The Role of Permanent Charge in Channels

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I want to be sure you (and the readers) understand how biology controls Q, permanent charge.

To a very good first approximation (and certainly true in the channels we have studied up to now) the permanent charge distribution represents a CHEMICAL (and thus hard to change, and thus permanent) property of the side chains of the channel protein that mix with ions in the pore of the protein.

To remind you, proteins have a polypeptide (polymeric) backbone, out of which project side chains of different chemical types. Some of these are acidic (e.g., glutamate) and have PERMANENT negative charge (that is the meaning of the word acidic) that can only be changed by a covalent chemical reaction, which can occur, but is rare and not  significant so far as we know. Some are basic (e.g., lysine) and have  PERMANENT positive charge (that is the meaning of the word acidic) that can only be changed by a covalent chemical reaction, which can occur, but is rare and not  significant so far as we know.

In some channels these side chains project into the pore of the channel protein (i.e., into the hole down the middle) and mix with the ions that go through the channel and water. Those are the calcium, sodium, and ryanodine receptor  channels we have studied.

There are OTHER channels in which the side chains do NOT project into the channel's pore. Potassium channels are an example and so is gramicidin. In those channels, the side chains form part of the INTERIOR of the protein NOT NOT the interior of the pore of the protein. In those channels, the wall of the channel is actually the backbone of the polypeptide. In these cases, the meaning and role of the permanent charge Q is tricky because INDUCED charge (i.e., charge that depends on local potential, the charge at a dielectric boundary for example) may be and probably is very important.

The side chains of a protein are under DIRECT control of the DNA (genes) that codes the protein. So evolution has a direct and easy way to control Q and biological function.

Natural selection will then find it easy to control Q and biological function, and will choose an "adaptation" (here a spatial distribution and size of) Q that lets the channel do its function optimally.

PLEASE BE SURE TO ASK ANY AND ALL QUESTIONS ABOUT THESE IDEAS since biologists take them for granted but there is NO NO NO reason that you should understand them a priori.