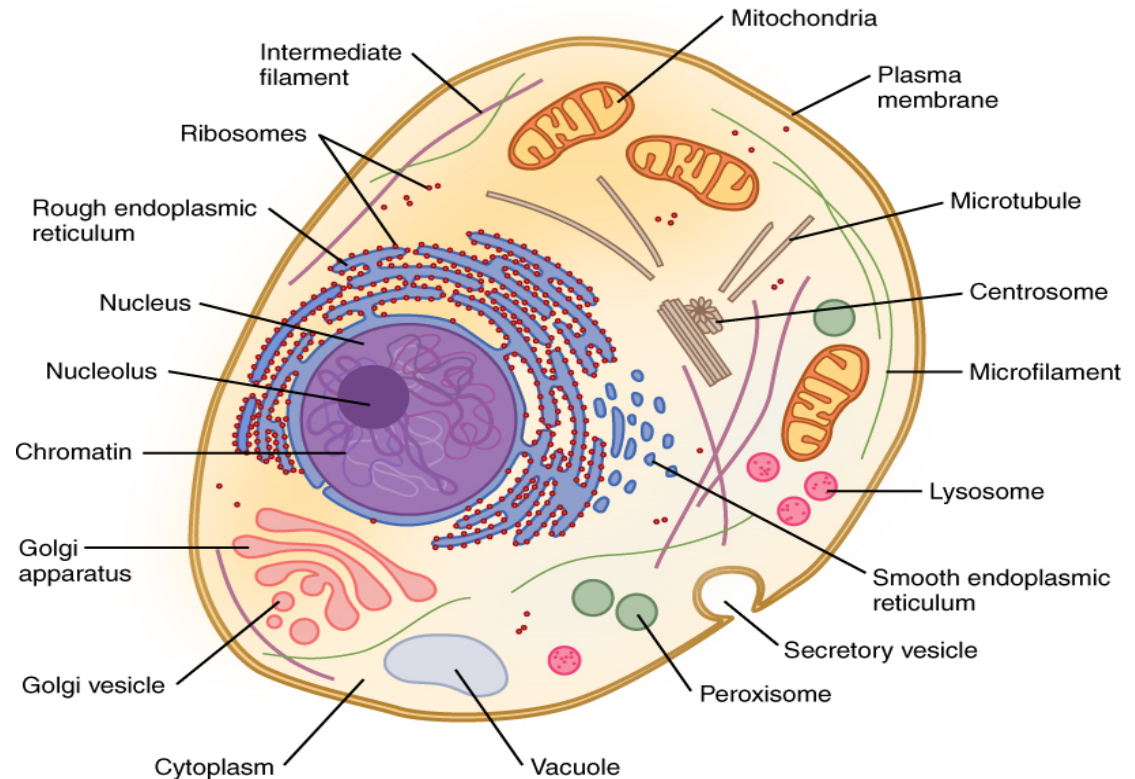


BIOLOGY 1103/1109

Human Anatomy and Physiology I

UNIT 4

Cell structure and function



Cell structure and function

Objectives

1. Specify the characteristics associated with life and explain why the cell is considered to be the basic unit of life.
2. Describe the levels of structural organization in the body.
3. Describe the structure and the function of major components of a cell.
5. Define metabolism and distinguish between anabolism and catabolism.
6. Describe the cellular processes involved in the growth of the human body from a fertilized egg cell to an adult.
7. Define cell specialization and describe its importance to an organism.
8. Describe the general characteristics of each of the following cell types and relate their characteristics to their functions: nerve cell, muscle cell, red blood cell white blood cell.

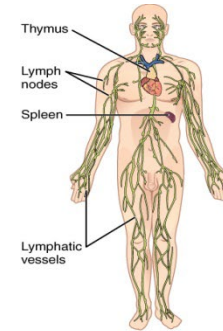
What is life?

What are the characteristics of life?

Characteristics of living organisms:

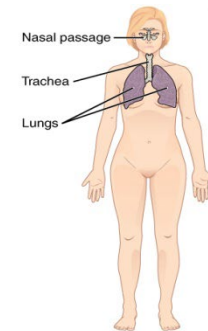
organization

- Cells and organ systems that are **organized** in a way that maintains distinct internal compartments which are separate from the external environment.



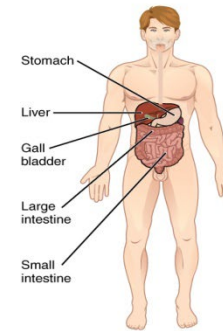
Lymphatic System

- Returns fluid to blood
- Defends against pathogens



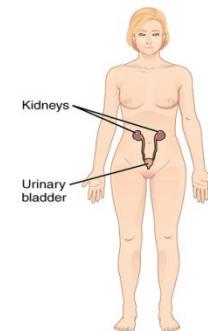
Respiratory System

- Removes carbon dioxide from the body
- Delivers oxygen to blood



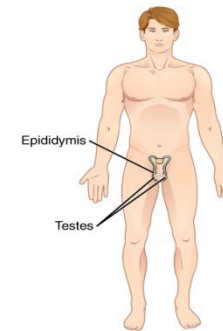
Digestive System

- Processes food for use by the body
- Removes wastes from undigested food



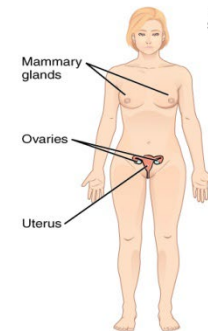
Urinary System

- Controls water balance in the body
- Removes wastes from blood and excretes them



Male Reproductive System

- Produces sex hormones and gametes
- Delivers gametes to female



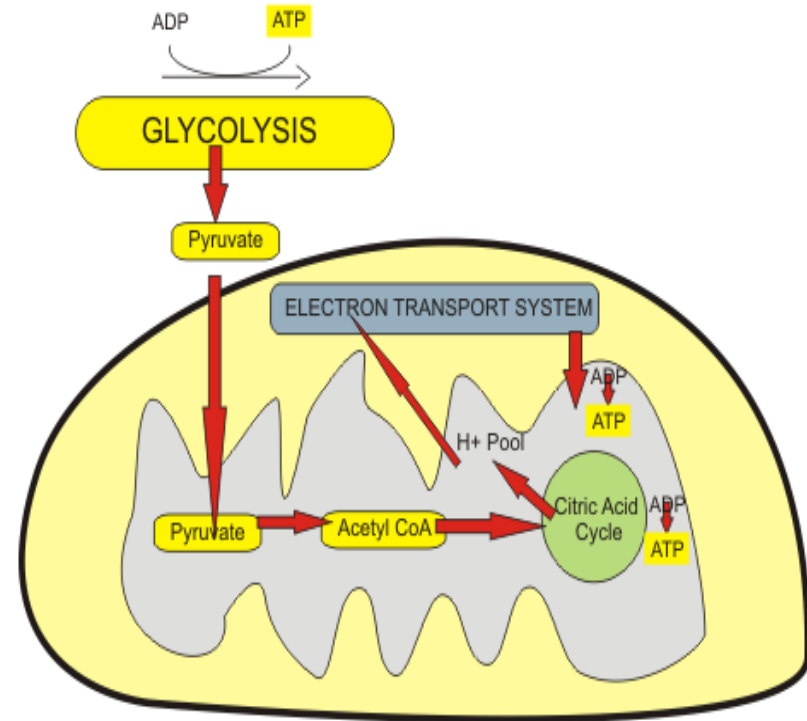
Female Reproductive System

- Produces sex hormones and gametes
- Supports embryo/fetus until birth
- Produces milk for infant

Characteristics of living organisms: obtain energy from organic molecules (metabolism)



Wikipedia

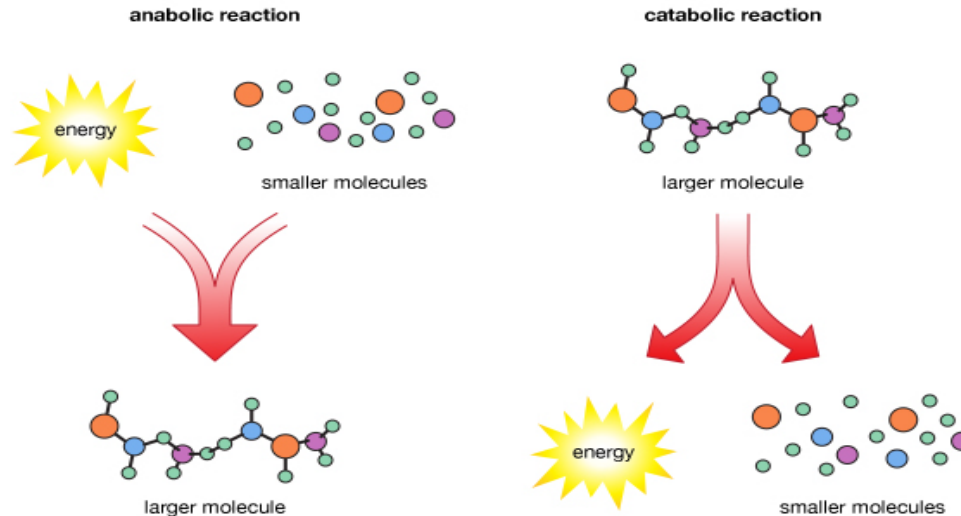


Frank Bounphrey M.D. 2009

- Cell metabolism is the **sum** total of all the chemical processes that occur in a cell

Metabolic reactions

Metabolism



© 2013 Encyclopædia Britannica, Inc.

Anabolism:

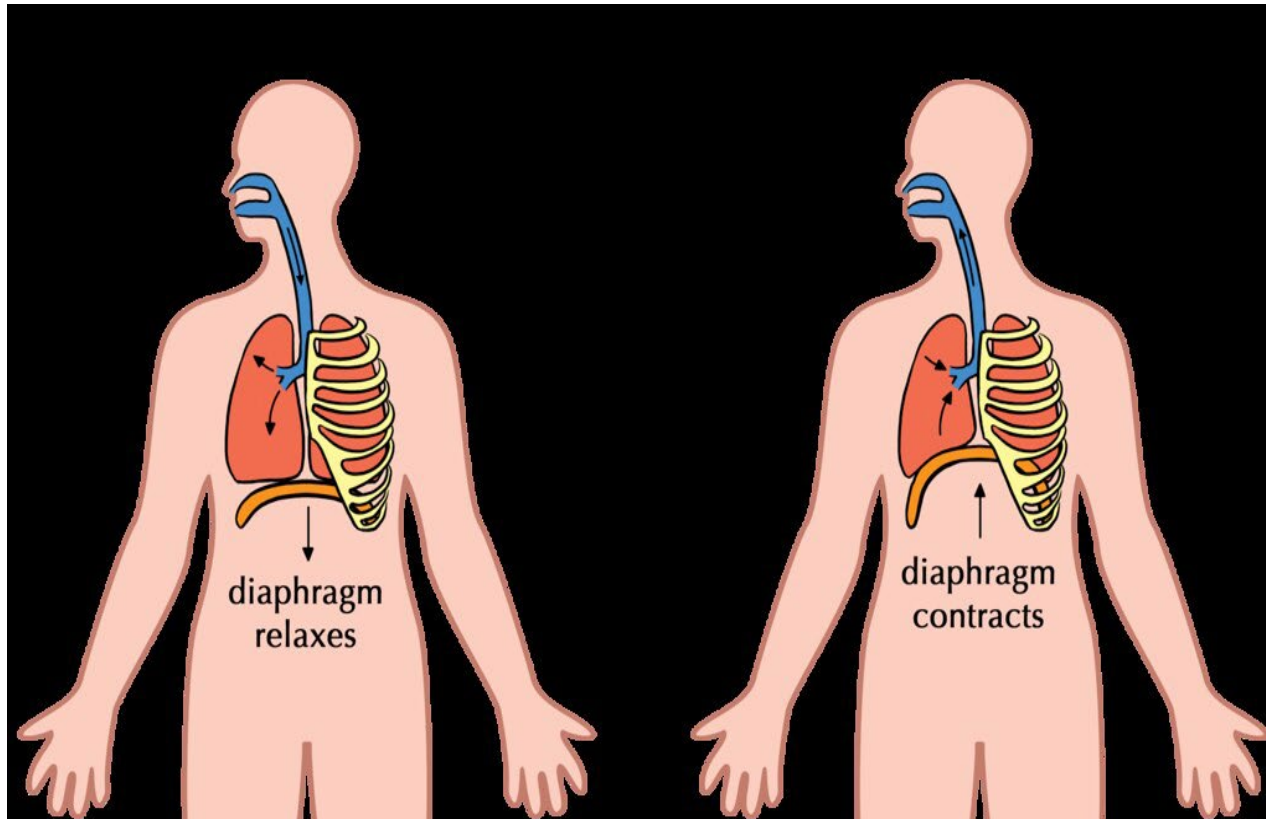
- **Build** complex molecules from simple building block molecules
- Involves creating new chemical bonds
- Energy (ATP) is used
- E.g. Protein synthesis

Catabolism:

- Breakdown complex molecules into simpler ones that may be used as building blocks
- Involves breaking chemical bonds
- Energy (ATP) is released
- E.g. “Burning” of glucose

Characteristics of living organisms:

exchange materials with the environment



Flickr

Characteristics of living organisms: respond to stimuli from the environment (responsiveness)



Wikimedia Commons



Pixabay

Characteristics of living organisms:

movement

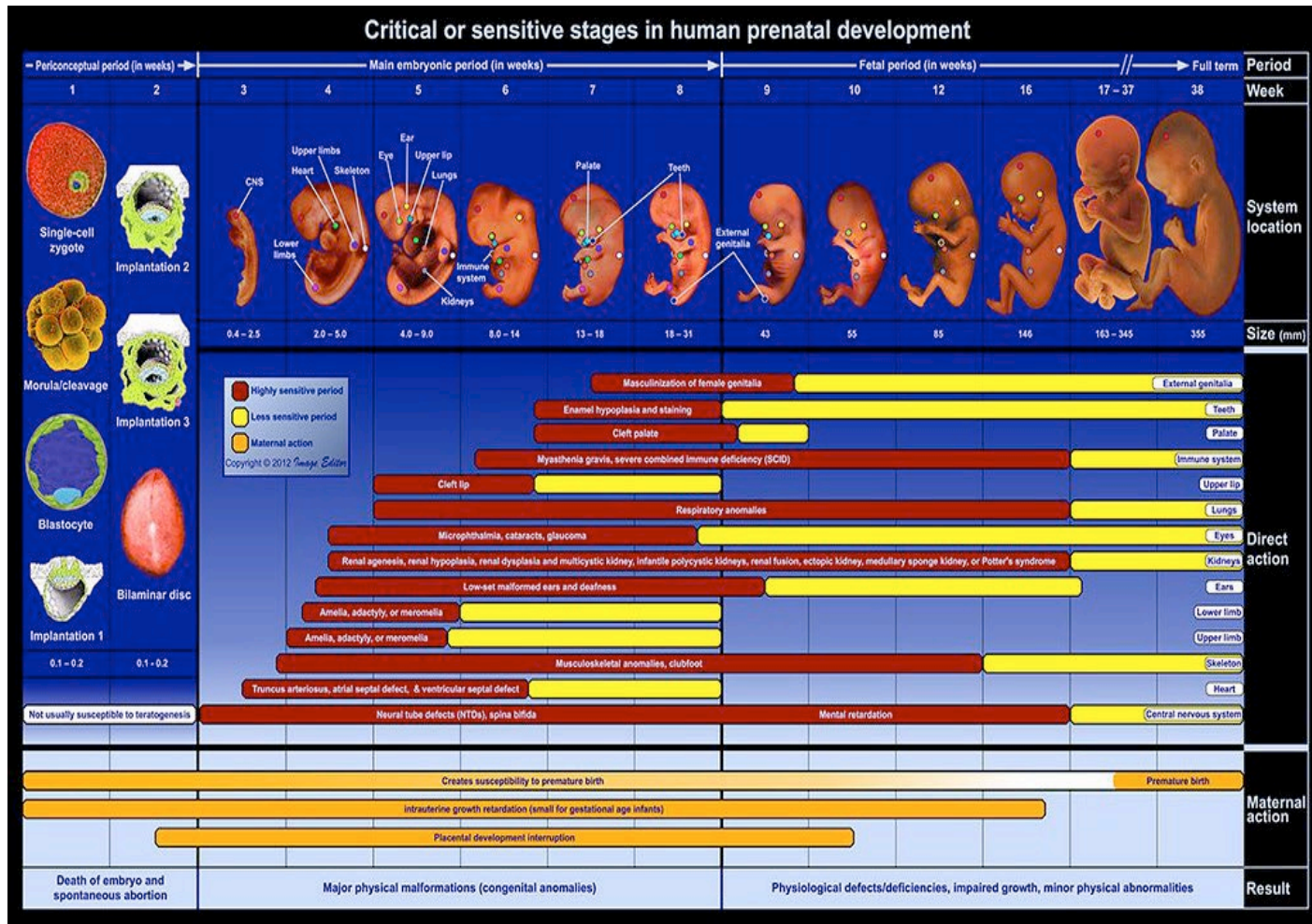


PxHere

Characteristics of living organisms:

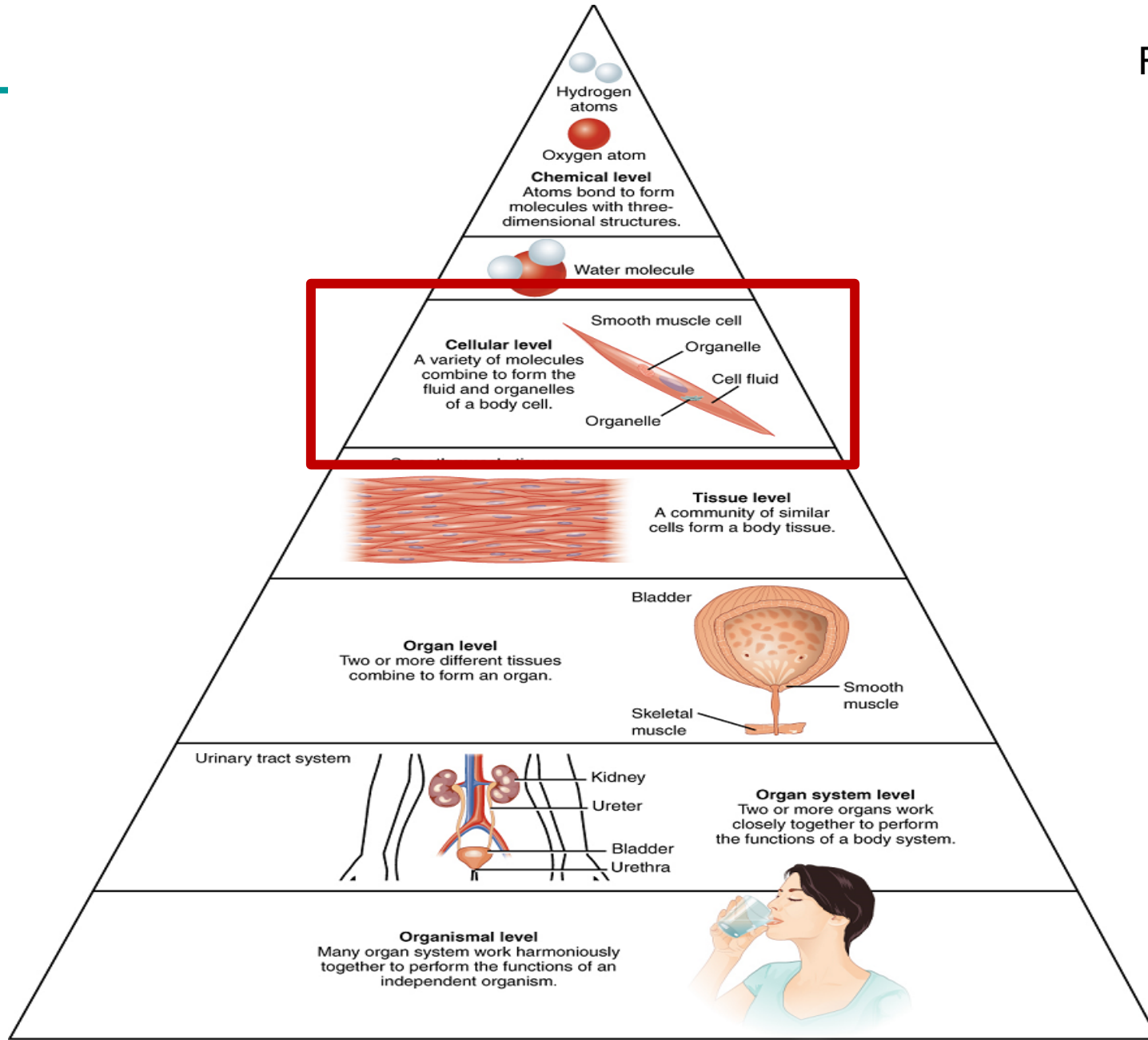
Development, growth and

reproduction



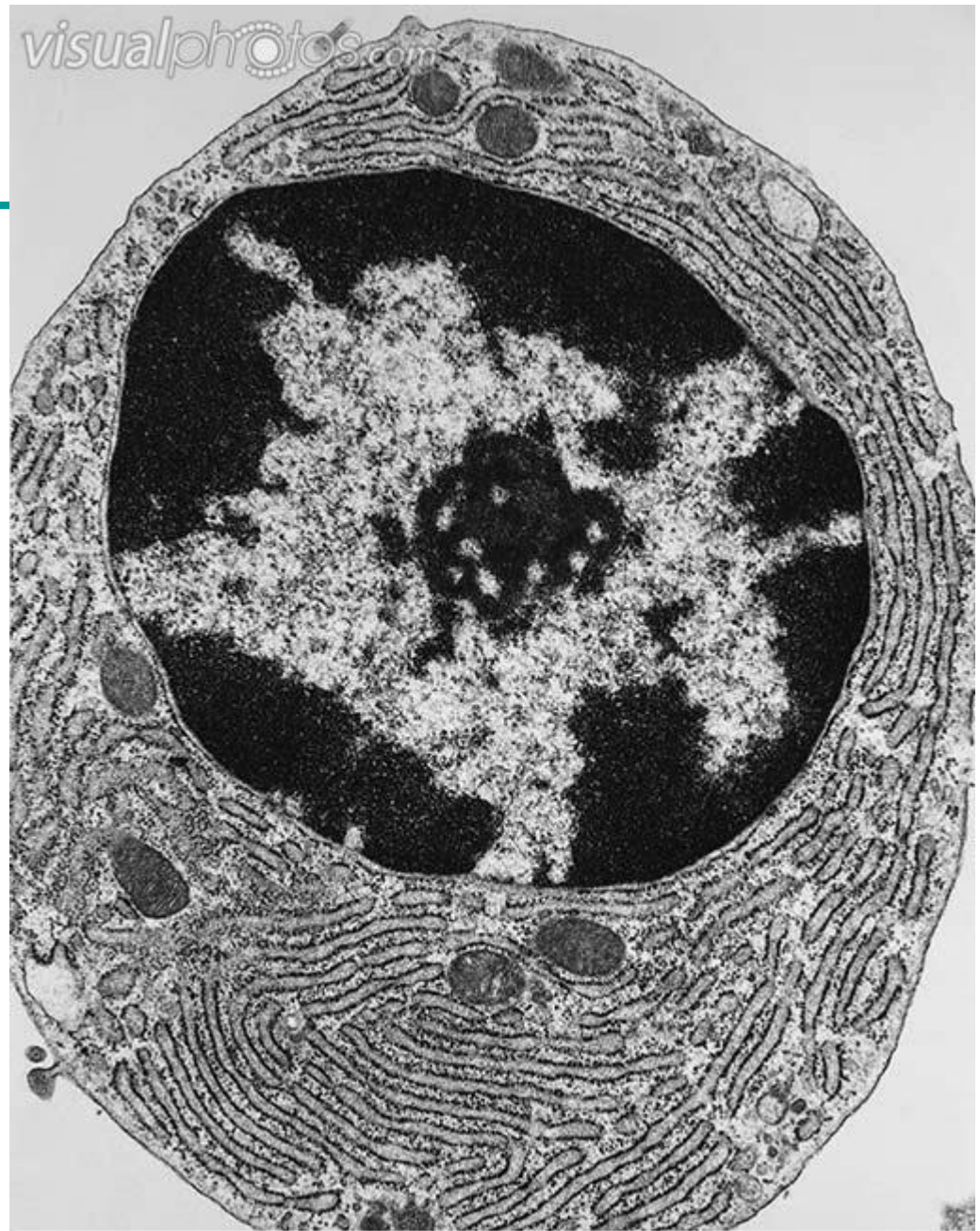
Levels of structural organization of the body

Figure 1



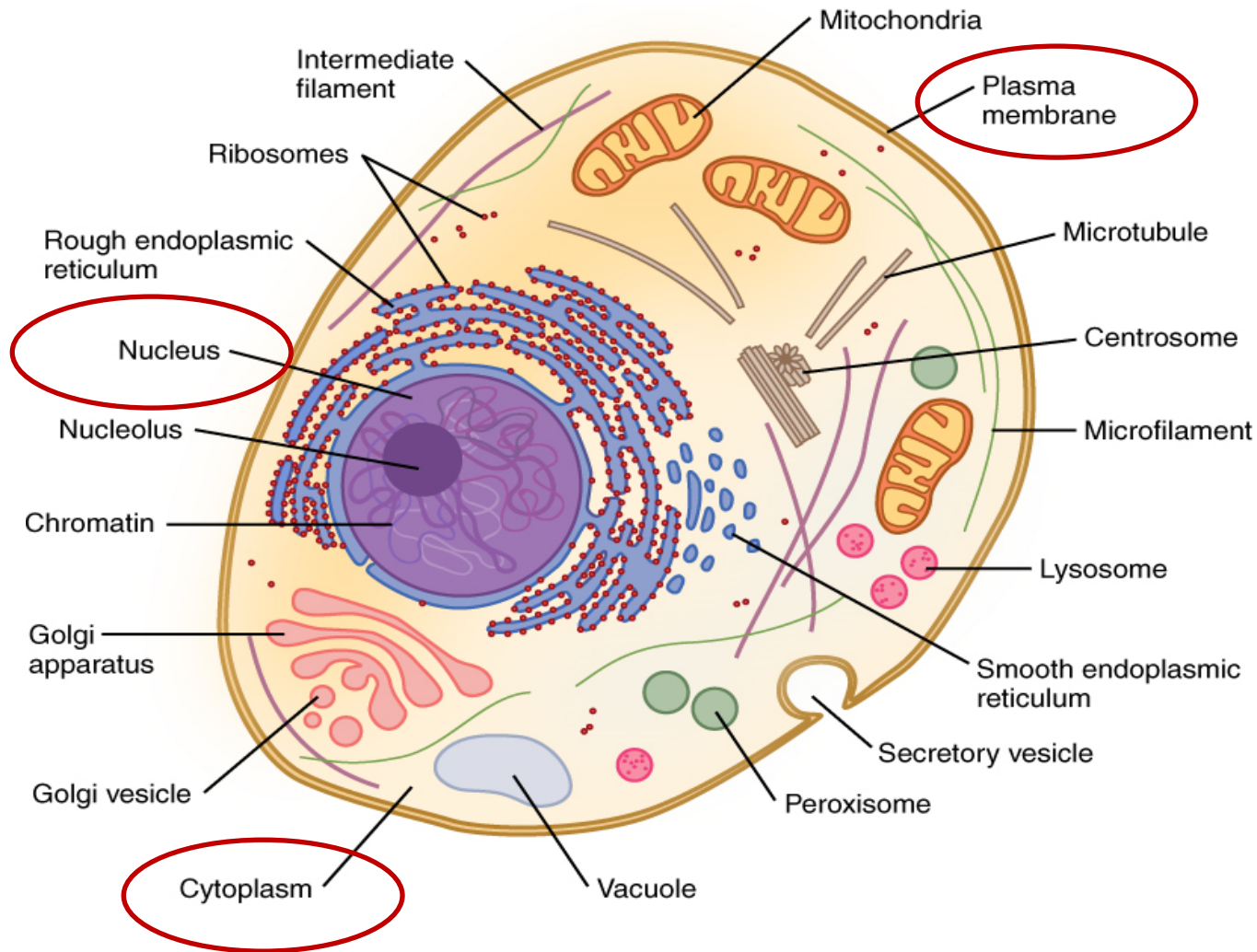
Cell

- The **basic** structural and functional units of an organism that are composed of chemicals
- They contain **all** of the basic characteristics of organisms
- It carries out living processes at the cellular level



General cell structure of an animal cell

Figure 2



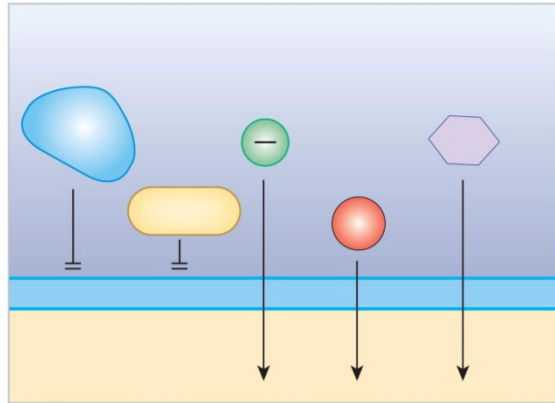
Major components of animal cells

1. Plasma membrane
2. Cytoplasm which contains cytosol and organelles
3. Nucleus

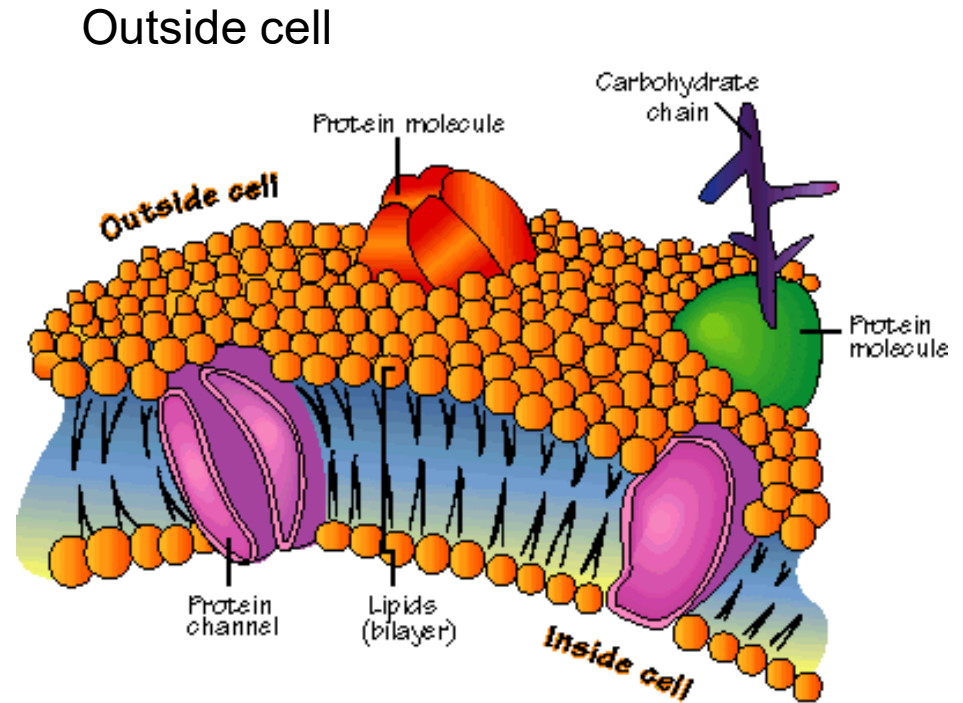
1. Animal cell (or plasma)

membrane

a selective barrier for the exchange of substances between the cell and its environment



- **Selective** means only some substances can pass through the plasma membrane



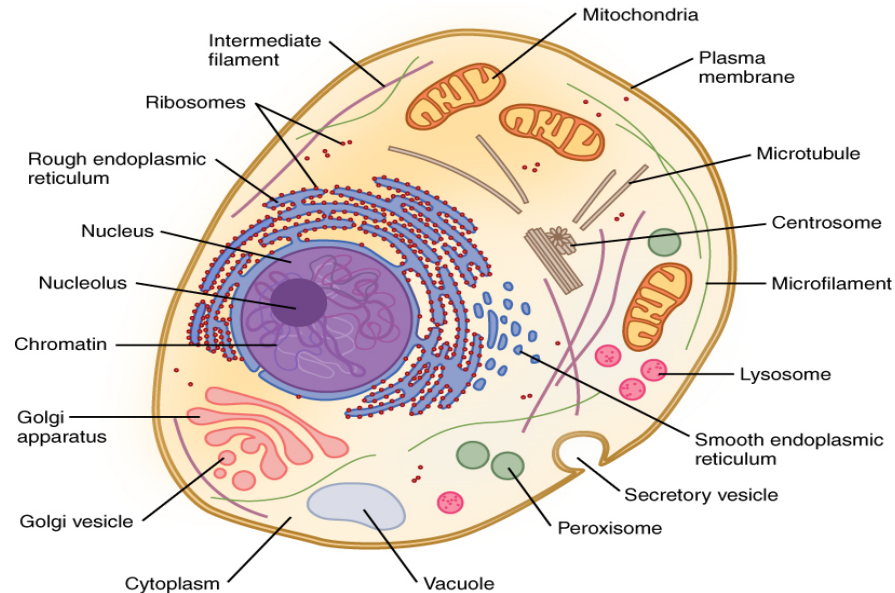
Inside cell

Researchgate.net

Functions to regulate which materials enter and leave the cell

Components of animal cells

2. Cytoplasm



a) CYTOSOL

- H₂O & dissolved solutes
- 55% of cell volume
- Mostly water (75-90%)
- Also contains the cytoskeleton

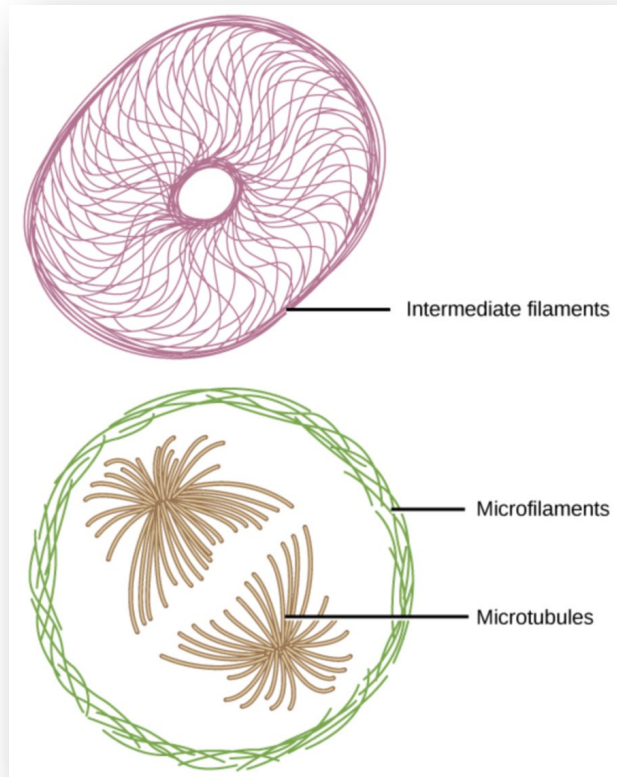
2a.

Cytoskeleton

Microfilaments are the thinnest fibers and function in moving cellular components.

Intermediate filaments are of intermediate diameter and have structural functions like maintaining cell shape and anchoring organelles.

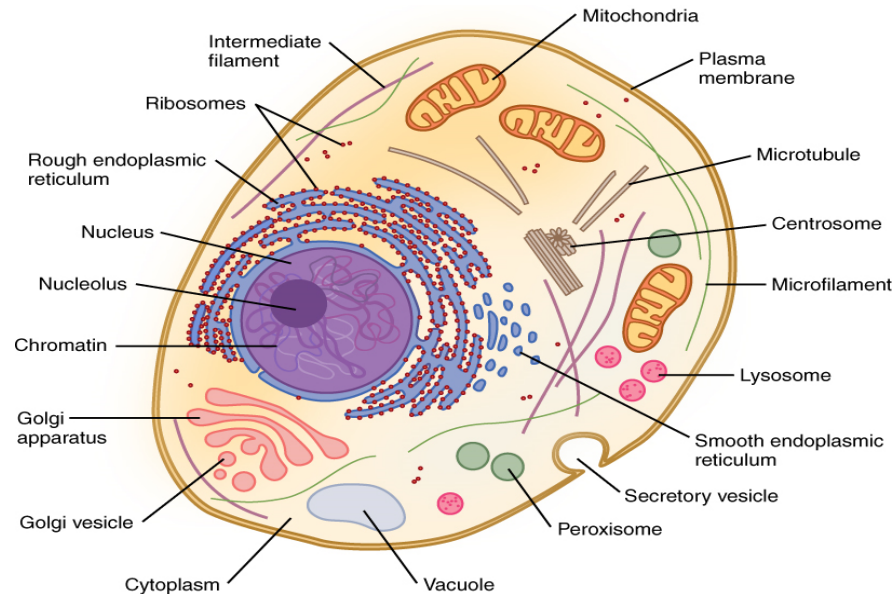
Microtubules are the thickest fibers - hollow tubes that can dissolve and reform quickly - functioning in guiding organelle movement.



- Within the cytoplasm there exists a network of protein fibers that helps to maintain the shape of the cell - **the cytoskeleton**.
- It also helps individual cells to move independently.
- There are three types of fibers: **microfilaments**, (actin filaments), **intermediate filaments**, and **microtubules**.

Components of animal cells

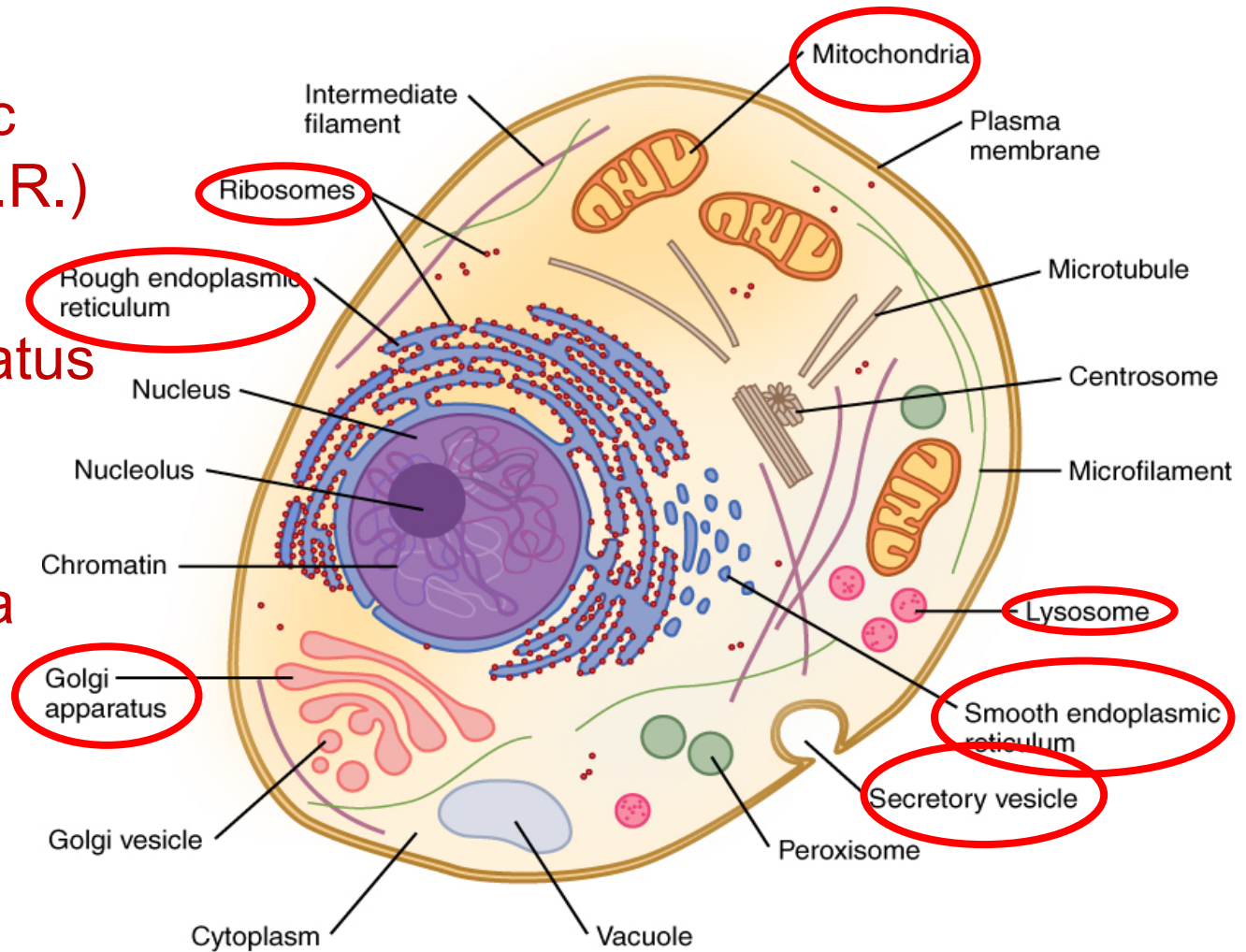
2. Cytoplasm



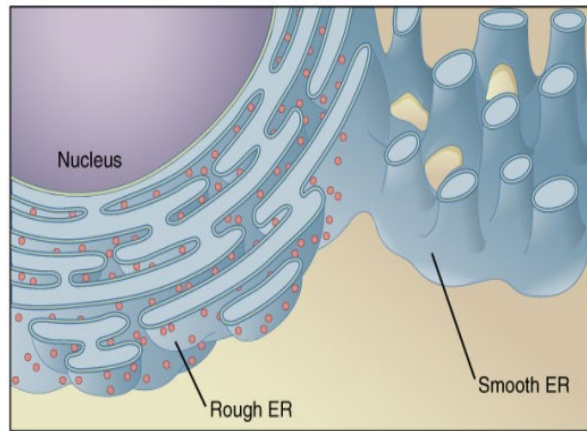
a) CYTOSOL	<ul style="list-style-type: none">- H₂O & dissolved solutes- 55% of cell volume- Mostly water (75-90%)- Also contains the cytoskeleton
b) <u>ORGANELLES</u>	<ul style="list-style-type: none">- Specialized structures that serve various functions- Vary in shape- Different cell types may contain different numbers and/or types of organelles

2b. Organelles

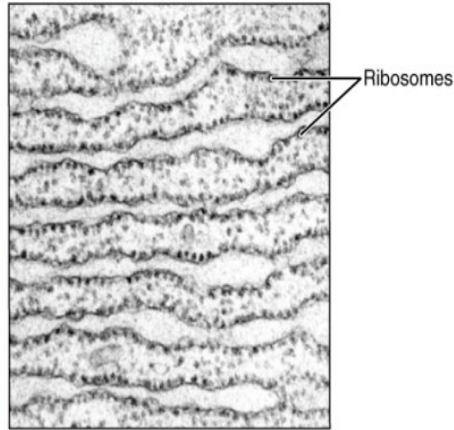
- a) Endoplasmic reticulum (E.R.)
- b) Ribosomes
- c) Golgi apparatus or complex
- d) Lysosomes
- e) Mitochondria
- f) Vesicles



2b. Endoplasmic reticulum: a biosynthesis factory



(a)



(b)

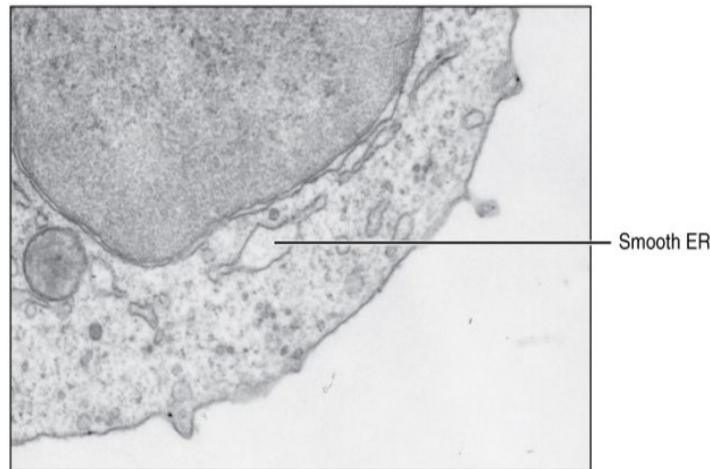
Rough ER

Structure

- Network of interconnected membranous sacs (cisterns)
- Ribosomes on outer surface

Function

Synthesis of secretory & membrane proteins



(c)

Smooth ER

Structure

- Network of interconnected membranous sacs (cisterns)
- No ribosomes

Function

Lipid metabolism & synthesis, carbohydrate metabolism, detoxification of drugs

Figure 3

2b. Ribosomes:

site of protein synthesis

Structure

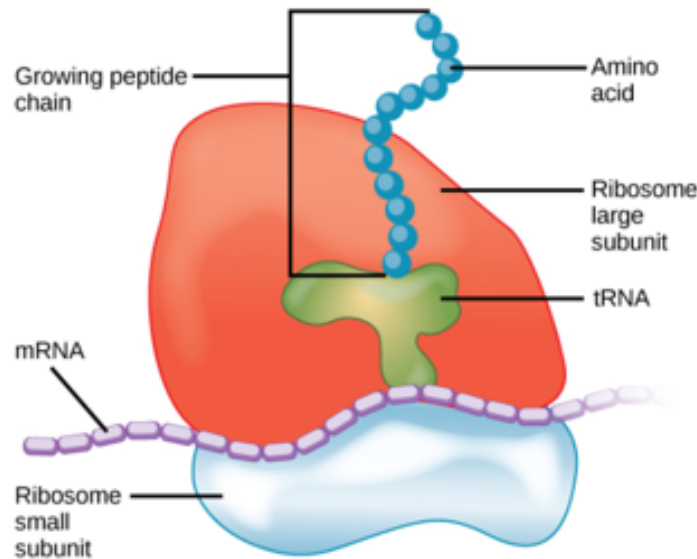
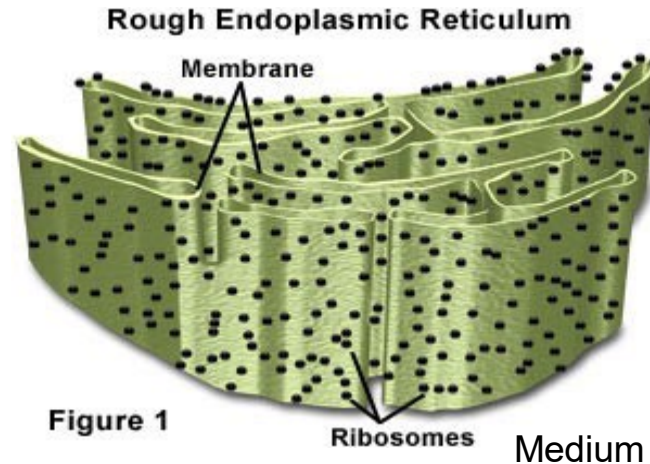
- No membrane
- Made up of rRNA

Function

Protein synthesis

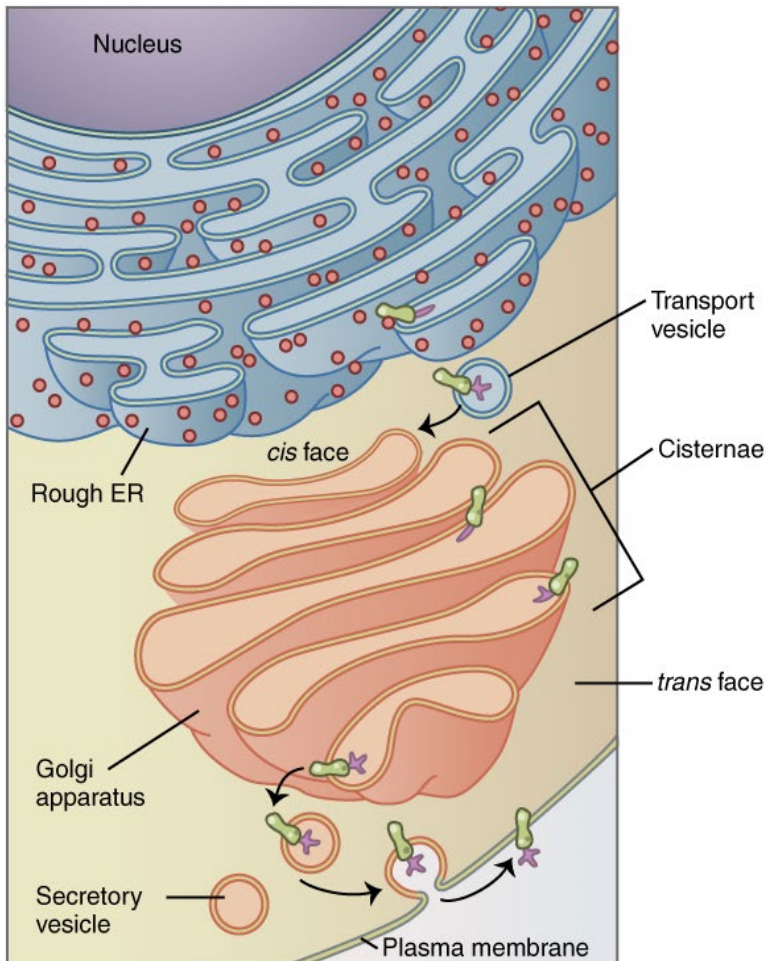
Locations

- free in cytosol
- on Rough ER
- inside mitochondria

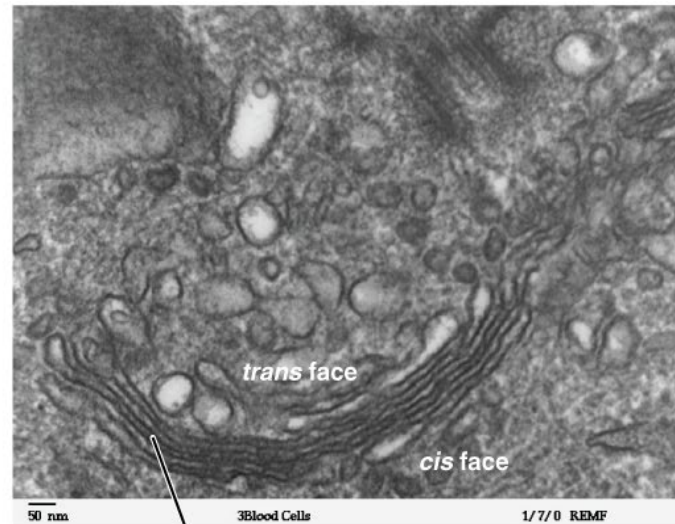


MicroscopeMaster

2b. Golgi apparatus: the shipping & receiving centre



(a)



Golgi apparatus

(b)

Structure

- Network of membranous sacks

Function

- Protein/lipid sorting, packaging & transport

Figure 4

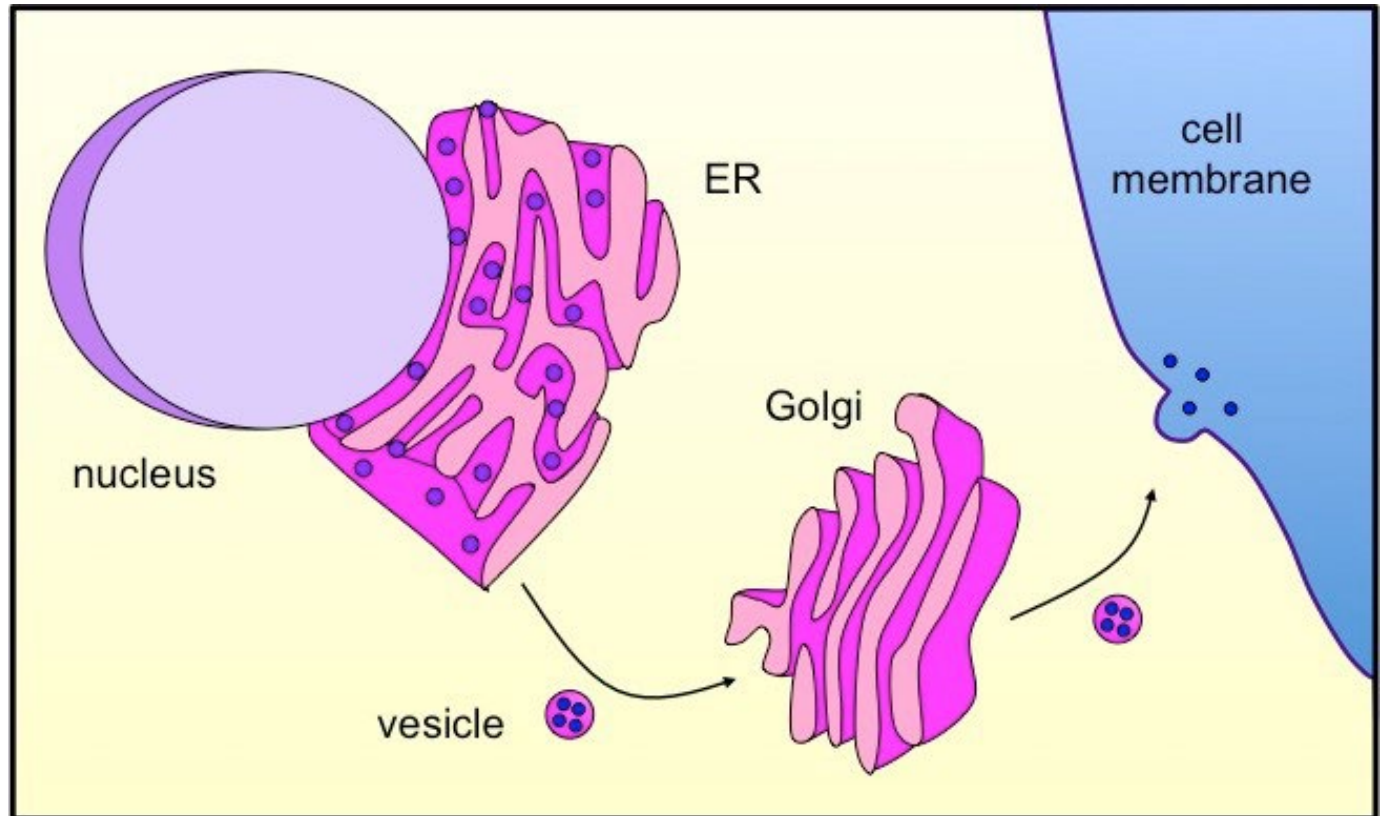
2b. Vesicles (vacuole): membrane bound sacs

Structure

- Membranous sacs

Function

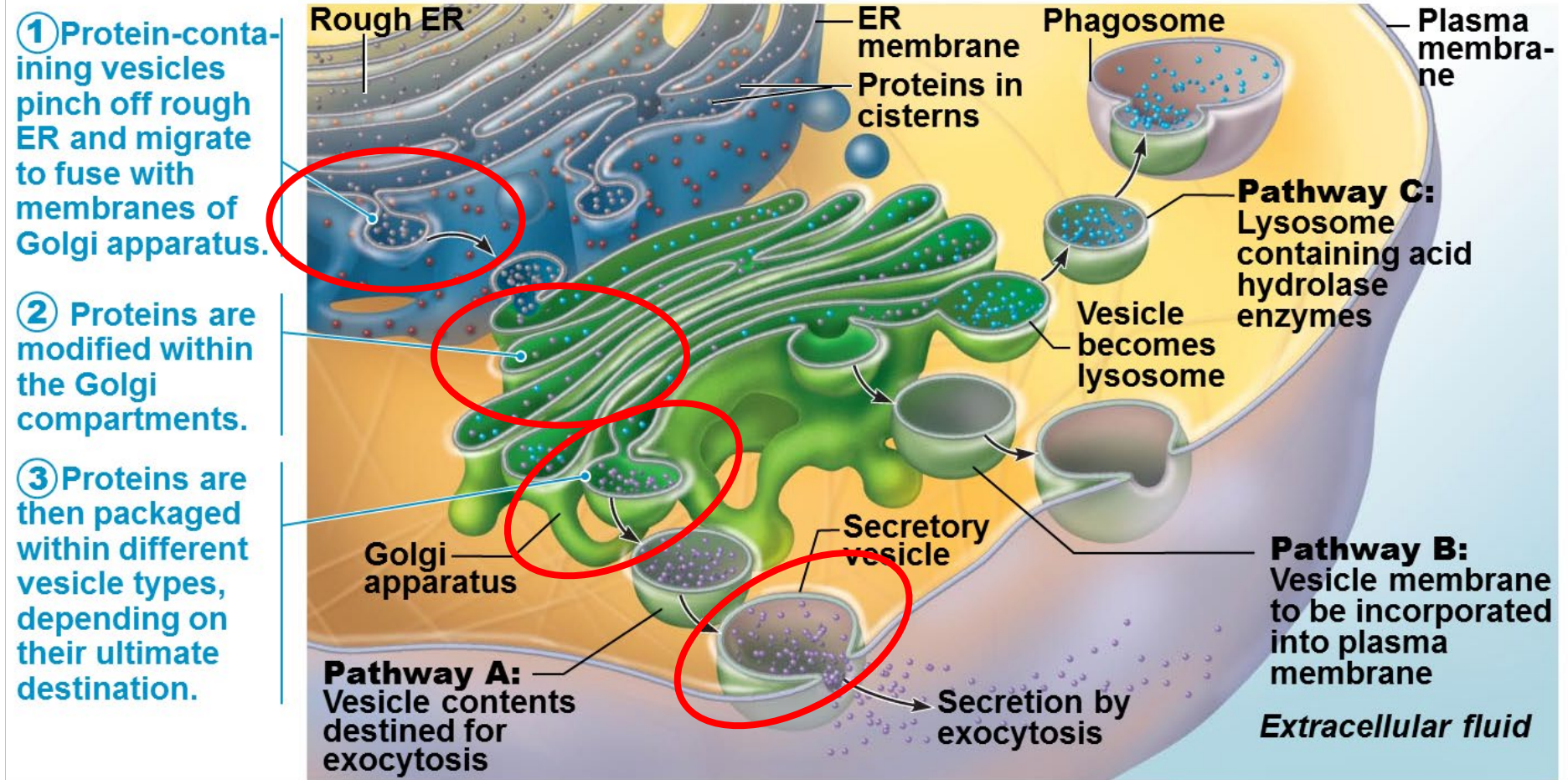
- Used in secretion, transport or to renew the membrane



BioNinja

Endomembrane system

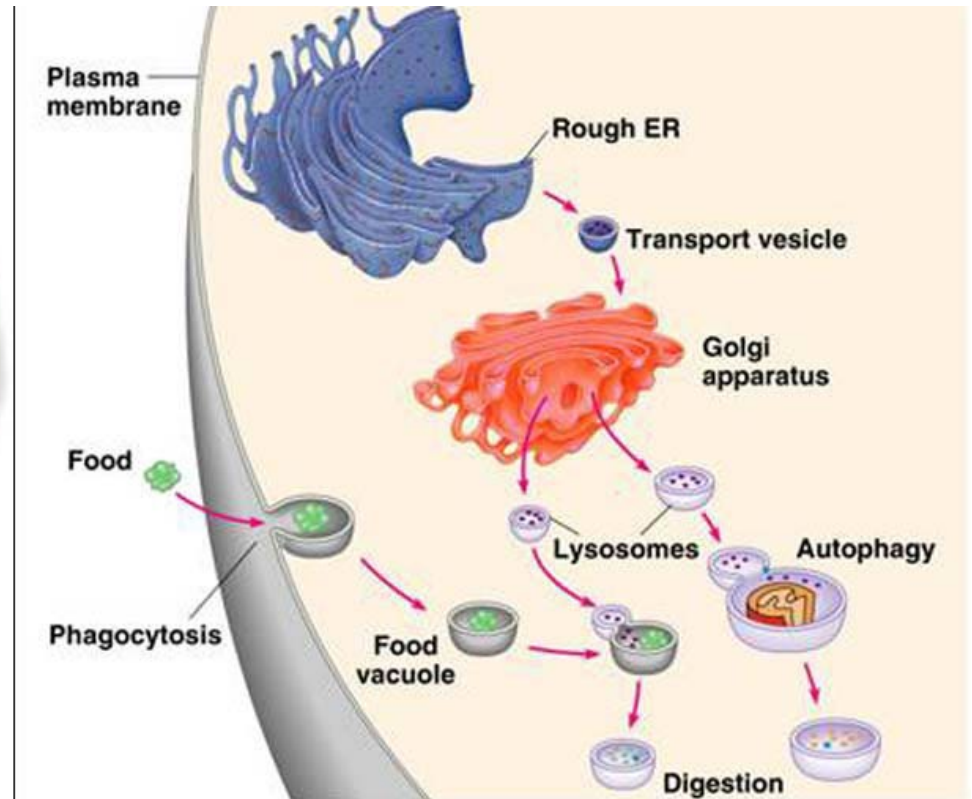
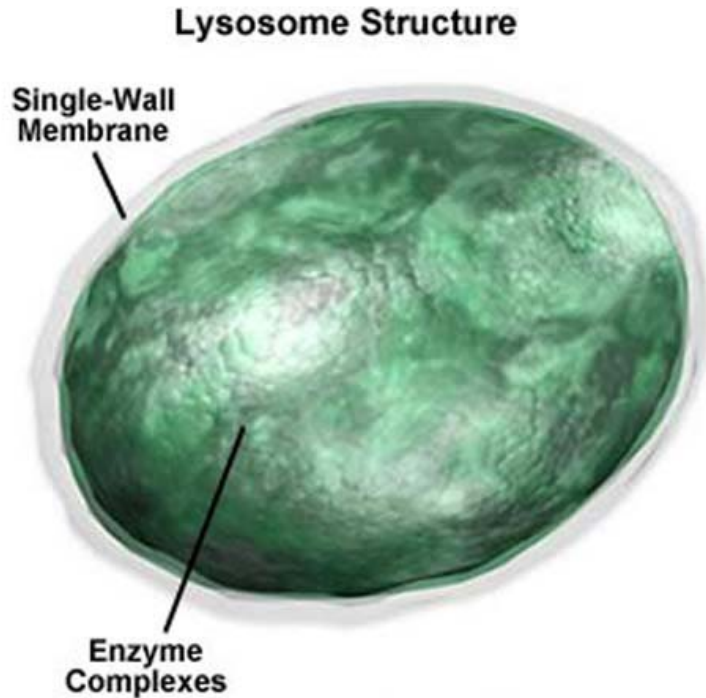
processing compounds across a series of membranous organelles



Marieb and Hoehn, Figure 3.17

2b. Lysosomes

digestion



Structure

- Single membrane sack

Function

- **Enzymatic** digestion of substances

2b. Mitochondria: the power station

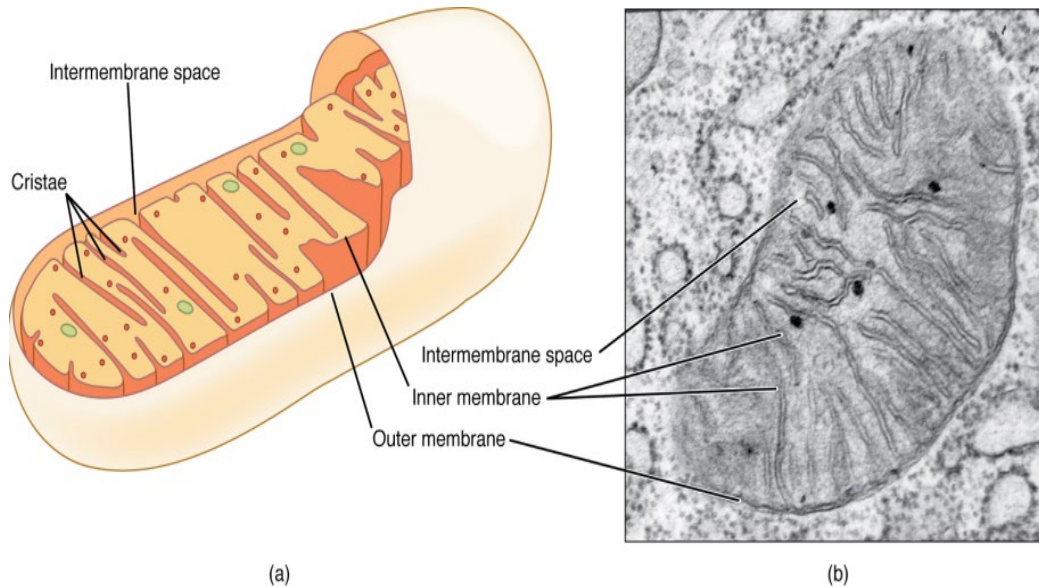


Figure 5

Structure

- Organelle enclosed by two membranes
- Contains genetic material & protein production system

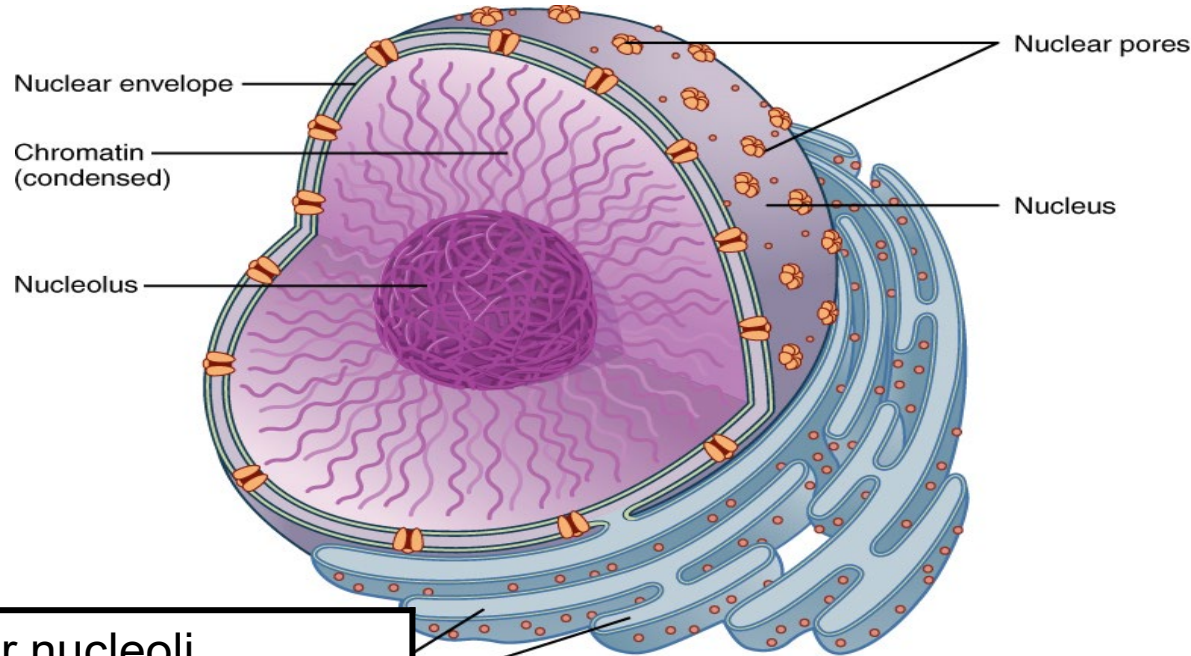
Function

- Production of energy for the cell
- Site of aerobic cellular respiration (where glucose is broken down to make ATP which is used as an energy source)

3. Nucleus of an animal cell

home of the DNA

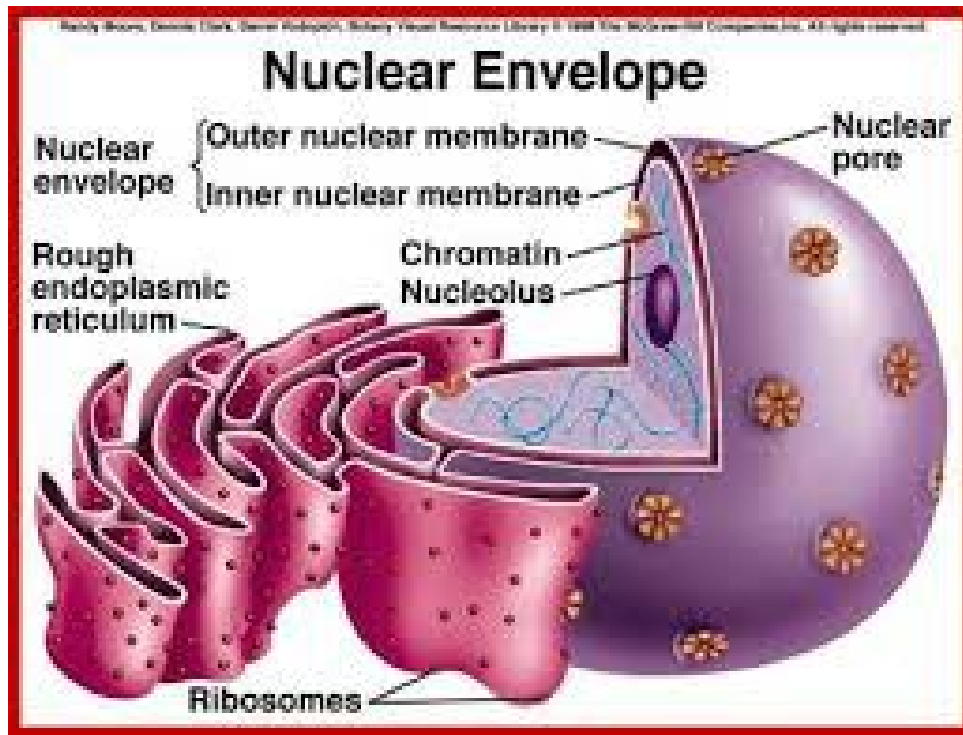
Figure 6



Main components	<ul style="list-style-type: none">- Nucleolus or nucleoli- Nuclear envelope with pores- Genetic material (DNA, RNA)- Support proteins
Main functions	<ul style="list-style-type: none">- Control cell structure- Direct cellular functions- Produce ribosomes

Nuclear envelope :

regulates the movement of material in and out the nucleus



Plant Cell Biology For Masters

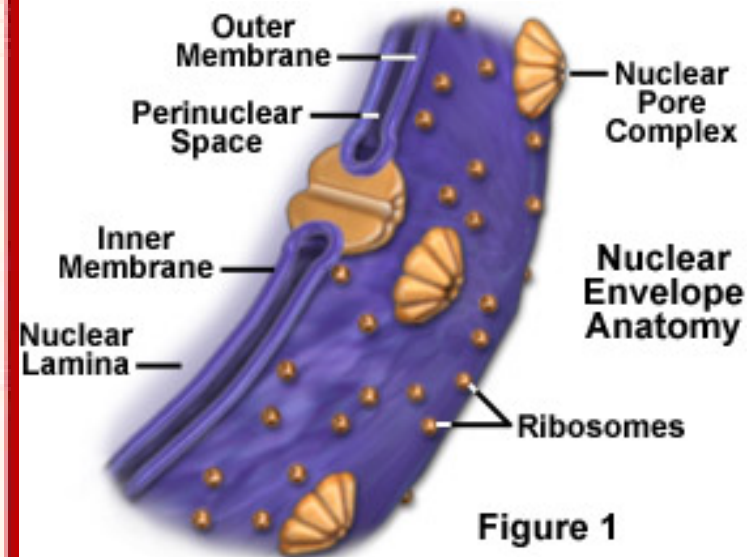


Figure 1

Molecular Expressions

- Surrounds the nucleus and regulates the **movement** of material through pores

Chromatin and Chromosomes:

Figure 7

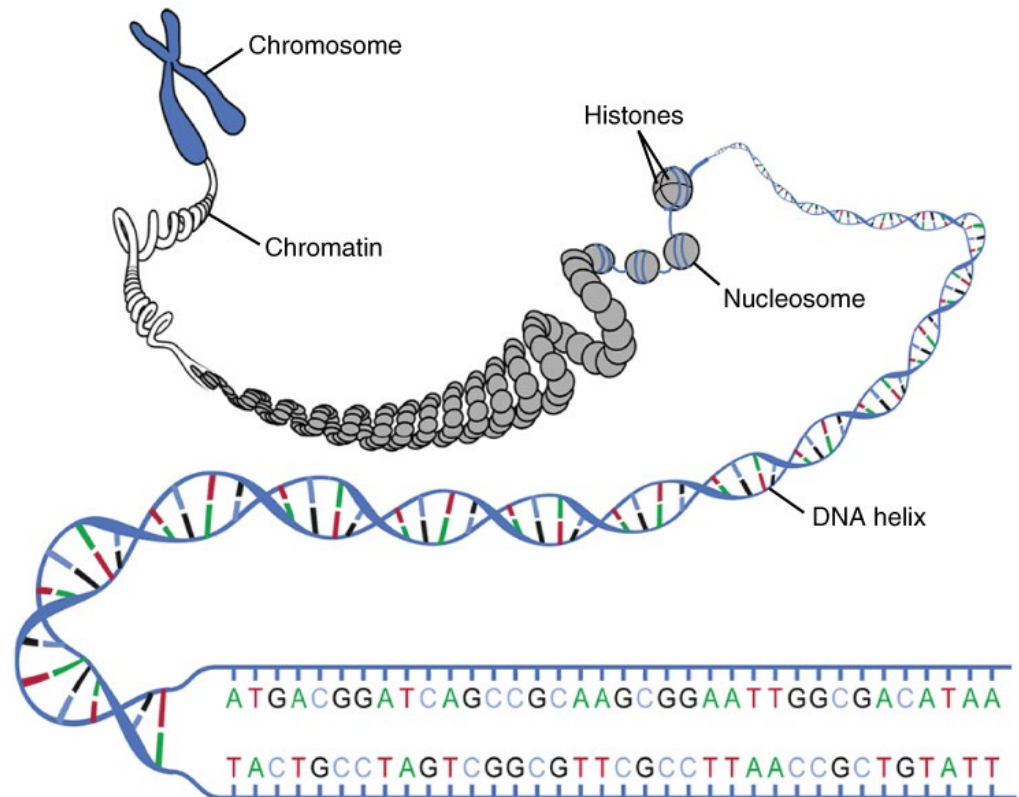
compacted DNA + proteins

Function

- **Packaging** & protection of DNA in nucleus

Structure

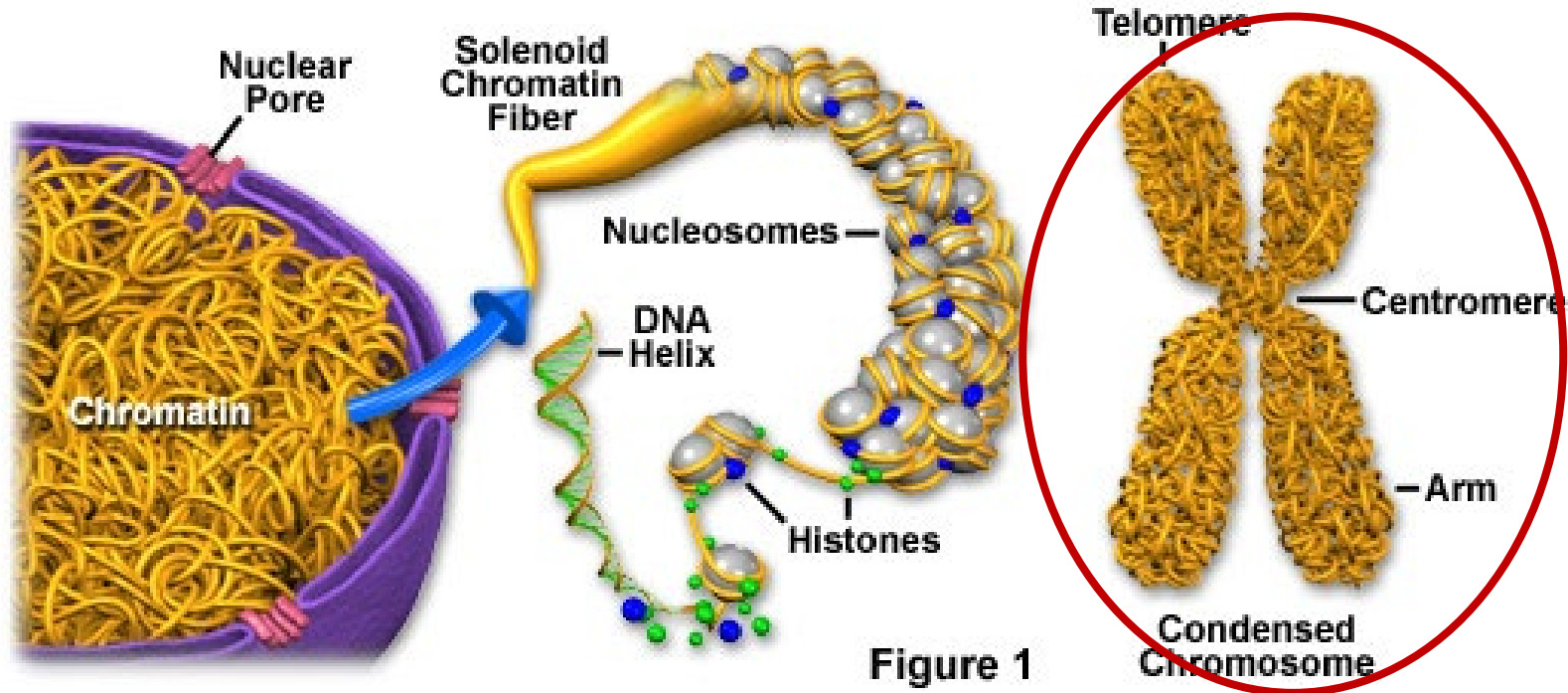
- DNA/RNA/protein package that can coil & uncoil
- Non-dividing cell:
Loose chromatin fibers
- Dividing cell:
Very dense chromatin fibers forming chromosomes



Chromosomes

only found in cells that are dividing

Chromatin and Condensed Chromosome Structure



Molecular Expressions

- Coiled and condensed DNA found only in cells that are about to **divide**

Chromatin

diffuse DNA in cells that are nondividing

Chromatin and Condensed Chromosome Structure

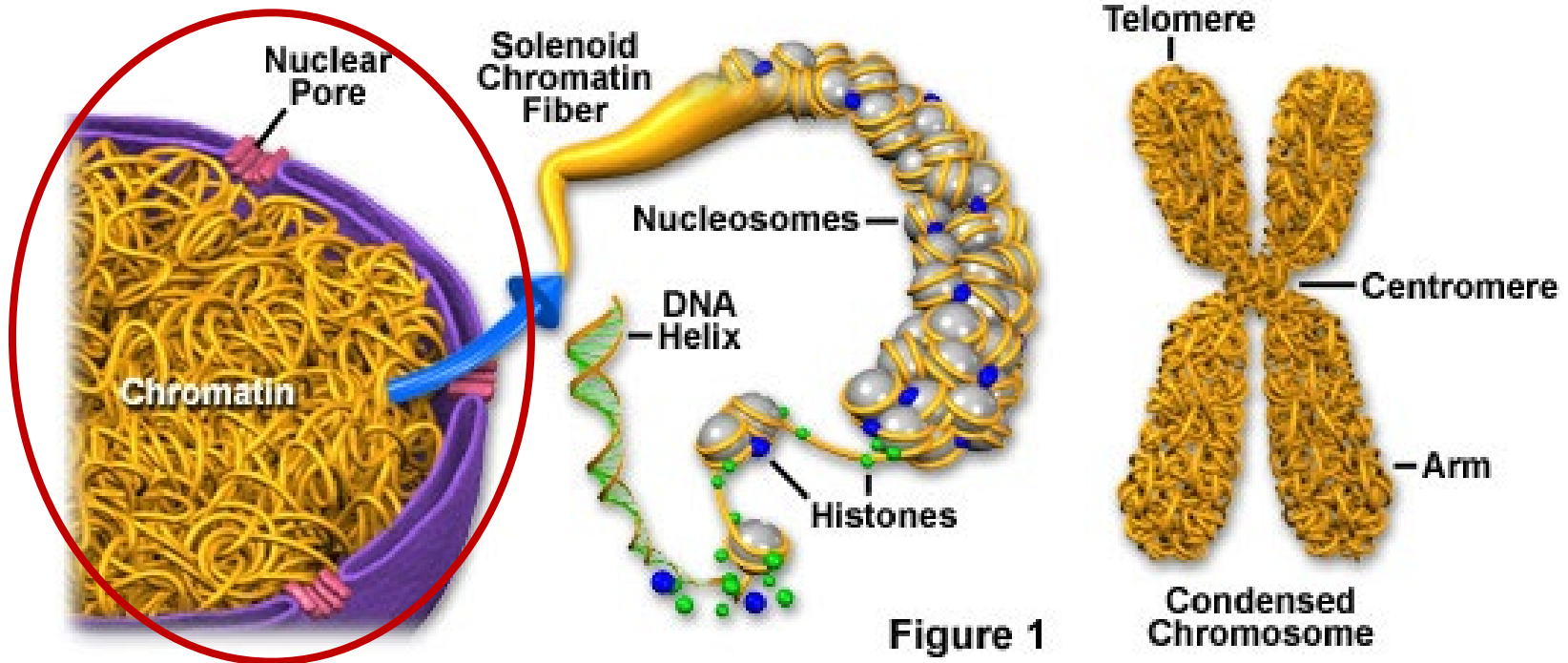


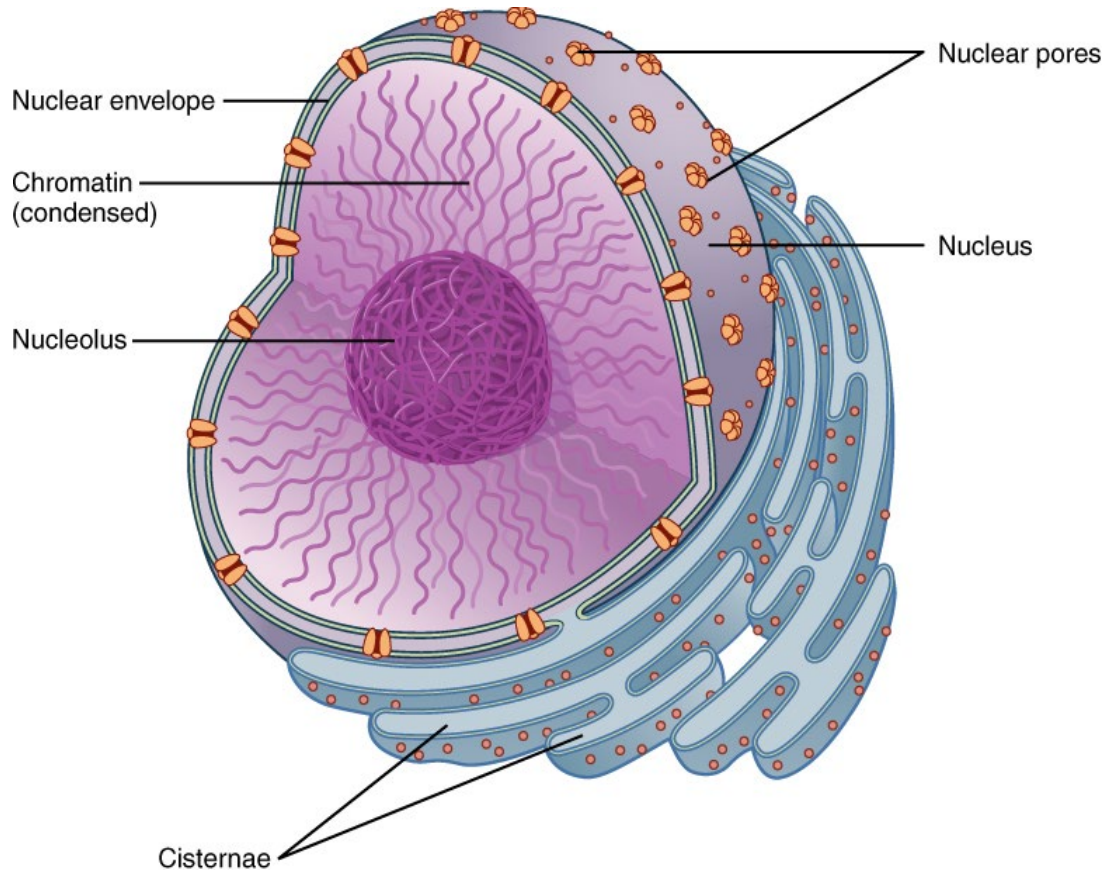
Figure 1

Molecular Expressions

- Diffuse DNA in a **non-dividing** cell

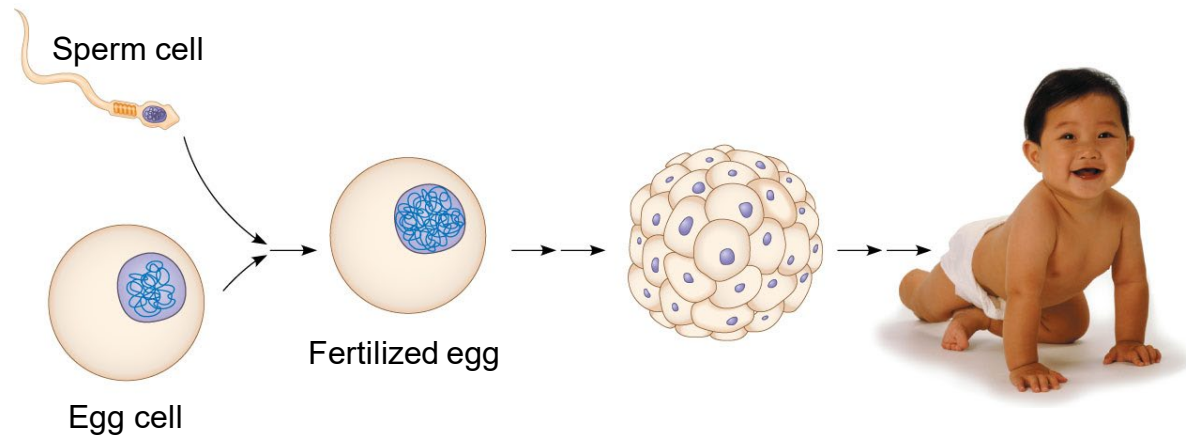
Nucleolus:

produces the subunits of ribosomes



- Site of ribosome subunit **synthesis**.
- Subunits are transferred and assembled in the cytoplasm

How to go from a fertilized egg to a newborn?

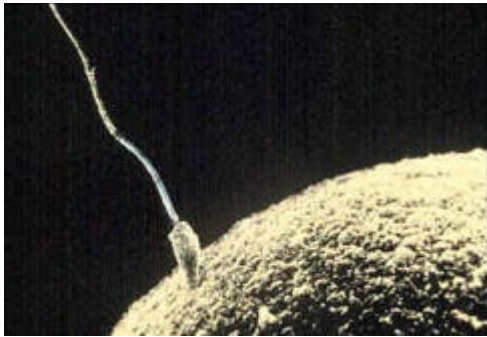


Cellular processes involved in growth

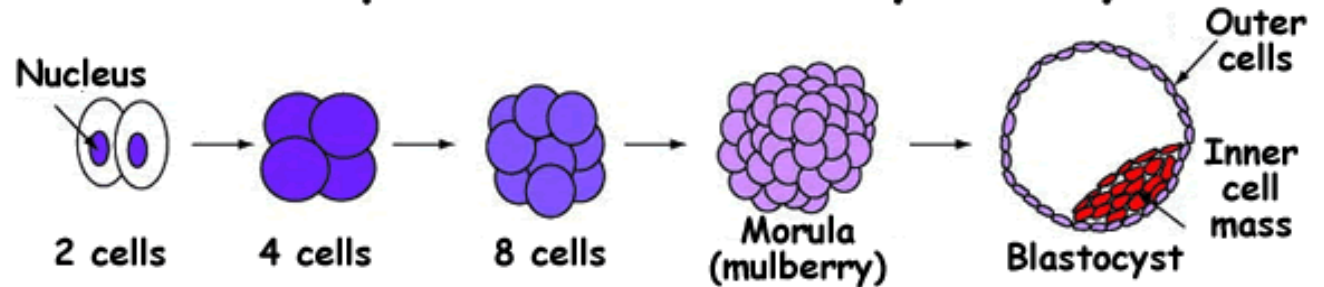
- 1) Cell division (increase in number of cells)
- 2) Cell growth (increase in cell size)
- 3) Cell specialization via differentiation

Cellular processes involved in the development of the human body:

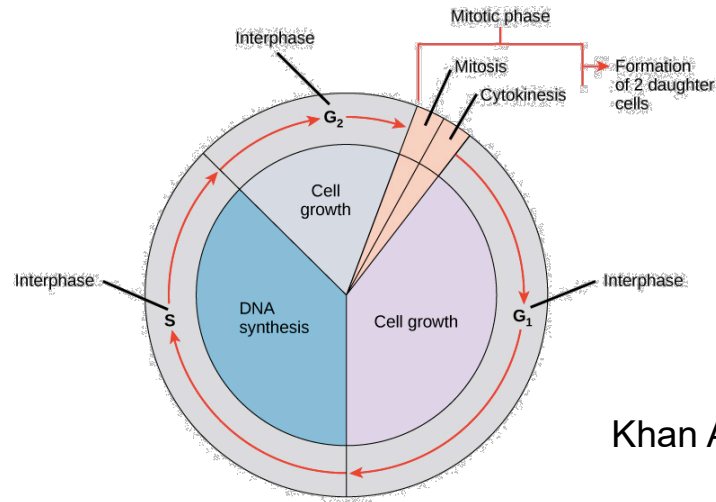
cell division



Development of the Early Embryo



thenakedscientists.com



Khan Academy

Cellular processes involved in the development of the human body:

cell growth

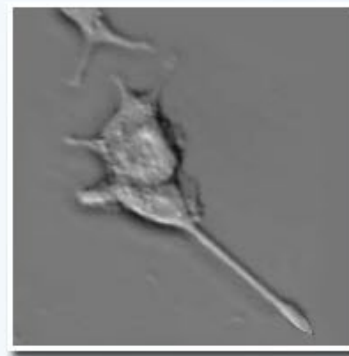
- As cells are dividing, they also grow and **increase** in size



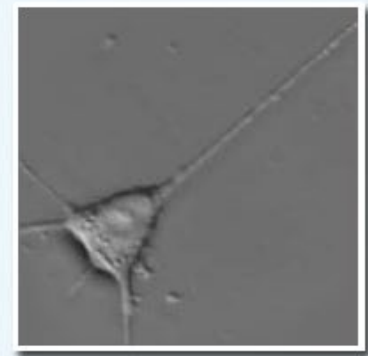
Day 0



Day 1



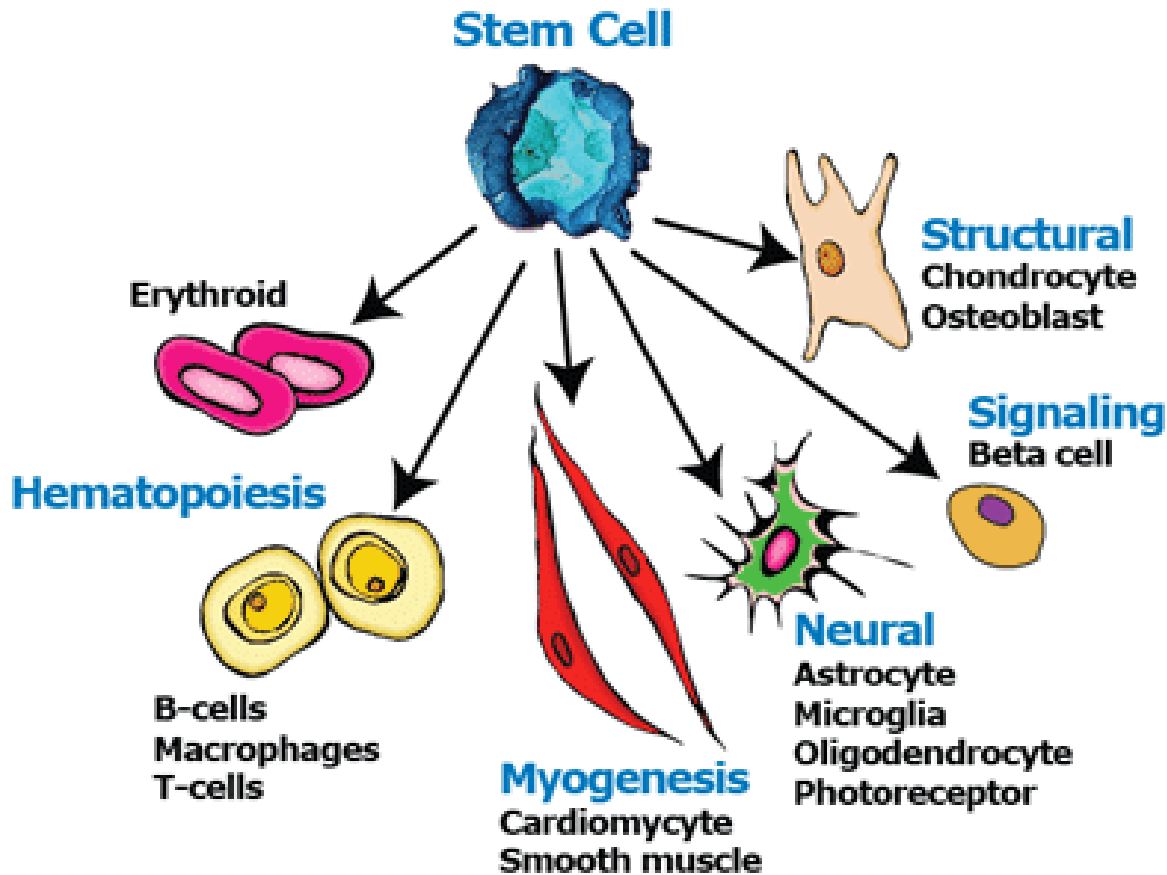
Day 3



Day 5

Cellular processes involved in the development of the human body:

cells differentiate



- Early cells become specialists via **differentiation**. There are 200-300 different types of cells in our body which have distinct structure and functions.

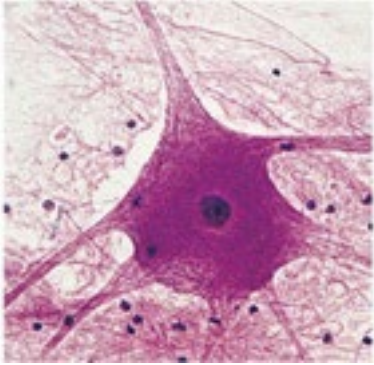
Cell

specialization

:

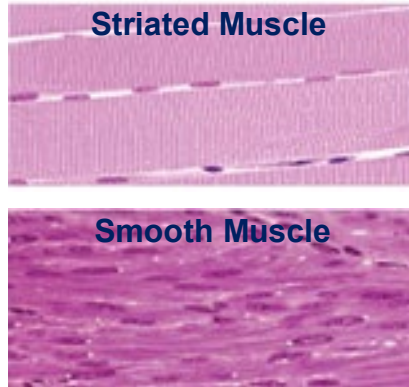
Four (of 200) different cell types and their functions

Nerve Cells
(neurons)



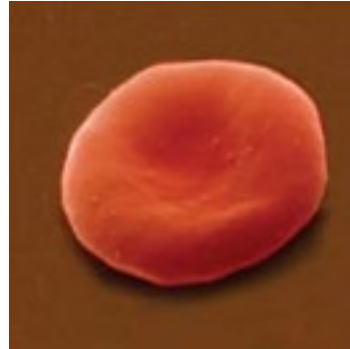
Conduct electrical signals.

Muscle Cells



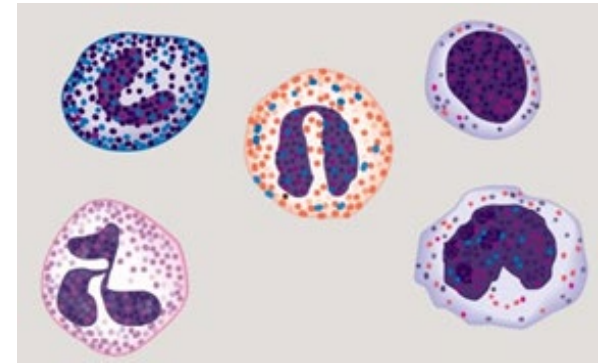
Contract and move a body part or organ.

Red Blood Cells
(erythrocytes)

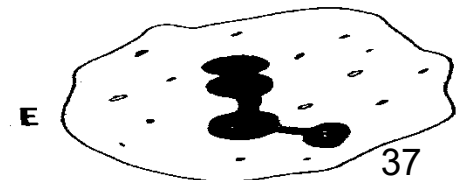
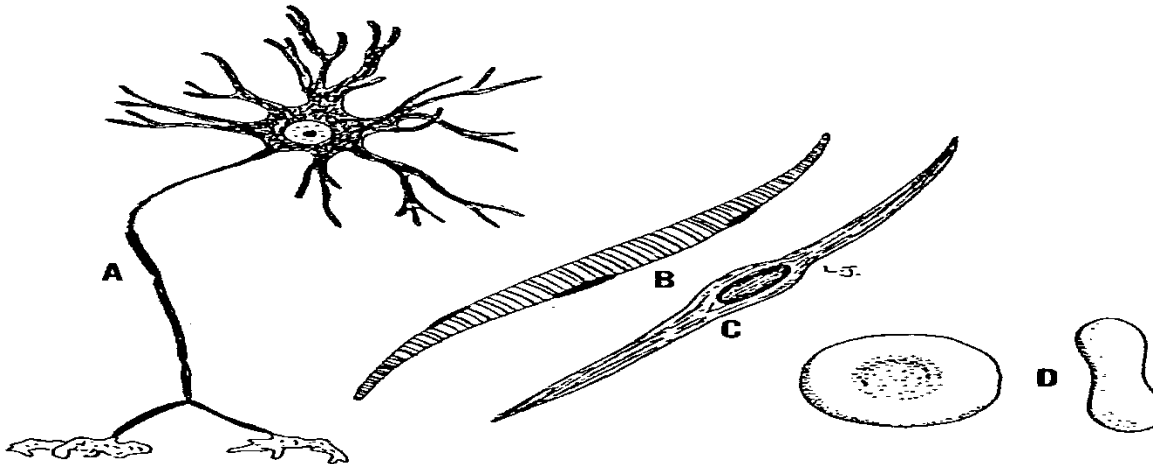


Carry oxygen.

White Blood Cells
(leukocytes)



Protect the body against microbes.



Cell structure and function

Objectives

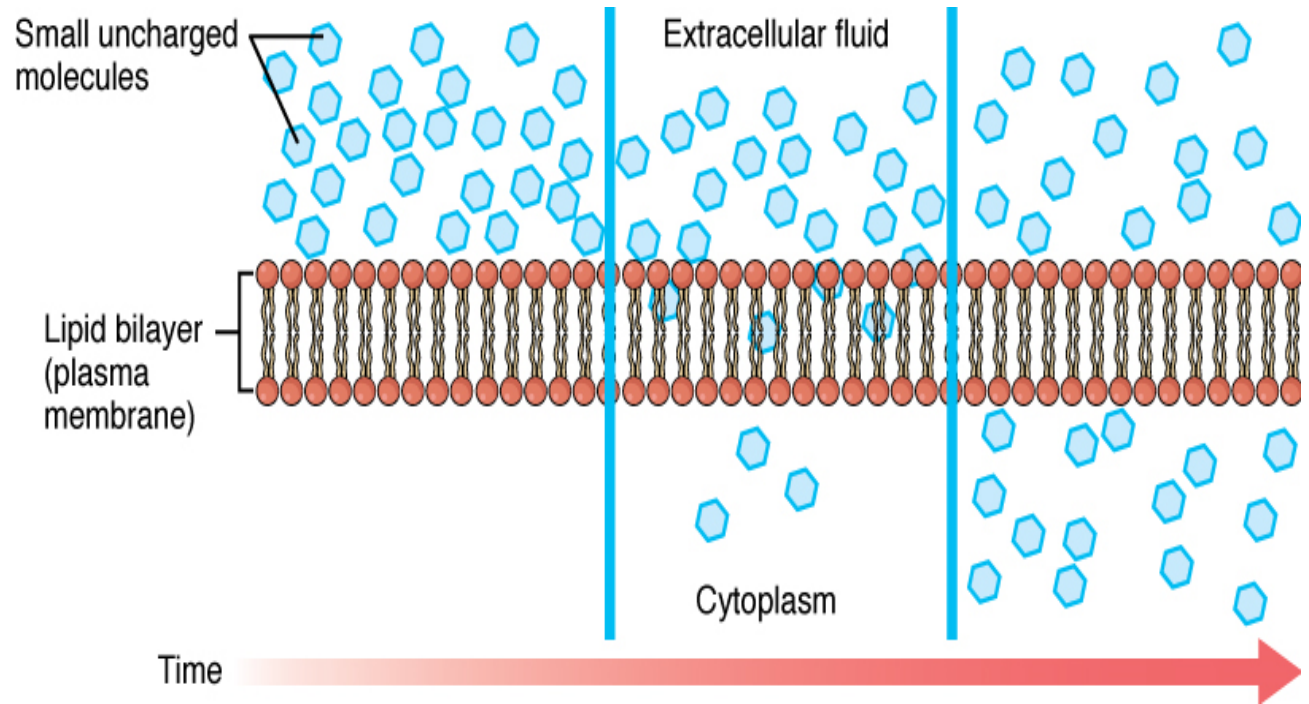
1. Specify the characteristics associated with life and explain why the cell is considered to be the basic unit of life.
2. Describe the levels of structural organization in the body.
3. Describe the structure and the function of major components of a cell.
5. Define metabolism and distinguish between anabolism and catabolism.
6. Describe the cellular processes involved in the growth of the human body from a fertilized egg cell to an adult.
7. Define cell specialization and describe its importance to an organism.
8. Describe the general characteristics of each of the following cell types and relate their characteristics to their functions: nerve cell, muscle cell, red blood cell white blood cell.

BIOLOGY 1103/1109

Human Anatomy and Physiology I

UNIT 5

Membrane transport



Membrane transport

Objectives

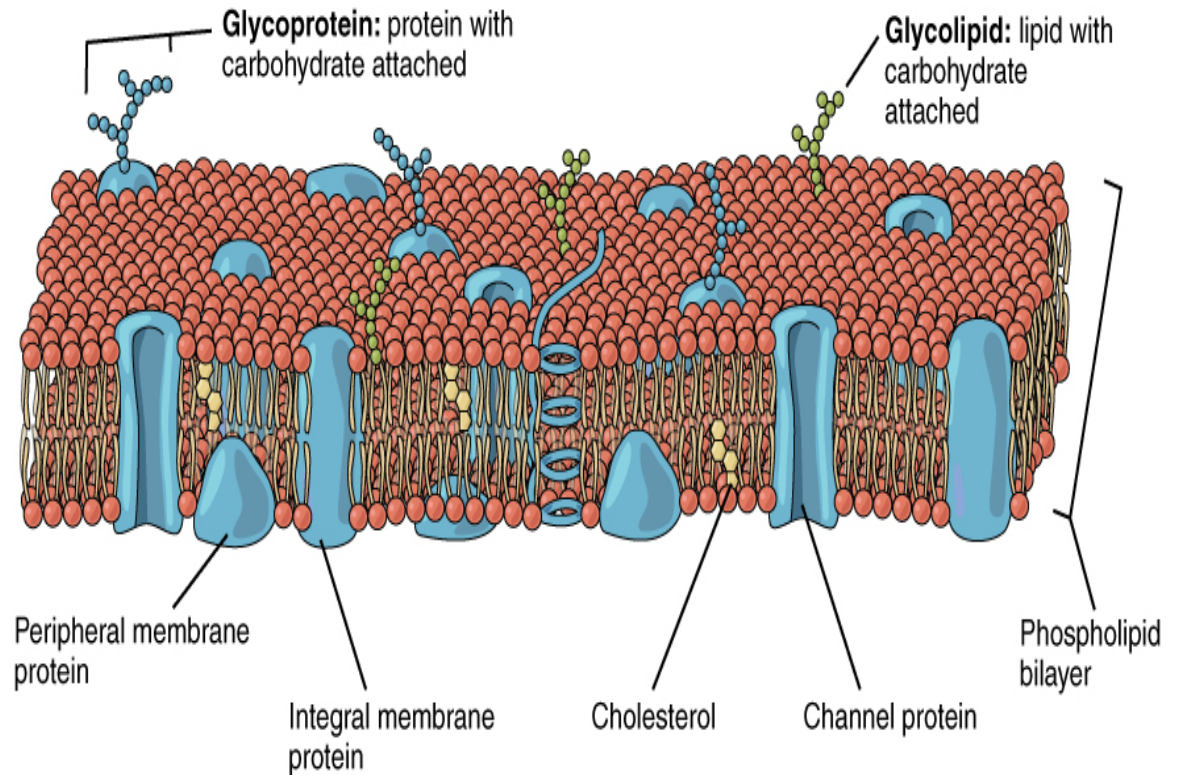
1. Describe the Fluid Mosaic (Singer-Nicholson) model of membrane structure including the membrane components.
2. Describe how the structure of the cell membrane affects membrane permeability.
3. Describe the following passive processes: diffusion, facilitated diffusion and osmosis. Explain the function of each in a cell.
4. Describe and explain the effects of placing red blood cells in hypertonic, hypotonic and isotonic solutions, respectively.
5. Describe the following active processes :primary and secondary active transport, endocytosis (phagocytosis, pinocytosis), and exocytosis. Explain the function of each in a cell.

The cell membrane

a fluid mosaic model

Figure 3

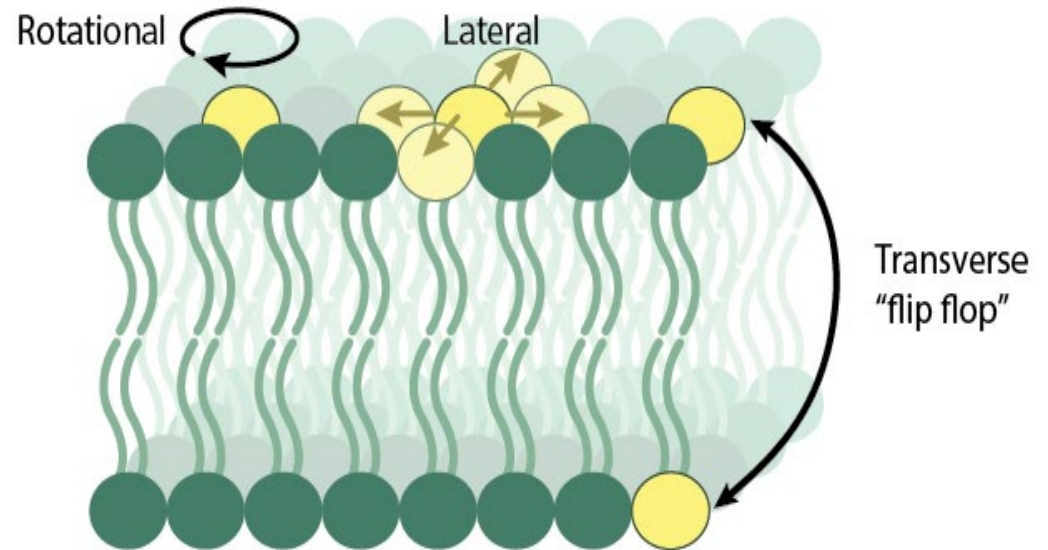
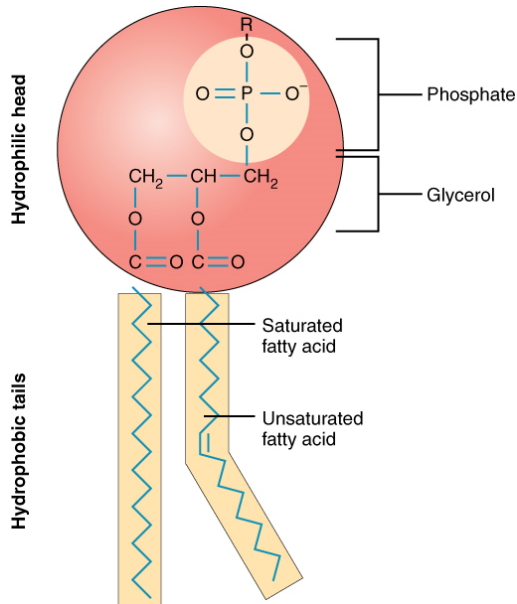
- Lipid components of the membrane is:
 - 75% phospholipids
 - 20% cholesterol
 - 5% glycolipids
- Other major component:
 - Proteins



The cell membrane

a fluid mosaic

- **Fluid** because its components move



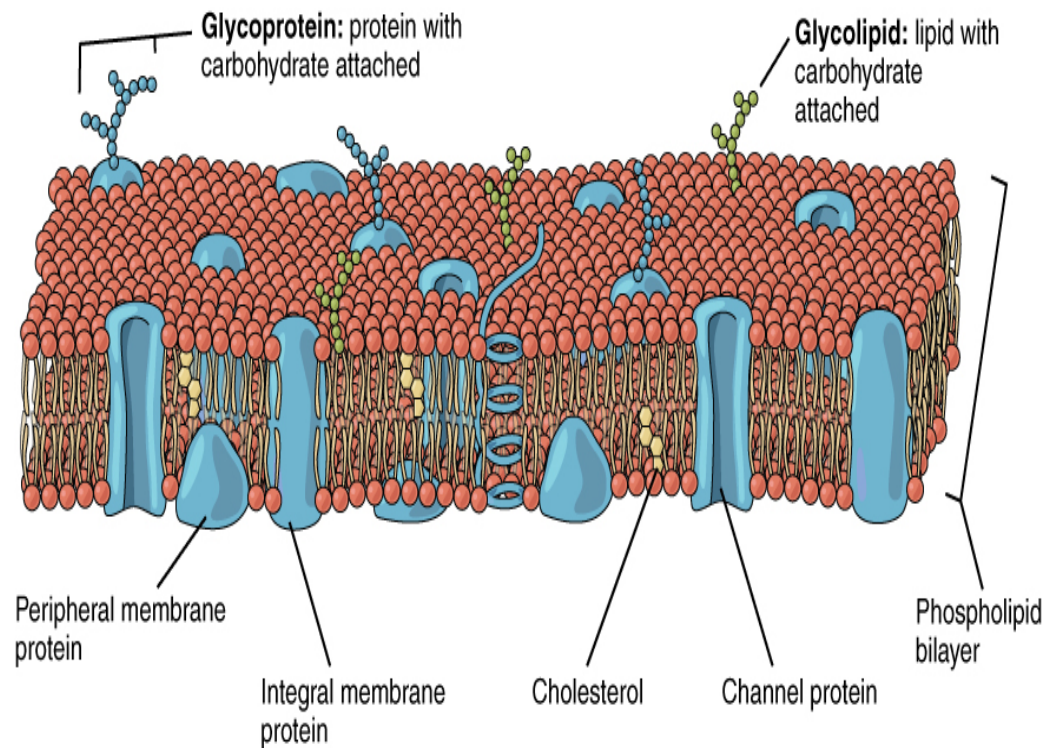
MBInfo

Figure 1

The cell membrane

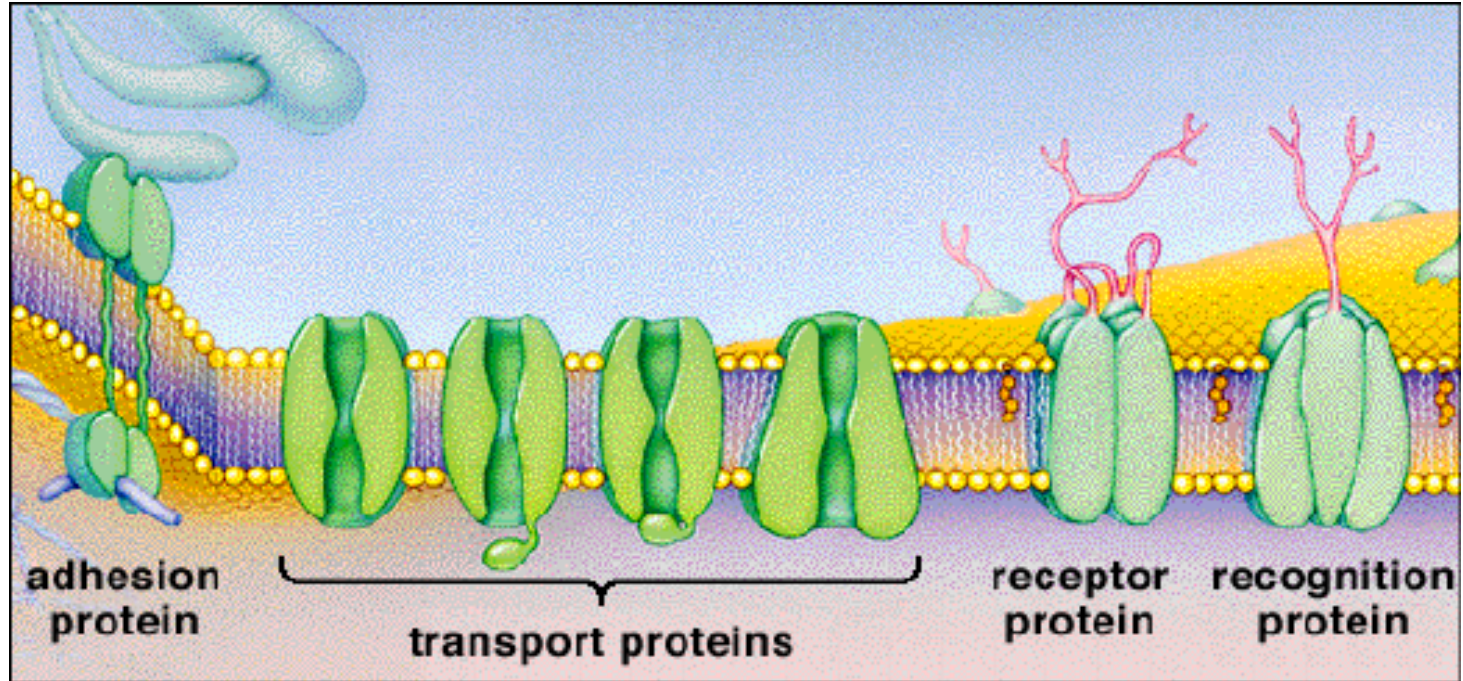
a fluid mosaic

- **Mosaic**: because of the collage of proteins that is present
- Two groups of proteins:
 - Integral (including transmembrane) proteins which penetrate or cross the membrane
 - Peripheral proteins which are not inserted into the membrane



The cell membrane

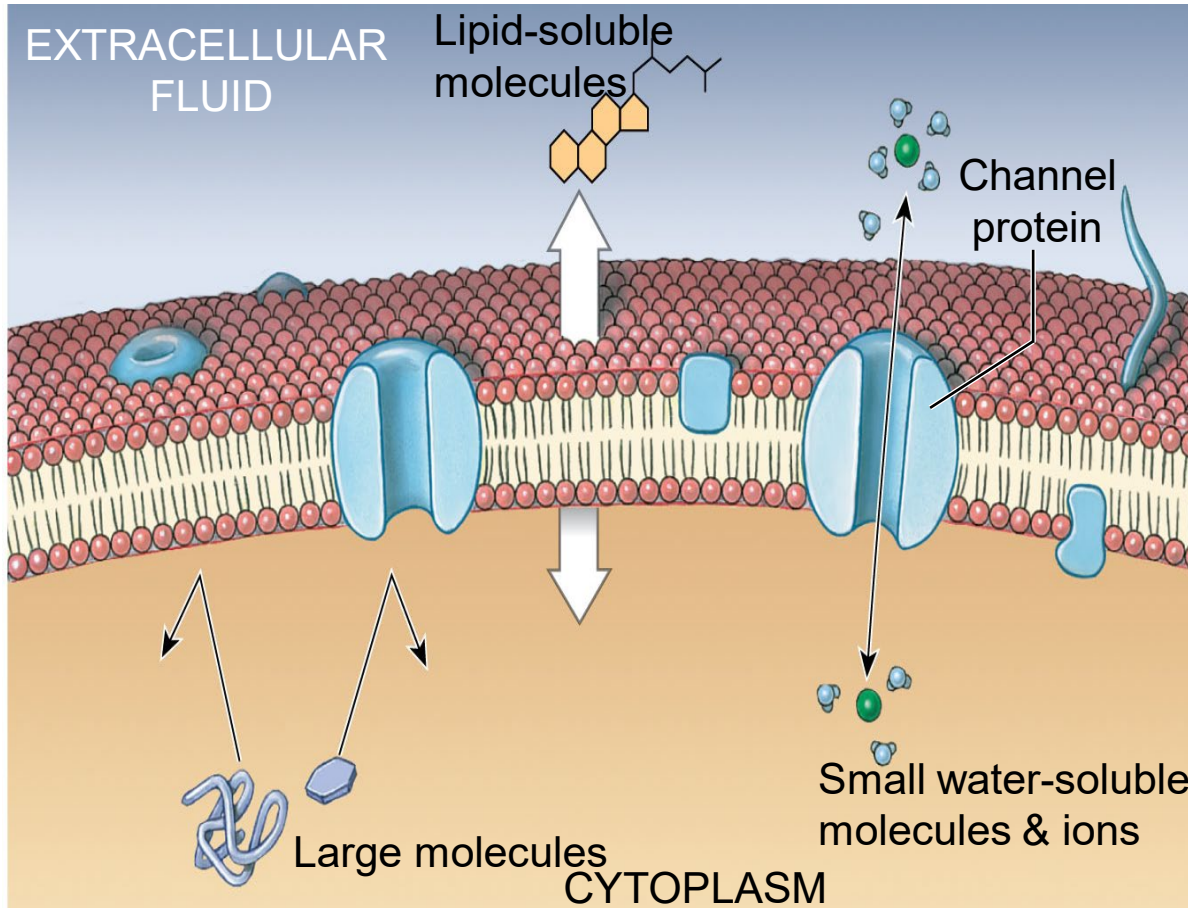
function of membrane proteins



Guam.net

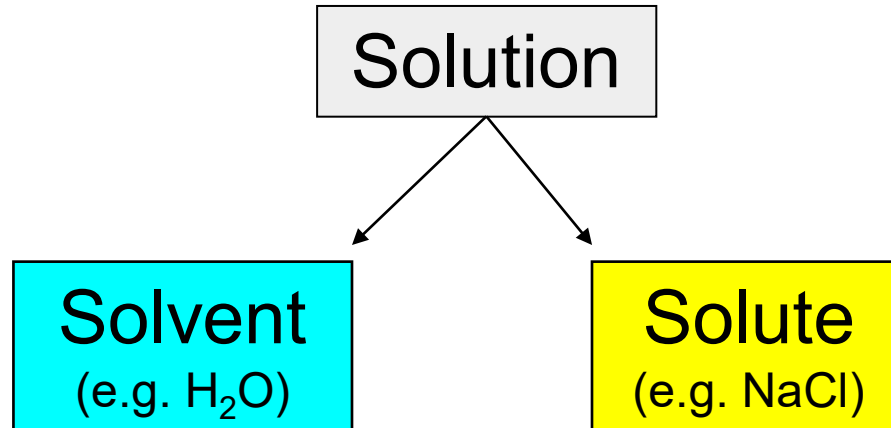
The cell membrane

membrane permeability



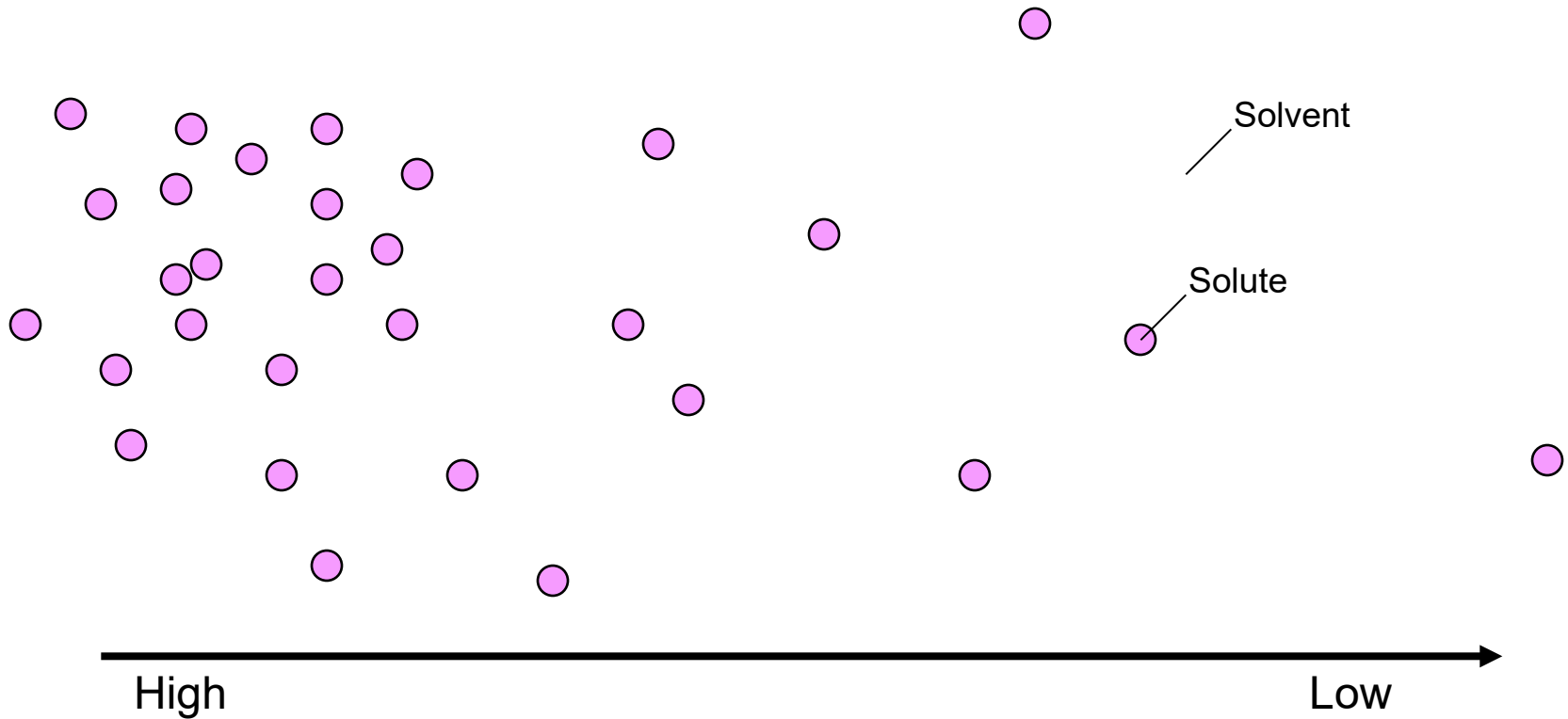
- Bilayer is a barrier to most hydrophilic molecules
- It is permeable to **hydrophobic, non-polar molecules** like O_2 , CO_2
- Proteins increase permeability (passive and active mechanisms)

Solutions



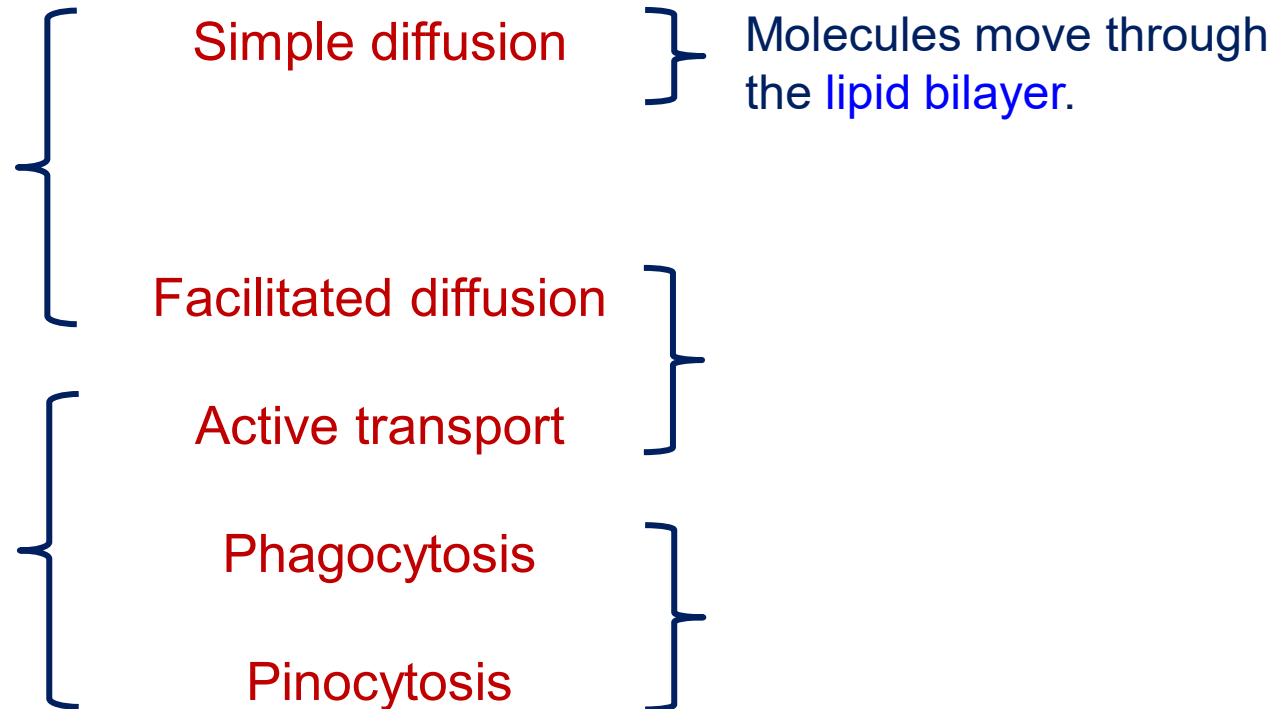
Concentration of a solution = amount of solute in solvent

Concentration gradient



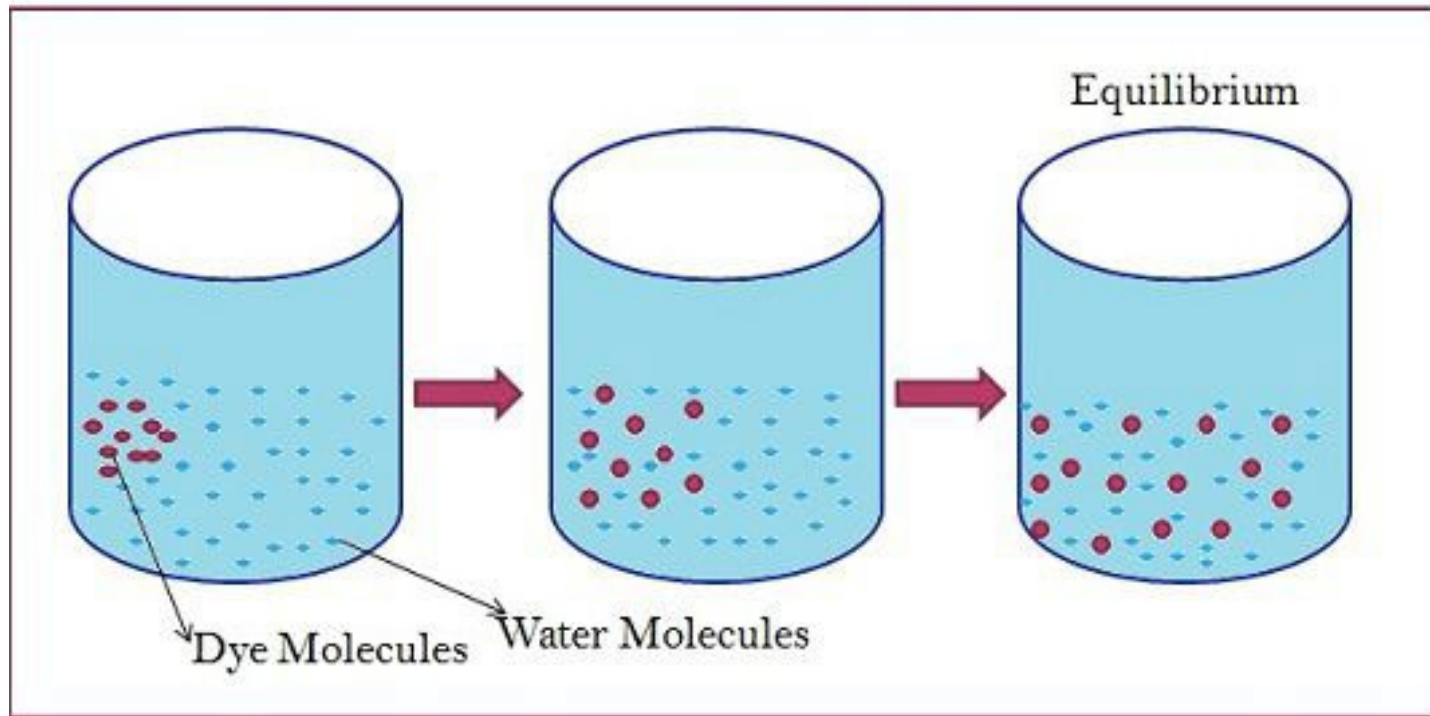
The cell membrane

six mechanisms for the traffic of molecules



Diffusion

molecules move from an area of high solute concentration to an area of low solute concentration

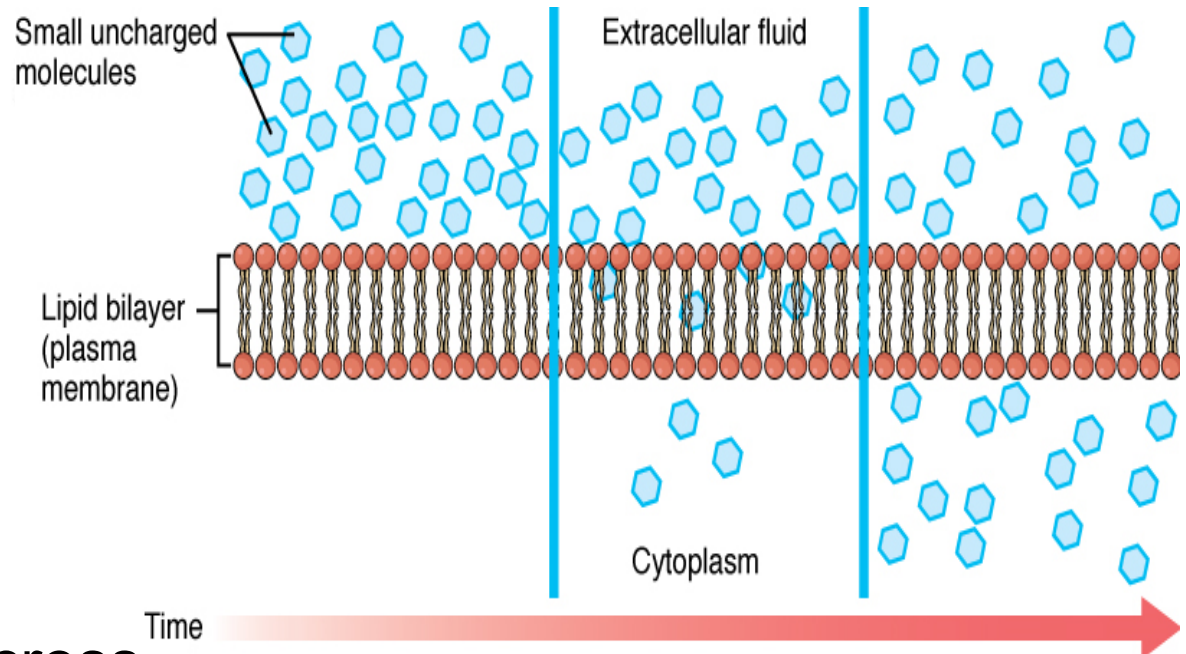
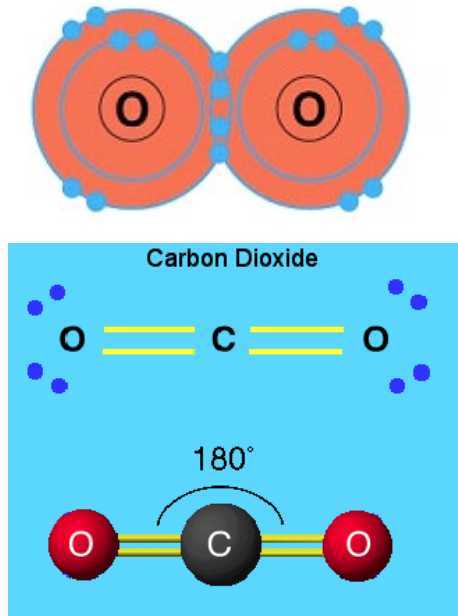


Bio Differences

- This is a **passive** process

Diffusion through the cell membrane

Only for hydrophobic or small uncharged molecules

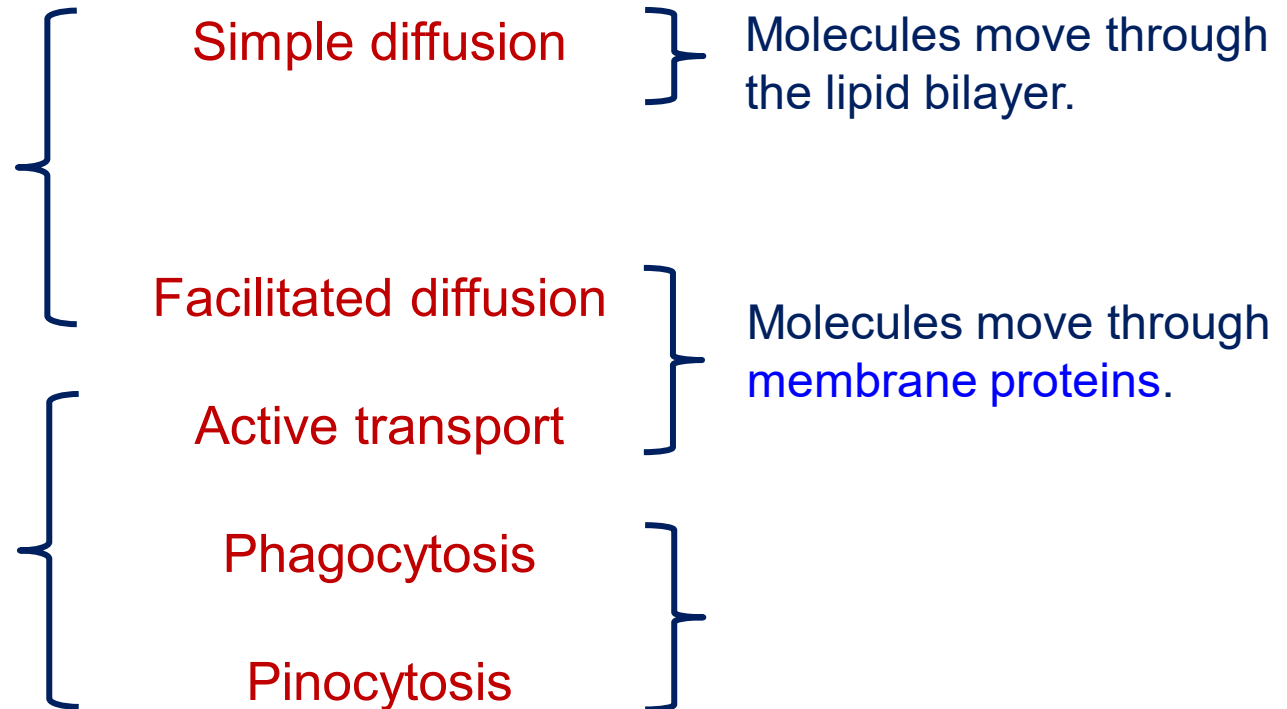


- Solute diffusing across the **phospholipid bilayer** of a selectively-permeable membrane.

Figure 4

The cell membrane

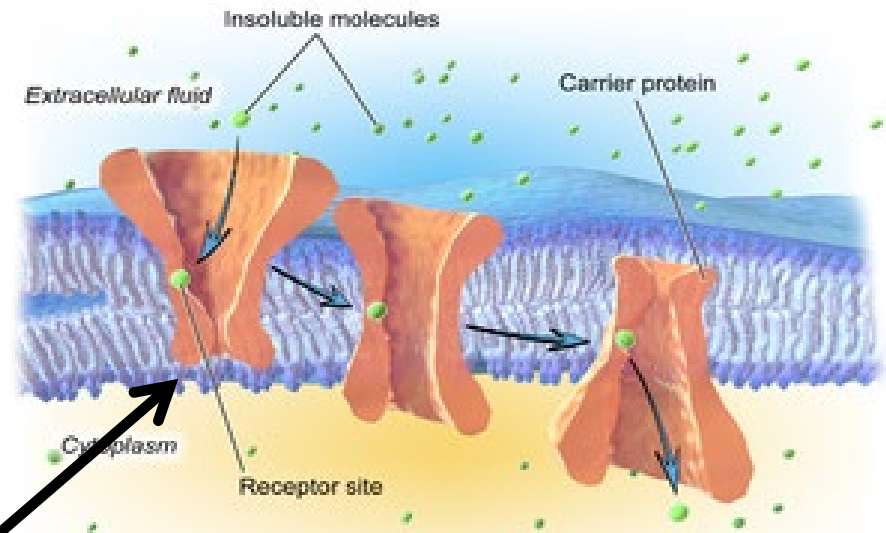
six mechanisms for the traffic of molecules



Facilitated diffusion

carrier proteins

- To move a large or polar molecule; proteins are needed
- Proteins facilitate (helps) the molecules move across the membrane = facilitated diffusion
- Two types of proteins:
Carrier proteins
- This is a passive process



Facilitated Diffusion

Wikipedia

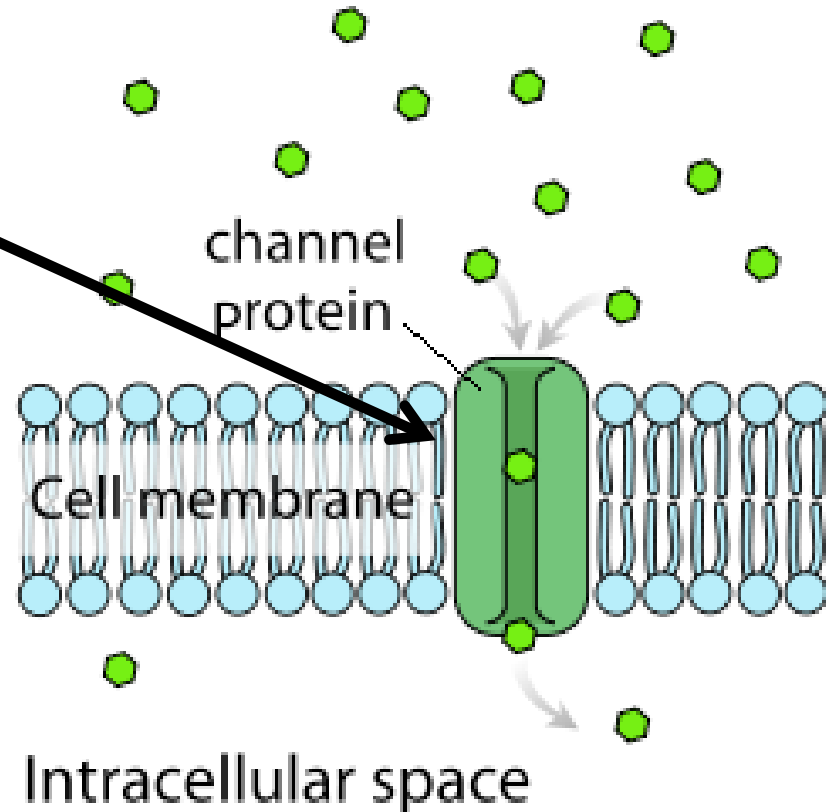
Facilitated diffusion

channel proteins

- Two types of proteins:

Channel proteins

Extracellular space

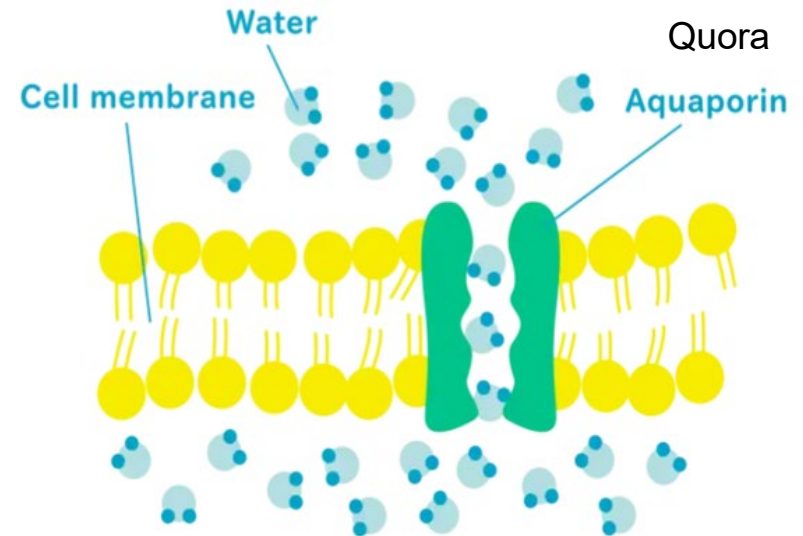


Khan Academy

- This is a passive process

What about water?

- Water is special:
Simple diffusion and Facilitated diffusion through a specific channel proteins called **Aquaporin**

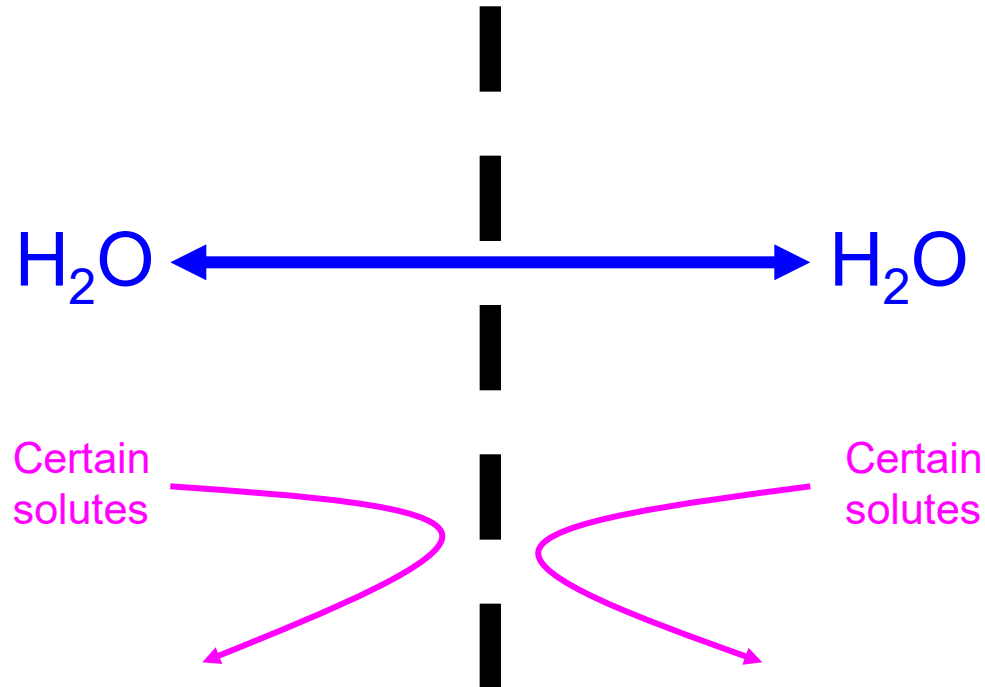


- Osmosis

- This is a passive process

Osmosis

Diffusion of a **solvent** (typically H_2O) across a selectively-permeable membrane.



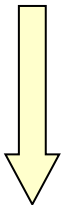
Osmosis

diffusion of water

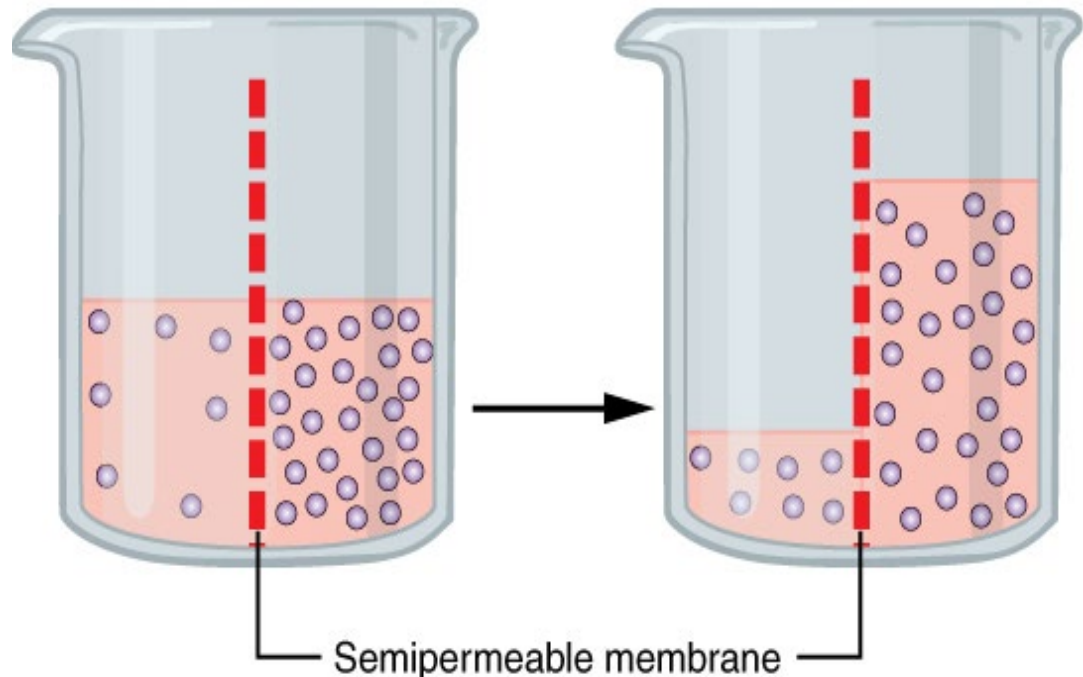
Figure 6

Key here is the semi-permeable membrane; which allows the water (solvent) across but not the substance (solute)

High Concentration of H₂O
(Low Concentration of solute)



Low Concentration of H₂O
(High Concentration of solute)



Osmosis terminology

Type of solution	Definition
Isotonic	Same concentration of solutes as in a cell.
Hypertonic	<u>Higher</u> concentration of solutes than in a cell.
Hypotonic	<u>Lower</u> concentration of solutes than in a cell.

Osmosis

Figure 7

effects on the structure of a red blood cell (Erythrocyte)

Concentration of solutes

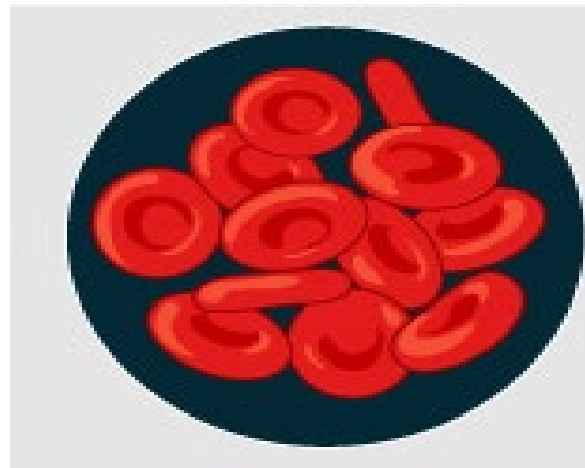
outside the cell > inside the cell outside the cell = inside the cell outside the cell < inside the cell

Hypertonic solutions

Isotonic solutions

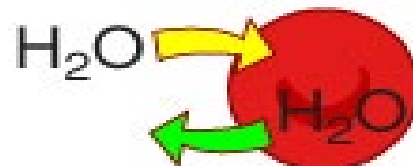
Hypotonic solutions

Isotonic



Crenation is when the cells get shrunk

Lysis is when the cells get expended



The cell membrane

six mechanisms for the traffic of molecules

- No energy required.
- Movement occurs along concentration gradient.
- Passive processes

Simple diffusion

Molecules move through the lipid bilayer.

Facilitated diffusion

Molecules move through membrane proteins.

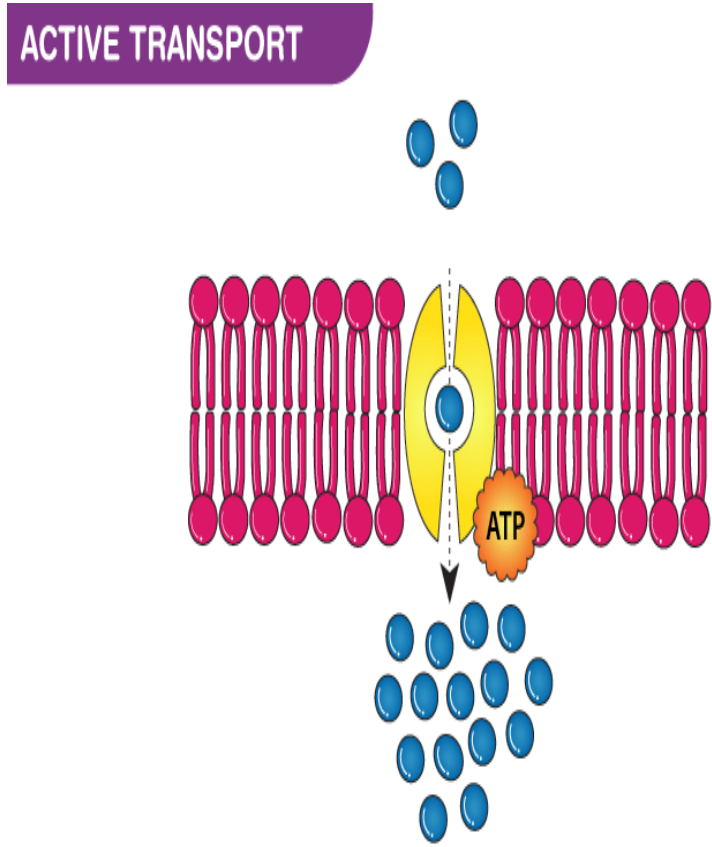
Solutes moving down (with) the concentration gradient (from high to low)

No energy required

Active transport

protein pumps

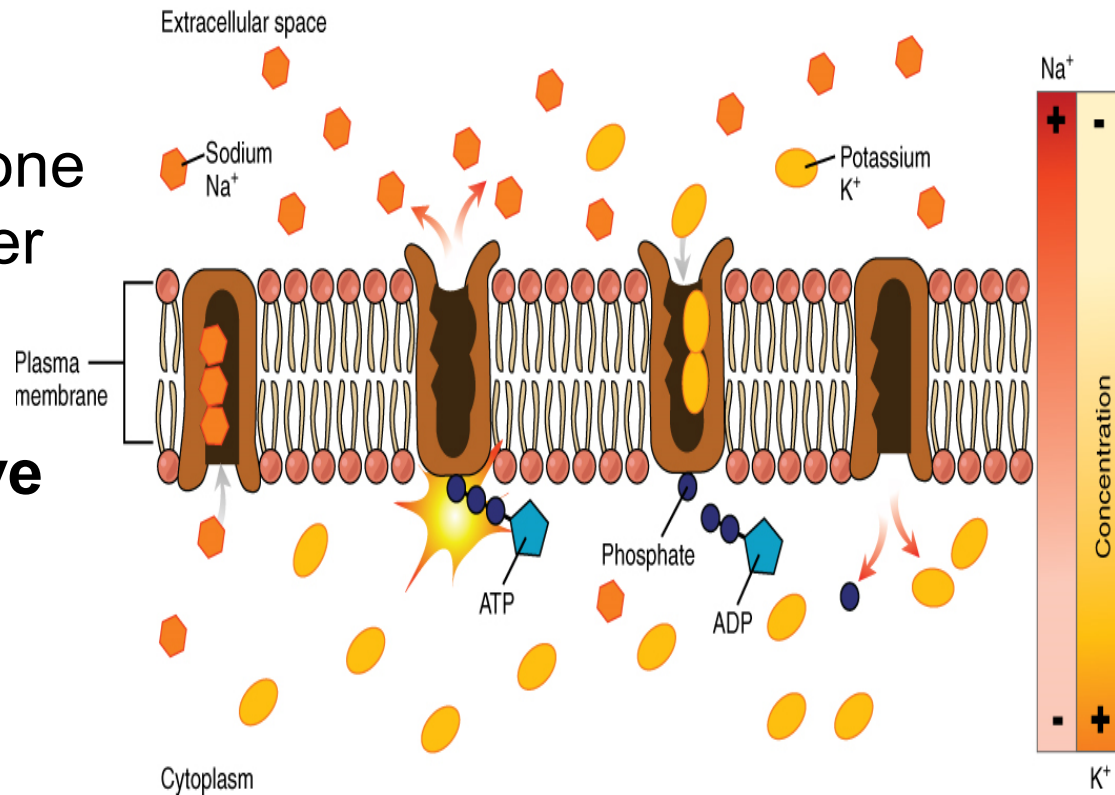
- Solutes moving against the concentration gradient
- As a result, requires energy
- This is an active process
- And energy comes from the hydrolysis of ATP
- Primary active transport occurs when energy from ATP directly drives the movement
- Note that a protein is still required



Active transport

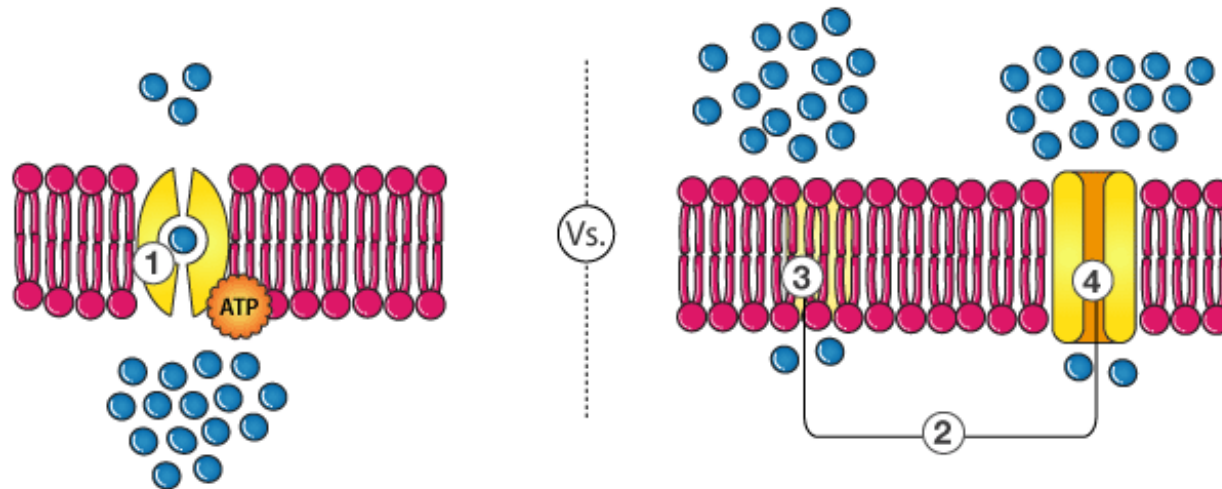
the Na^+/K^+ ATPase pump

- When active transport of one substance is used to power the transport of another substance in this way, it is called secondary **active transport**



Passive and active transport compared

ACTIVE AND PASSIVE TRANSPORT



- 1 Active transport
- 2 Passive transport
- 3 Diffusion
- 4 Facilitated diffusion

The cell membrane

six mechanisms for the traffic of molecules

Solutes moving against the concentration gradient

As a result, requires energy

Active Transport

Molecules move through membrane proteins.

Phagocytosis

Molecules are engulfed by the membrane (Endocytosis).

Pinocytosis

Endocytosis

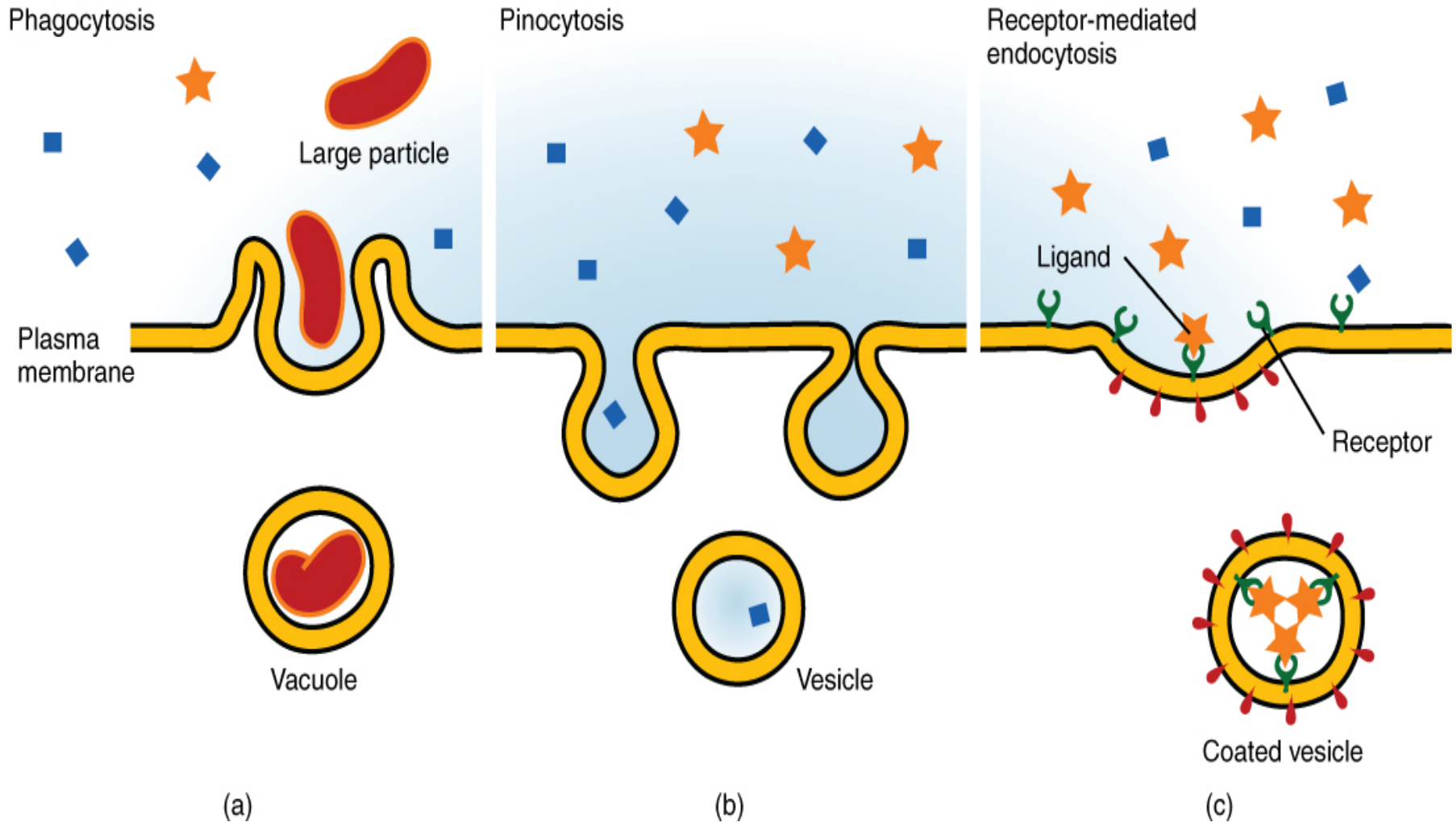
- A type of **active** transport that does not require membrane carries
- Energy is required
- Cell ingesting
- **Large molecules are engulfed**
 - Phagocytosis
 - Pinocytosis
 - Receptor-mediated endocytosis

Endocytosis

“the cells eating”

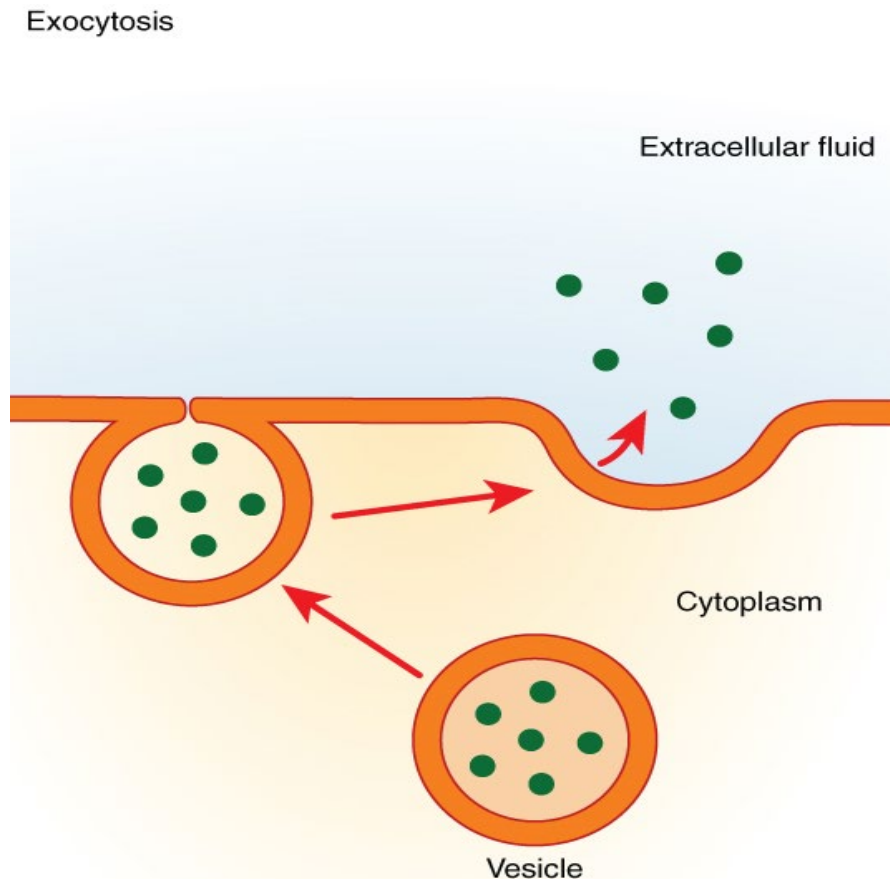
“the cells drinking”

Figure 9



Exocytosis

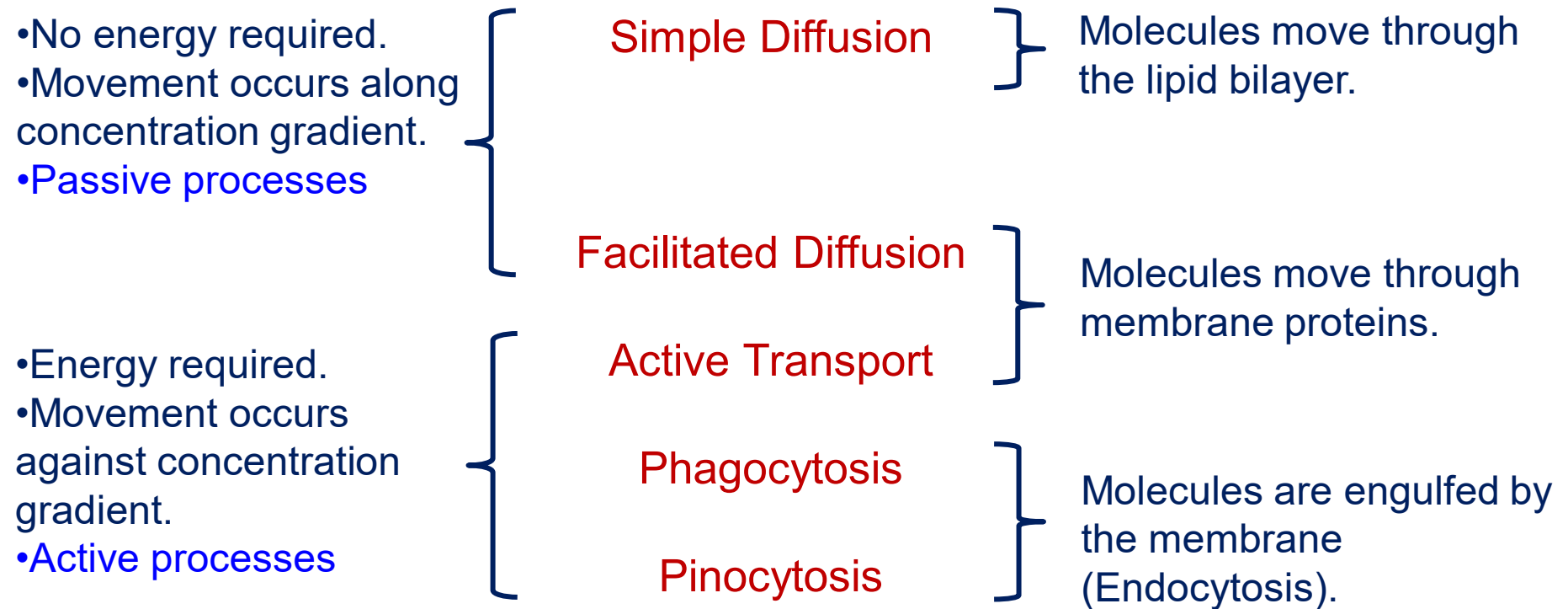
Figure 10



- Cell exporting material using vesicular transport
- A particle enveloped in a vesicle fuses with the cell membrane, causing the contents to be emptied from the cell.

The cell membrane

six mechanisms for the traffic of molecules



Membrane transport

Objectives

1. Describe the Fluid Mosaic (Singer-Nicholson) model of membrane structure including the membrane components.
2. Describe how the structure of the cell membrane affects membrane permeability.
3. Describe the following passive processes: diffusion, facilitated diffusion and osmosis. Explain the function of each in a cell.
4. Describe and explain the effects of placing red blood cells in hypertonic, hypotonic and isotonic solutions, respectively.
5. Describe the following active processes :primary and secondary active transport, endocytosis (phagocytosis, pinocytosis), and exocytosis. Explain the function of each in a cell.