Membranes and Cell Transport

- All cells are surrounded by a plasma membrane. Eukaryotic cells also contain internal membranes and membrane-bound organelles.
- In this topic, we will examine the structure and function of cell membranes. We will also look at how materials move within cells and across cell membranes.

Objective # 1

Describe the Fluid Mosaic Model of membrane structure.

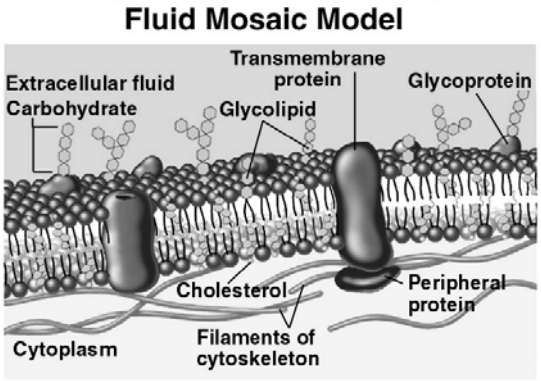
Objective 1

- In 1972, S. Singer and G. Nicolson proposed the Fluid Mosaic Model of membrane structure.
- According to this model, cell membranes are composed of a lipid bilayer with globular proteins embedded in the bilayer.

Objective 1

- On the external surface of the membrane, carbohydrate groups join with some lipids to form glycolipids. Carbohydrate groups may also join with proteins to form glycoproteins.
- Glycolipids and glycoproteins function as cell identity markers:

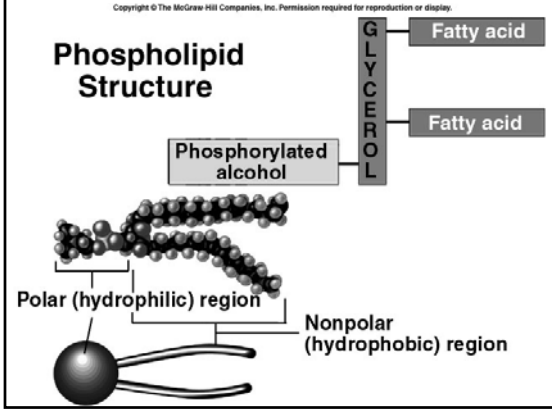
Objective 1, Membrane Structure



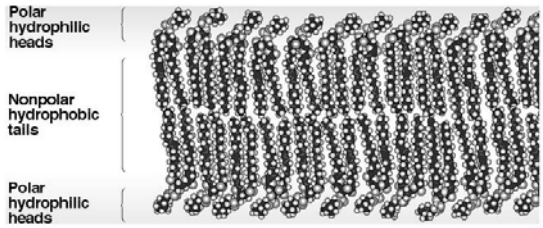
Objective 9, Raven pp. 104 - 107

- The membrane's lipid bilayer:
  - is mainly 2 layers of phospholipids; the non-polar tails point inward and the polar heads are on the surface.
  - contains cholesterol in animal cells.
  - is fluid, allowing proteins to move around within the bilayer.

Objective 9, Raven Fig 6.2



Objective 9, Raven Fig 6.3



Objective # 2

Explain the importance of cell transport.

Objective 2

- No cell exists as a closed system. In order to survive, materials must be transported into and out of the cell, across the plasma membrane.
- In addition, because different processes take place in different parts of the cell, materials must be transported from one part of the cell to another.

Objective # 3

- Explain the following terms:
  - solution
  - solute
  - solvent
  - aqueous solution

Objective 3

- To explain what a solution is, we will use a simple example:
  - If you dissolve some sugar in a glass of water, the resulting mixture is called a solution. In this case, the sugar is the solute and the water is the solvent. When water is the solvent, we call the solution an aqueous solution.

Objective # 4

Explain what passive transport is, and describe the following methods of passive transport across membranes:

a) Simple diffusion
b) Dialysis
c) Osmosis
d) Facilitated diffusion

Objective 4

- Passive transport is when substances move according to their own natural tendency without an expenditure of energy by the cell. No ATP is required.
- To understand how passive transport works, we need to examine the kinetic theory of matter.

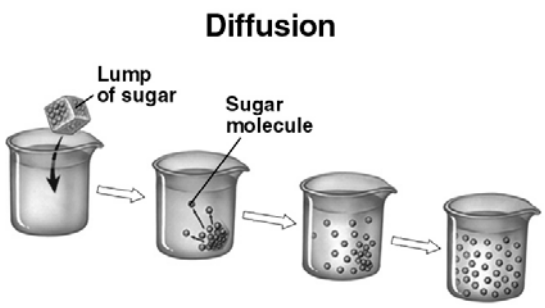
Objective 4

- Kinetic theory of matter:
  - States that all atoms and molecules are in constant random motion. (Energy of motion is called kinetic energy.)
  - The higher the temperature, the faster the atoms and molecules move.
  - We detect this motion as heat.
  - All motion theoretically stops only at absolute zero.

Objective 4a

- Diffusion:
  - is the net movement of a substance from an area where it has a higher concentration to an area where it has a lower concentration i.e. down a concentration gradient.
  - is caused by the constant random motion of all atoms and molecules.

Objective 4a



Objective 4a

- During diffusion, movement of individual atoms and molecules is always random, but net movement of each substance is down its own concentration gradient (from higher to lower concentration).

Objective 4

- In addition to simple diffusion, there are 3 specialized types of diffusion that involve movement of materials across a semipermeable membrane:
  - dialysis
  - osmosis
  - facilitated diffusion

Objective 4b

- A semipermeable membrane is a membrane where some substances can pass through while others cannot.
- Dialysis refers to the diffusion of solutes across a semipermeable membrane.
- The ability of solutes to pass through cell membranes depends mainly on size and electrical charge.

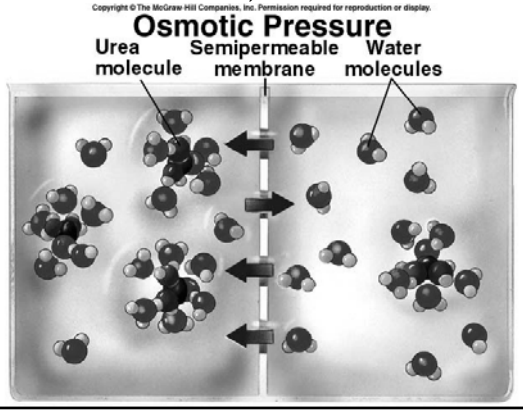
Objective 4c

- Osmosis refers to the diffusion of the solvent across a semipermeable membrane.
- In living systems the solvent is always water, so biologists generally define osmosis as the diffusion of water across a semipermeable membrane:

Objective 4c

- During osmosis, movement of water and solute molecules is random, but NET movement of water molecules across the semipermeable membrane is always from the area of higher WATER concentration (meaning lower solute concentration) to the area of lower WATER concentration (meaning higher solute concentration).

Objective 4c



Objective 4c

- If 2 aqueous solutions have the same concentration of solutes, we say they are isotonic or isosmotic.
- When isotonic solutions are separated by a semipermeable membrane, there is no NET movement of water across the membrane. Water molecules move randomly across the membrane in both directions at the same rate.

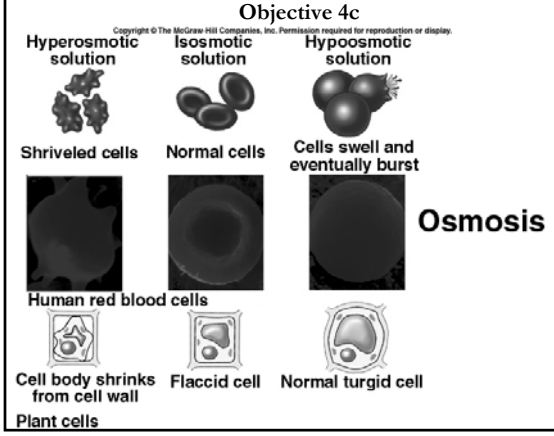
Objective 4c

- If 2 solutions have different concentrations of solutes:
  - The one with the higher conc. of solutes, and lower conc. of water, is hypertonic or hyperosmotic.
  - The one with the lower conc. of solutes, and higher conc. of water, is hypotonic or hypoosmotic.

Objective 4c

- What will happen to a cell if it is placed in a hypertonic solution?
  - net movement of water is out of the cell and it shrinks
- What will happen to a cell if it is placed in a hypotonic solution?
  - net movement of water is into the cell and it swells

Objective 4c



Objective 4c

- Cells have developed several ways to survive in a hypotonic environment:
  - Pump water out using a contractile vacuole.
  - Adjust the conc. of solutes so it is isotonic relative to the environment.
  - Develop a thick cell wall that can withstand high turgor pressure.

Objectives 4a, b, and c

- To learn more about diffusion, dialysis, and osmosis, complete the exercise "Diffusion, Dialysis, and Osmosis" in unit 1 of the *Process of Science* CD-ROM.

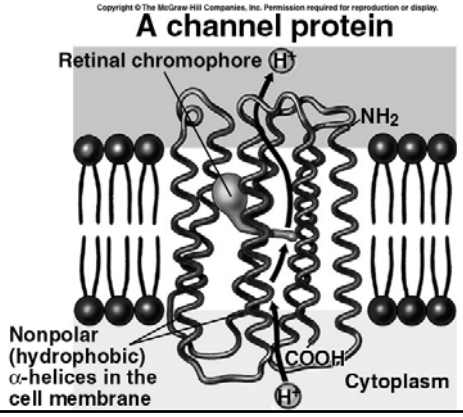
Objective 4d

- Facilitated diffusion refers to the diffusion of solutes through a semipermeable membrane with the help of special transport proteins:
  - Non-polar molecules and small polar molecules can diffuse through the lipid bilayer of a membrane without any help.
  - Large polar molecules and ions cannot, they need help from transport proteins.

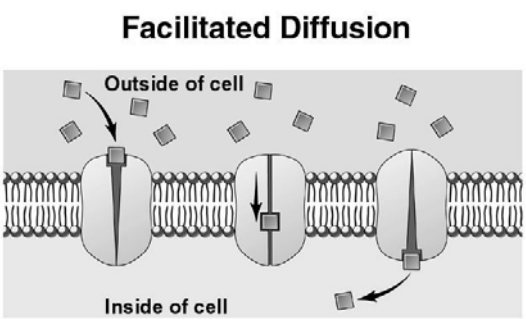
Objective 4d

- Two types of transport proteins can help ions and large polar molecules diffuse through cell membranes:
  - Channel proteins – provide a narrow channel for substance to pass through.
  - Carrier proteins – physically bind to substance on one side of membrane and release it on the other.

Objective 4d



Objective 4d



Objective 4d

- Facilitated diffusion:
  - is specific – each channel or carrier transports certain ions or molecules only
  - is passive – direction of net movement is always down the concentration gradient
  - saturates – once all transport proteins are in use, the rate of diffusion cannot be increased further

Objective # 5

Explain what active transport is, and describe the following methods of active transport across membranes:

a) membrane pumps
b) cotransport

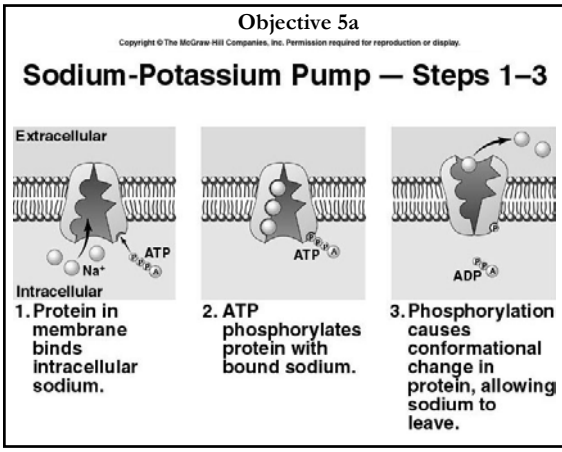
Objective 5

- Active transport:
  - a cell expends some of its own energy (from ATP) to move a substance against its natural tendency e.g. up a concentration gradient.
  - requires the use of carrier proteins (transport proteins that physically bind to the substance being transported).

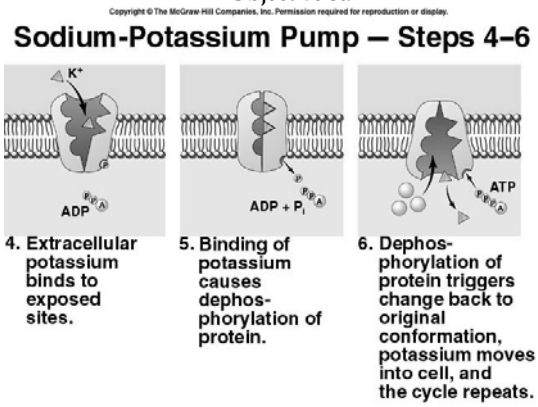
Objective 5a

- We will examine 2 types of active transport: membrane pumps and cotransport.
- With membrane pumps, a carrier protein uses energy from ATP to move a substance across a membrane, up its concentration gradient:

Objective 5a



Objective 5a



Objective 5b

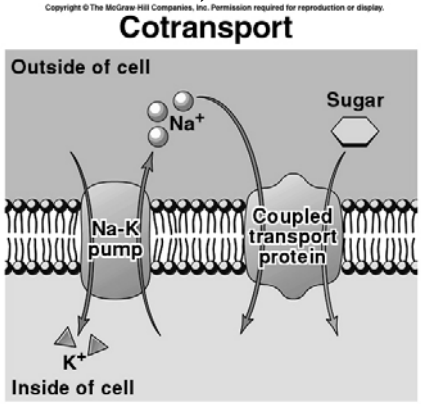
- Cotransport occurs in 2 stages:

➢ First, a carrier protein uses energy from ATP to move a substance across the membrane, up its concentration gradient. This gradient stores energy.

Objective 5b

➢ Second, a cotransport protein allows the substance to move back down its concentration gradient. As this happens, the stored energy is released and used to move a second substance up its concentration gradient:

Objective 5b



Objective # 6

Explain what bulk transport is, and describe the following methods of bulk transport:

a) Endocytosis including phagocytosis and pinocytosis

b) exocytosis

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Objective 6

- Bulk transport allows small particles, or groups of molecules to enter or leave a cell without actually passing through the membrane.
- We will examine 2 types of bulk transport: endocytosis and exocytosis.

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Objective 6a

- In endocytosis, part of the plasma membrane envelops small particles or fluid, then seals on itself to form a vesicle which enters the cell:
  - Phagocytosis – the substance engulfed is a solid particle
  - Pinocytosis - the substance engulfed is a liquid

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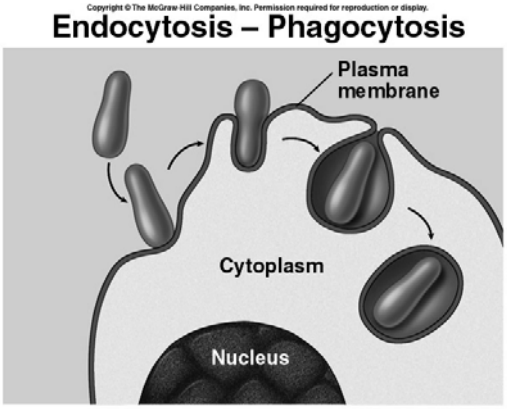
Objective 6a



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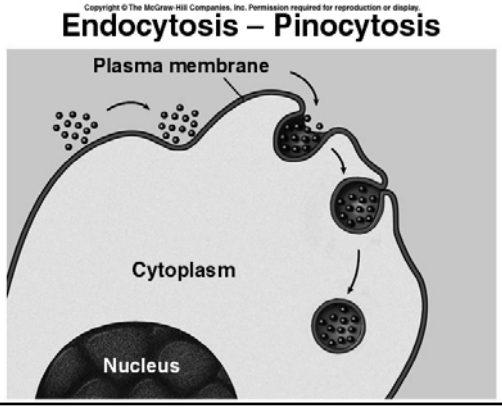
Objective 6a



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Objective 6b

- The reverse of endocytosis is called exocytosis.
- During this process, the membrane of a vesicle fuses with the plasma membrane and its contents are released outside the cell:

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Objective 6b

Exocytosis