5.4

H^+ are protons ⇒ hence, "proton" pumps.

⇒ remember when you are considering H^+ concentration on either side of the membrane, you are actually talking about **pH** !

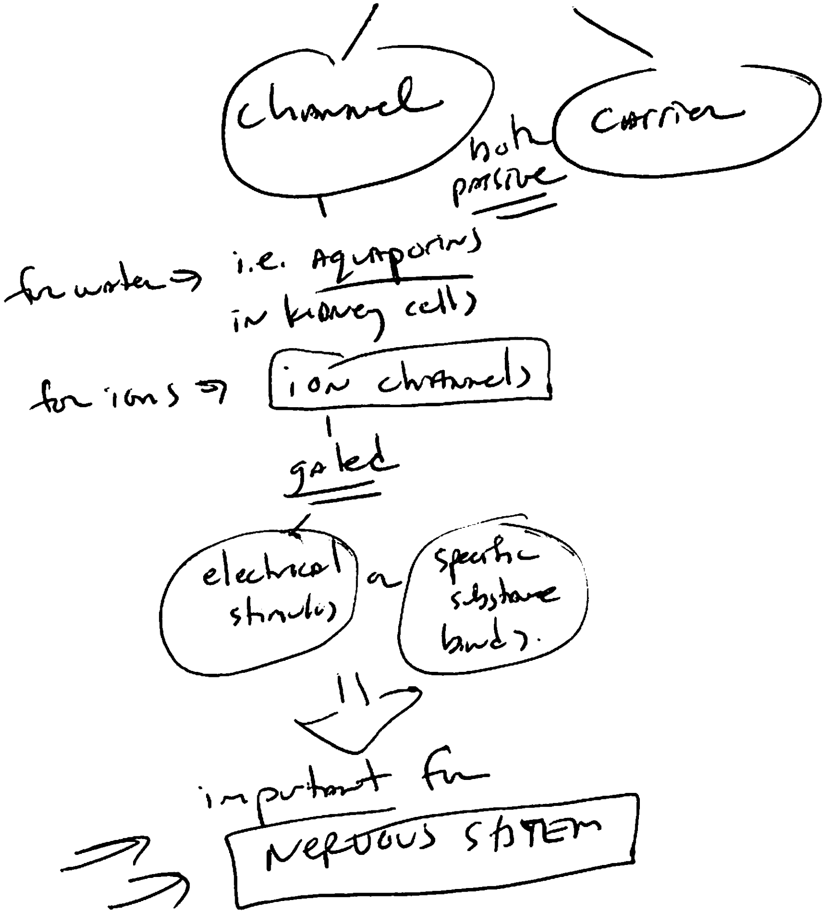
⇒ increase $[H^+]$ and you are **decreasing** the pH

(see question #6 on p115)

5-3

Transport Proteins

- most are very **specific**



5.4

- ATP provides the energy for active transport
- ↑ K^+ in cell and lower Na^+ due pumping against gradient

ATP ⇒ transfer terminal phosphate to the transport protein ⇒ conformational change ⇒ translocates solute bound to the protein across membrane.

SODIUM – POTASSIUM PUMP

FIG 5.14 on p. 104

3 Na^+ out for every 2 K^+ in

phosphorylation drives the process through conformational changes

VOLTAGE – a separation of opposite charges.

Membrane Potential

-50 to -200 millivolts (mV)

inside of cell is negative relative to outside

2 forces actually DRIVE Diffusion of ions

↓ Chemical force

↓ concentration GRADIENT

↓ Electrical force

MEMBRANE potential effect on ion's movement

Electro-Chemical GRADIENT

☆ Sodium-potassium Pump is the major electrogenic pump of animal cells

☆ Proton pumps (H^+) are main electrogenic pumps of plants, fungi, and bacteria;

- powered by ATP
- also in ATP synthesis in cellular respiration and CO-TRANSPORT

CO-TRANSPORT

- "coupling" of transport proteins

☆ A substance that has been pumped across the membrane ~~[illegible]~~ can do work as it moves back across the membrane by Diffusion

example 1 → Sucrose-H^+ cotransporter
⇒ used to load sucrose into veins of leaves for distribution throughout plants.

example 2 → sodium-glucose cotransporter
→ on surface of intestinal cells
⇒ re-hydration ⇒ GATORADE !!

5.5

Bulk transport for big molecules like proteins and polysaccharides

Exocytosis

Endocytosis

require energy

Golgi → transport vesicles — micro-tubules → plasma membrane

→ insulin secreted from pancreas cells

→ neurotransmitters secreted to muscle cells

FIG 5.18

① phagocytosis

② pinocytosis

③ receptor-mediated endocytosis

LDL's - low-density lipoproteins

- particles containing a complex of lipids (including cholesterol) and a protein.
- bind to LDL receptors on membrane, then brought into cell by R-M-E

Example of RME

★ Hypercholesterolemia - no LDL receptors so LDL's cannot enter cells and accumulate in the blood → atherosclerosis (lipid deposits in vessels)

5.6

Cell SIGNALING

LOCAL SIGNALING
- GAP JUNCTIONS (animals)
- PLASMODESMATA (plants)
- SURFACE MOLECULES.

PARACRINE

i.e. growth factors
(LOCAL REGULATORS)

SYNAPTIC

i.e. neurotransmitters

LONG-DISTANCE SIGNALING

ENDOCRINE System → Hormones.

NOTE - some plant hormones can travel through air as a gas (ethylene ⇒ fruit ripening)
(C_2H_4)

Cell Signaling

- pioneer work was on epinephrine stimulating the breakdown of glycogen yet NOT entering the cell.

① RECEPTION → receptor proteins (surface or inside)

② TRANSDUCTION → "relay" molecules in A signal transduction pathway

③ Response.

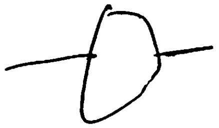
see FIG 5-20 !!
on p109. !!

LIGANDS

- A molecule that specifically binds to another molecule, often a larger one
- attachment of the ligand causes a conformational change in the receptor

SIGNAL RECEPTORS → plasma membrane proteins

→ MOST are Transmembrane Proteins



G-Protein Coupled Receptors

LIGAND-GATED ION CHANNELS

NOTE: Binding of SIGNALING MOLECULES IS REVERSIBLE

↳ GPCR's and G proteins are all very similar – suggesting early evolution.

→ most common cell-surface receptor.

→ involved in DISEASES and CURES (60% of MED's)

allow or block diffusion of specific ions like Na^+ or Ca^{2+} through a channel or protein.

→ NERVOUS SYSTEM → NEUROTRANSMITTERS

✱ INTRA-cellular Receptors ALSO exist!!

Either in cytoplasm or nucleus — but the SIGNAL MOLECULE must be hydrophobic to pass through the membrane

EXAMPLE – testosterone (steroid, hydrophobic) enters cell, binds to receptor, activates it, enters nucleus, binds to DNA, and acts as a TRANSCRIPTION FACTOR for certain genes to be transcribed to mRNA.

Relay Molecules – usually proteins.

⇒ undergo SHAPE (conformational) CHANGES

⇒ shape changes often caused by the ADDITION of a phosphate group to the protein

⇓

PHOSPHORYLATION !!!

PROTEIN KINASE – an enzyme that transfers phosphate groups from ATP to a protein

- many of the relay molecules are protein kinases
- 2% of our genes code for PK's; abnormal PK's → cancer

---

phosphorylation ⟷ dephosphorylation system
(protein phosphatases)

molecular "on-off" switch

Second Messengers (small molecules and ions)
(cAMP) (Ca^{2+})

* first messenger is the signaling molecule (ligand)

cAMP – cyclic Adenosine monophosphate

– activation of receptor leads to activation of ADENYLYL CYCLASE that converts ATP to cAMP.

cAMP
⇓
protein kinase A
⇓
phosphorylation cascade

common scenario.

RESPONSE

in nucleus or in cytoplasm

↓ final molecule in pathway can be a transcription factor

↓
- can activate a protein (or enzyme)
- open or close a channel
- affect metabolism.

☆ Similarities in cell signaling support evolutionary theory. !!