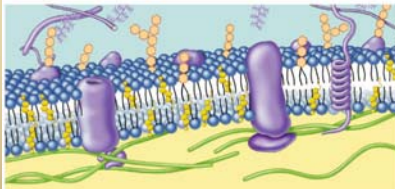


AICE Biology

(D) Cell membranes and transport

AICE Biology



AICE Ch 4 – Raven Ch 5

Content

- Fluid mosaic model of membrane structure
- Movement of substances into and out of cells

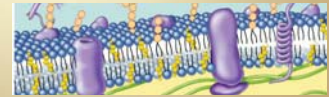
Learning Outcomes

Candidates should be able to:

- (a) describe and explain the fluid mosaic model of membrane structure, including an outline of the roles of phospholipids, cholesterol, glycolipids, proteins and glycoproteins;
- (b) outline the roles of cell surface membranes;
- (c) describe and explain the processes of *diffusion*, *facilitated diffusion*, *osmosis*, *active transport*, *endocytosis* and *exocytosis* (terminology described in the IOB's publication *Biological Nomenclature* should be used; no calculations involving water potential will be set);
- (d) [PA] investigate the effects on plant cells of immersion in solutions of different water potential
- (e) use the knowledge gained in this section in new situations or to solve related problems.

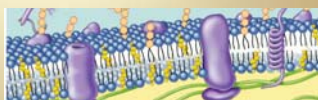
Cell Membranes

- Structure of a cell membrane
 - Phospholipid
 - Bilayer
 - Cholesterol
 - Protein
 - Glycolipids
 - Glycoproteins
- Fluid mosaic model



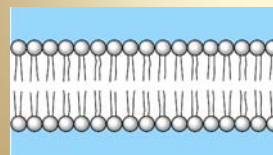
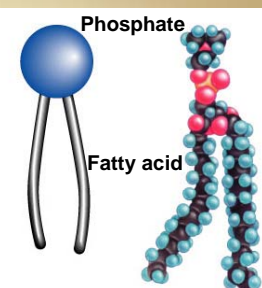
Overview

- Cell membrane **separates** living cell from nonliving surroundings
 - thin barrier = 8 nm thick
- Controls traffic in & out of the cell
 - **selectively permeable**
 - allows some substances to cross more easily than others
 - hydrophobic vs hydrophilic
- Made of **phospholipids**, **proteins** & other macromolecules



Phospholipids

- Fatty acid tails
 - **hydrophobic**
- Phosphate group head
 - **hydrophilic**
- Arranged as a **bilayer**



Aaaah, one of those structure-function examples



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Phospholipid bilayer

polar hydrophilic heads

nonpolar hydrophobic tails

polar hydrophilic heads

More than lipids...

- In 1972, S.J. Singer & G. Nicolson proposed that membrane proteins are inserted into the phospholipid bilayer

It's like a fluid...
It's like a mosaic...
It's the Fluid Mosaic Model!

Membrane is a collage of proteins & other molecules embedded in the fluid matrix of the lipid bilayer

Membrane fat composition varies

- Fat composition affects flexibility
 - membrane must be fluid & flexible
 - about as fluid as thick salad oil
 - % unsaturated fatty acids in phospholipids
 - keep membrane less viscous
 - cold-adapted organisms, like winter wheat
 - increase % in autumn
 - cholesterol in membrane

Membrane Proteins

- Proteins determine membrane's specific functions
 - cell membrane & organelle membranes each have unique collections of proteins
- Membrane proteins:
 - peripheral proteins**
 - loosely bound to surface of membrane
 - cell surface identity marker (**antigens**)
 - integral proteins**
 - penetrate lipid bilayer, usually across whole membrane
 - transmembrane protein**
 - transport proteins
 - channels, permeases (pumps)

Classes of amino acids

What do these amino acids have in common?

nonpolar & hydrophobic

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Classes of amino acids

What do these amino acids have in common?

Polar

Serine (Ser) Threonine (Thr) Cysteine (Cys) Tyrosine (Tyr) Asparagine (Asn) Glutamine (Gln)

Acidic **Basic**

Aspartic acid (Asp) Glutamic acid (Glu) Lysine (Lys) Arginine (Arg) Histidine (His)

Electrically charged

polar & hydrophilic

I like the polar ones the best!

Many Functions of Membrane Proteins

Outside

Plasma membrane

Inside

Transporter

Enzyme activity

Cell surface receptor

Cell surface identity marker

Cell adhesion

Attachment to the cytoskeleton

Membrane carbohydrates

- Play a key role in **cell-cell recognition**
 - ability of a cell to distinguish one cell from another
 - **antigens**
 - important in organ & tissue development
 - basis for rejection of foreign cells by **immune system**

Any Questions??

Movement across the Cell Membrane

Outside cell

Protein molecule

Carbohydrate chain

Protein molecule

Protein channels

Lipid (bilayer)

Inside cell

Passive transport

- Diffusion
- Facilitated diffusion
- Osmosis
- Water movement between cells

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Diffusion

- 2nd Law of Thermodynamics governs biological systems
 - universe tends towards disorder (entropy)

Molecules of dye Membrane WATER Equilibrium

▪ **Diffusion**

- ◆ movement from **high** → **low** concentration

Diffusion

- Move from **HIGH** to **LOW** concentration
 - “passive transport”
 - no energy needed

movement of water

diffusion osmosis

Diffusion across cell membrane

- Cell membrane is the boundary between inside & outside...
 - separates cell from its environment

Can it be an impenetrable boundary? NO!

IN
food
carbohydrates
sugars, proteins
amino acids
lipids
salts, O₂, H₂O

OUT
waste
ammonia
salts
CO₂
H₂O
products

cell needs materials in & products or waste out

Diffusion through phospholipid bilayer

- What molecules can get through directly?
 - fats & other lipids

What molecules can NOT get through directly?

- ◆ polar molecules
 - H₂O
- ◆ ions
 - salts, ammonia
- ◆ large molecules
 - starches, proteins

Channels through cell membrane

- Membrane becomes **semi-permeable** with protein channels
 - specific channels allow specific material across cell membrane

inside cell H₂O aa sugar outside cell

NH₃ salt

Facilitated Diffusion

- Diffusion through protein channels
 - channels move specific molecules across cell membrane
 - no energy needed

facilitated = with help

open channel = fast transport

Hydrophilic region of protein Hydrophobic region of protein

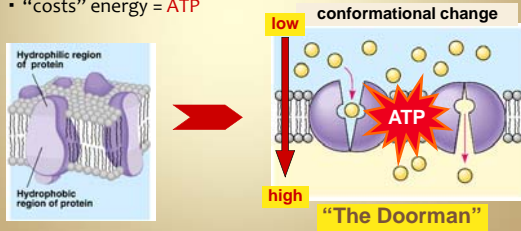
high low

“The Bouncer”

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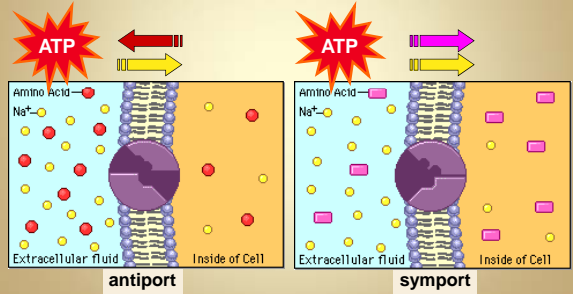
Active Transport

- Cells may need to move molecules *against* concentration gradient
 - shape change transports solute from one side of membrane to other
 - protein "pump"
 - "costs" energy = ATP



Active transport

- Many models & mechanisms

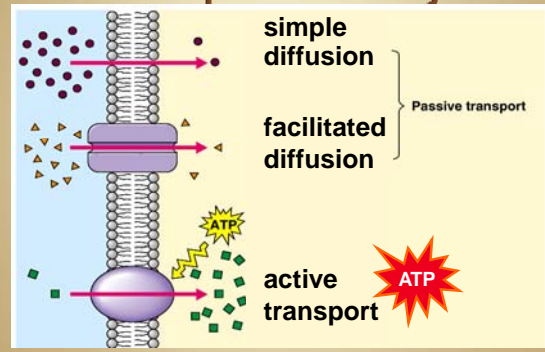


Getting through cell membrane

- Passive Transport**
 - Simple diffusion**
 - diffusion of nonpolar, hydrophobic molecules
 - lipids
 - high → low concentration gradient
 - Facilitated transport**
 - diffusion of polar, hydrophilic molecules
 - through a **protein channel**
 - high → low concentration gradient
- Active transport**
 - diffusion *against* concentration gradient
 - low → high
 - uses a **protein pump**
 - requires **ATP**

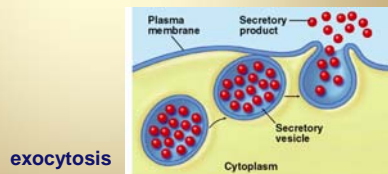


Transport summary

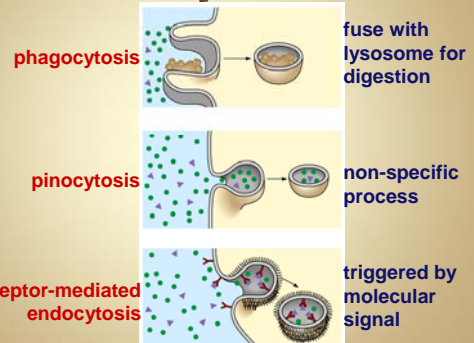


How about large molecules?

- Moving large molecules into & out of cell
 - through vesicles & vacuoles
 - endocytosis**
 - phagocytosis** = "cellular eating"
 - pinocytosis** = "cellular drinking"
 - exocytosis**



Endocytosis



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The Special Case of Water

Movement of water across the cell membrane

Osmosis is diffusion of water

- Diffusion of water from **high concentration** of water to **low concentration** of water
- across a semi-permeable membrane

Concentration of water

- Direction of osmosis is determined by comparing total solute concentrations
 - Hypertonic** - more solute, less water
 - Hypotonic** - less solute, more water
 - Isotonic** - equal solute, equal water

Managing water balance

Cell survival depends on balancing water uptake & loss

Hypotonic solution	Isotonic solution	Hypertonic solution	
			Animal cell
			Plant cell
freshwater	balanced	saltwater	

Managing water balance

- Isotonic**
 - animal cell immersed in **mild salt** solution
 - example: **blood cells in blood plasma**
- no net movement** of water
 - flows across membrane equally, in both directions
- volume of cell is stable

Blood

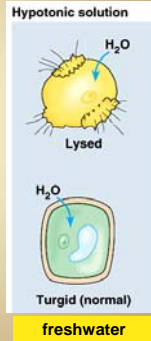
- A red blood cell placed in a **hypotonic** solution (pure water) bursts immediately from the influx of water.
- When red blood cells are placed in a 0.9% salt solution, they neither gain nor lose water by osmosis.
 - solution is **isotonic**
- If red cells are placed in sea water (about 3% salt), they lose water by osmosis and the cells shrivel up.
 - Sea water is **hypertonic** to their cytosol.

(Kimball, 2011)

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Managing water balance

- Hypotonic
 - a cell in **fresh water**
 - example: *Paramecium*
 - problem: **gains water**, swells & can burst
 - water continually enters *Paramecium* cell
 - solution: **contractile vacuole**
 - pumps water out of cell
 - ATP
 - plant cells
 - Turgid- pressure built up
 - Combination of solute potential and pressure potential



Water regulation

- Contractile vacuole in *Paramecium*



Managing water balance

- Hypertonic
 - a cell in **salt water**
 - example: shellfish
 - problem: **lose water & die**
 - solution: take up water or pump out salt
 - plant cells
 - plasmolysis = wilt



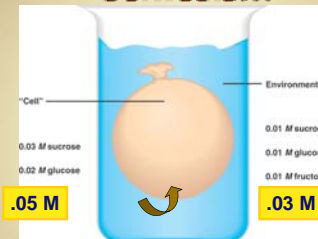
Water Potential

- By convention, the water potential of pure water is set at zero
 - Pure water has the **highest** water potential
 - Solutes make water potential lower
 - Less than zero (negative)
 - The more solute, the lower the water potential (or more negative)
- The amount the solute molecules lower the water potential of a solution is called **solute potential**
 - **Solute potential is always negative**

Pressure Potential

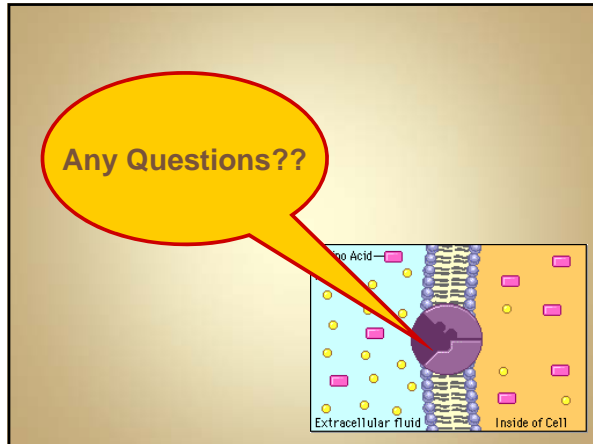
- ... defined as the contribution made by pressure to water potential
- Just as tendency of water molecules to move from one place to another is measured as water potential, increasing the **pressure** increases the water potential
 - See diagram in AICE textbook page 56
- The pressure potential makes the water potential less negative and is therefore positive
 - Important in plant cells
 - Pressure builds against cell walls

Osmosis...



Cell (compared to beaker) → hypertonic or hypotonic
 Beaker (compared to cell) → hypertonic or hypotonic
 Which way does the water flow? → in or out of cell

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Resources

Jones, M. (2010). Cambridge International A/AS- Level Revision Guide. London, NW1. Hodder Education.

Jones, M., Fosbery, R., Taylor, D., & Gregory, J. (2007). AS Level and A Level Biology, 2nd ed. Cambridge, UK: Cambridge University Press.

Kimball, J. (2011). Cell membranes. Retrieved October 31, 2011 from website <http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/D/Diffusion.html>