Lecture 4

January-10-11
4:36 PM

Biology Lecture 4

Protein activity (cont..)
Transport I

Relationship between [S] and reaction rate

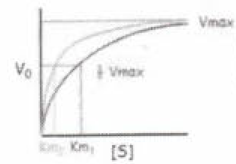
The quantitative description of enzyme reaction rates to [S], constants Vmax and Km occurs by the:

Michaelis-Menten equation: $V_0 = \frac{[S]\,Vmax}{Km + [S]}$

Km = substrate concentration ([S]) at which $V_0 = \frac{1}{2}$ Vmax

If affinity increases then the # of ES complexes increase at any given [S] or the same # of [ES] at lower [S] (i.e. Km decreased)

In other words at high affinities ½ Vmax occurs at a lower [S]



Km can be determined from this plot

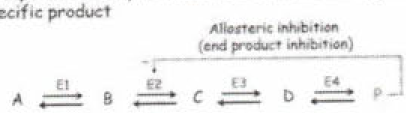
1/Km = affinity

Affinity is inversely proportional to Km

Most of the important work done in body are proteins such as enzymes

Metabolic pathways

A sequence of enzyme-mediated reactions leading to a specific product



Specific reaction steps may be regulated to control flux through the entire pathway.

Classically these are called "rate limiting" steps but modern control theory does not use this term

Looks at the relative control at each enzymatic step

Enzymes are in pathways, and some are important for controlling pathway

Metabolic pathways
Carbohydrates
Lipids (fats)
Proteins

Metabolic Pathways - ATP Synthesis

One of the major roles of metabolic pathways is to convert the energy in food (stored as fuel) to ATP to power cellular functions

ATP production

ATP consumption — Movement, membrane transport, molecular synthesis

ATP can be produced by:

a) Substrate level phosphorylation
(occurs in a absence of O_2)

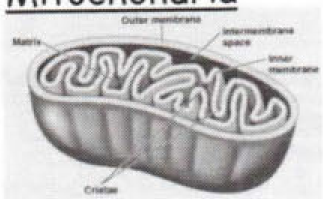
b) Krebs cycle (TCA, citric acid cycle)

c) Oxidative Phosphorylation
(by definition uses O_2 in mitochondria)

--More on metabolism in later Lectures--

Want to keep stable (homeostatic)

Mitochondria



Functions:

- **"Power house" of cell (generates ATP)**
- **Enzymes of** Kreb's cycle **in matrix**
- **Electron transport chain on cristae of** inner **membrane**

Fig 2.20

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Mitochondria

Outer membrane: Freely permeable to Small molecules and ions

Inner membrane: Impermeable to most small molecules and ions including H+ (protons)

Contains respiratory complexes (ETC)

ATP Synthase F1F0

Matrix: Contains the citric acid cycle enzymes (also called Kreb's Cycle or TCA)

Fat oxidizing enzyme (Beta-oxidation)

Pyruvate dehydrogenase (PDH)

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Transport mechanisms

Transport across membranes important for physiological function

Membrane provide a Selective barrier to control movement in and out of cells

*See Table 4.1 for differences between ICF and ECF

Transport mechanisms include:

1. Diffusion: a) Across the lipid bilayer
2. Mediated transport: a) Through a Transmembrane protein channel
   b) ~~Facilitated diffusion~~ Facilitated diffusion

Active transport { c) Primary active transport; d) Secondary active transport

See Table 4-2

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Simple diffusion

See Fig 4-2
Fig 4-4

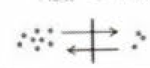
Diffusion: "the movement of molecules from one location to another due to ~~Random thermal~~ Random thermal motion

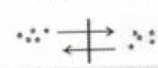
Movement is from a region of higher to a region of lower concentration until there is Uniform distribution

Flux: movement from one compartment to another ~~Per unit time~~ Per unit time

flux = rate of flow

Net flux = flux 1 - flux 2 and is in the direction of lower concentration [ ]





Net flux from compartment with higher [ ] to that with lower [ ]

Gradient for diffusion causes ~~downhill~~ downhill movement of solute

Net flux is zero when the system reaches Diffusive equilibrium

No gradient for diffusion exists

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Net flux depends upon:
1) Temperature (+T = +Flux)
2) Mass of the Molecule (+size = -flux)
3) Surface area btw 2 regions (+A=+flux)
4) Medium of transport (air vs. water)

Diffusion:
- times (t) are proportional to the distance $(x)^2$ over which diffusion occurs.
- therefore is only effective over Short distances

Single cells are small enough (10-20μm) for diffusive exchange

Large animals need a Circ. system for long-distance transport

For example transport of gases (e.g. O_2 and CO_2) can occur by diffusion from capillaries to cells.

BUT- circulatory system needed to transport from Lungs to cells

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Diffusion continued:

See Fig 4-1
Fig 4-10, 4-9
Box p113 (p105)

1. (a) Flux across the lipid bilayer

Described by Fick's Eqn

$$F = Kp \times A \times (Co - Ci)$$

F: Net Flux; Kp: Permeability Constant; A: Cross sectional area; (Co - Ci): Con'c diff. btw. outside and inside of cell

Kp: is a measure of the ease of passage of a substance across a phospholipid membrane

It is a function of:
i) Temperature
ii) Solubility of lipid bilayers (i.e. nonpolar vs. polar)

O_2, CO_2, fatty acids and steroid hormones are nonpolar (high Kp) and diffuse rapidly

Most organic molecules are charged (polar) or ionized (ionized phosphate groups) and diffuse slowly or not at all (low Kp)

iii) Size and shape of the molecule

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- Know this equation

→ an integral membrane protein, one that spans the entire biological membrane

2. a) Diffusion through transmembrane protein channels

Important for the movement of Charged ions which normally do not diffuse across lipid bilayers

Na^+, K^+, Cl^- and Ca^{2+} pass through the membrane with the aid of selective transmembrane proteins channels

Both diffusion and Electrical forces important for movement of ions also called Electrochemical gradient

Membrane potential involves the separation of electrical charges across a membrane.

Chemical driving force — Electrical driving force (due to membrane potential)

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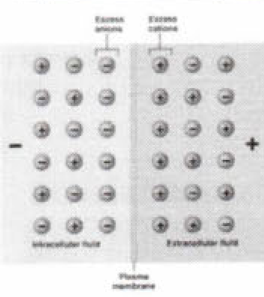
The membrane potential is always negative inside a resting cell

Separation of Charge Across a Membrane



- Separation of charge = Potential energy

-Electrical forces
  - Opposite charges attract
  - Like charges repel

-Membrane potential is negative (always relative to inside)
  - Electrical driving force on cations = Into cell
  - Electrical driving force on anions = Out of cell

-Magnitude of electrical driving force
  - Size of membrane potential
  - Valence of ion

Fig 4.2

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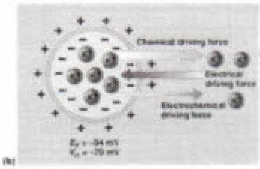
Electrochemical Driving Forces



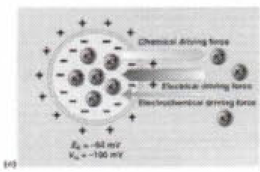
Direction of ion movement depends on balance between chemical and electrical driving forces

If equal the electrochemical force is 0

For this example:

Chemical > electrical = Outward force → electrochemical force ~~is~~ goes from inside to outside of cell.

Chemical < electrical = Inward force → ec. force goes fr. outside to inside of cell.



E_K = equilibrium potential for K^+ reflects the chemical driving force

~~Different from membr~~ane potential

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Fig 4-5

chemical driving force (chemicals go out of cell)

electrical driving force (cations go into cell)