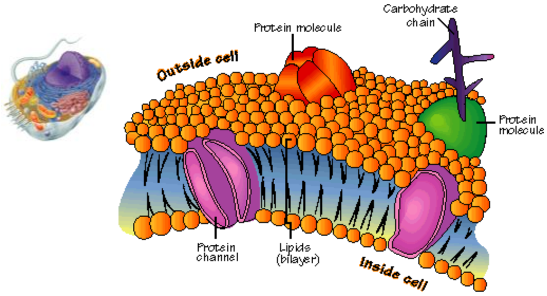
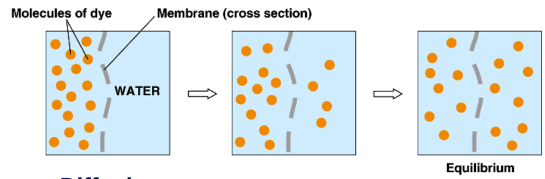
Chapter 6
The Plasma Membrane



Diffusion

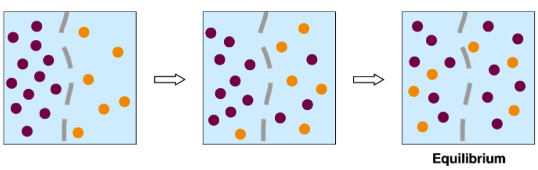
- 2nd Law of Thermodynamics governs biological systems
  - Universe tends towards disorder—ENTROPY!



- Diffusion
  - movement of particles from high → low concentration

Diffusion of 2 solutes

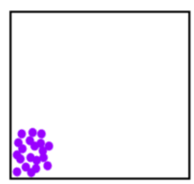
- Each substance diffuses down its ***own*** concentration gradient, independent of concentration gradients of other substances



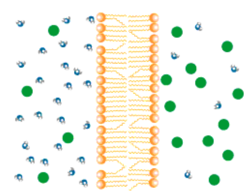
(b) Diffusion of two solutes

Diffusion

- Move from HIGH to LOW concentration
  - "passive transport" across a membrane
  - no energy needed



diffusion



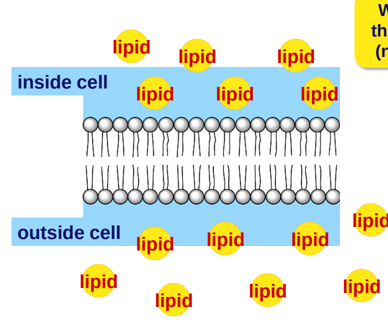
passive transport

Semi-permeable membrane

- Need to allow passage through the membrane for a lot of stuff!
- But it needs to control what gets in or out
  - membrane needs to be semi-permeable

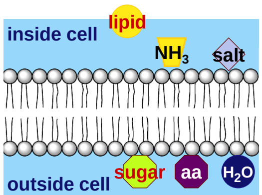
Simple diffusion across membrane

Which way will the lipids move? (net movement)



Phospholipid bilayer

- What molecules can get through directly?



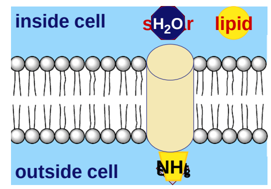
Fats and other non-polar (hydrophoblic) molecules can slip directly through the phospholipid bilayer membrane, but…

…what about all the other stuff?

Permeable cell membrane

- Need to allow other material through
  - membrane needs to be permeable to…
    - all materials a cell needs to bring <u>in</u>
    - all wastes a cell needs excrete <u>out</u>
    - all products a cell needs to *export* <u>out</u>

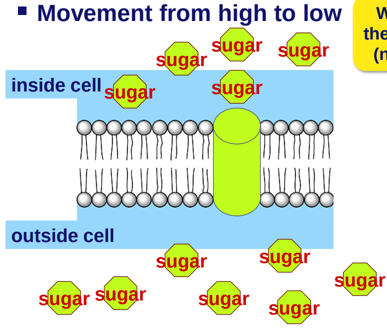
"holes" or <u>channels</u> in cell membrane allow polar (hydrophilic) materials in & out



Diffusion through a channel

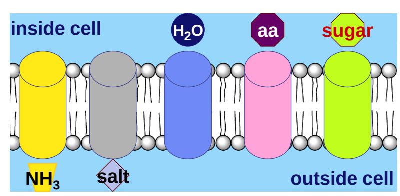
- Movement from high to low

Which way will the sugars move? (net movement)



Semi-permeable cell membrane

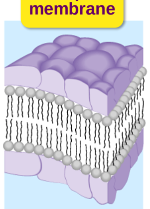
- But the cell still needs control
  - membrane needs to be <u>semi-permeable</u>
    - specific channels allow specific material in & out



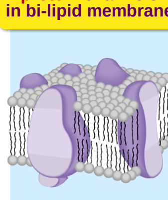
So… how do you build a selectively permeable cell membrane?

- What molecule will sit "comfortably" in a phospholipid bilayer forming channels?

bi-lipid membrane

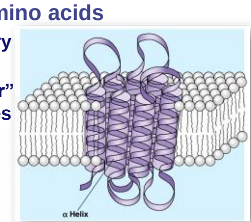


protein channels in bi-lipid membrane



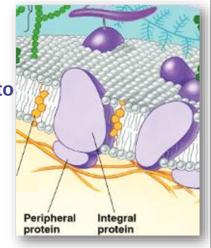
Why proteins?

- Proteins are *mixed* molecules
  - some <u>hydrophobic</u> amino acids
    - stick in the lipid membrane
    - anchors the protein in membrane
  - some <u>hydrophilic</u> amino acids
    - stick out in the watery fluid in & around cell
    - specialized "receptor" for specific molecules



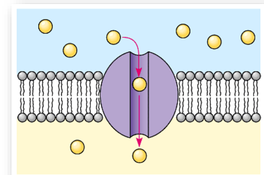
Membrane Proteins

- Proteins determine most of membrane's specific functions
  - cell membrane & organelle membranes each have unique collections of proteins
- Membrane proteins:
  - peripheral proteins = loosely bound to surface of membrane
  - integral proteins = penetrate into lipid bilayer, often completely spanning the membrane
    - *a.k.a. transmembrane* proteins



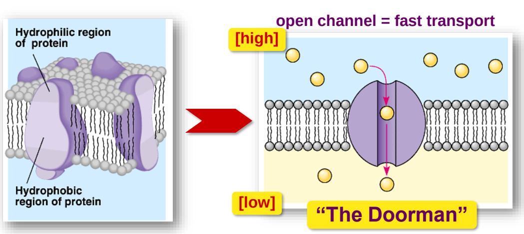
Facilitated Diffusion

- Movement from HIGH to LOW concentration through a protein channel
  - passive transport
  - no energy needed
  - facilitated = with help



Facilitated Diffusion

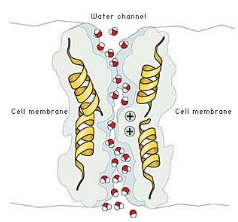
- Globular proteins act as doors in membrane
  - channels to move specific molecules through cell membrane

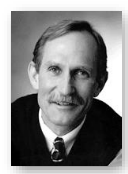


Aquaporins

1991 | 2003

- Water moves rapidly into & out of cells
  - evidence that there were water channels



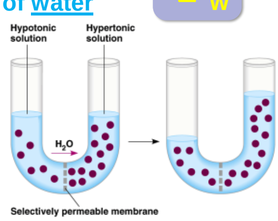


Peter Agre
John Hopkins

Roderick MacKinnon
Rockefeller

Osmosis is "DIFFUSION OF WATER"

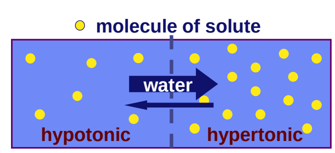
- Water is very important, so we talk about water separately—but same idea!
- Diffusion of water from ***high concentration*** of water to ***low concentration*** of water
  - across a semi-permeable membrane



Concentration of water

- Direction of osmosis is determined by comparing total *solute* concentrations!
  - hypertonic - more solute, less water, $\downarrow\Psi_w$
  - hypotonic - less solute, more water, $\uparrow\Psi_w$
  - isotonic - equal solute, equal water, $=\Psi_w$

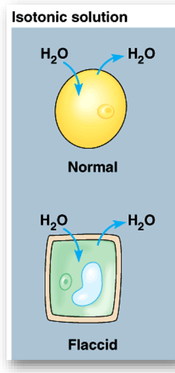
Which way will the water move? (net movement)



net movement of water

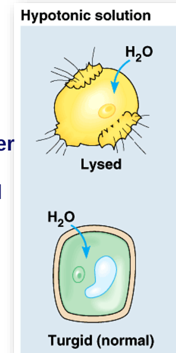
Managing water balance

- Isotonic
  - animal cell immersed in <u>isotonic</u> solution
    - blood cells in blood
    - no <u>net</u> movement of water across plasma membrane
    - water flows across membrane, at same rate in both directions
    - volume of cell is stable



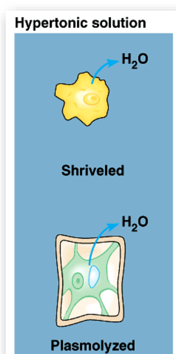
Managing water balance

- Hypotonic
  - animal cell in <u>hypotonic</u> solution will gain water, swell & burst
    - *Paramecium* vs. pond water
    - *Paramecium* is hypertonic
    - H_2O continually enters cell
    - to solve problem, specialized organelle, <u>contractile vacuole</u>
    - pumps H_2O out of cell using ATP
  - plant cell
    - turgid



Managing water balance

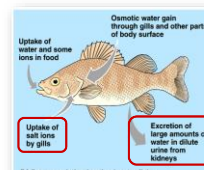
- Hypertonic
  - animal cell in <u>hypertonic</u> solution will lose water, shrivel & probably die
    - salt water organisms are hypotonic compared to their environment
    - they have to take up water & pump out salt
  - plant cells
    - <u>plasmolysis</u> = wilt

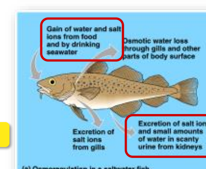


Osmoregulation

- Water balance
  - freshwater
    - <u>hypotonic environment</u>
    - water flow into cells & salt loss
  - saltwater
    - <u>hypertonic environment</u>
    - water loss from cells
  - land
    - dry environment
    - need to conserve water
    - may need to conserve salt

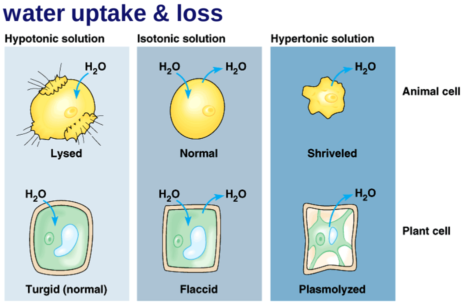
Why do all <u>land</u> animals have to conserve water?

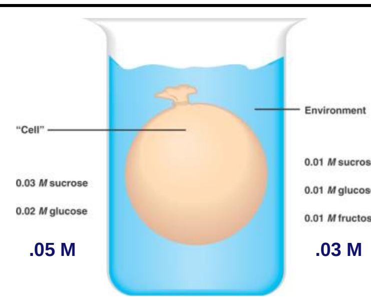




Osmoregulation

- Cell survival depends on balancing water uptake & loss





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

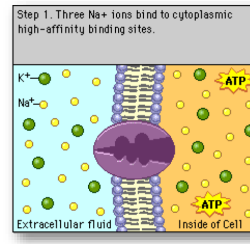
Facilitated Diffusion: Gated Channels

- Some channel proteins open only in presence of stimulus (signal)
  - stimulus usually different from transported molecule
    - ex: <u>ion-gated channels</u>
      when neurotransmitters bind to a specific gated channels on a neuron, these channels open = allows Na^+ ions to enter nerve cell
    - ex: <u>voltage-gated channels</u>
      change in electrical charge across nerve cell membrane opens Na^+ & K^+ channels

Active Transport

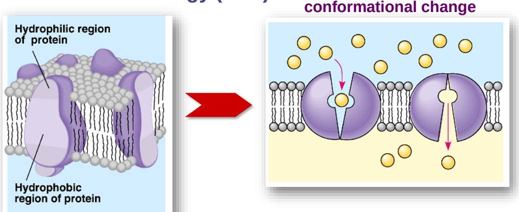
- Cells may need molecules to move ***<u>against</u>*** concentration gradient
  - need to pump against concentration
  - protein pump
  - requires energy
    - ATP

Na+/K+ pump in nerve cell membranes



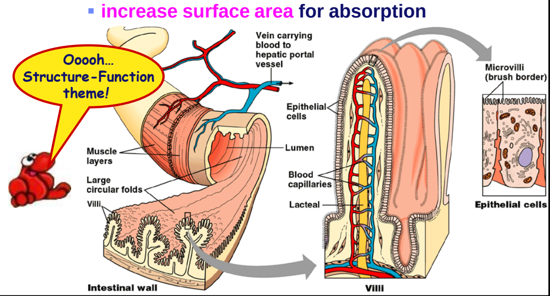
Active Transport

- Globular proteins act as ferry for specific molecules against the [gradient]
  - shape change transports solute from one side of membrane to other → protein "pump"
  - "costs" energy (ATP)



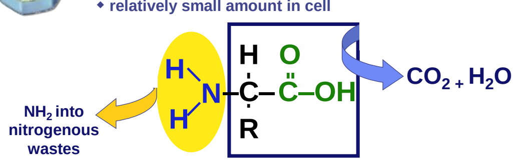
Absorption by Small Intestines

- Absorption through villi & microvilli
  - finger-like projections
    - increase surface area for absorption



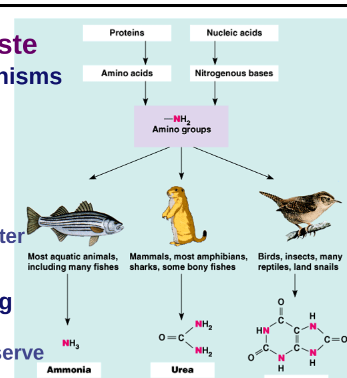
Waste Disposal

- What waste products?
  - what do we digest our food into…
    - carbohydrates = CHO → $CO_2 + H_2O$
    - lipids = CHO → $CO_2 + H_2O$
    - proteins = CHON → $CO_2 + H_2O$ + N
    - nucleic acids = CHOPN → $CO_2 + H_2O$ + P + N
      - relatively small amount in cell

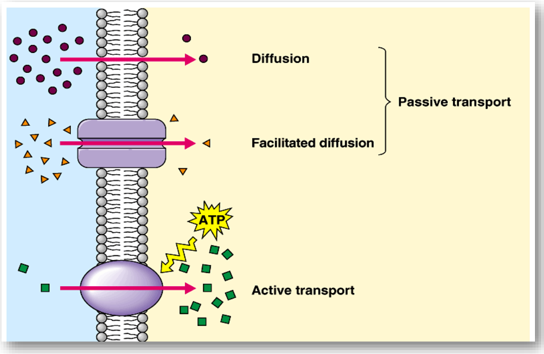


Nitrogen Waste

- Aquatic organisms
  - can afford to lose water
  - ammonia
    - most toxic
- Terrestrial
  - need to conserve water
  - urea
    - less toxic
- Terrestrial egg layers
  - need to conserve most water
  - uric acid
    - least toxic

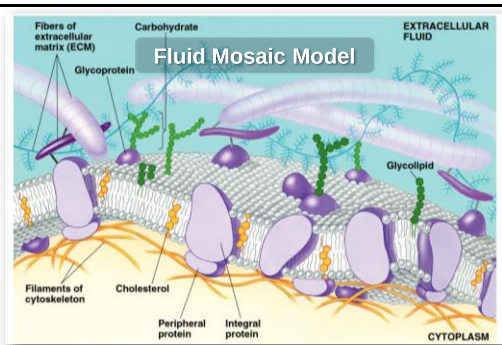


Transport summary



Getting through cell membrane

- Passive transport
  - diffusion of hydrophobic (lipids) molecules
    - high → low concentration gradient
- Facilitated transport
  - diffusion of hydrophilic molecules
  - through a <u>protein channel</u>
    - high → low concentration gradient
- Active transport
  - diffusion against concentration gradient
    - low → high
  - uses a <u>protein pump</u>
  - requires energy – often ATP



Any Questions??