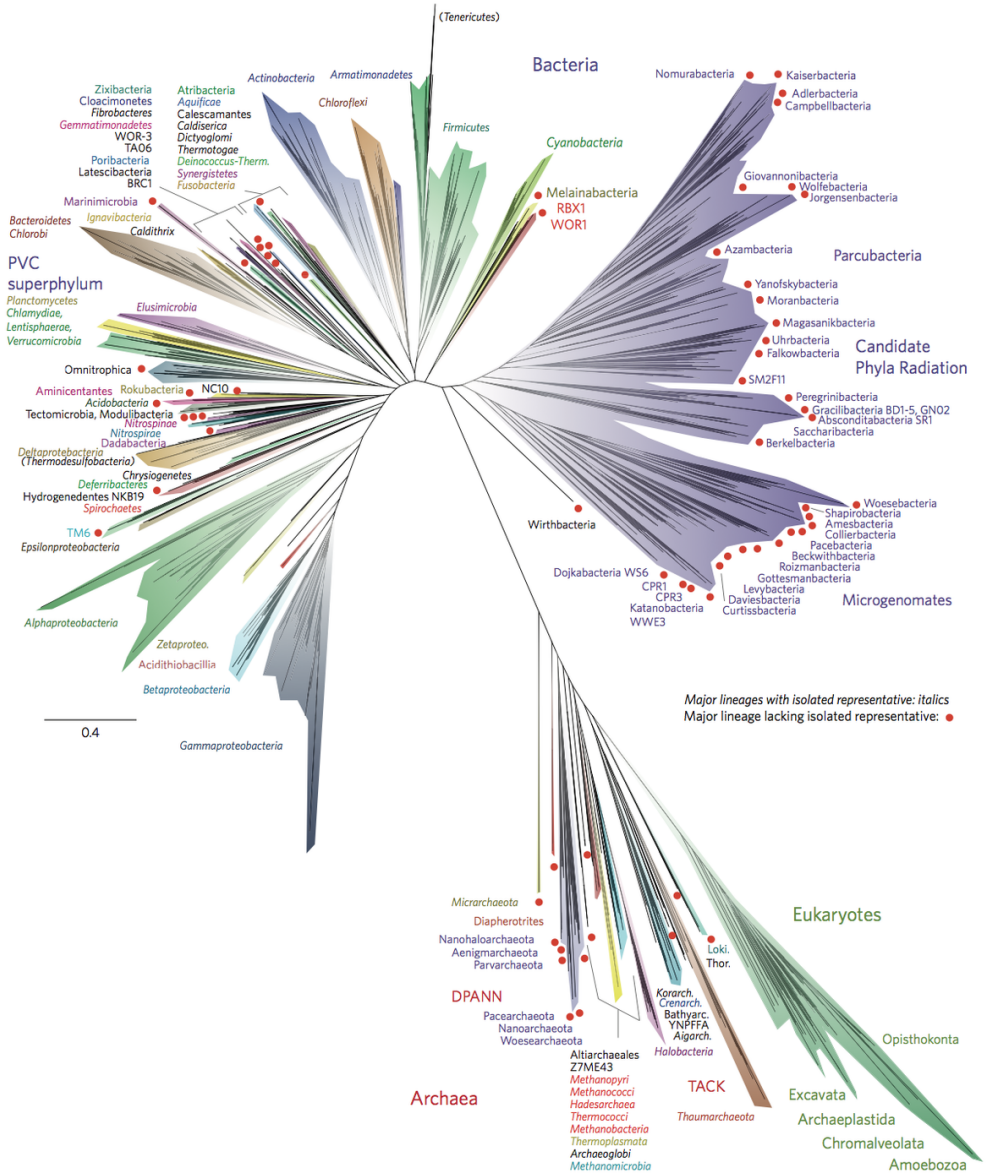
Cell Structure

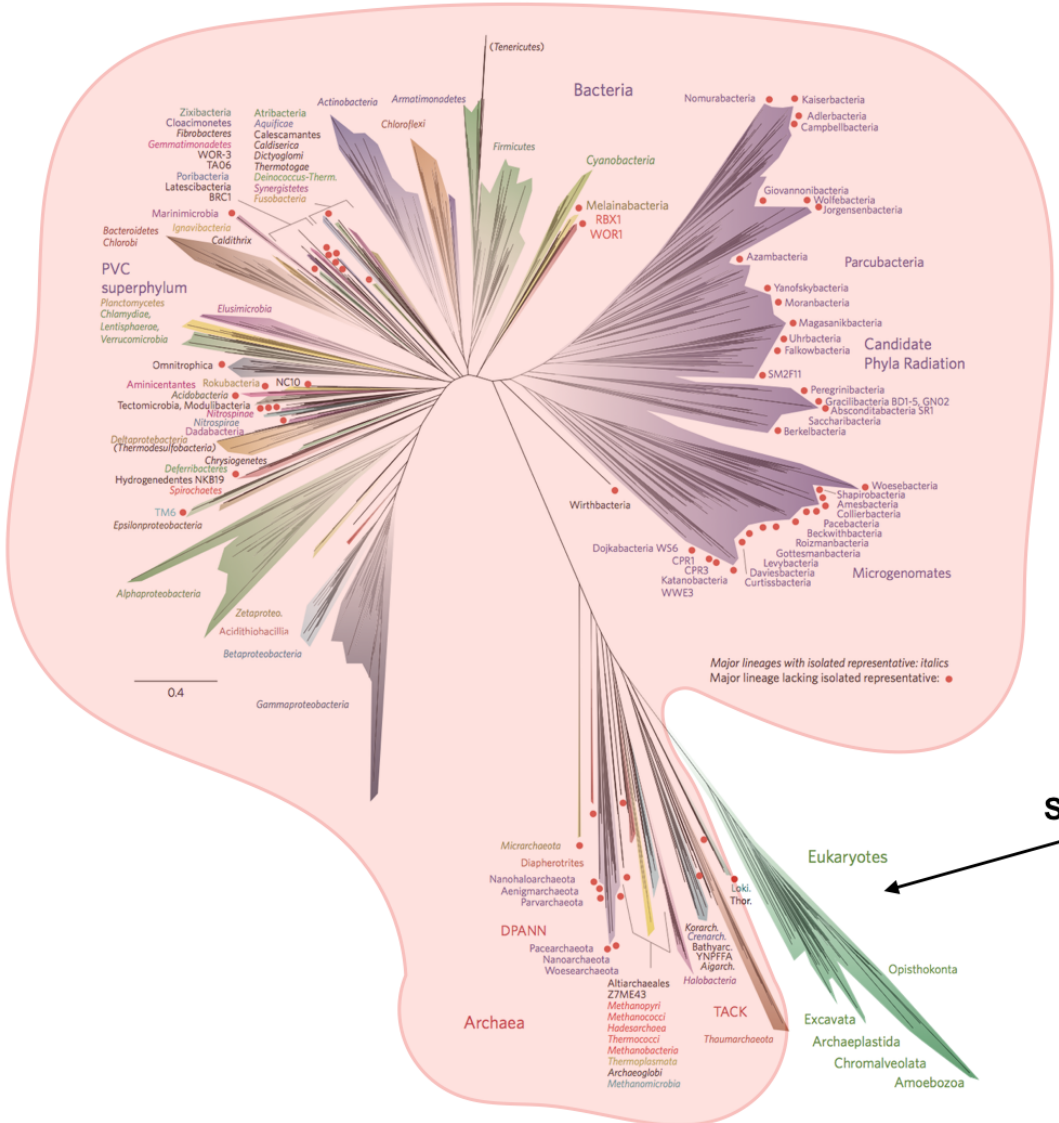
Cells are the basic unit of life!

Smallest unit of living things:

- Single-celled organisms are the smallest units of life
- Are the basic units of multi-cellular organisms



Tree from Hug et al. (2016) *Nature Microbiology* **1**: 16048.

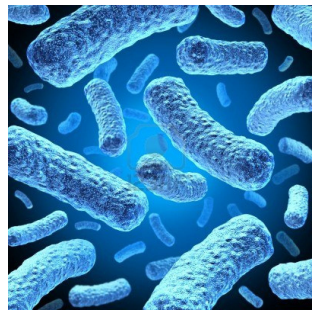


All of these are single-celled organisms

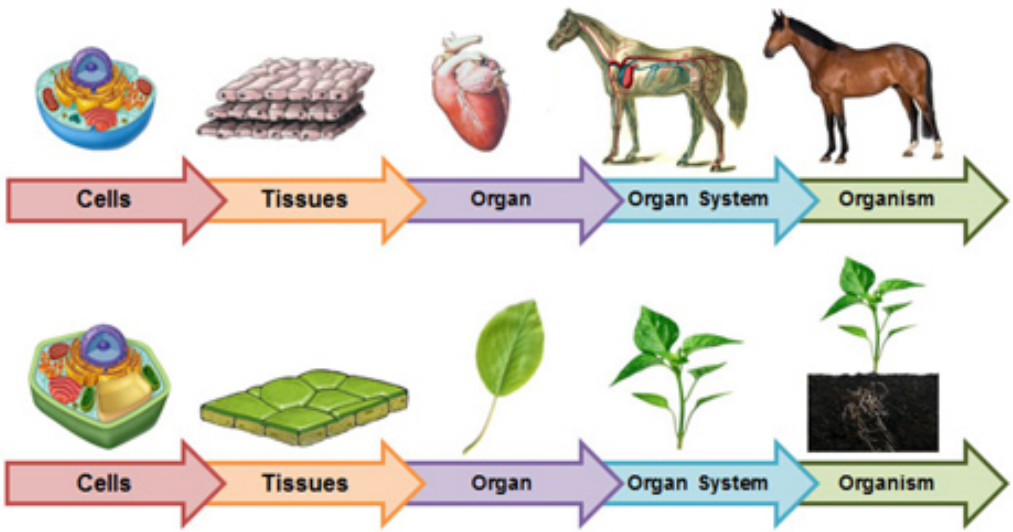
So are many of these

Basic Unit of Life

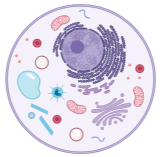
In single-celled organisms, importance of the cell is obvious.



In multi-cellular organisms, they are the basic unit of organization.

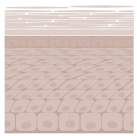


Basic Unit of Life



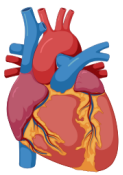
Cell

Smallest unit that can carry out life's activities



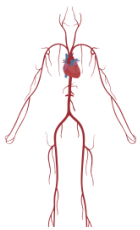
Tissue

Group of *cells* working together to perform a specific job



Organ

Group of *tissues* working together to perform a specific job



Organ System

Group of *organs* working together to perform a specific job

Organism

Group of *systems* working together to perform a specific job

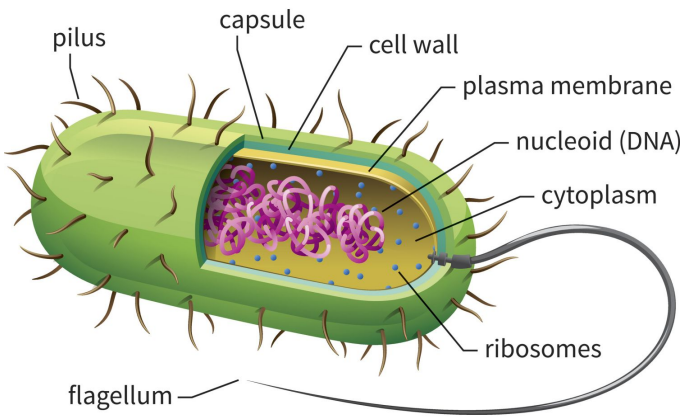
The Cellular/Plasma Membrane

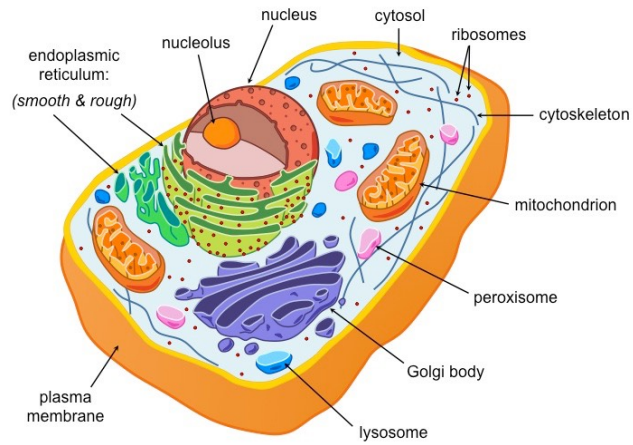
Cellular Membrane

All cells have a cellular membrane (also called a *plasma* membrane)

Important for:

- Controlling what goes in and out of the cell (*selective permeability*)
- Maintaining internal conditions (*homeostasis*)





Cellular Membrane

Homeostasis

The steady-state equilibrium conditions (pH, ionic concentrations, temperature, etc.) required for a biological entity (cells, organs, organisms, etc.) to maintain its function.

Cellular Membrane

"Like dissolves like"

- Polar things (**hydrophilic**) dissolve other polar things
- Non-polar things (**hydrophobic**) dissolve other non-polar things

Cellular Membrane

So. . . how do detergents work?

Goal:

- Make oils (hydrophobic) soluble in water (hydrophilic)

Micelle

Micelle

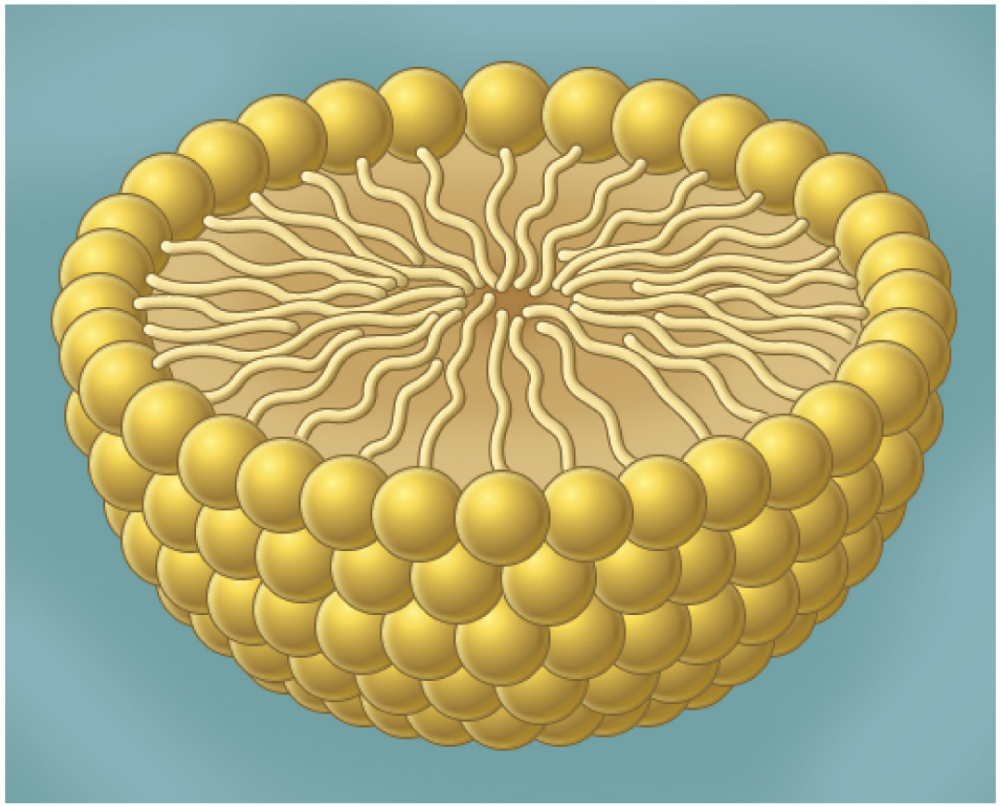


Figure 5.3a
Biology: How Life Works, Second Edition

Phospholipid Bilayer

Plasma membranes are made of a **phospholipid bilayer**

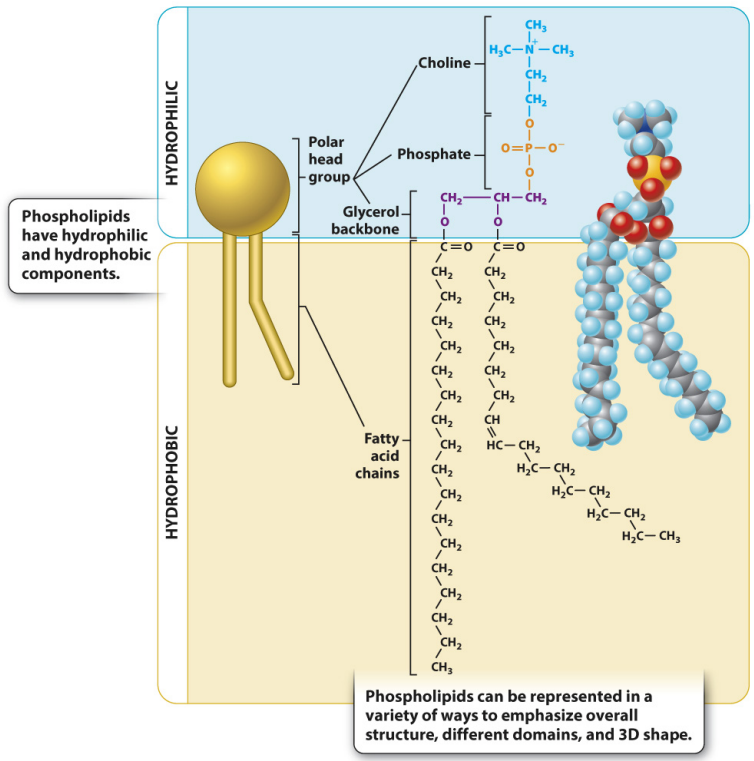


Figure 5.2
Biology: How Life Works, Second Edition
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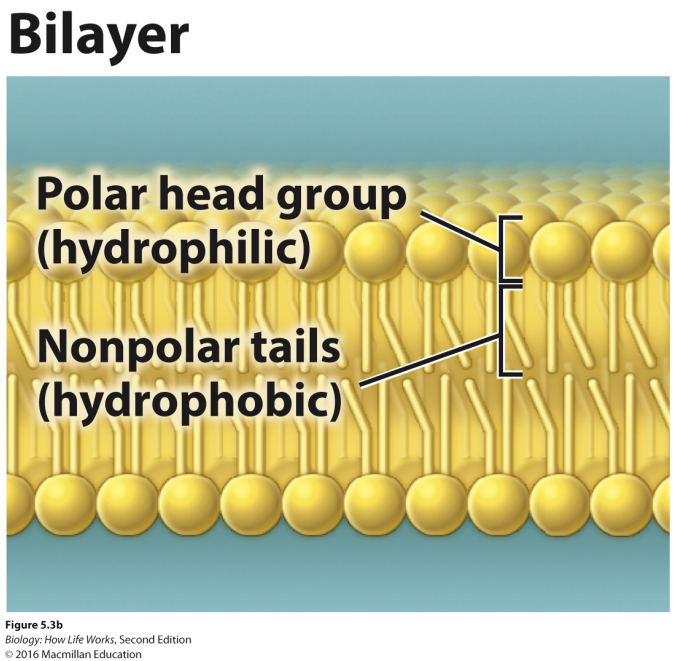

Figure 5.3b
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Phospholipid Bilayer

Shape formed in aqueous (water-based) solutions depends on structure

- Phospholipids with bulky heads and a single hydrophobic tail tend to form micelles
- Phospholipids with less bulky head groups and two hydrophobic tails tend to form bilayers

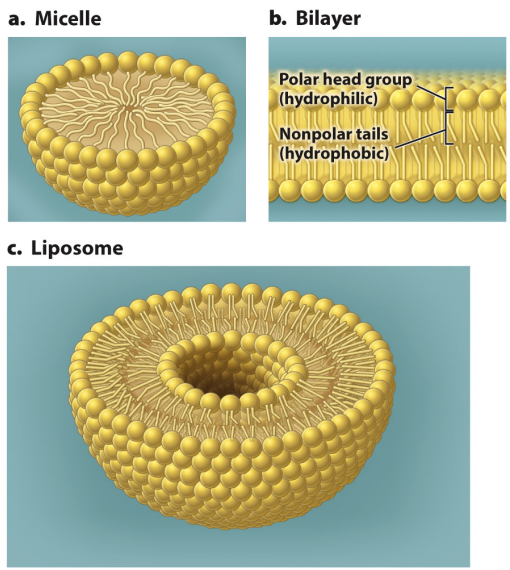


Figure 5.3
Biology: How Life Works, Second Edition

Phospholipid Bilayer

Other important components:

- Cholesterol
- Proteins

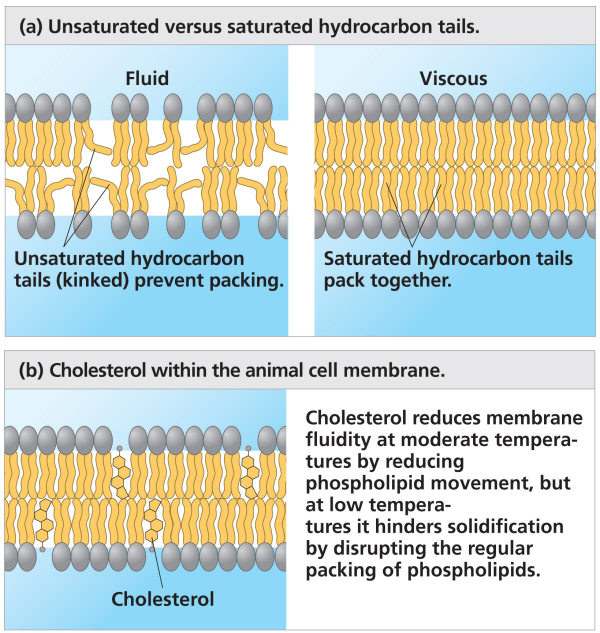
Phospholipid Bilayer

Other important components:

- Cholesterol
- Proteins

Phospholipid Bilayer

Cholesterol



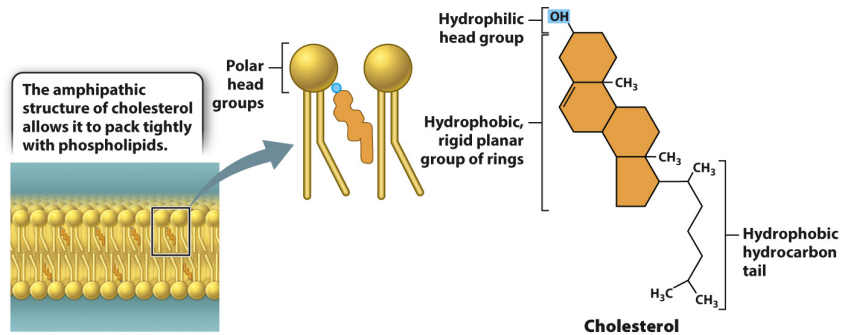


Figure 5.5
Biology: How Life Works, Second Edition

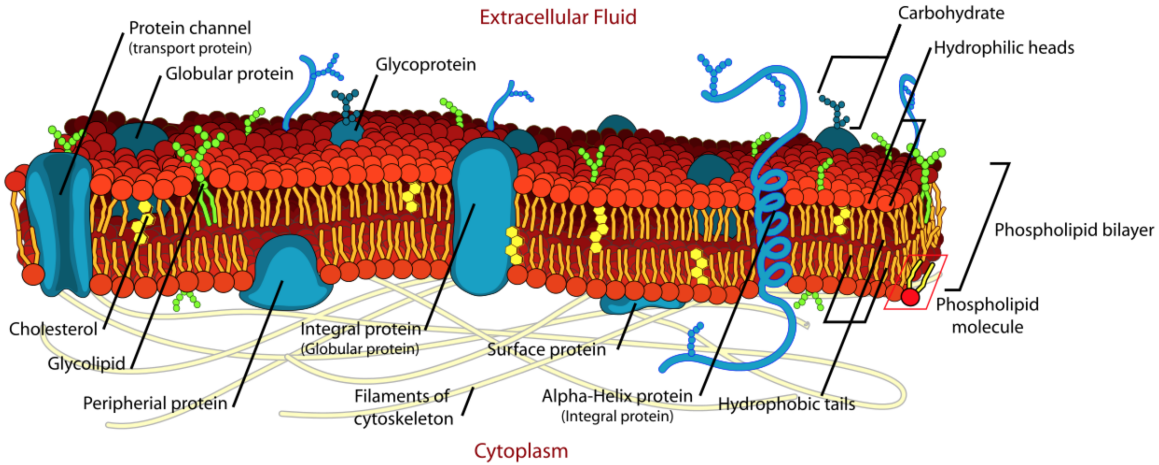
Phospholipid Bilayer

Other important components:

- Cholesterol
- Proteins

Phospholipid Bilayer

Proteins



Cell membranes are full of proteins that serve a number of different roles:

- Controlling what is aloud into and out of the cell
- Facilitating cellular communation
- Allowing cells to evaluate their environment
- etc.

We will deal with each of these throughout the term

Phospholipid Bilayer

Proteins

Proteins are not static in their position within the membrane

- Move around in a lateral manner
- "Fluid mosaic model"
  - Membrane is a mosaic of protein molecules bobbing around in the phospholipid bilayer

Cell Membranes Have Selective Permeability

Passive Transport

Does not require energy

1. Diffusion/osmosis
2. Facilitated diffusion
   - 2.1 Channel proteins
   - 2.2 Carrier proteins

Active Transport

Does require energy

Cell Membranes Have Selective Permeability

Passive Transport

Does not require energy

1. Diffusion/osmosis
2. Facilitated diffusion
   - 2.1 Channel proteins
   - 2.2 Carrier proteins

Active Transport

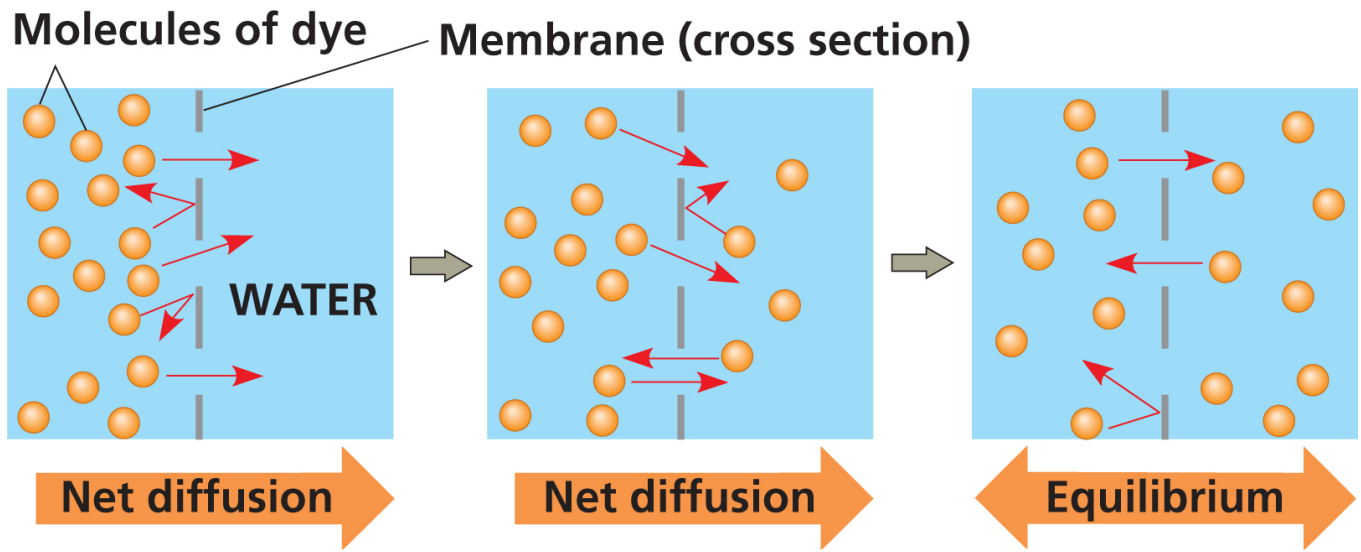
Does require energy

Passive Transport

Diffusion

When the concentration of molecules differs in different locations, they will move to equalize their concentration: "*Move down their concentration gradient*"

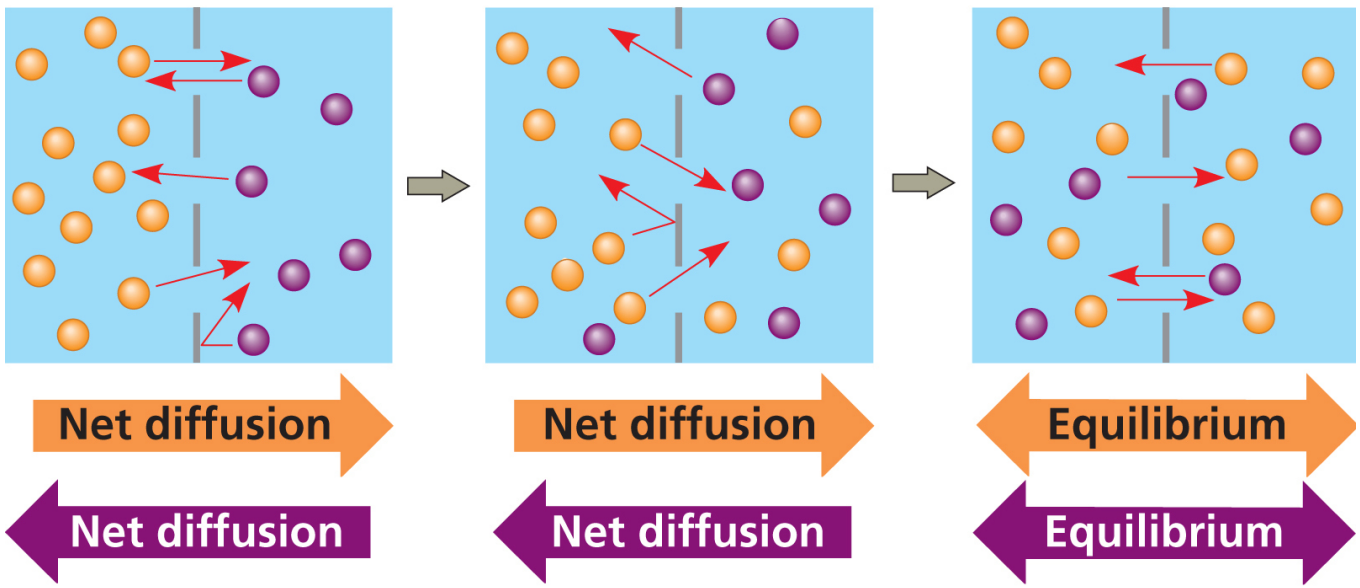
Reach a dynamic equilibrium: molecules still moving, but relative [ ] remains the same



Passive Transport

Diffusion

Equilibrium is independent for each molecule type (not overall!)



Passive Transport

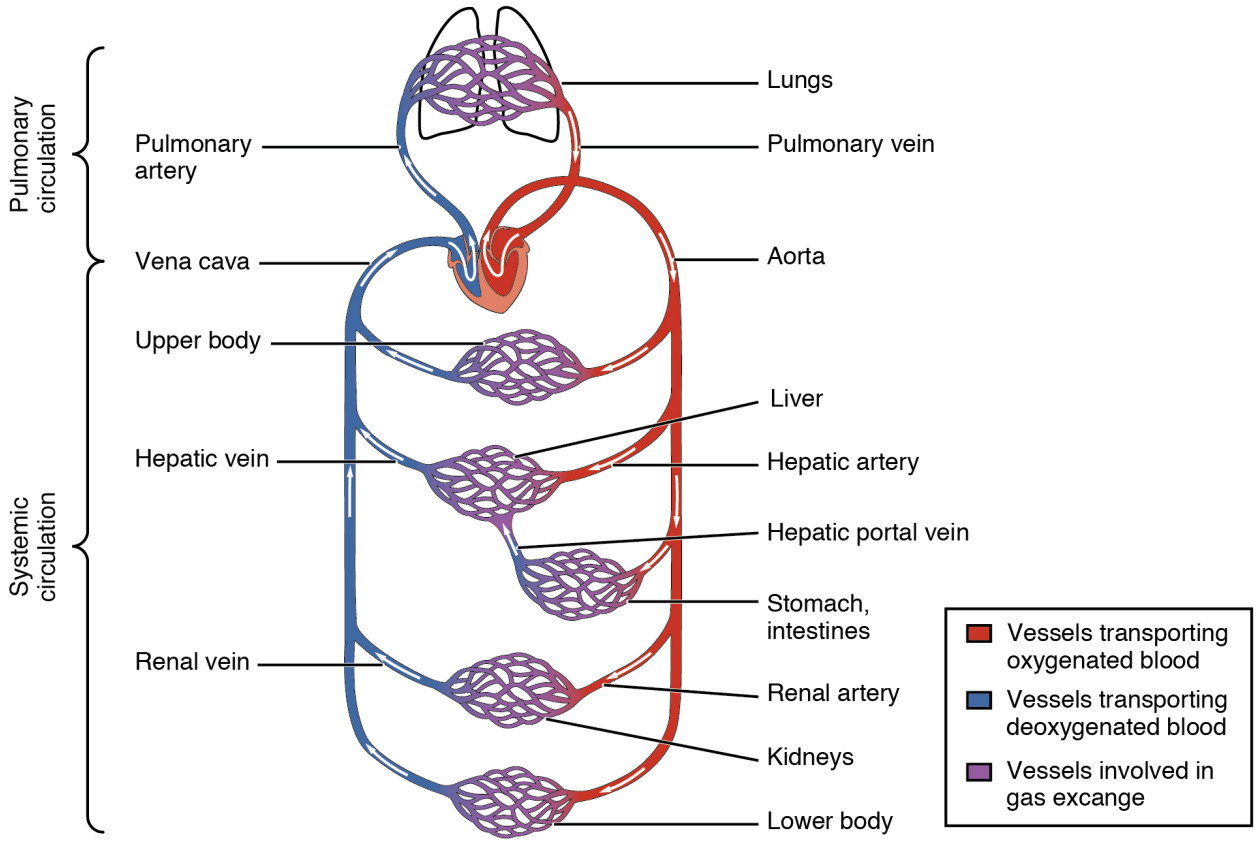
Diffusion

Small non-polar (hydrophobic) molecules can diffuse across the membrane

- O_2
- CO_2

Passive Transport

Diffusion

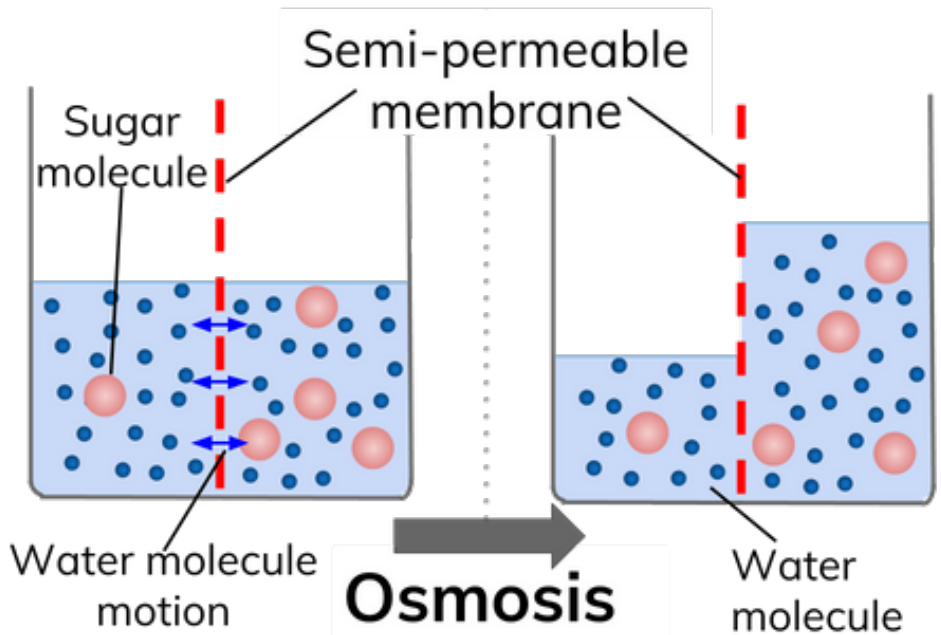


Passive Transport

Osmosis

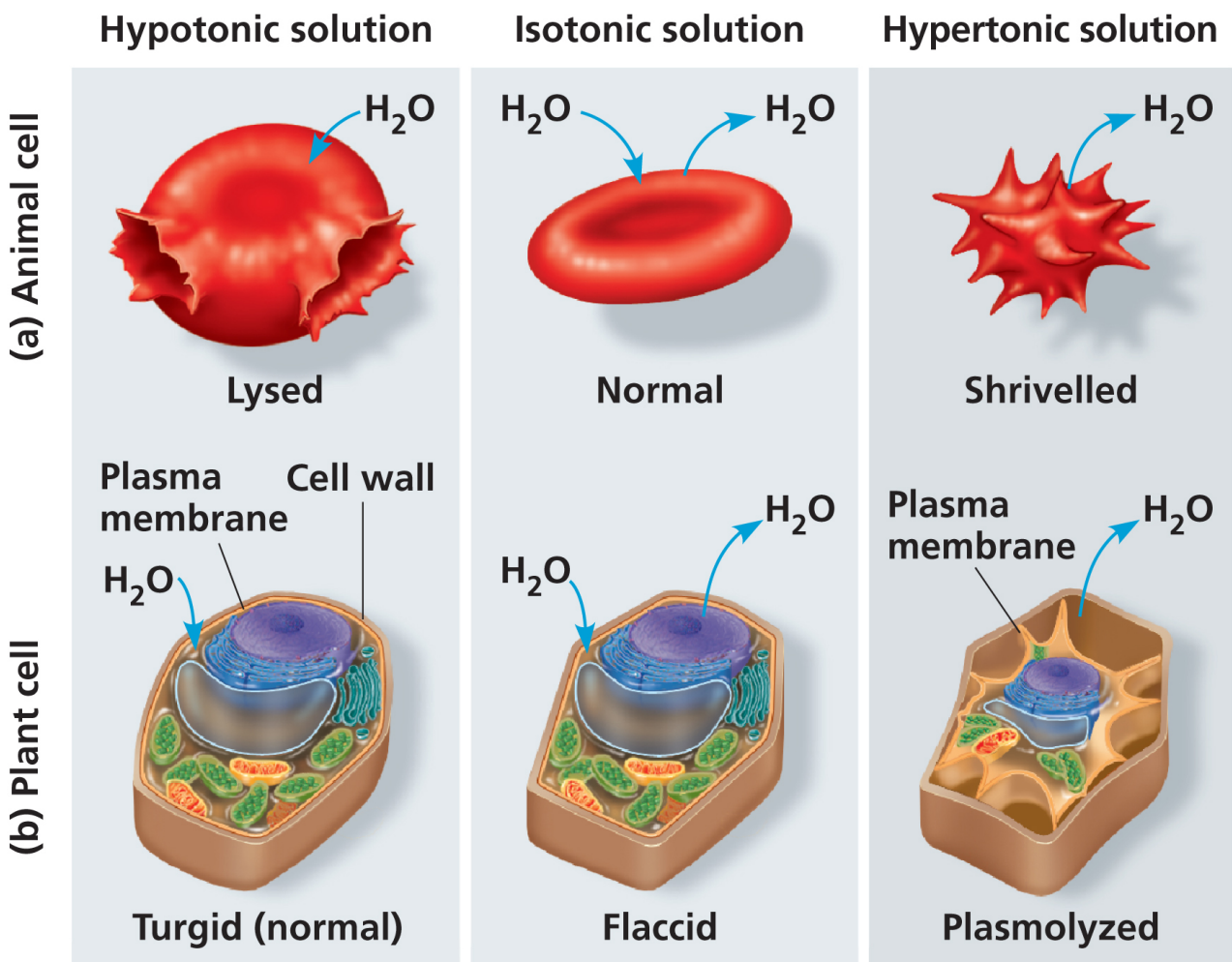
When the diffusing molecule is water

- Water mostly passes through specialized channels (not diffusion)
- Concept is similar to diffusion



Passive Transport

Osmosis



Passive Transport

Osmosis

Passive Transport

Passive Transport

Does not require energy

1. Diffusion/osmosis
2. Facilitated diffusion
   - 2.1 Channel proteins
   - 2.2 Carrier proteins

Active Transport

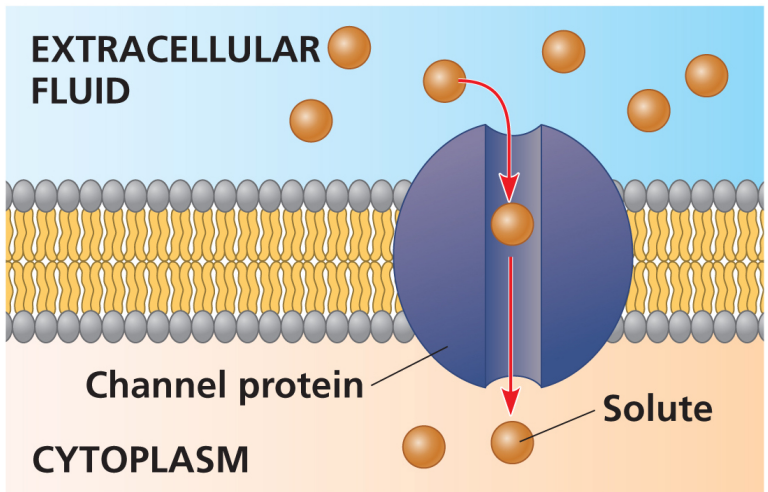
Does require energy

Passive Transport

Facilitated Diffusion 1 - Channel Proteins

Just provide a "safe" passageway through which molecules can pass

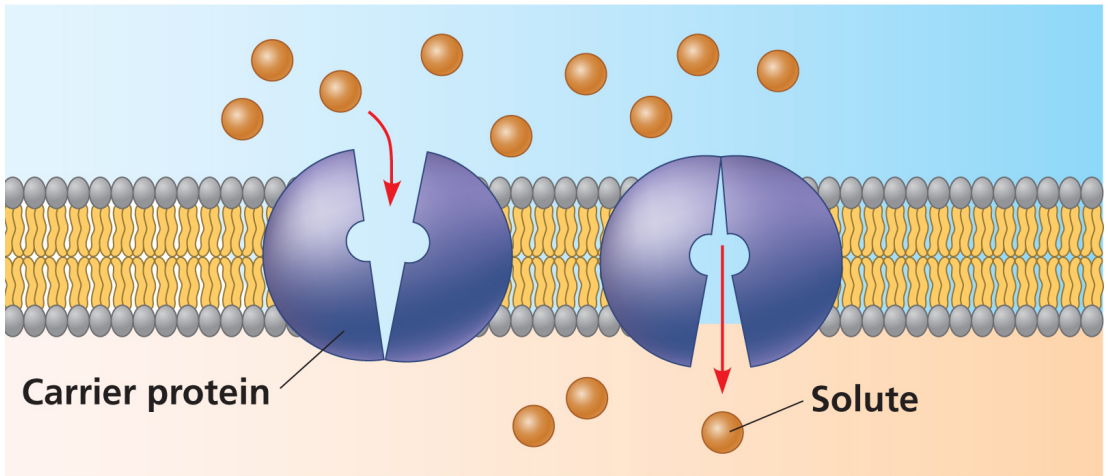
- Usually specialized for a particular molecule or type of molecules
- Aquaporins for water



Passive Transport

Facilitated Diffusion 2 - Carrier Proteins

Undergo a change in shape when bound to molecules that facilitates their passage through the membrane



Passive Transport

Facilitated Diffusion 2 - Carrier Proteins

Video

Passive Transport

Passive Transport

Does not require energy

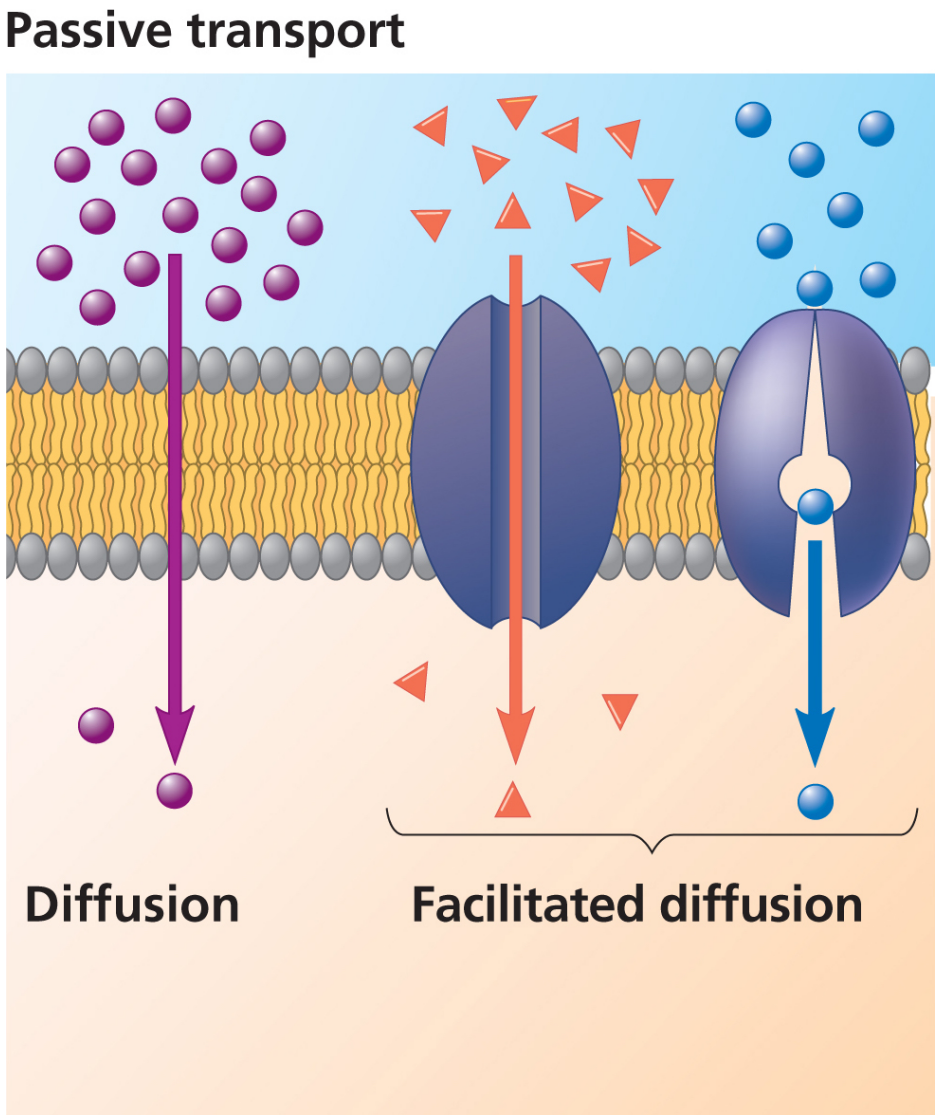
1. Diffusion/osmosis
2. Facilitated diffusion
   - 2.1 Channel proteins
   - 2.2 Carrier proteins

Active Transport

Does require energy

All involve molecules moving down their concentration gradient.

Passive Transport



Active Transport

Passive Transport

Does not require energy

1. Diffusion/osmosis
2. Facilitated diffusion
   - 2.1 Channel proteins
   - 2.2 Carrier proteins

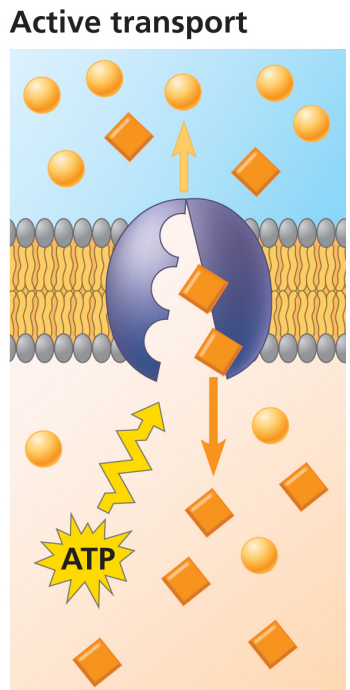
Active Transport

Does require energy

Active Transport

Moves molecules **against** their concentration gradient

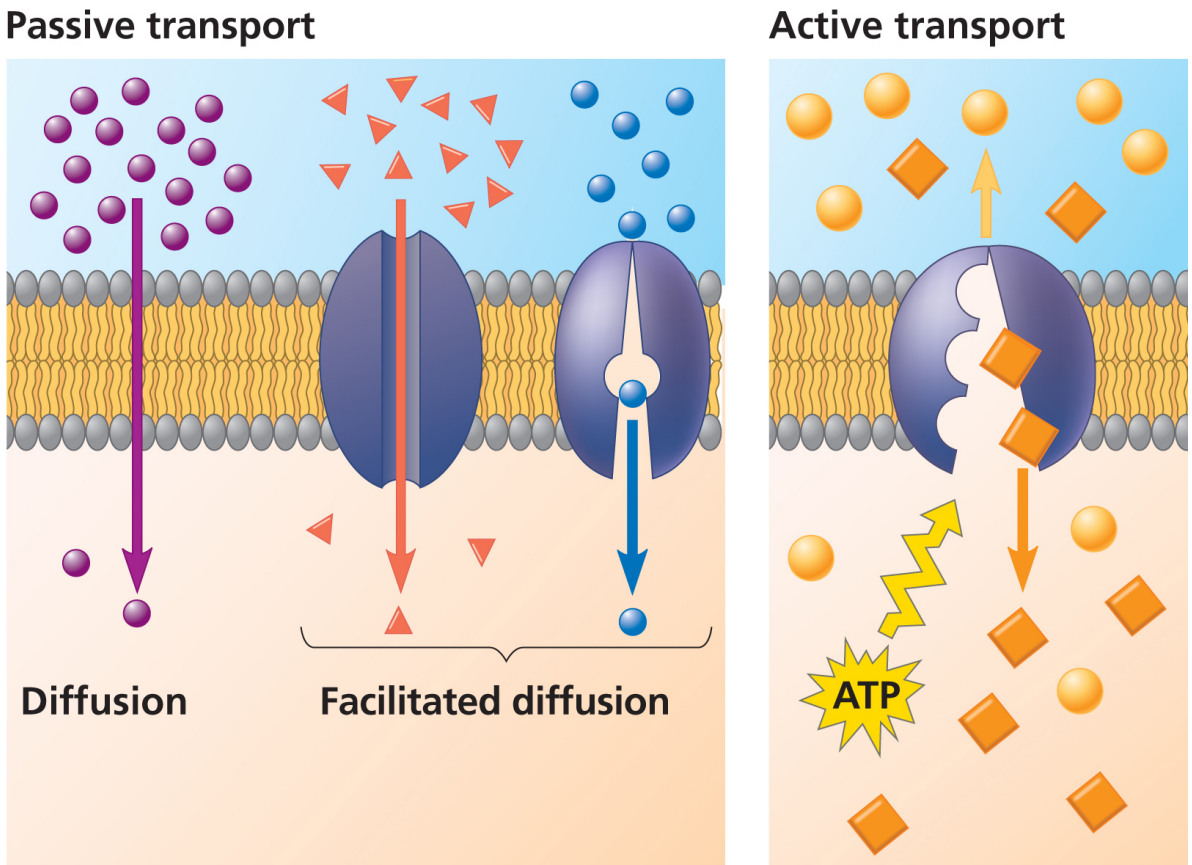
- Requires energy! (usually in the form of ATP)
- Extremely important: Allows cells to maintain internal conditions that are *different* from the external environment



Active Transport

Video

Selective Permeability

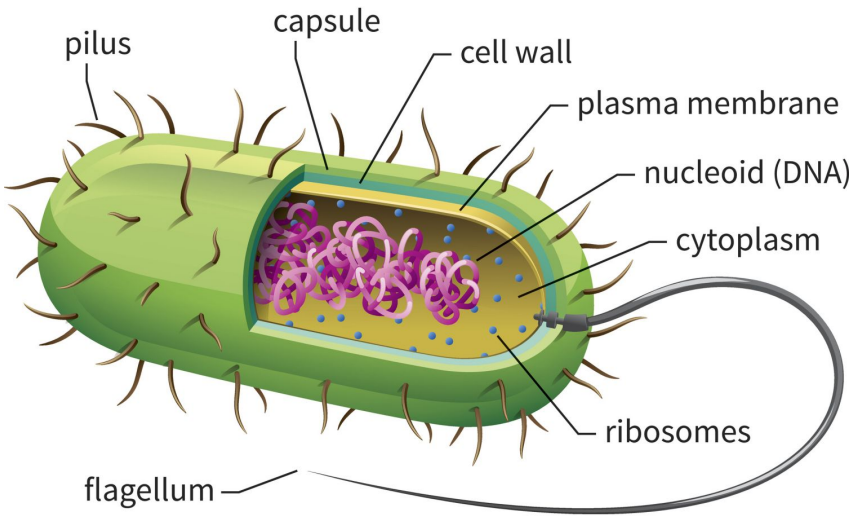


Internal Components of the Cell

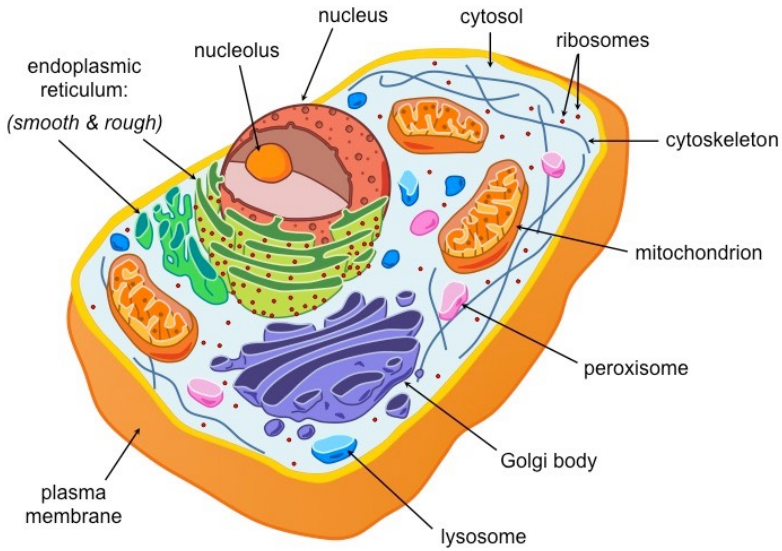
Are two main types of cells: **prokaryotic** cells and **eukaryotic** cells

Characteristic	**Prokaryotes**	**Eukaryotes**
Size	`small (1-5`μ`m)`	`larger (10-100`μ`m)`
Nucleus	`No`	`Yes`
Membrane-bound organelles	`No`	`Yes`
DNA	`single, circular chromosome`	`paired chromosomes, often many`
etc.		

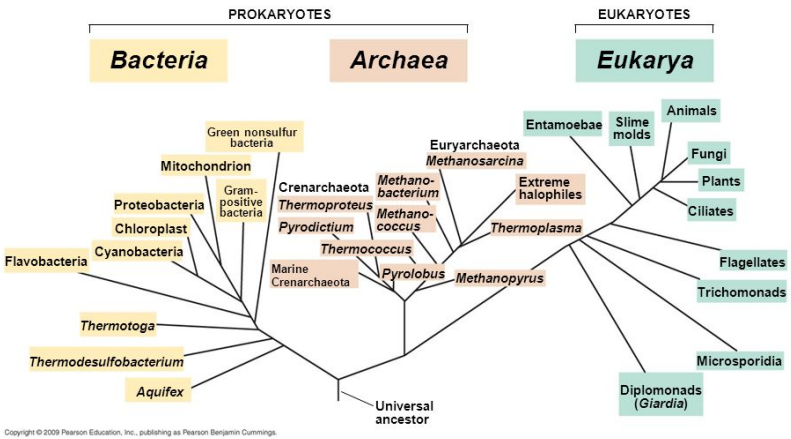
Prokaryotic Cell

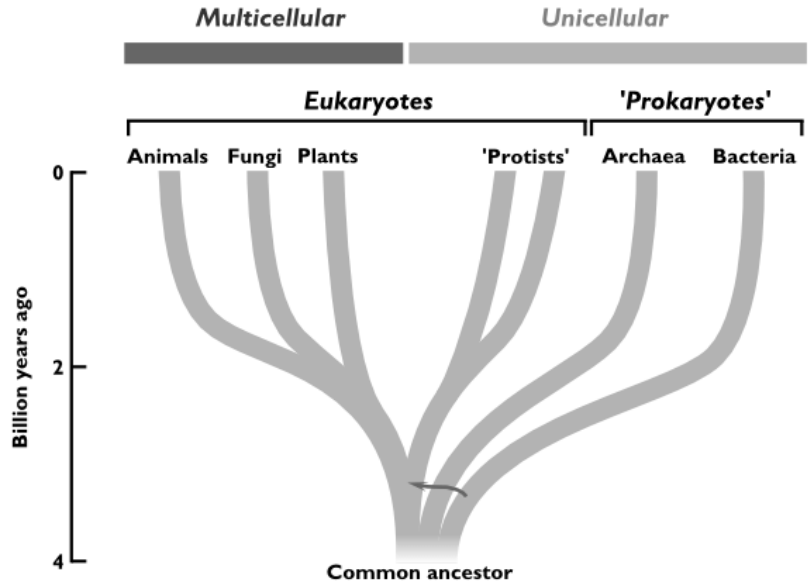


Eukaryotic Cell



Tree of life



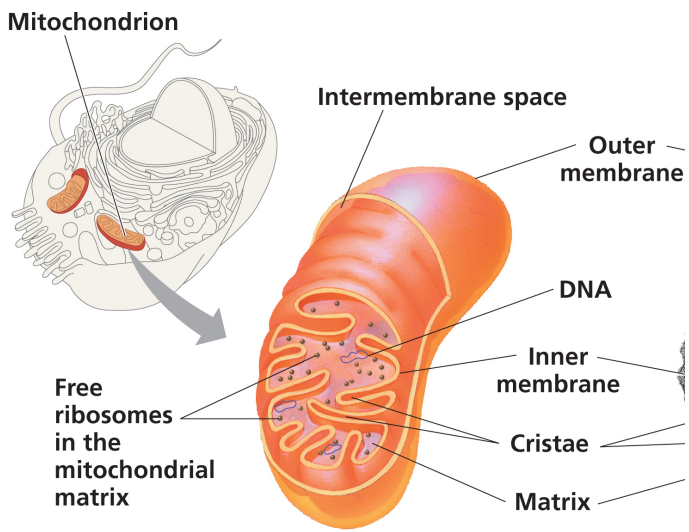


Prokaryotes & Eukaryotes

How are they related?

First clue came from mitochondria:

- The energy producers of the cell
- About the size of a prokaryote cell
- Have their own circular DNA molecule, just like prokaryotes (that you inherit from mom)

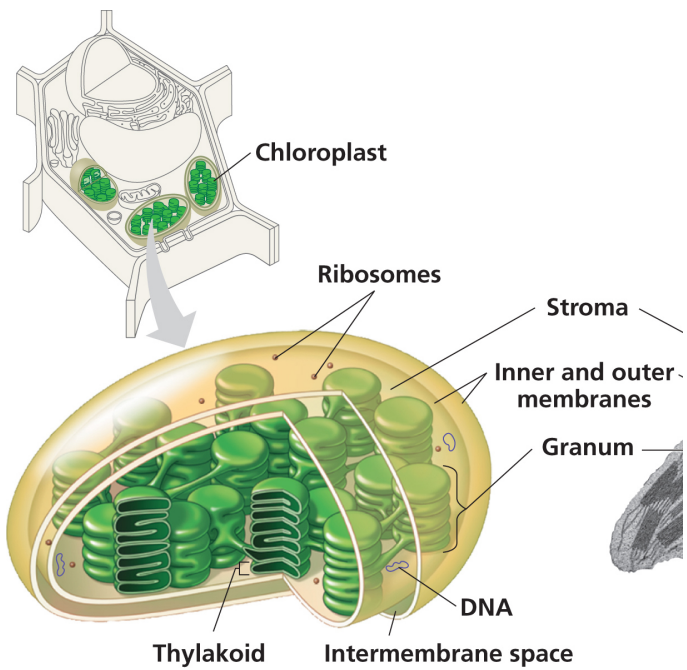


Prokaryotes & Eukaryotes

How are they related?

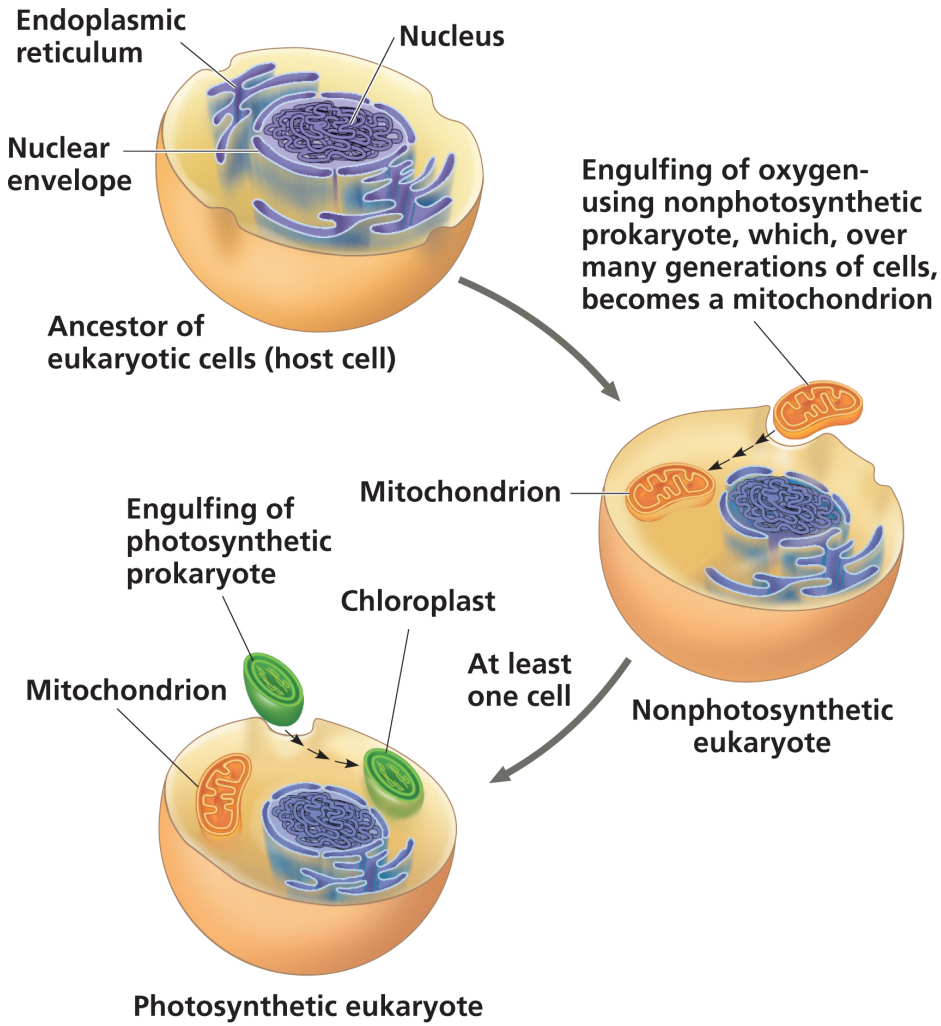
Similar situation with chloroplasts (plants):

- Convert sunlight into chemical energy
- About the size of a prokaryote cell
- Have their own circular DNA molecule, just like prokaryotes (that you inherit from mom)

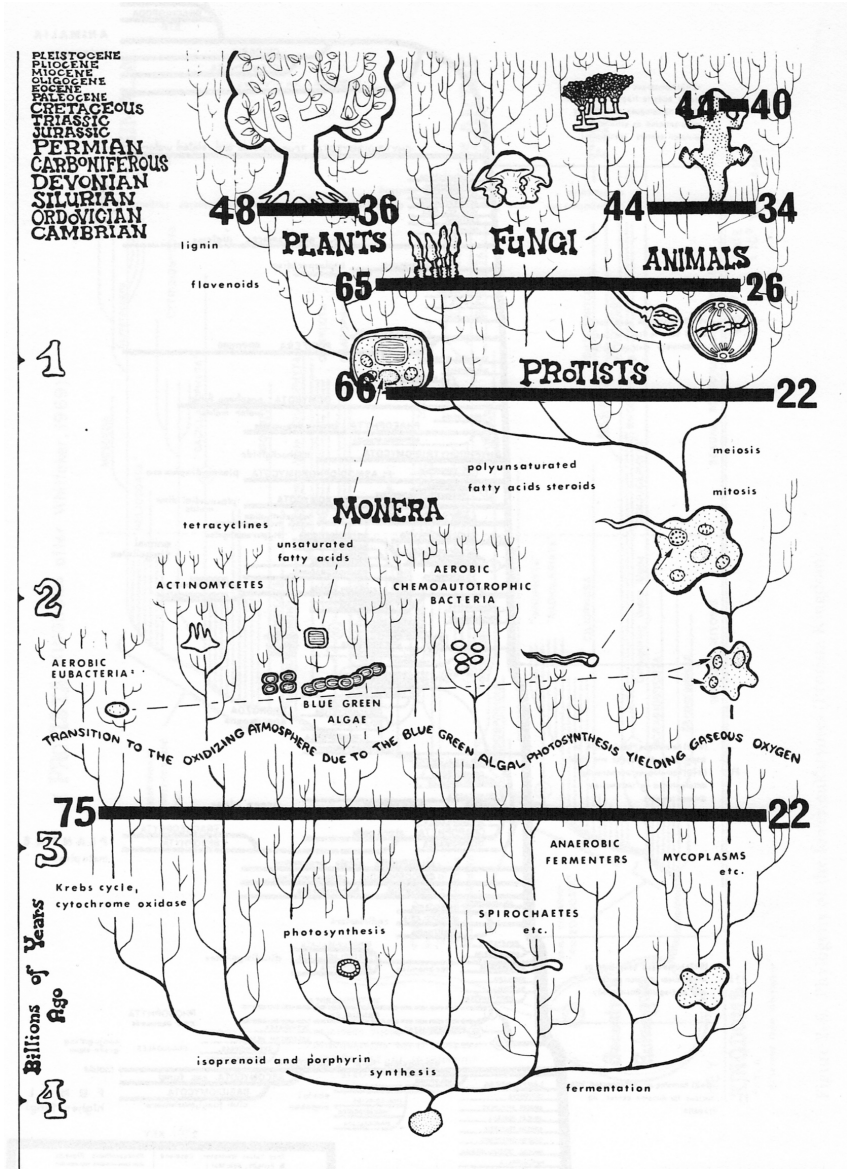


Prokaryotes & Eukaryotes

Endosymbiont theory



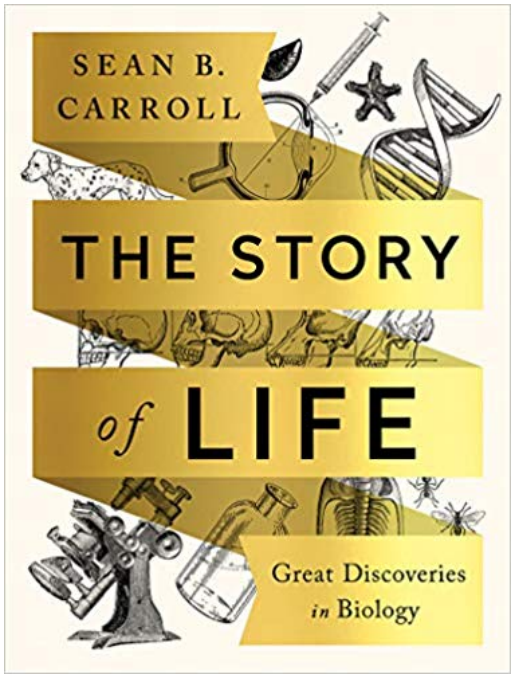
Prokaryotes & Eukaryotes



From Margulis L (1970) *Origin of Eukaryotic Cells*. Yale University Press.

Case Study

Chapter 9



Lynn Margulis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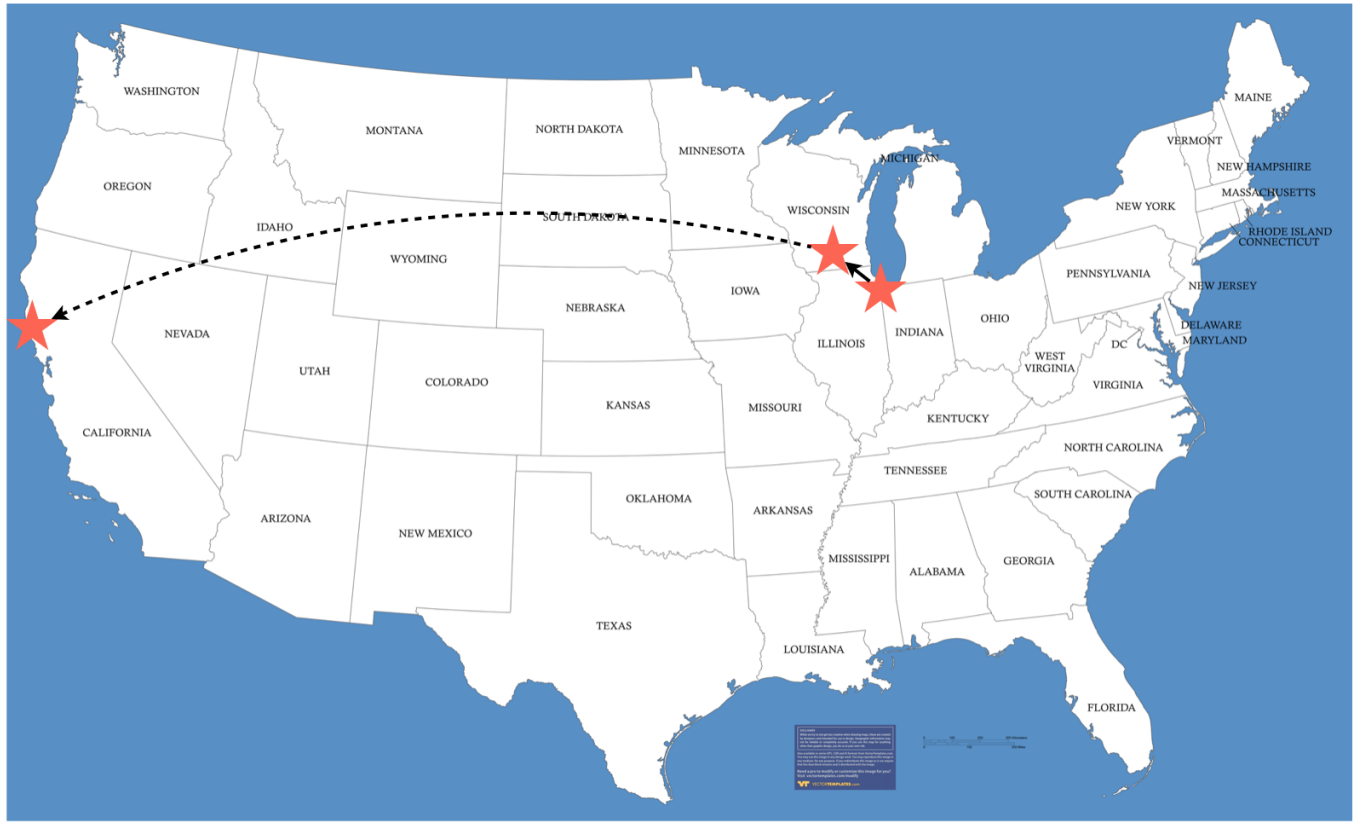
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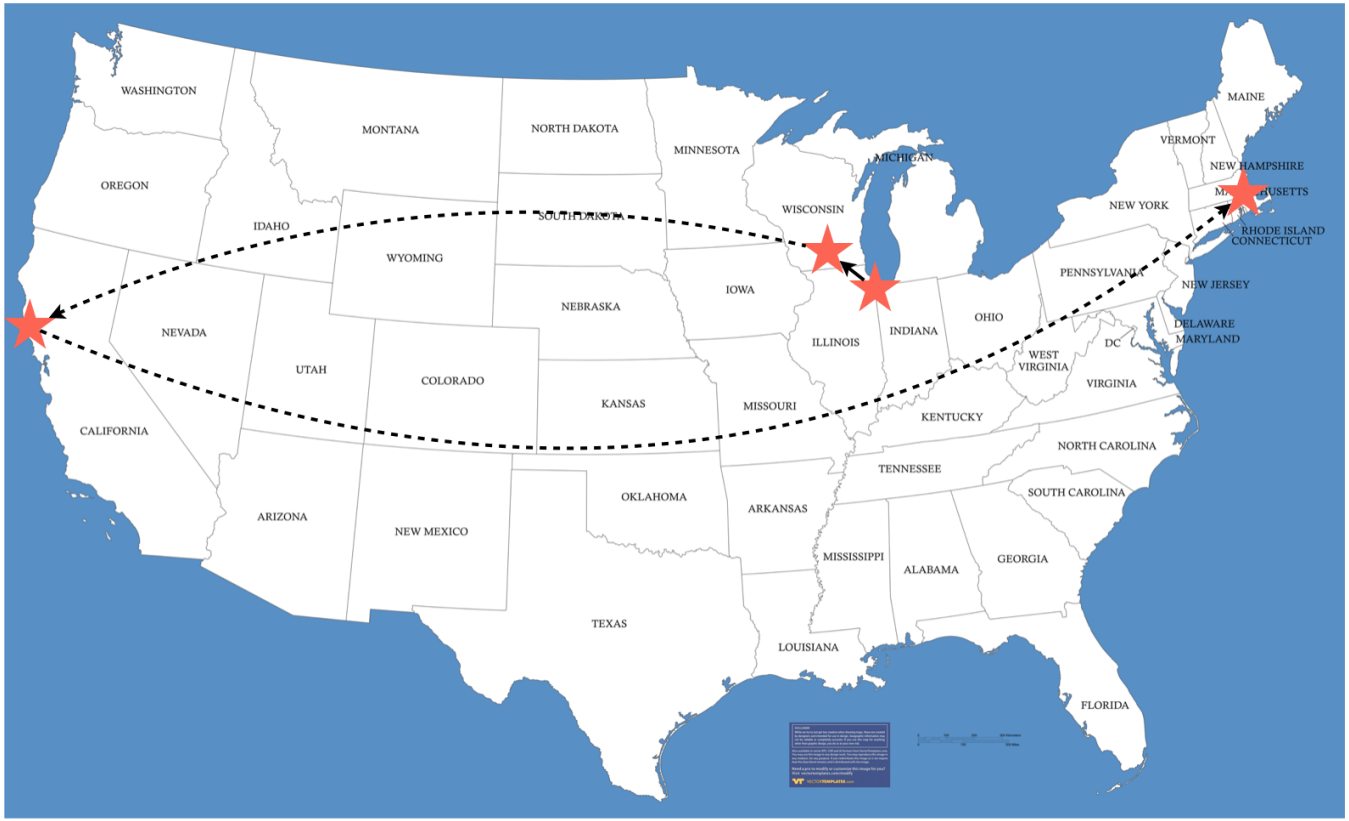
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DELAWARE
MARYLAND
DC

Internal Structures

1. Nucleus

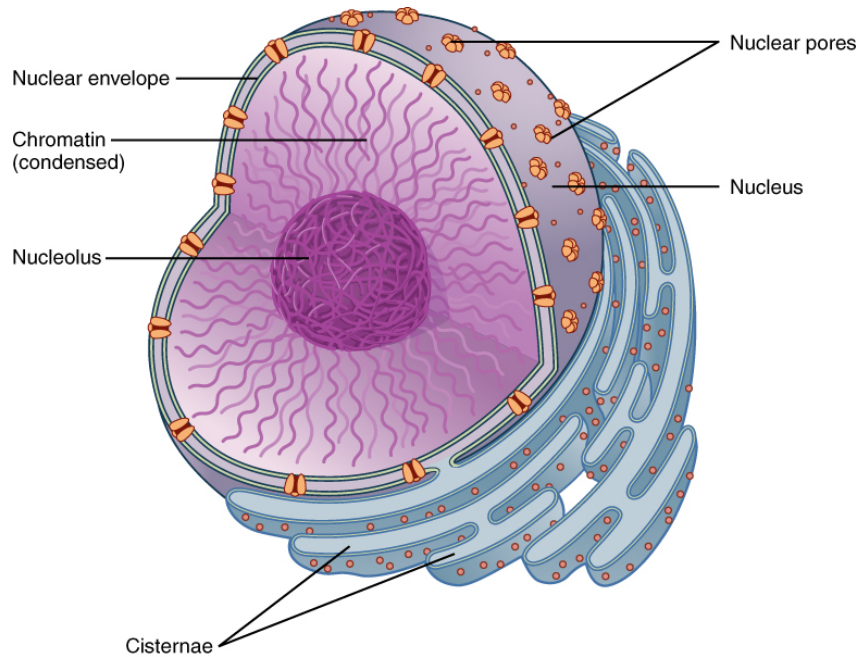
Has 2 bilayers instead of 1

- Outer one joins ER

Pores for allowing movement of molecules in and out

Nucleolus: Where ribosomal RNA, and ribosomes are synthesized (will come back to these later)

Chromatin: DNA + proteins

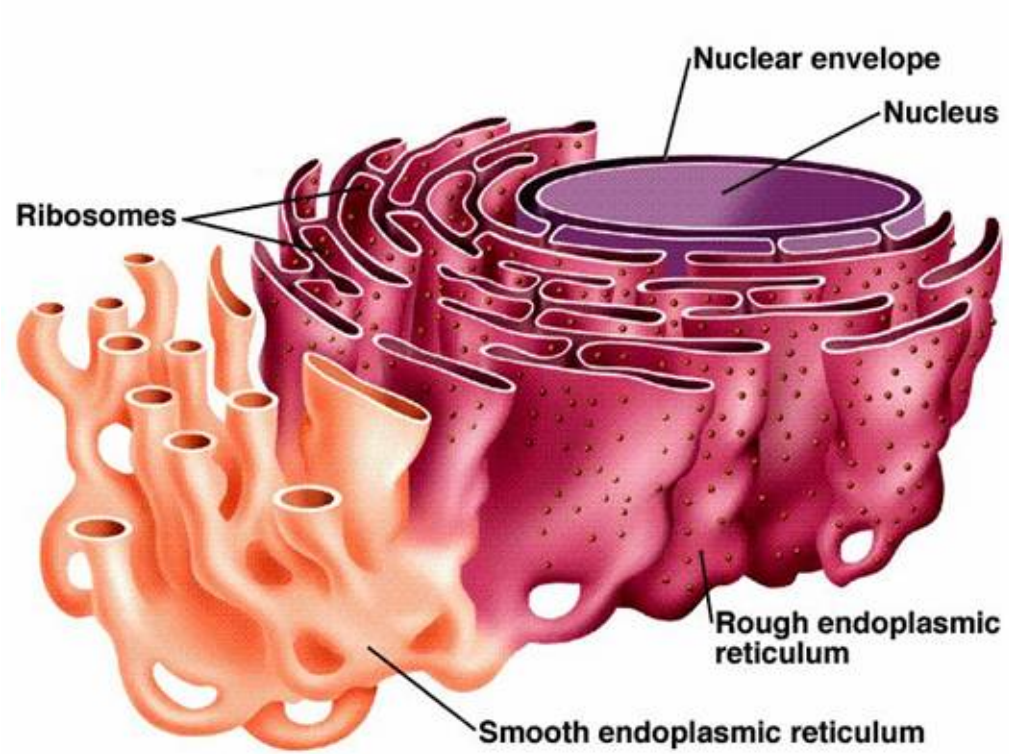


Internal Structures

2. Rough Endoplasmic Reticulum (ER)

Studded with ribosomes

Where proteins are synthesized

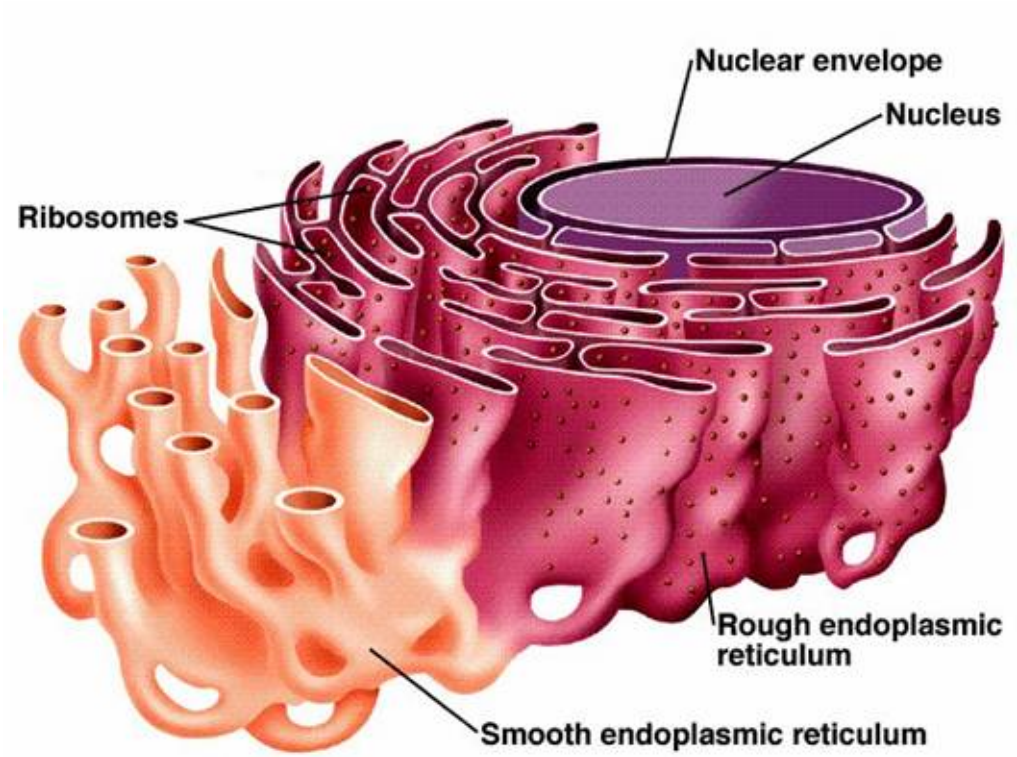


Internal Structures

3. Smooth Endoplasmic Reticulum (ER)

Variety of functions depending on cell type, including:

- Synthesis of lipids
- Metabolism of carbohydrates
- Detoxification of drugs and poisons (especially in the liver)

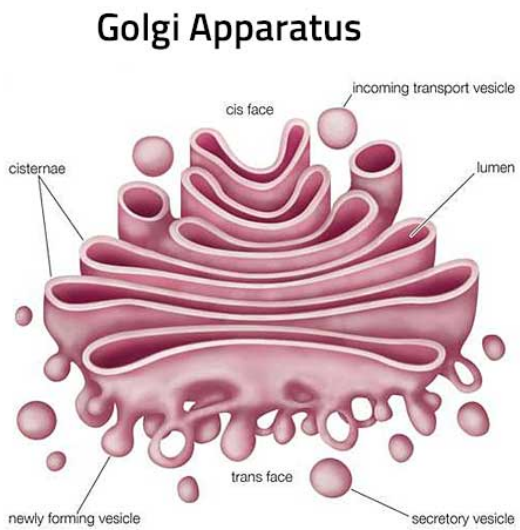


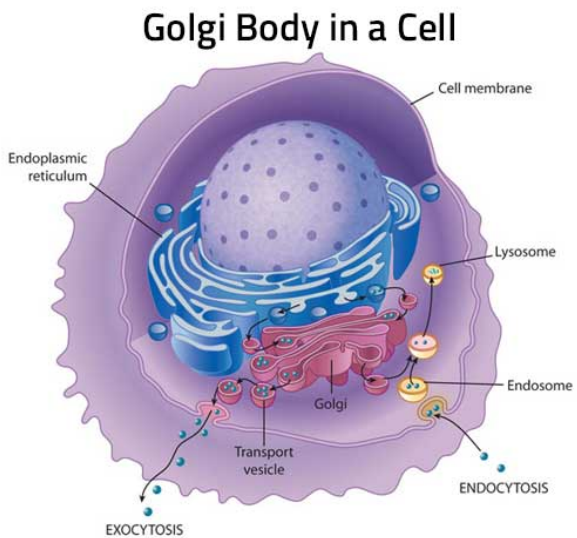
Internal Structures

4. Golgi Apparatus

Modification and sorting of products of the ER

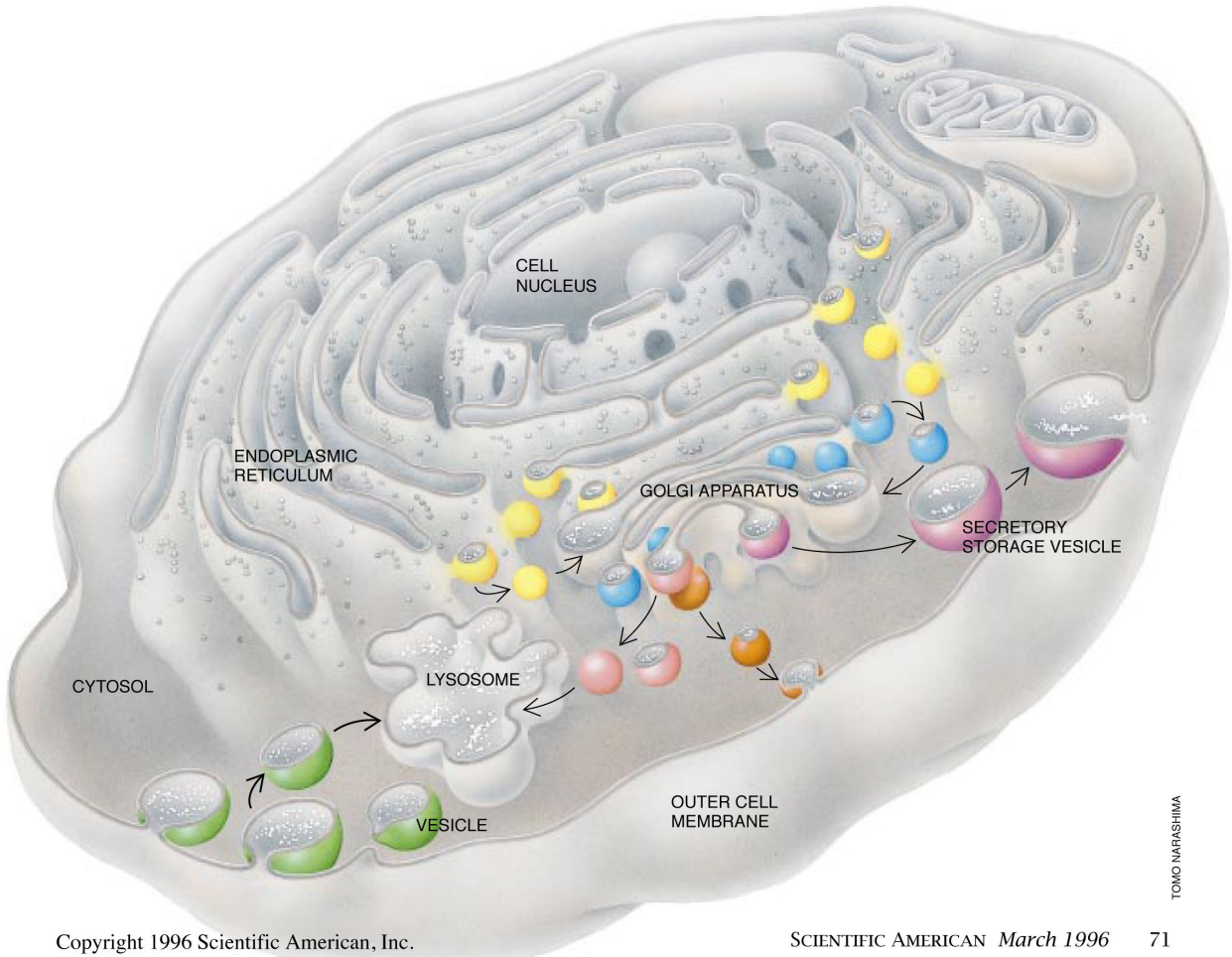
Each section (cisternae) a different stage of modification





Internal Structures

5. Vesicles



SCIENTIFIC AMERICAN *March 1996* 71

Video

Organelles that transform energy

Internal Structures

6. Mitochondria

Sugars and other molecules broken down into ATP

Have an inner and outer membrane

in cell depends on cell's function

Present in animal and plant cells

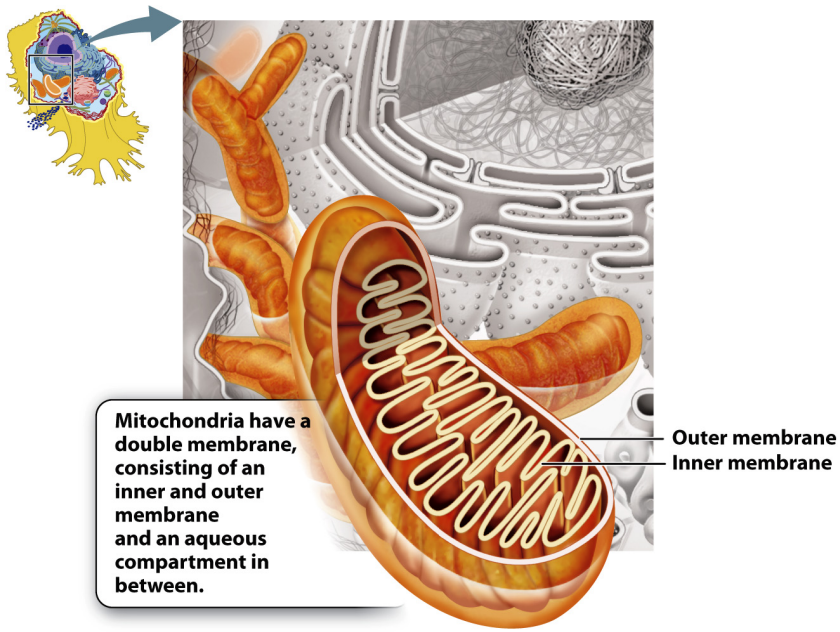


Figure 5.27 part 1
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Internal Structures

7. Chloroplasts

Use energy from the sun to synthesize simple sugars (**photosynthesis**)

Like the nucleus, also have a double-membrane system

Also have an internal membrane called the **thylakoid**

- Contains light-collecting pigments such as **chlorophyll** - green

Present in plants and green algae

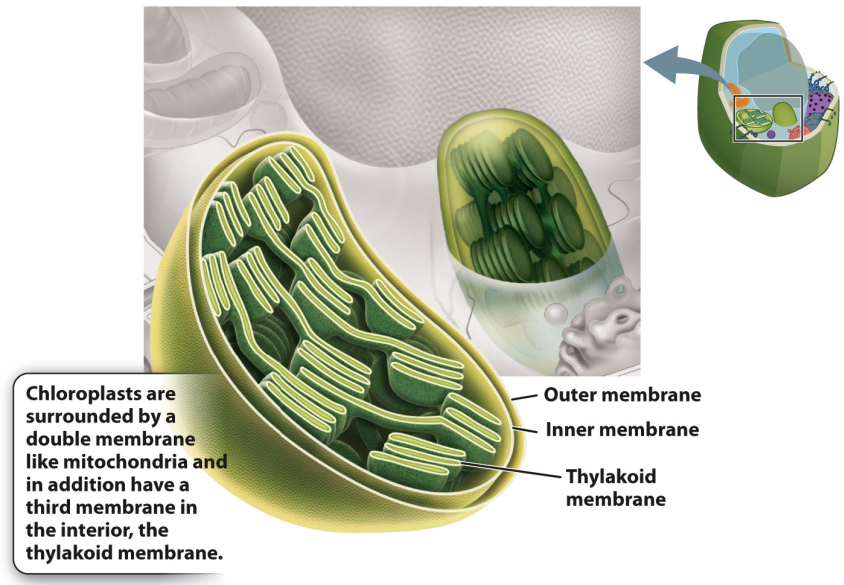

Figure 5.28 part 1
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