Glossary of Ion Channels for Mathematicians

as suggested by Prof. Yuxi Zheng

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1) Ion Channel

   A protein embedded in a cell membrane that has a hole down its middle. The hole is about twice the diameter of ions (hard spheres) sodium Na^+ potassium K^+ , Ca^{2+} , and Cl^- that move through the hole driven by ONLY electrical and diffusional forces. Bulk flow is thought to be negligible but that needs to be examined.

   About one third of all the proteins in a human are channels or transporters (nearly channels). Most biological functions are controlled by channels. Channels are the nanovalves of life.

   Each channel is made from a different sequence of amino acids and different structure and different function. Many diseases are produced by defects in channels, usually in the opening and closing of channels.

   Ion channels open and close. When closed almost nothing goes through them. The closing may involve a movement of substantial mass or it may only involve the change in shape of a profile of electrical potential. The opening and closings are very fast (less than one microsecond 10^{-6}sec. Once open the channel stays open a stochastic time ranging from microseconds to seconds, very different for different types of channels. Once open the (ensemble average) of the current is INDEPENDENT OF TIME with great accuracy. This strongly suggests that the OPEN channel has one structure on biological time scales slower than one microsecond 10^{-6}sec. Open channels are MUCH easier to study than most other proteins because we do not (I repeat NOT) need to have a theory of how they change structure.

   Open channels are selective. They allow different ions to pass at different rates depending on the diameter and charge of the ion more than anything else. Selectivity can be very very great while current flow is larger, sometimes seen as a paradox.

   Open channels rectify. They pass current more easily in one direction than another.

2) Protein is an UNbranched sequence of amino acids connected by peptide covalent bonds called a polymer or polypeptide with the amino acids being like beads on a string, with side chains dangling from the beads. The side chains have different INTRINSIC permanent electrical charges that do not change in most biological function. Side chains are called acid if they have intrinsic negative charge. Glutamate and aspartate are the usual negative side chains. Side chains are called basic if they have intrinsic positive charge. Lysine and arginine are typical basic positive side chains.

The string of beads of a protein is twisted and bent to form complex biological structures. Machines as complicated as the simplest internal combustion engine are made from the twisted string.

The structure of channels is much simpler fortunately.

ALL the information needed for a protein is coded in blueprints called genes, that are made of DNA.

The only information passed from one generation to another in living organisms is in the blueprint DNA.