Membrane Transport

How Things Get Across a Membrane  [4 Ways]

by DISSOLVING IN a membrane
hydrophobic solutes into a lipid bilayer
Partition vs. Permeability Coefficients (fig)

by membranes ENGULFING particles
ENDOCYTOSIS = phagocytosis & pinocytosis
EXOCYTOSIS (fig)

by CARRIER PROTEINS
protein receptors w specificity for a solute
transport solute through a lipid bilayer
CARRIER MEDIATED TRANSPORT
Facilitated Diffusion
Active Transport
  Na-Pumps and Proton Pumps

by CHANNEL PROTEINS via diffusion
ions and small hydrophilics through
a hydrophobic PORE
  Action Potentials
  Synaptic Transmissions
Brief Review of Cell Membrane Transport

- **Unit Membrane Hypothesis** - "all membranes look alike in TEM"
- Current structural model - **Fluid Mosaic model**
  - lipids = phospholipids
  - proteins =
    - a) Integral (**intrinsic** proteins)...denatured upon release
    - b) Peripheral (**extrinsic**)... easily extractable
  - Extra-cellular Matrix- glycoproteins secreted by cell = "a cell wall"
- Ion [ligand] flux rates proportional to lipid solubility (except water)
- **CARRIER PROTEINS** - intrinsic proteins transport solutes via small, conformational changes in shape - move water soluble molecules
- KINDS of TRANSPORT -
  - **UNIPORT** - one way
  - **SYMPORT** - Two same way
  - **ELECTROGENIC** - one way charged
  - **ANTIPORT** - Two way opposite
- **PASSIVE** - solute movement w existing electrochemical gradient
  - no energy is expended; movement toward equilibrium
    - **Diffusion** - net random thermal motion of a solute [hi --> lo]
    - Water Movement...an anomaly; not lipid soluble, yet permeable
    - **Osmosis** - net movement of water from [high] --> [low]
- **ACTIVE** - solute movement against existing electrochemical gradient
  - requires input of energy; movement away from equilibrium
    - **NaK-ATPase** [Na Pump] - carrier actively transports \( \text{Na}_{\text{out}} / \text{K}_{\text{in}} \)
- **ELECTROCHEMICAL GRADIENT** - driving force established by
  - difference in conc/p.d.. on either side of membrane
- **COUPLED TRANSPORT** - transfer of one solute depends upon
  - simultaneous transfer of 2nd solute
    - **Na/Glucose cotransport**
ION Channels & Membrane Potential

- **Carrier Mediated Transport - Plants vs. Animals**
  - **Animal**
    - NaK-ATPase = Na gradient
    - Na driven symport
    - H+ATPase (lysosomes)
  - **Plant**
    - H+ATPase = H+ gradient
    - H+ driven symport
    - H+ATPase (vacuole)

- **BULK TRANSPORT**
  - movement of large volumes of solute via membrane compartmentation

- **Exocytosis**
  - solute packaged membrane vesicles [endomembrane system]
  - fuse w plasma membrane releases bulk material to outside

- **Endocytosis**
  - uptake via invagination of exterior cell membrane packaging solutes into interior membrane bound endocytotic vesicles
    - **phagocytosis** - solid particle uptake by specialized phagocytes [macrophages] = phagosomes (>250 nm)
    - **pinocytosis** - liquid uptake into small vesicles (<150nm)
    - **receptor mediated endocytosis**
      - LDL receptors (cholesterol) fig 14.29p475
ION Channels & Membrane Potential

ION CHANNELS - transmembrane aqueous pore formed by a

CHANNEL PROTEIN - membrane transport proteins which
form a hydrophilic pore allowing small molecules and
ions to move via passive uniport [in/out].

esp: Na / K / Cl / Ca

ROLE: makes membranes transiently permeable to charged ions

openinhhg of a channel = rush (pulse) of electrical charge

PROPERTIES:

1. Selective - permits only some ions to pass
   pore size based upon distance between & distribution
   of polar charged aa's (glu, asp, his, lys, arg)
   - negative channels = + ion flow & vice versa
   - often sphere of hydration of ions is shed

2. Gated - exist in open/closed conformation states
   VOLTAGE Gated - open state controlled via cell potential
   LIGAND Gated - controlled by binding of solute [Ach]
   STRESS ACTIVATED - mechanical force [auditory hair cells]

Patch Clamp Recording

microelectrode [micrometer glass tube] contacts membrane surface
vary conc ions on either side or clamp voltage at set value
records voltage changes across membrane
current = on/off as conformation of channel protein changes
MEMBRANE POTENTIAL.... [RESTING POTENTIAL]
- voltage difference [(+/-)] across membrane
- net distribution of ions across cell is often not equal
  i.e., = non-zero (neutral) charge differential
- electric charge exhibited by most typical cells is [ - ]
- potential - (in electrical terms) is amount of electrical charge
  at one point in an electric circuit compared to some other point
  in the same circuit
- measured inside vs. outside of cells - via microelectrode
  SGA - 65mVi                  Frog muscle fibers - 90mVi
  Nitella - 150mVi              Valonia + 15mVi

NERNST POTENTIAL [equation - defines passive ion equilibrium]
\[ E_{mv} = \frac{RT}{zF} \ln \frac{C_{o}}{C_{i}} = +/- 62 \ \text{lg} \ \frac{C_{o}}{C_{i}} \]
\[ E = \frac{(273 + 37) \times (1.98)}{(+/-1) \times (23,000)} [2.303] = 0.062V \]

Causes of Resting Potential - all which make inside (-)
enequal distribution of "sexy" ions (Na,K,Ca,Cl,H)
active transport NaK-ATPase = 3 Na out & 2 K in
differential permeability of Na (slower in) & K (faster out)
 lots of protein [anions -] inside cells
diffusion of Cl- in faster than Na in
Measured Resting Potential = -65 mV inside

Nernst Potentials

\[ E(K) = +62 \log \frac{5}{140} = +62 \times (-1.45) = -90 \text{ mV} \]

\[ E(\text{Na}) = +62 \log \frac{145}{15} = +62 \times (+0.98) = +60 \text{ mV} \]

\[ E(\text{Cl}) = -62 \log \frac{110}{10} = -62 \times (1.04) = -65 \text{ mV} \]
ACTION POTENTIAL - a self-propagating change in the voltage (depolarization = reversal of charge) across membranes of nerve cell (fig).

name given to changes in electrical charges that occur during the stimulation of a nerve cell, usually visualized graphically from an oscilloscope recording

PROPERTIES of an AP

requires a living cell, i.e., requires O₂ for metabolism eliminated by metabolic poisons as cyanide measured using microelectrodes impaled into cells has a threshold - amount of stimulus needed to "fire" an AP "all-or-none-phenomena"

rapid - time course = 2-3 msec

EVENTS DURING an AP

depolarization - goes from negative to positive voltage gated Na channel opens - Na floods in = - 70mV to + 35mV [interior goes transiently +]

repolarization - Na channels close & voltage gated K channels open - K floods out

refractory period - time before another AP can 'fire'

CONDUCTION of an AP along an axon local spreading of electric charge = change in Na channels of adjacent membrane regions autocatalytic - "domino effect"
ION Channels & Post Synaptic Potential

Synapse - functional connection between neurons

synaptic cleft - space between neurons across parts - synaptic knob - site of vesicles -
hold neurotransmitter (acetylcholine)

events -
pre-synaptic side - AP reaches synaptic knob
opens voltage gated Ca\(^{+2}\) channel [Ca flood in]
synaptic vesicles fuse w presynaptic membrane
release neurotransmitter

post-synaptic side - neurotransmitter binds to receptor
receptors are ligand gated ion channels
ion channels open - change potential charge of
post-synaptic membrane ----> new AP

removal of stimulus = enzyme destroys transmitter

**Excitatory** neurons --> open Na/Ca channels = + = AP
neurotransmitters are acetylcholine & glutamate

**Inhibitory** neurons --> open Cl channels = - = no AP
neurotransmitters are GABA and glycine

**Drugs** - barbituates & tranquilizers (valium)
bind to GABA-gated Cl channels = inhibitory
antidepressant prozac - blocks reuptake of serotonin (?)