BB101 Lec 5 short notes

Cell: structure and some functions

- **Cell membrane parts:** 1. Lipid bilayer 2. Globular integral proteins with watery channels and selective permeability 3. Peripheral proteins attached to cell membrane
- **Cell nutrients, apart from water and electrolytes:**
  1. Proteins: two types structural and globular: Structural proteins are long filamental and sometimes group together to form tubules. They mostly give structural support to the organelles and membranes. Globular ones are not filament. Mostly soluble in fluid of the cell and controls the metabolism of the cell.
  2. Lipids: phospholipids and cholesterol. These are soluble in fat. They are mostly insoluble in water. Role: they form membranes like cell membrane, nuclear membrane etc.
  3. Carbohydrates: Mostly in the form of glucose and is readily available in the extracellular fluid.

  (Simplest forms of these are amino acids, fatty acids, and glucose)
- **Mitochondria function:** in the presence of Acetyl co enzyme (made of glucose, fatty acids, and amino acids) and oxygen, Adenosine di Phosphate is converted to Adenosine tri phosphate, which requires energy to be spend (The energy is stored in the ATP and can be utilized whenever required)

The circulatory system: extracellular fluid transport (refer to slide)

Transport of ions through cell membrane

- **Relative composition of ions in intracellular and extracellular regions:** Sodium is abundant outside while potassium is abundant inside. Calcium(cardiac) is relatively high outside.
- **Diffusion:** Always from a high concentration to a lower concentration. Does not need energy for this purpose.
  - **a) Simple diffusion:**
    1. **Through lipid bilayer:** Lipid soluble substances like alcohol, oxygen, nitrogen can permeate it. Water (although insoluble in lipid) diffuses via osmosis due to small size and high KE. Glucose, though small, cannot diffuse as insoluble. Charged ions cannot diffuse due to charge & since they form hydrated ions.
    2. **Through watery channels in transport protein:**

       CHANNEL PROPERTIES:

       -> Selective permeability: is determined by 1. diameter of channel 2. shape of channel and 3. electric charge at the surface of the channel.

       -> Opening and closing of gates Channels have gates that can close or open (via conformational changes of the proteins): either by voltage gating or by ligand gating
       - Voltage gating: A potential difference is responsible for conformational change of the proteins gates and hence its opening and closing
       - ligand gating: some molecules can stick to the transport protein and can initiate the conformational change and hence the opening and closing. Such molecules are called ligands and this process is the ligand gating. E.g. Acetylcholine

Sodium channel	Potassium channel
• Inner surface is negatively charged • 0.3 X 0.5 nm size, permeable to only Na. • Gates can be closed and opened • the activation gates near the extracellular region • When the Potential difference is negative inside the cell (w r t outside), then sodium channel will remain tightly closed • PD inside becomes more positive (again relative) then gate opens and tremendous sodium enter inside This is stopped when another gate, called inactivation gate which is inside, is closed	• No charges in the inner surface. • 0.3 X 0.3 nm size and permeable to only K • Gates can be close and opened • the gate is inner near to the intercellular region • This also opens when the inside is more positively charged However this is a bit delayed compared to sodium channel • This works in coordination with sodium channel. When sodium enters, the inner cell becomes more positive. After a delay, the potassium channel opens and potassium moves out of the cell, reducing the positivity of inner cell

Thus, the sodium goes inside creating more positivity inside and after a delay the potassium goes out making the PD more towards negative at the intercellular region

b) **Facilitated diffusion:** via protein channels but by a carrier binded to the substances to be transported. Main difference between simple and facilitated diffusion: simple diffusion is proportional to concentration, that is as concentration increases the rate of diffusion increases. But in facilitated diffusion, even the concentration increases after a threshold, the rate of diffusion does not increase. E.g., Amino acid, glucose (by insulin), fatty acid (by protein)

- **Active transport-** It can be from a lower concentration to higher concentration. It can also be towards a higher potential from lower potential. Both cases require energy: ATP. Movement against electrochemical gradient.

  a) Sodium Potassium pumps:

  ACTION: Upon activation, ATP is converted to ADP with a release in the energy This energy causes conformational change in the protein which causes the movement and release of 3 sodium ions from the inner receptors to outside of the cell and 2 potassium ions from the outer receptors to inside of the cell.

  FUNCTION: (Net decrease in charge by +1) * and (decrease in conc of cell cytoplasm) **, Thus:

  *It helps maintain an equilibrium potential or resting potential across the membrane.

  **It helps to protect the cell from bursting due to water entering inside because of osmosis

Potentials

The factors affecting the net rate of diffusion are Permeability of the membrane, Difference in concentration across the membrane, Pressure difference across the membrane, for charged substance like ions potential difference across the membrane

- **Membrane potential:** Membrane behaves like a capacitor.
  1) **Resting potential-**
     - The movement due to concentration gradient balances the movement due to the potential gradient. One can write the Nernst potential (Formula important- in slides) for sodium and ion separately to see the potential difference induced across the membrane upon the movement to electrochemical gradient.
     - On actual measurement (clamp method) one can find that the equilibrium or resting potential of cell membrane is 90mV which is closer to that of potassium ion. Thus, potassium is seen more inside and since its permeability is high (In resting case) compared to the sodium, it determines the effective potential of the cell.
     - Incorporating this permeability diff gives Goldman eqn (Formula important- in slides). By this, the predicted potential is 86mV and the 4mV diff due to Na K pumps
  2) **Action potential-**
     - In transport protein (voltage gated channels), in addition to the gate at outside there is also a gate opening to inside of cell The outside gate is called activation gate and inside one is called the inactivation gate.
     - When due to some external disturbance, the membrane potential moves from 90 mV to say 70 to 50 mV Then the sodium channel activation gate will open. At this time, the inactivation gate is already open. This causes NA to go inside and increases the membrane potential abruptly to 35 mV. This process is called depolarization
     - Then after a delay the “inactivation gate” is closed, causing the influx of the sodium to cease.
     - When the sodium channel is activated, the potassium channel is also activated, but there is a delay in its gate to open and it will happen only when the sodium channel is deactivated This causes the potassium to go out although after a delay of depolarization, thus reducing the membrane potential from 35 mV to 90 mV (that is back to resting potential) This process is called repolarization
     - Note: Voltage gated sodium channel will now be activated only when the membrane potential reaches the resting potential
     - When there is a disturbance, the membrane potential will rise to say 70 mV This causes some sodium channels to get activated and causes influx of the sodium ion This will in turn causes more positive potential to cell which initiates more sodium channels to open This will cause more sodium to reach the cell increasing the positive potential further more Thus the action potential is generated by this positive feedback This is called the Hodgkin cycle
     - There is threshold value 65 mV) above which the action potential is guaranteed to occur
     - The positive potential also activates neighboring sodium channels and so the action potential spreads in both directions.
     - All Or Nothing principle: the amplitude of the action potential is same irrespective of the duration or intensity of the stimulus or disturbance
     - Voltage clamp system: (refer to slide) Uses a differential amplifier and negative feedback.
     - Sodium potassium pumps redistribute ions after action potentials.