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A note on the falsification of the ionic theory of hair cell transduction

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A criticism of the paper, that I published in this journal,[1] which pointed out the contradiction between measured and theoretical hair reversal potential has validity and is addressed in this note. This paper, "Falsification of the ionic channel theory of hair cell transduction "applies the Nernst equation to hair cell measurements which deal with the movement of ions through the putative 'transduction ion channel'. The Nernst equation applied to these measurements yielded a reversal potential that did not match the measured reversal potential.

The criticism is that there is not only sodium on both sides of the cell membrane but there is also 140 mM of potassium inside the cell (Ki)while there is no potassium outside the cell (Ko). To take into account the presence more than one type of ion simultaneously traversing a ion channel the Nernst equation is not adequate. An expanded version of the Nernst equation the Goldman equation must be used.

In the measurement by Corey and Hudspeth,[3] described above, the only ion available for transduction outside the cilia is 124 mM Na^+. However inside the cell there is not only 12 mM Na^+ but also 140 mM K+. In order to take into account the effect of both sodium and potassium ions passing in opposite directions through this proposed nonspecific ion channel we use an extension of the Nernst equation adapted for multiple ions which is the Goldman equation. A discussion of the Goldman equation can be found in Hill.[2]

The Goldman equation gives us an expression for the reversal potential of a nonspecific ion channel.

$$E_{rev} = \frac{RT}{ZF} In \frac{P_{Na}Na_o + P_kK_o}{P_{Na}Na_i + p_kK_i}$$

With only one permeable ion, E_{rev}becomes the Nernst potential for that ion. With several permeable ions, $E_{rev}$is a weighted mean of all the Nernst potentials.[2]

To solve this equation for zero reversal potential it is necessary to set the argument of the natural log function on the right side of the Goldman equation equal to 1.

$$\frac{P_{Na}Na_o + P_kK_o}{P_{Na}Na_i + p_kK_i} = 1$$

From Cory and Hudspeth[1] we get an estimate of the relative ion permeability of $P_{Na} = .9$ and $P_k = 1$

The ion concentrations: $Nao = 129$ mM; $N_{ai} = 12$ mM; and $k_i = 140$mM are known. The value of K_0 may therefore be solved for.

The resulting value for the concentration of potassium outside the cell which is necessary to obtain a zero reversal potential is $K_0 = 33$ mM. But in this experiment there is no potassium in the external medium. This result reaffirms the "falsification of the ionic theory of hair cell transduction" that is developed in ref. 1. Before embracing new satisfyingly simple theories, we would do well to keep in mind the observation made by Italio Calvino in 1943: "When a man cannot give clear form to his thinking, he expresses it in fables."[4]

Disclosure of potential conflicts of interest

No potential conflicts of interest were disclosed.

References

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