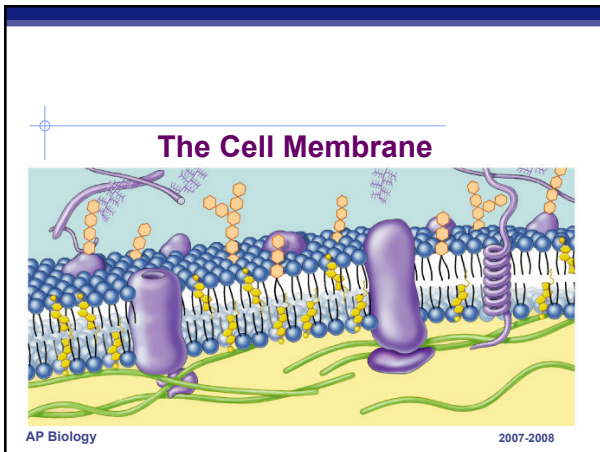


AP Biology



### Phospholipids

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

Aaah, one of those structure-function examples

### Arranged as a Phospholipid bilayer

- Serves as a cellular barrier / border

AP Biology

### Cell membrane defines cell

- Cell membrane **separates** living cell from aqueous environment
  - thin barrier = 8nm thick
- Controls traffic in & out of the cell
  - allows some substances to cross more easily than others
    - hydrophobic (nonpolar) vs. hydrophilic (polar)

AP Biology

### Permeability to polar molecules?

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

© Holt

### Cell membrane is more than lipids...

- Transmembrane proteins embedded in phospholipid bilayer
  - create semi-permeable channels

AP Biol

AP Biology

**Why are proteins the perfect molecule to build structures in the cell membrane?**

$\alpha$  Helix

**Classes of amino acids**

What do these amino acids have in common?

<chem>NC(C)C(=O)O</chem> Glycine (Gly)	<chem>NC(C)C(=O)O</chem> Alanine (Ala)	<chem>NC(C)C(C)C(=O)O</chem> Valine (Val)	<chem>NC(C)C(C)C(=O)O</chem> Leucine (Leu)	<chem>NC(C)C(C)C(=O)O</chem> Isoleucine (Ile)
<chem>NC(C)C(C)C(=O)O</chem> Methionine (Met)	<chem>NC(C)C(C)C(=O)O</chem> Phenylalanine (Phe)	<chem>NC(C)C(C)C(=O)O</chem> Tryptophan (Trp)	<chem>NC(C)C(C)C(=O)O</chem> Proline (Pro)	

**nonpolar & hydrophobic**

AP Biology

**Classes of amino acids**

What do these amino acids have in common?

<chem>NC(C)C(O)C(=O)O</chem> Serine (Ser)	<chem>NC(C)C(O)C(=O)O</chem> Threonine (Thr)	<chem>NC(C)C(S)C(=O)O</chem> Cysteine (Cys)	<chem>NC(C)C(O)C(=O)O</chem> Tyrosine (Tyr)	<chem>NC(C)C(N)C(=O)O</chem> Asparagine (Asn)	<chem>NC(C)C(N)C(=O)O</chem> Glutamine (Gln)
<chem>NC(C)C(O)C(=O)O</chem> Aspartic acid (Asp)	<chem>NC(C)C(O)C(=O)O</chem> Glutamic acid (Glu)	<chem>NC(C)C(N)C(=O)O</chem> Lysine (Lys)	<chem>NC(C)C(N)C(=O)O</chem> Arginine (Arg)	<chem>NC(C)C(N)C(=O)O</chem> Histidine (His)	

**polar & hydrophilic**

I like the polar ones the best!

**Proteins domains anchor molecule**

- Within membrane
  - nonpolar amino acids
    - hydrophobic
    - anchors protein into membrane
- On outer surfaces of membrane in fluid
  - polar amino acids
    - hydrophilic
    - extend into extracellular fluid & into cytosol

**Examples**

aquaporin = water channel in bacteria

Porin monomer  $H_2O$

$\beta$ -pleated sheets

Bacterial outer membrane

Retinal chromophore

$H^+$

$NH_2$

Nonpolar (hydrophobic)  $\alpha$ -helices in the cell membrane

Cytoplasm

proton pump channel in photosynthetic bacteria

$COOH$

$H^+$

function through conformational change = protein changes shape

**Many Functions of Membrane Proteins**

Outside

Plasma membrane

Inside

“Channel”

Transporter

Enzyme activity

Cell surface receptor

“Antigen”

Cell surface identity marker

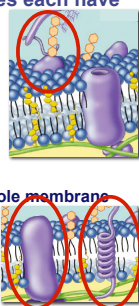
Cell adhesion

Attachment to the cytoskeleton

# AP Biology

## Membrane Proteins

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

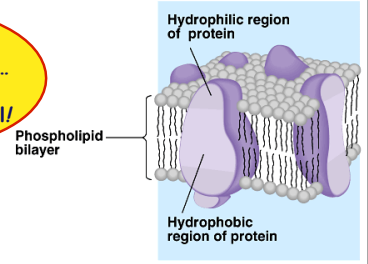


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## Cell membrane must be more than lipids...

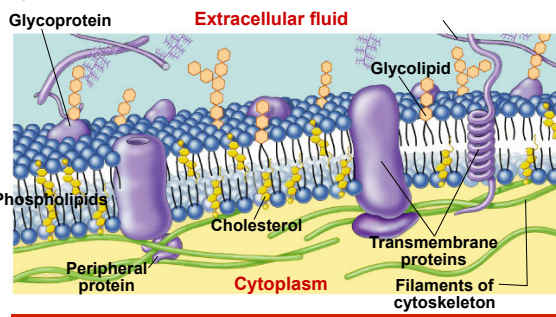
- In 1972, S.J. Singer & G. Nicolson proposed that membrane proteins are inserted into the phospholipid bilayer

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



AP Biology

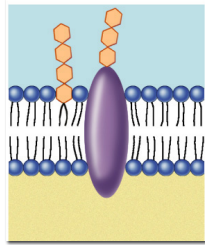
## Membrane is a collage of proteins & other molecules embedded in the fluid matrix of the lipid bilayer



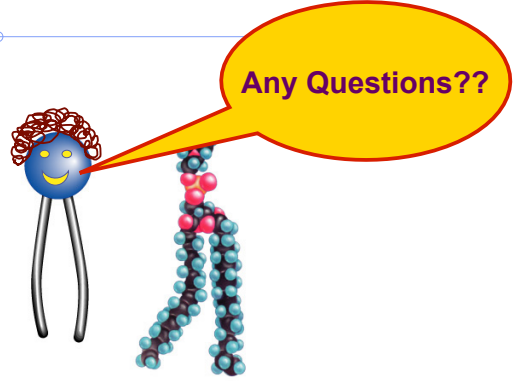
1972, S.J. Singer & G. Nicolson proposed Fluid Mosaic Model

## 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**

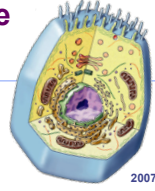


AP Biology



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## Movement across the Cell Membrane



AP Biology 2007-2008

# AP Biology

## 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

## Simple Diffusion

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

movement of water

**diffusion** **osmosis**

## 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”

## Active Transport

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

conformational change

Hydrophilic region of protein  
Hydrophobic region of protein

LOW HIGH  
ATP  
“The Doorman”

## Active transport

- Many models & mechanisms

ATP

Amino Acid Na<sup>+</sup>

Extracellular fluid Inside of Cell

antiport symport

## 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

ATP

AP Biology

### Transport summary

simple diffusion

facilitated diffusion

active transport

Passive transport

ATP

ATP

A

### How about large molecules?

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

Plasma membrane

Secretory product

Secretory vesicle

Cytoplasm

AP Biology

exocytosis

### Endocytosis

- phagocytosis**
  - fuse with lysosome for digestion
- pinocytosis**
  - non-specific process
- receptor-mediated endocytosis**
  - triggered by molecular signal

AP Biology

### The Special Case of Water

#### Movement of water across the cell membrane

H<sub>2</sub>O

H<sub>2</sub>O

Normal

H<sub>2</sub>O

H<sub>2</sub>O

Flaccid

2007-2008

### Osmosis is just diffusion of water

- Water is very important to life, so we talk about water separately
- Diffusion of water from **HIGH concentration of water** to **LOW concentration of water**
  - across a semi-permeable membrane

Hypotonic solution

Hypertonic solution

H<sub>2</sub>O

Selectively permeable membrane

AP Biology

### 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

water

hypotonic

hypertonic

net movement of water

AP Biology



AP Biology

### Managing water balance

- Cell survival depends on balancing water uptake & loss

Solution Type	Animal Cell	Plant Cell
Hypotonic solution	Lysed	Turgid (normal)
Isotonic solution	Normal	Flaccid
Hypertonic solution	Shriveled	Plasmolyzed

AP Biology **freshwater** **balanced** **saltwater**

### Managing water balance

- Hypotonic**
  - a cell in **fresh water**
  - high concentration of water around cell
  - problem:** cell gains water, swells & can burst
  - example:** *Paramecium*
    - ex: water continually enters *Paramecium* cell
  - solution:** contractile vacuole
    - pumps water out of cell
    - ATP
- plant cells**
  - turgid = full
  - cell wall protects from bursting

AP Biology **freshwater**

### Pumping water out

- Contractile vacuole in *Paramecium***

AP Biology

### Managing water balance

- Hypertonic**
  - a cell in **salt water**
  - low concentration of water around cell
  - problem:** cell loses water & can die
  - example:** shellfish
  - solution:** take up water or pump out salt
- plant cells**
  - plasmolysis** = wilt
  - can recover

AP Biology **saltwater**

### Managing water balance

- Isotonic**
  - animal cell immersed in **mild salt** solution
  - no difference in concentration of water between cell & environment
  - problem:** none
    - no net movement of water
      - flows across membrane equally, in both directions
    - cell in equilibrium
    - volume of cell is stable
  - example:** **blood cells in blood plasma**
    - slightly salty IV solution in hospital

AP Biology **balanced**

### Aquaporins

1991 | 2003

- Water moves **rapidly** into & out of cells
- evidence that there were water channels
  - protein channels allowing flow of water across cell membrane

Peter Agre John Hopkins  
Roderick MacKinnon Rockefeller

AP Biology

AP Biology

### Do you understand Osmosis...

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

Any Questions??

AP Biology

### Ghosts of Lectures Past (storage)

AP Biology 2007-2008

### Diffusion through phospholipid bilayer

- What molecules can get through directly?
  - fats & other lipids
- What molecules can NOT get through directly?
  - polar molecules
    - H<sub>2</sub>O
  - ions (charged)
    - salts, ammonia
  - large molecules
    - starches, proteins

AP Biology

### 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

Fluid: Unsaturated hydrocarbon tails with kinks  
 Viscous: Saturated hydrocarbon tails

### 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, O<sub>2</sub>, H<sub>2</sub>O

**OUT**  
 waste  
 ammonia  
 salts  
 CO<sub>2</sub>  
 H<sub>2</sub>O  
 products

cell needs materials in & products or waste out