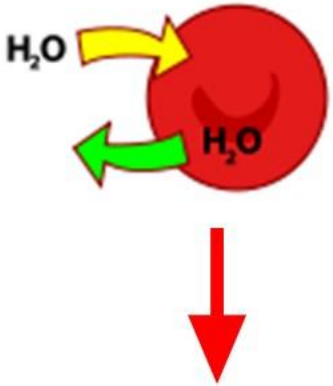
- **Diffusion**, facilitated diffusion, and **osmosis** are all types of **passive** transport. In all these processes, substances move from areas of **high** concentration to **low** concentration, which does not require the use of **energy**.

How does tonicity change a cell?

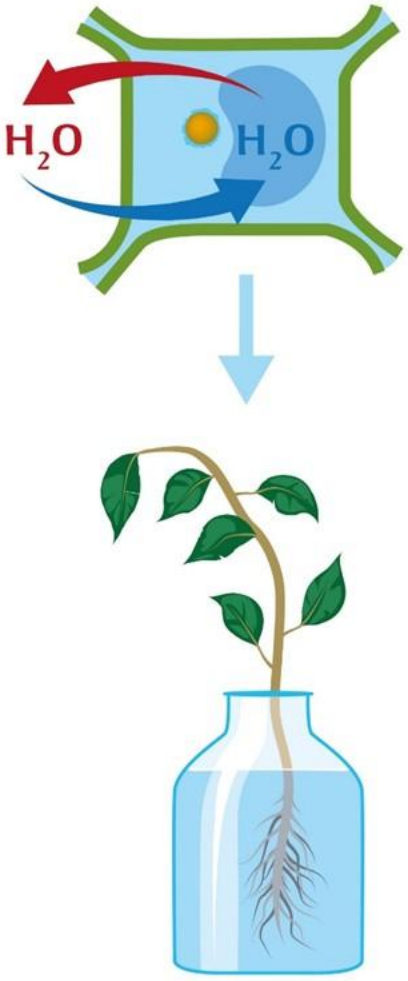
- Tonicity is the ability of a **solution** to cause a **cell** to gain or lose **water**.
- We will discuss 3 different types of solutions:
  - Isotonic
  - Hypertonic
  - Hypotonic

Apalone has a rocket pack.

- In an **isotonic solution**, the **amount of solute is the same inside the cell as it is outside.**
- Therefore, **water flows equally in and out** of the cell.



Animal cells are stable in an isotonic solution



Plant cells survive, but don't thrive in an isotonic solution

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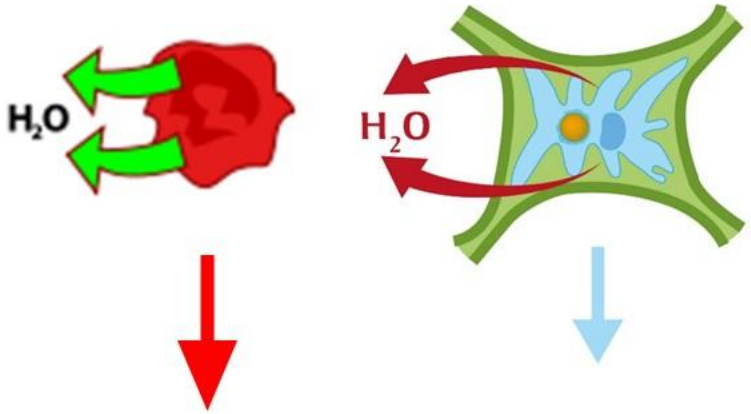
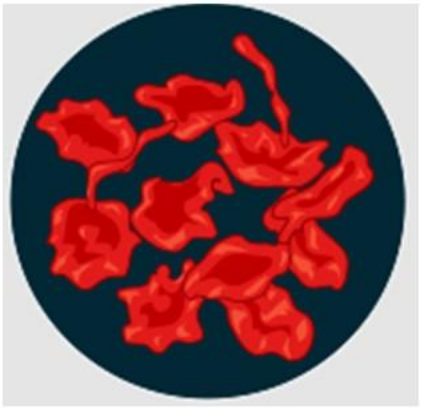
- A **hypertonic** environment has a **higher amount of solute** than the cell does.
- Because of this, water will flow **out of the cell** towards the environment.
- Remember: Solute sucks!

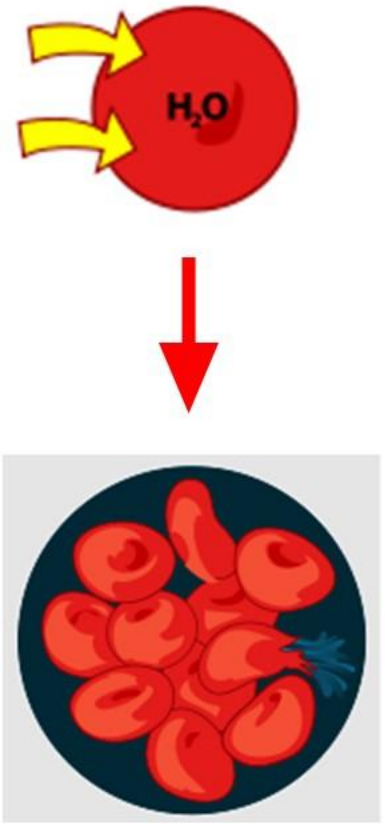




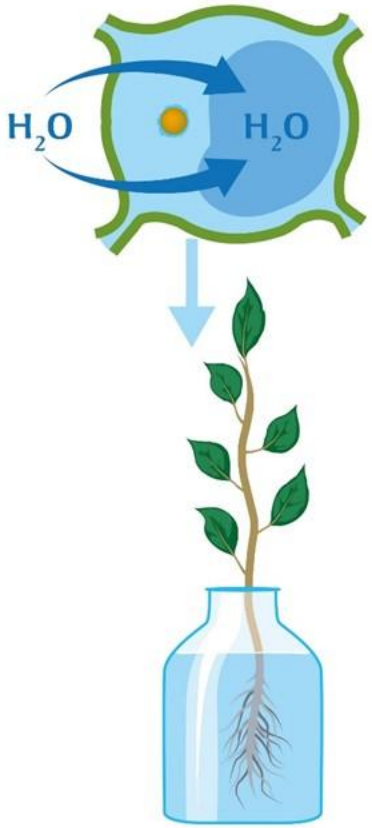
Animal cells will shrivel and die in a hypertonic solution

The vacuole of plant cells will shrivel in a hypertonic solution (called **plasmolysis**)

- In a **hypotonic** environment, the **amount of solute particles is lower than inside the cell**.
- Therefore, water will flow **into the cell**, where the concentration of solute is higher.



Animal cells will gain water and explode in a hypotonic solution



Plant cells thrive in a hypotonic solution because their vacuoles push on the cell wall (called **turgor pressure**)

Apalone has a rocket pack.

Types of Solutions: Quick Review

	Amount of solute compared to the cell	Water moves
Isotonic		
Hypertonic		
Hypotonic		

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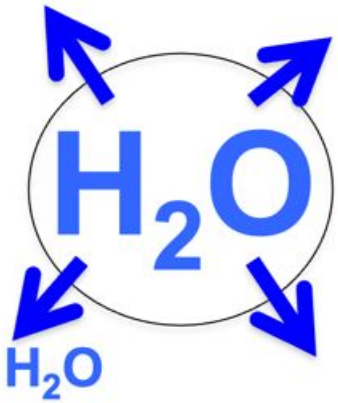
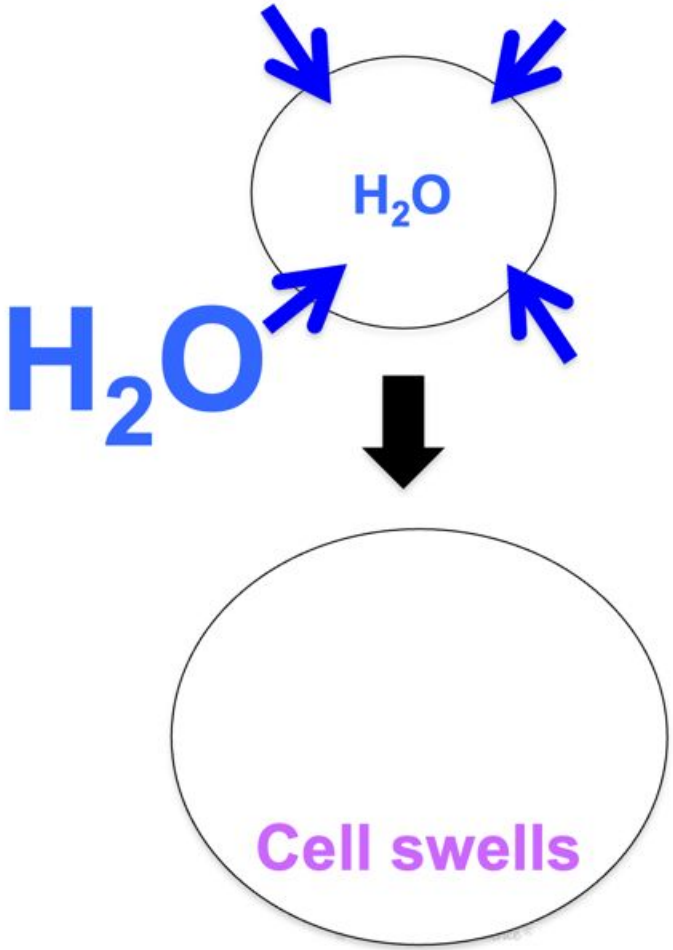
Tonicity

Hypertonic Solution

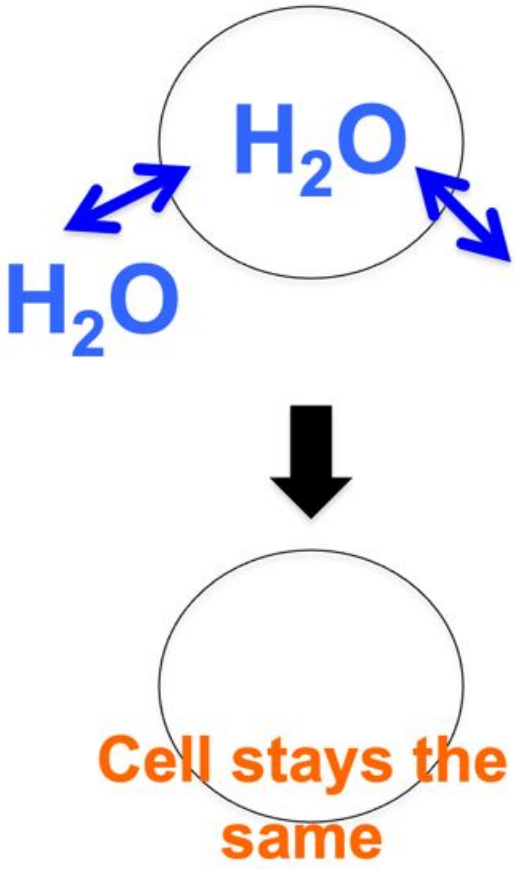


Cell shrivels

Hypotonic Solution



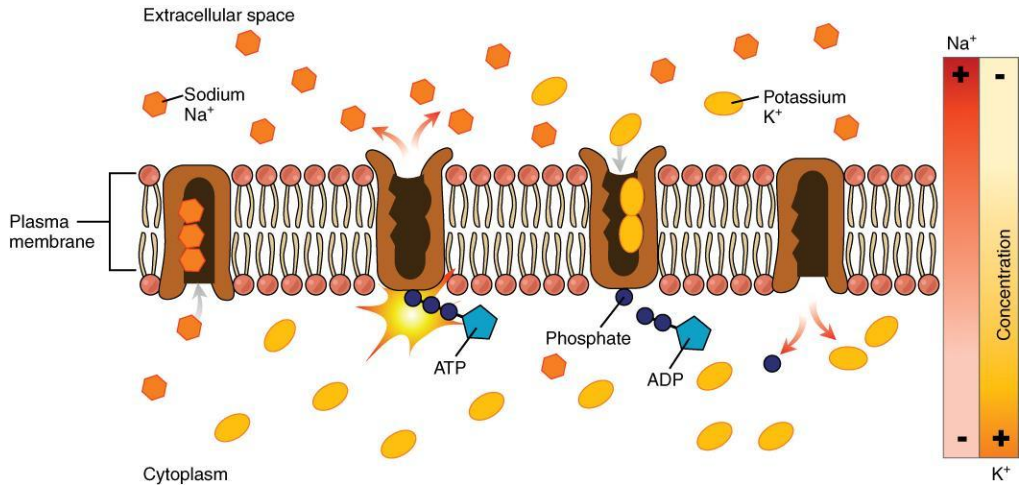
Isotonic Solution



How can a cell use energy to move substances across the cell membrane?

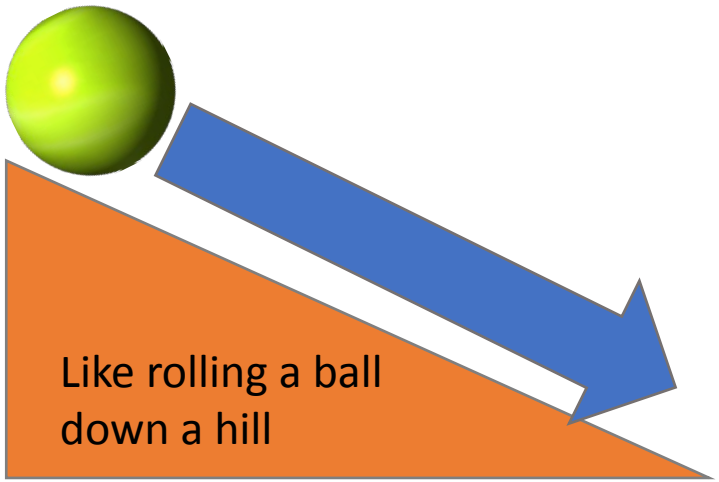
- **Active transport** uses **energy** to move substances in or out of the cell.
- There are 2 types of active transport:
  - Protein pumps
  - Bulk transport

- **Protein pumps** allow substances to move from **low** concentration to **high** concentration (opposite of the normal concentration gradient).
- Example: A pump that moves sodium & potassium to keep a steep imbalance is essential to pass information through nerves.



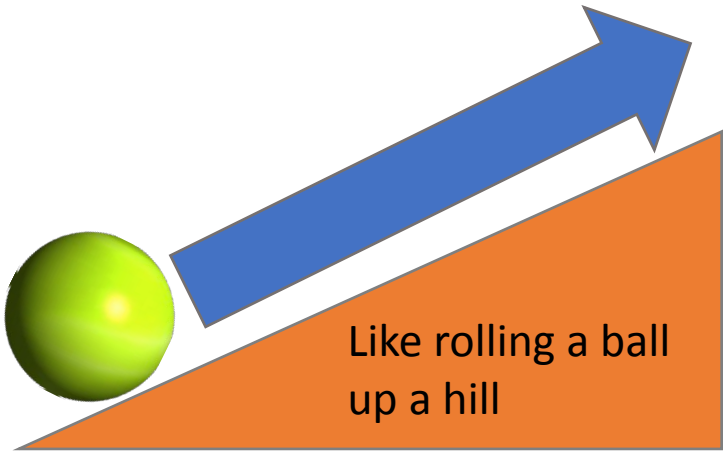
Passive Transport

Movement from high to low- does NOT require energy

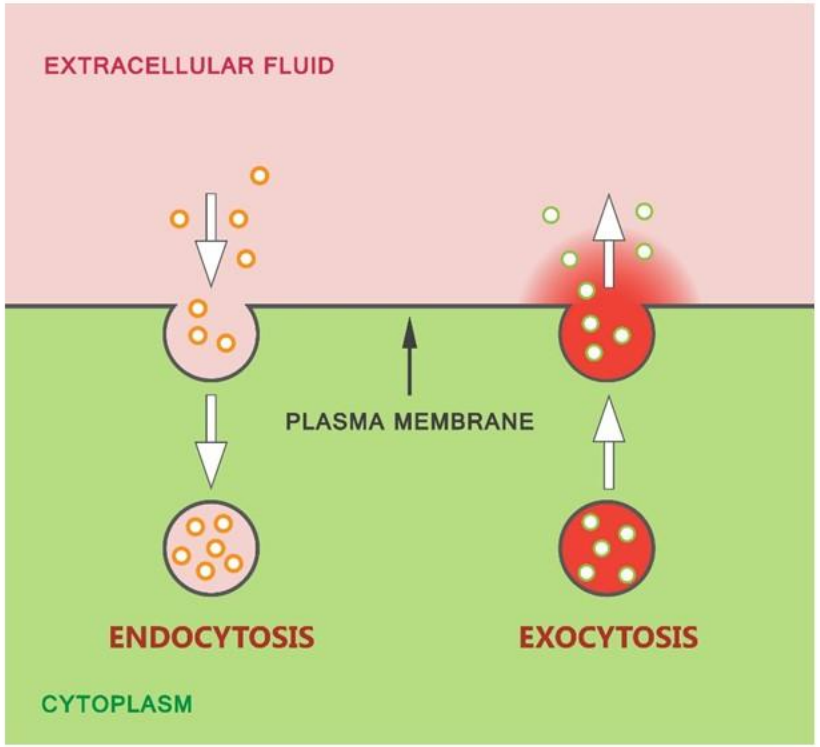


Active Transport

Movement from low to high- DOES require energy



- Bulk transport- Moving **large molecules** (or **clumps** of large molecules) in and out of the cell using:
  - **Endocytosis- using vesicles to move very large substances <u>into</u> the cell.**
  - **Exocytosis- using vesicles to move very large substances <u>out</u> of the cell**



Summary

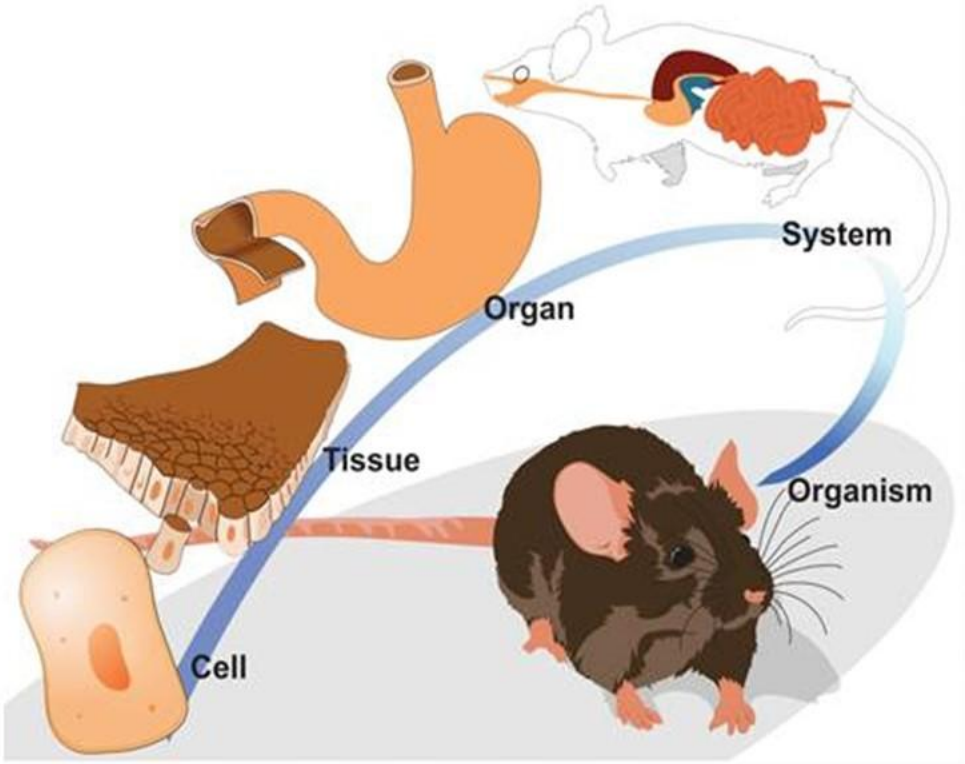
- The **solute** concentration outside the cell can cause the cell to **gain** or **lose** water. **Active** transport allows substances to be pumped from **low** to **high** concentration or for **large** substances to be moved into or out of the cell, but it requires **energy**.

How do unicellular and multicellular organisms differ?

- Unicellular organisms survive with **only one** cell.
  - Ex: bacteria, some algae, amoebas, yeast
- In a **unicellular** organism, a single cell is responsible for maintaining **homeostasis**.
  - **Homeostasis= the relatively constant internal conditions required for survival.**
- In a **multicellular** organism, many **differentiated** cells work together to maintain **homeostasis**.

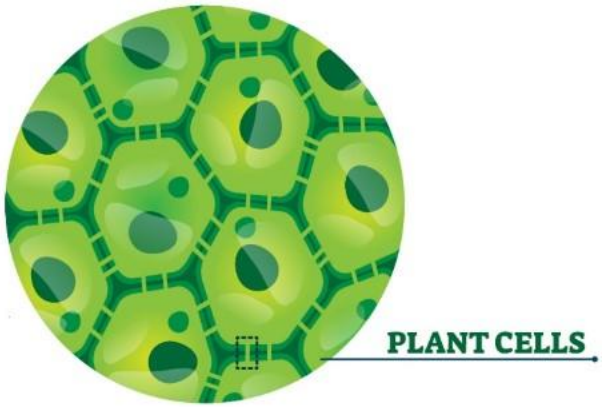
How are cells arranged in multicellular organisms?

- Cells in multicellular organisms are **specialized** and work together based on a common **function**.
- **Cells**
- **Tissues**
- **Organs**
- **Organ Systems**
- **Organism**



How do cells cooperate?

- Plant cells have **openings** in their cell walls that allow **water** and **solutes** to flow between cells.



- Animal cells have several types of **cellular junctions** that can either hold cells **tightly** together or **pass molecules** between cells.
- Specialized **receptors** determine how the cell will **act** when something is **passed** to it.

Summary

- Although **unicellular** organisms work to maintain **homeostasis** in one cell, **multicellular** organisms need many cells to communicate through tissues, **organs**, and organ **systems**.

Apalone has a rocket pack.