Transport across cell membranes

EXOCYTOSIS

- This is a calcium-dependent protein, mediated by the SNARE proteins, which results in the fusion of a vesicle to the internal part of a cell membrane, thus releasing the vesicle’s contents
- NON-CONSTITUTIVE PATHWAY: the vesicles go through some maturation and processing and only then do they get exocytosed
- CONSTITUTIVE PATHWAY: the vesicles just get thrown out of the cell as fast as they can make it

ENDOCYTOSIS

There are several types:

PHAGOCYTOSIS

- an object meets the membrane
- the membrane invaginates
- the object finds itself enveloped
- the vacuole pinches off from the membrane

PINOCYTOSIS

- exactly the same process as phagocytosis, except the vacuoles are smaller
- a cell can pinocytose its whole membrane’s worth in 1 hour

CLARITHRIN-MEDIATED ENDOCYTOSIS

- Occurs at the parts of the membrane where clarithrin accumulates
- Clarithrin is a three-pronged protein which forms a geometric array around the vacuole as it is forming, and DYNAMIN (a GTP-binding protein) causes the pinching-off of the vesicle’s neck
- This plays a role in internalizing many receptors and the ligands bound to them, as well as internalising low-density lipoprotein

RAFT and CAVEOLAE-DEPENDENT ENDOCYTOSIS

- RAFTS are areas of the membrane which are rich in cholesterol and sphingolipids
- CAVEOLAE are flask-shaped membrane depressions
- These are prominent in endothelial cells, where they mediate the uptake of nutrients from the blood

COATED VESICLE TRANSPORT

- All vesicles involved in transport are coated with protein
- The system of coating proteins is stupidly complex and is responsible for the vesicle reaching its destination

MEMBRANE PERMEABILITY AND MEMBRANE TRANSPORT PROTEINS

- SMALL NON-POLAR MOLECULES DIFFUSE ACROSS EASILY
- For example, O$_2$, N$_2$, CO$_2$
- Everything else requires a transport protein
- If the substance already wants to be inside (e.g., its moving down a concentration gradient) energy is not required and you might call this FACILITATED DIFFUSION – eg. glucose transport
- When you move against the gradient (electrical or chemical) energy in the form of ATP must be used, and the proteins doing this are called the ATPases, of which, one is the Na$^+$/K$^+$ ATPase
Ion channels

- They can be specific for K⁺, Na⁺, Ca²⁺, etc
- They can be non-selective cation or anion transporters
  - There are voltage gate, ligand gated, and other varieties

Na, K ATPase

Outside the cell

3 Na⁺

Inside the cell

Na⁺ K⁺

ATPase

2 K⁺

ATP

ADP

- Uses 1 ATP to carry 3 Na⁺ out of the cell and bring 2K⁺ into the cell
- Inhibited by the cardiac glycosides eg. DIGOXIN
- All tissues have it, but it is different in all tissues; there are special tissue-specific subunits
- Active transport of Na⁺ and K⁺ accounts for 24% of cellular energy use; 70% in neurons

REGULATION OF ITS ACTIVITY

- The amount of Na⁺ normally found in cells does not saturate the pump
- Thyroid hormone increases the number of pumps
- Dopamine in the kidney inhibits the pump, causing natriuresis
- Insulin INCREASES the pump activity (hence its use in treating hyperkalemia)

SECONDARY ACTIVE TRANSPORT

- Frequently, things move across membranes only because Na⁺ is moving as well; an example of this is the co-transport of glucose and sodium in the gut wall

References: Ganong’s Review of Medical Physiology, Chapter 1