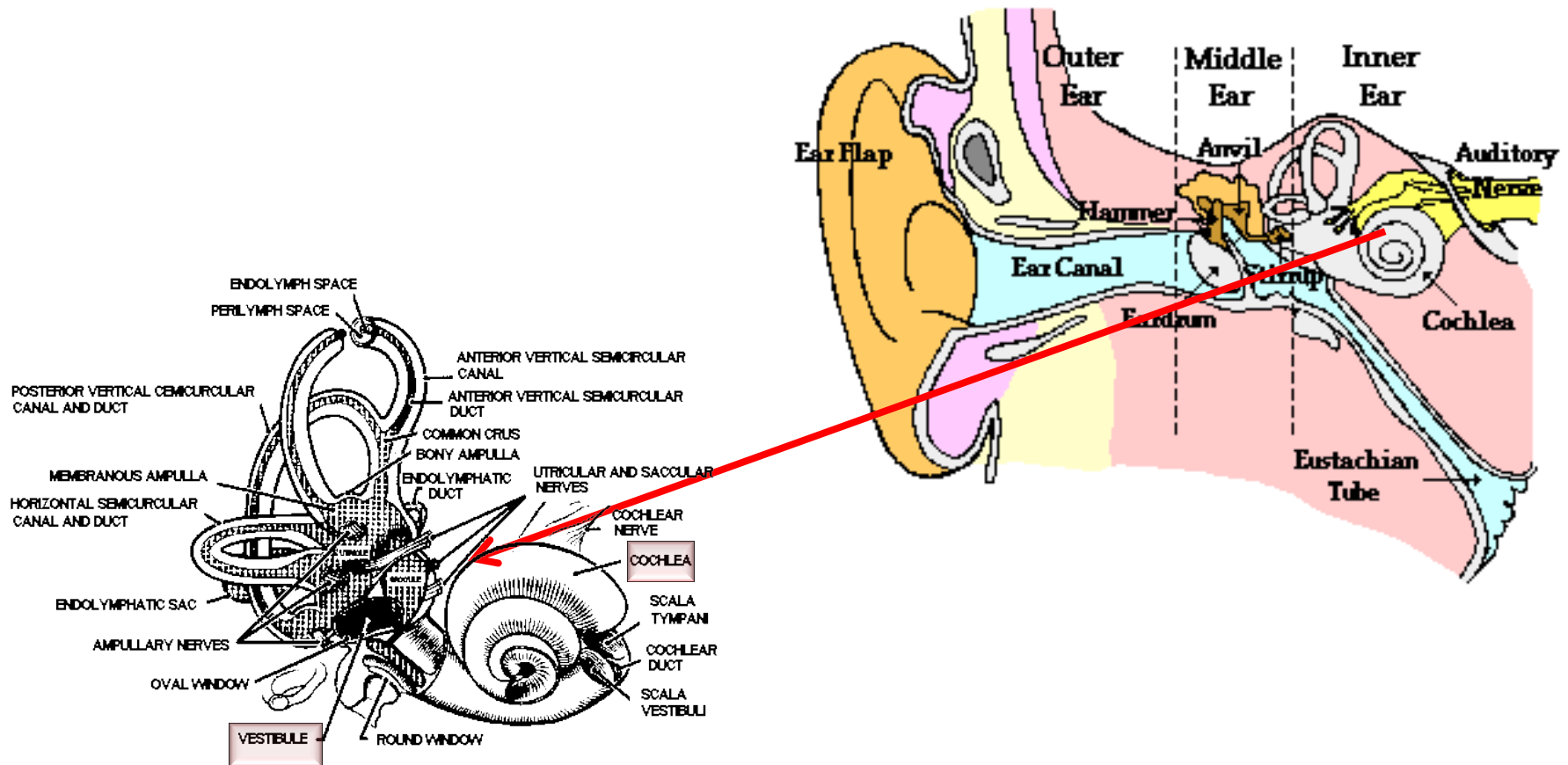


Computer Modeling of the Inner Ear

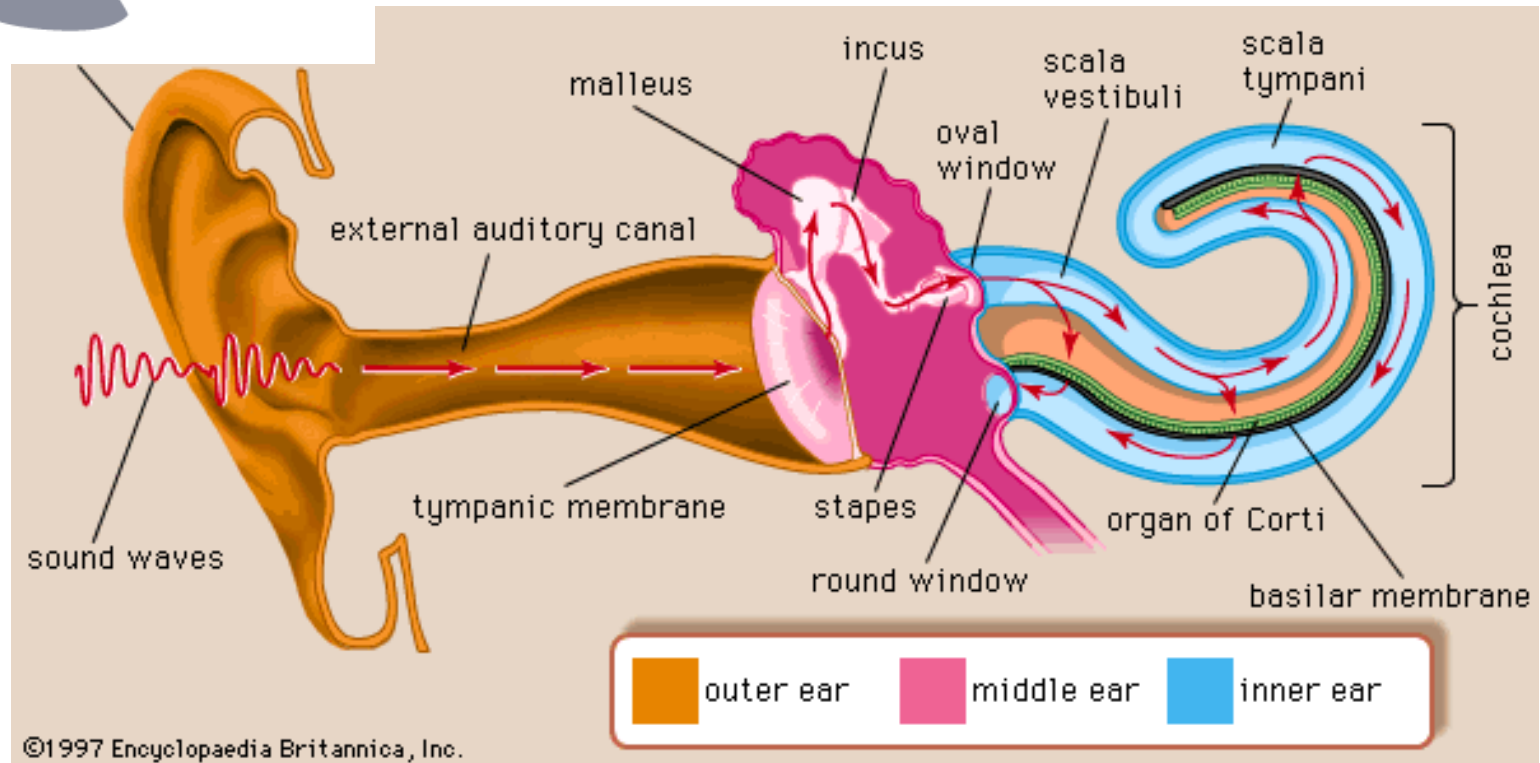
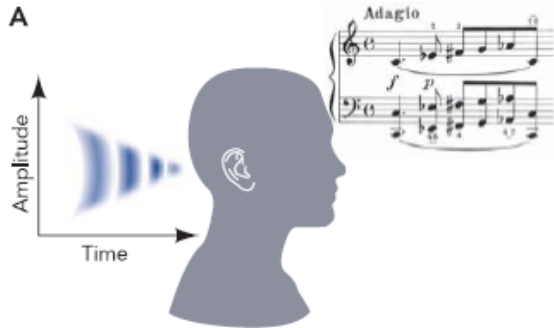
Pavel Jungwirth (Inst. Organic Chem. & Biochem. AS CR)

in collaboration with Pavel Mistrík (Medel Innsbruck)

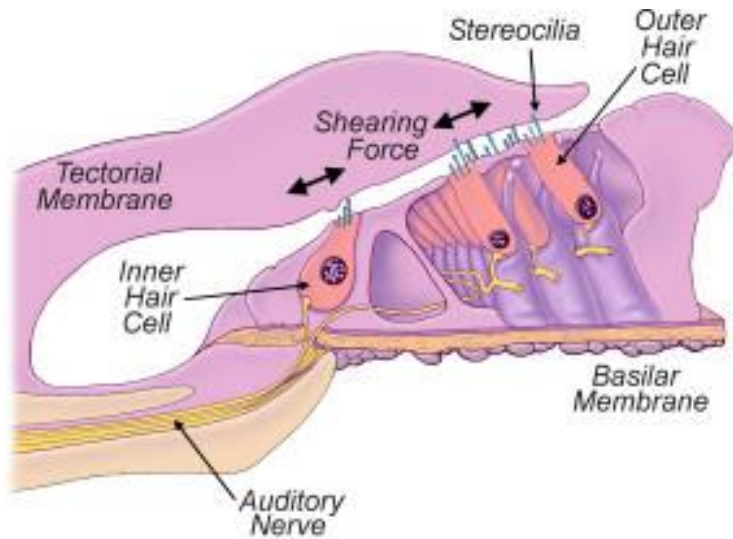
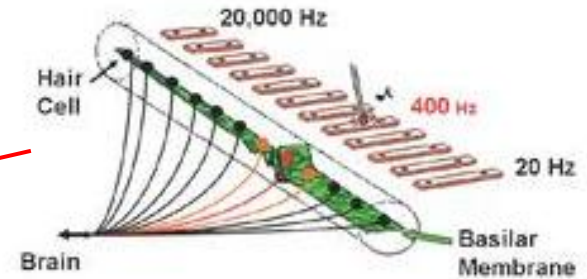
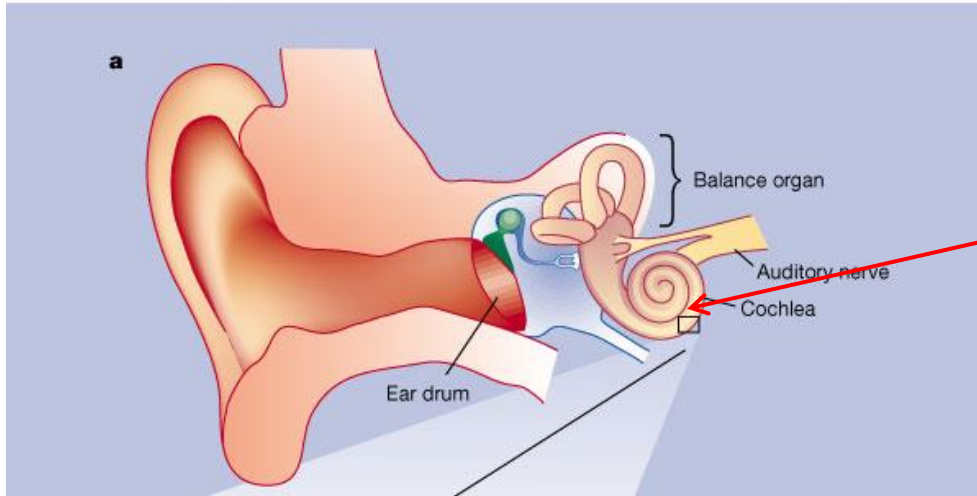


From: The Physics Classroom

Mechanism of hearing



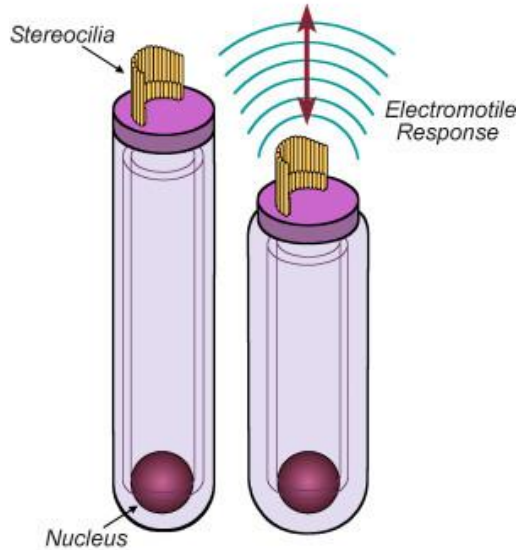
Excitation of hair cells



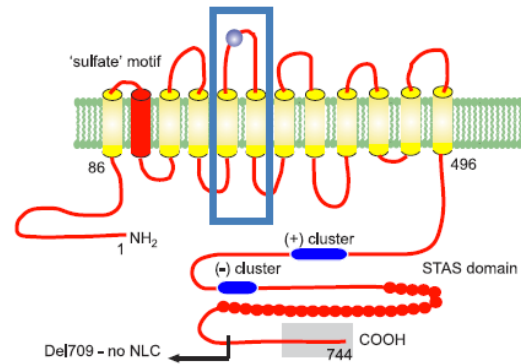
The Organ of Corti

- outer hair cells – amplify vibrations of the basilar membrane
- inner hair cells – excite the auditory nerve

Sound amplification by outer hair cells



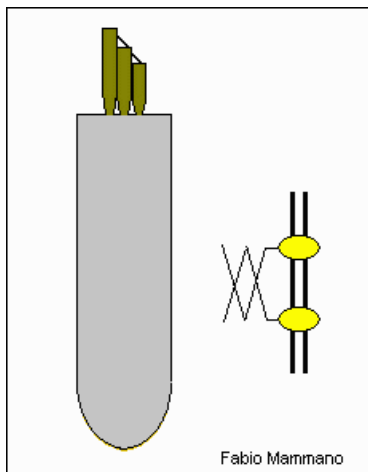
The Outer Hair Cell



prestin as calcium-triggered molecular motor: electromotility



"Dancing" hair cell:

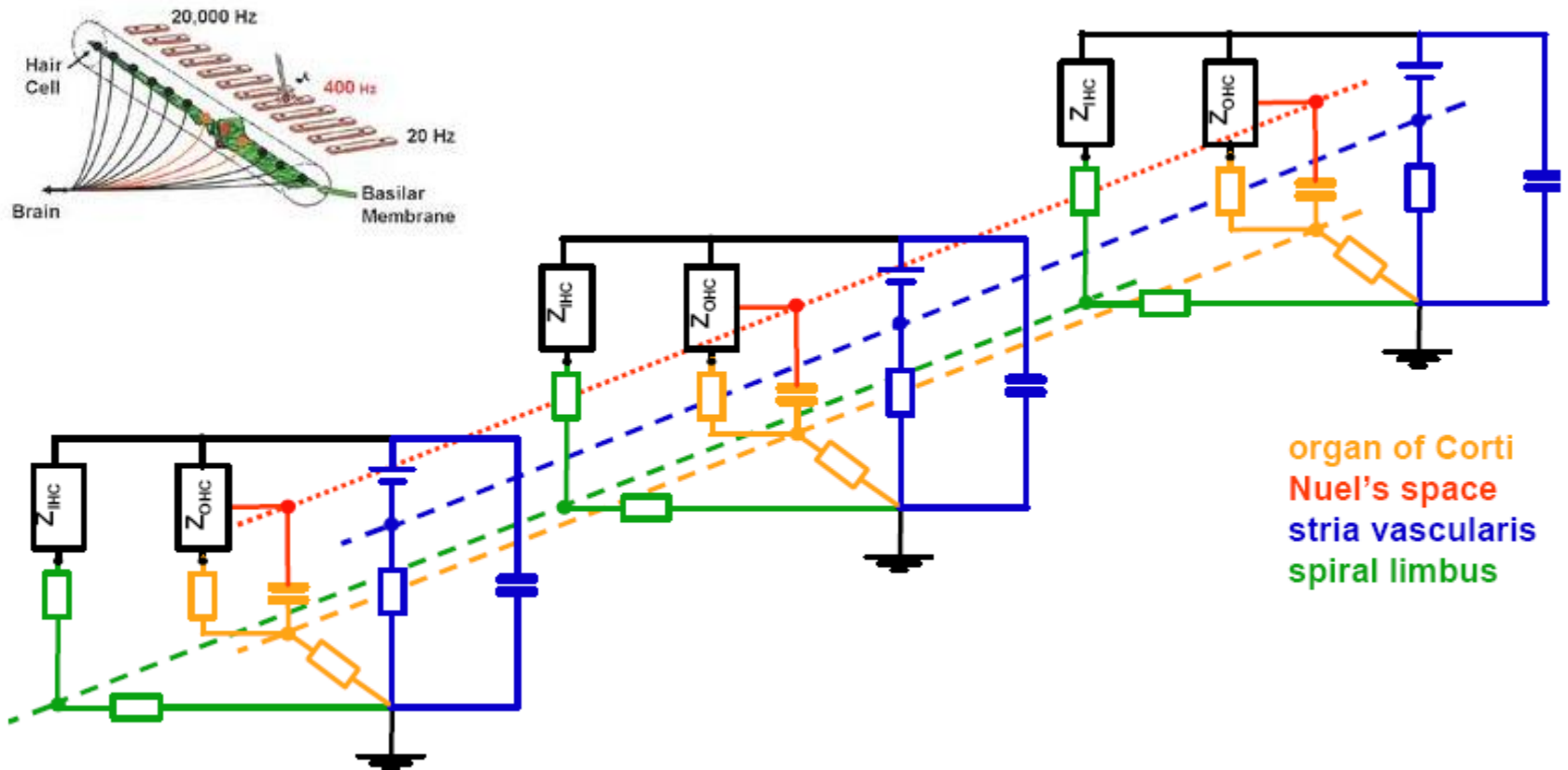


Fabio Mammano

Ashmore *Physiol. Rev.* 2008, 88, 173.

3D model of hair cells excitation

mimics the geometry of the cochlea



Equivalent circuit models

Mathematical formulation

$$\begin{bmatrix} C_{11} & & & 0 \\ & \ddots & & 0 \\ & & C_{nn} & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \frac{dV_1}{dt} \\ \vdots \\ \frac{dV_n}{dt} \\ 0 \end{bmatrix} + \begin{bmatrix} \frac{1}{R_{11}} & & & 0 \\ & \ddots & & 0 \\ & & \frac{1}{R_{nn}} & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} V_1 \\ \vdots \\ V_n \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ U^1 \end{bmatrix}$$

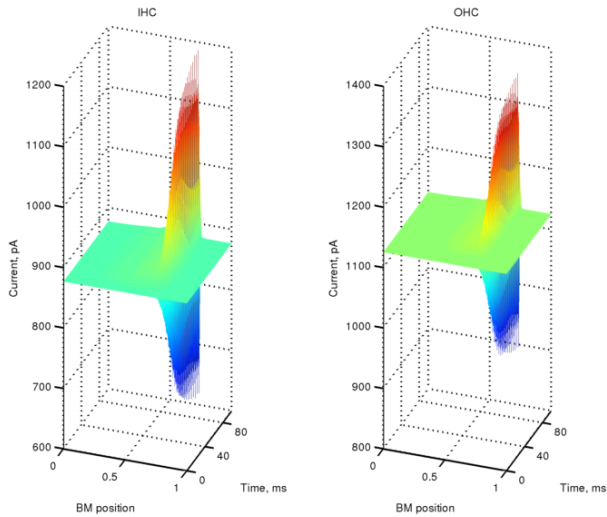
C_{ij} membrane capacitances

$1/R_{ij}$ membrane conductances

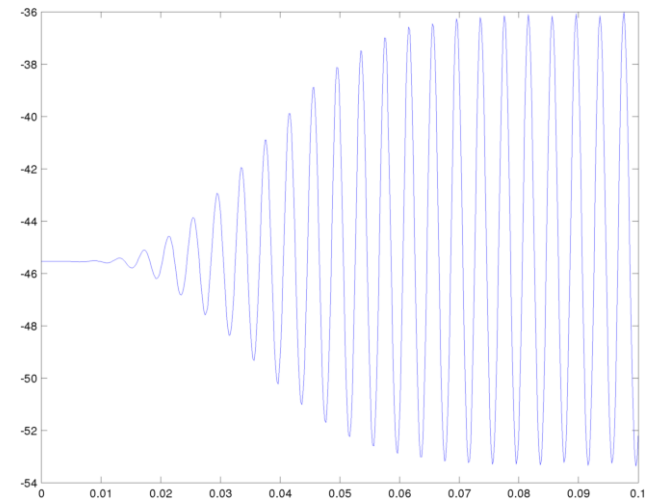
U^i electrochemical batteries

V_i voltages on the outer hair cells

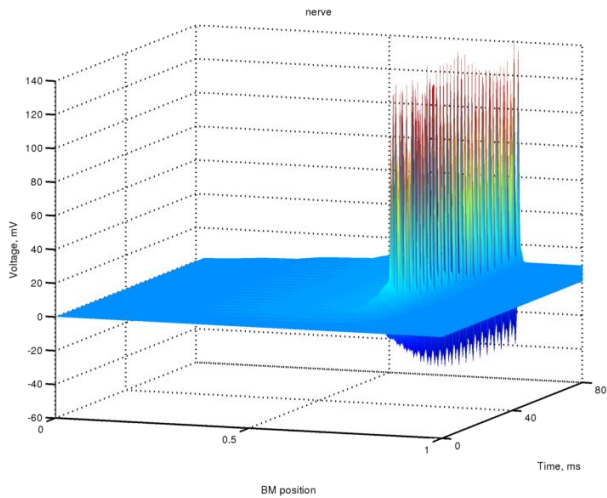
Results: 250 Hz tone



electric response
of hair cells

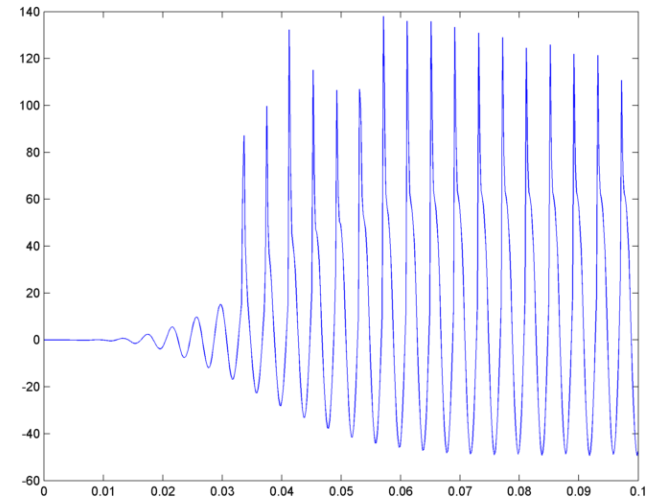


3D



electric response
of auditory nerve

2D (cross section with max. response)



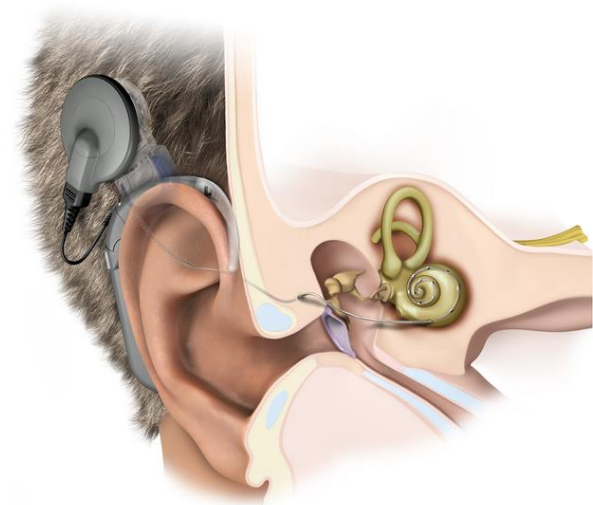
What to do next?

1. Improve connection between inner hair cells and nerve axons: from “Bulgarian” proportionality constant to a more physical model of the neurotransmitter release.
2. Complete building a 3D model “from acoustic excitation to nerve firing” of a normal ear.
3. Build in the model the possibility of direct electric excitation of the nerves by a cochlear implant.
4. Combine acoustic and electric excitation (relevant for a new generation of “gentler” cochlear implants – Medel company) and study possible interferences between these two types of excitation.

Interested???

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Program Kontakt



