Biophysics I (BPHS 3090)

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Website: http://www.yorku.ca/cberge/3090W2015.html

York University
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Lecture 17

Reference/Acknowledgement:
- TF Weiss (Cellular Biophysics)
- D Freeman

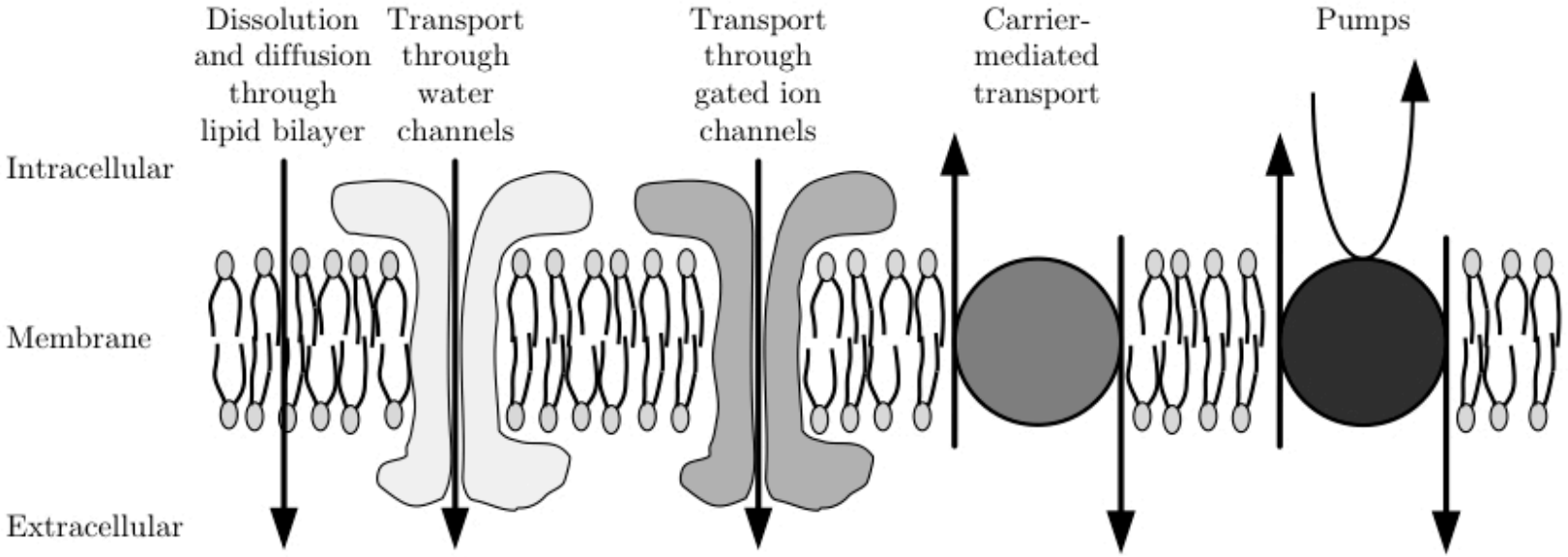

Dissolution and diffusion through lipid bilayer
Transport through water channels
Transport through gated ion channels
Carrier-mediated transport
Pumps
Intracellular
Membrane
Extracellular

Figure 2.19

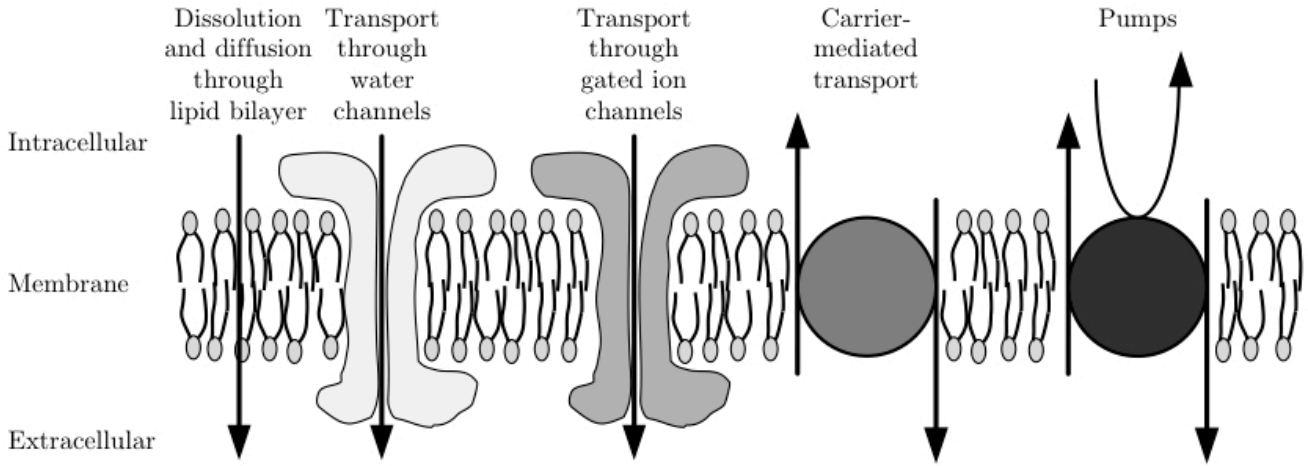


Figure 2.19

Variable conductance

(via voltage-gated ion channels)

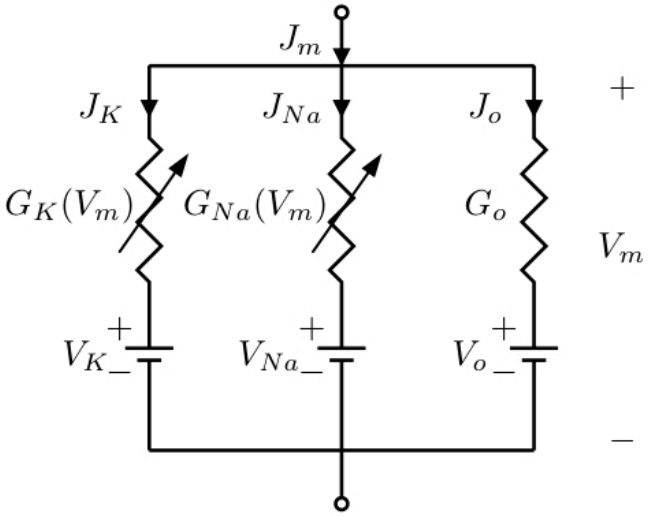


Figure 7.32

Pumps

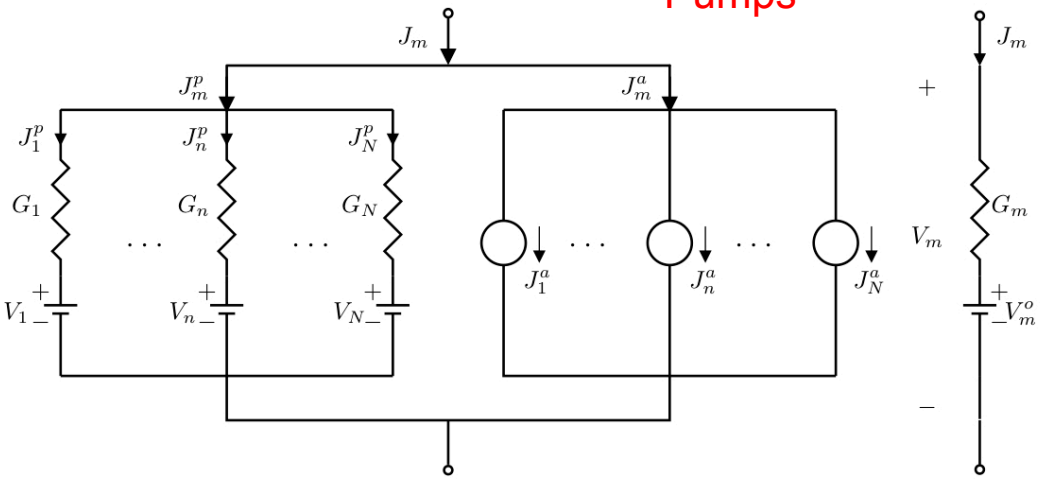
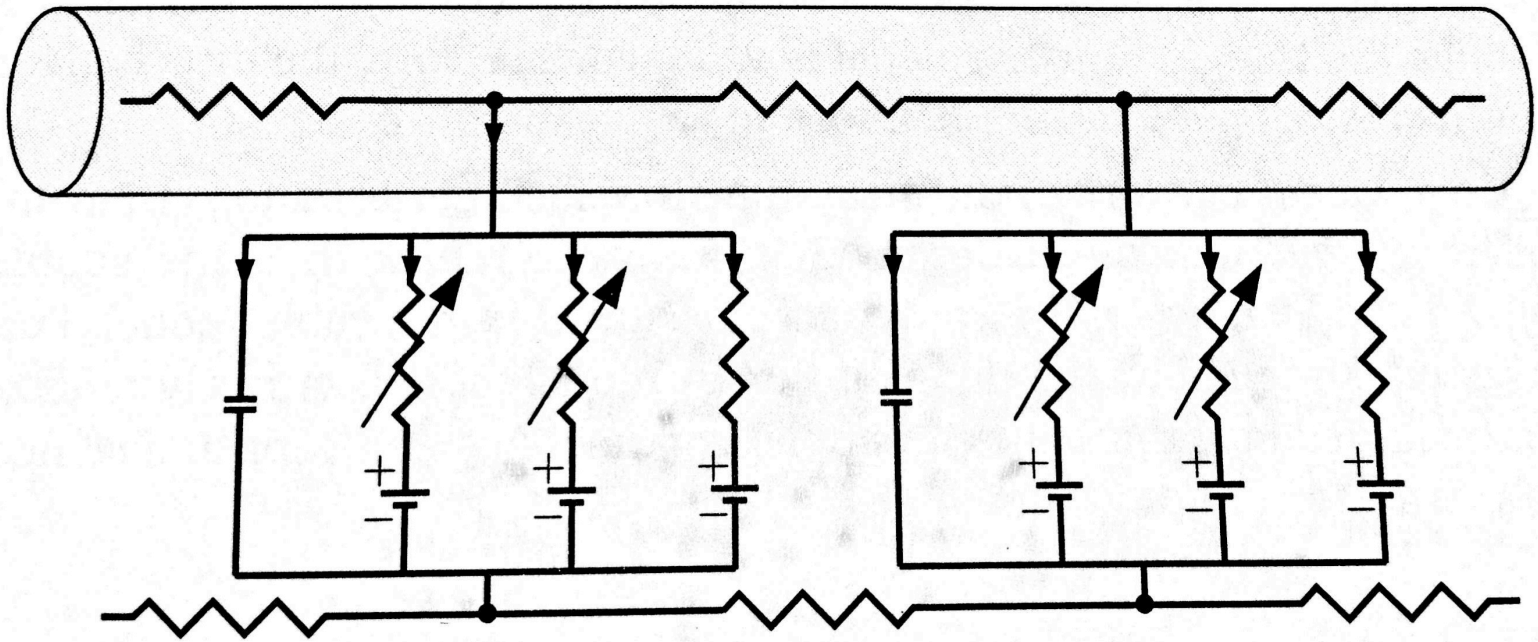


Figure 7.33

Looking Ahead: Hodgkin-Huxley network

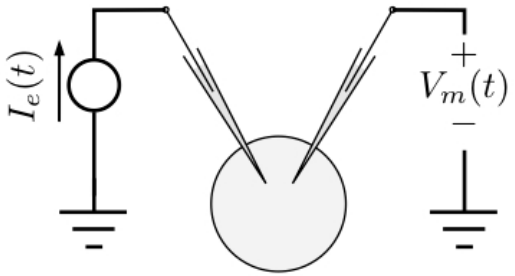
Figure 4.7 (vol.2)



Two main ingredients:

- "sections" of membrane behaving like parallel circuit w/ variable conductances & a capacitor
- successive elements spatially arranged like a "transmission line"

Electrical Properties of Cells



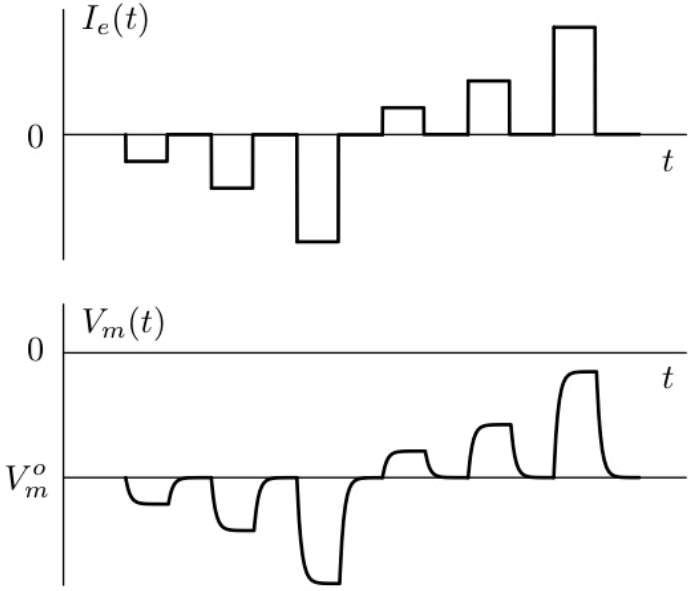
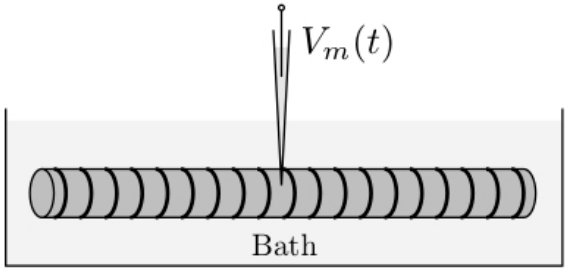


Figure 1.1



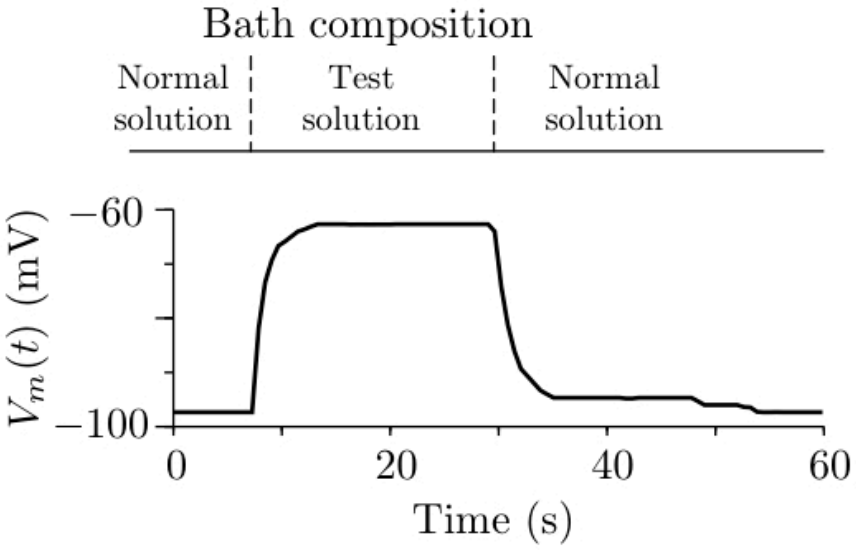
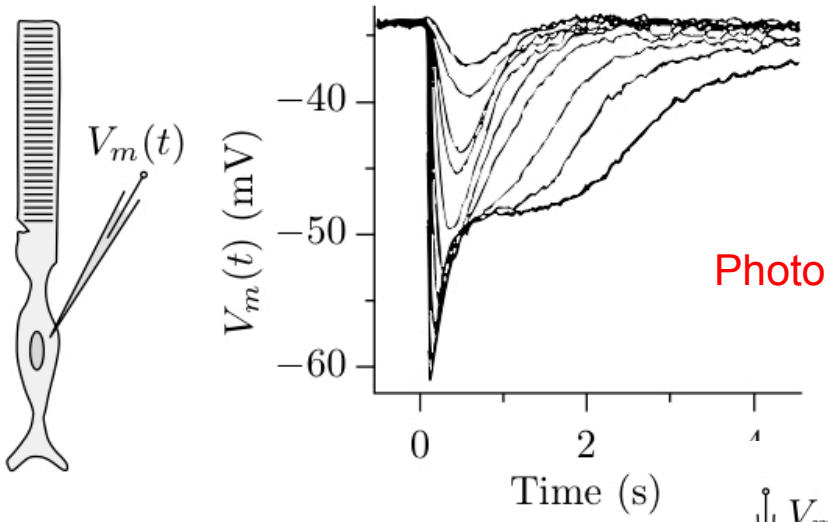


Figure 1.2

Graded potentials (note RC time constant!)

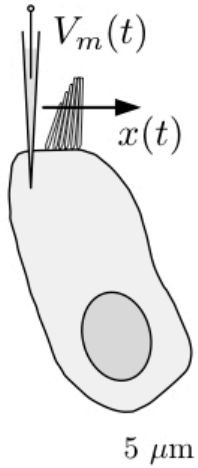
Extracellular solution can have a big effect

Electrical Responses in Sensory Systems



Photoreceptors

Figure 1.3



Auditory Hair Cells

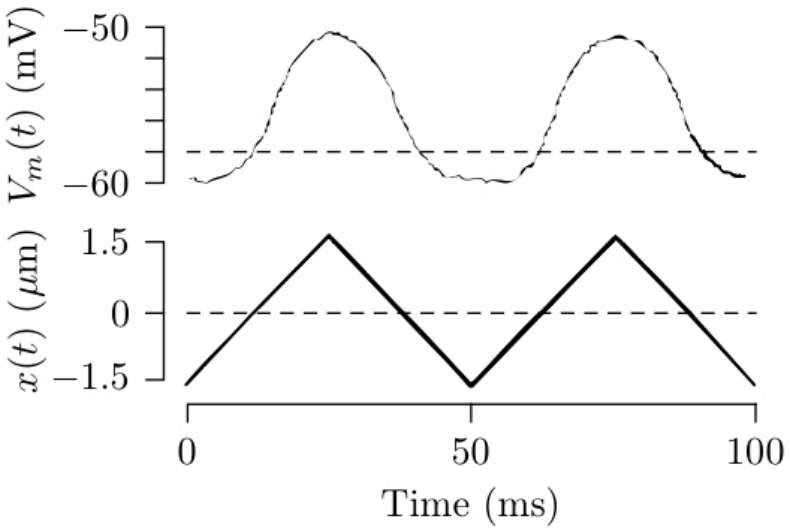


Figure 1.5

Electrical Responses in Sensory Systems

Mechanoreceptors

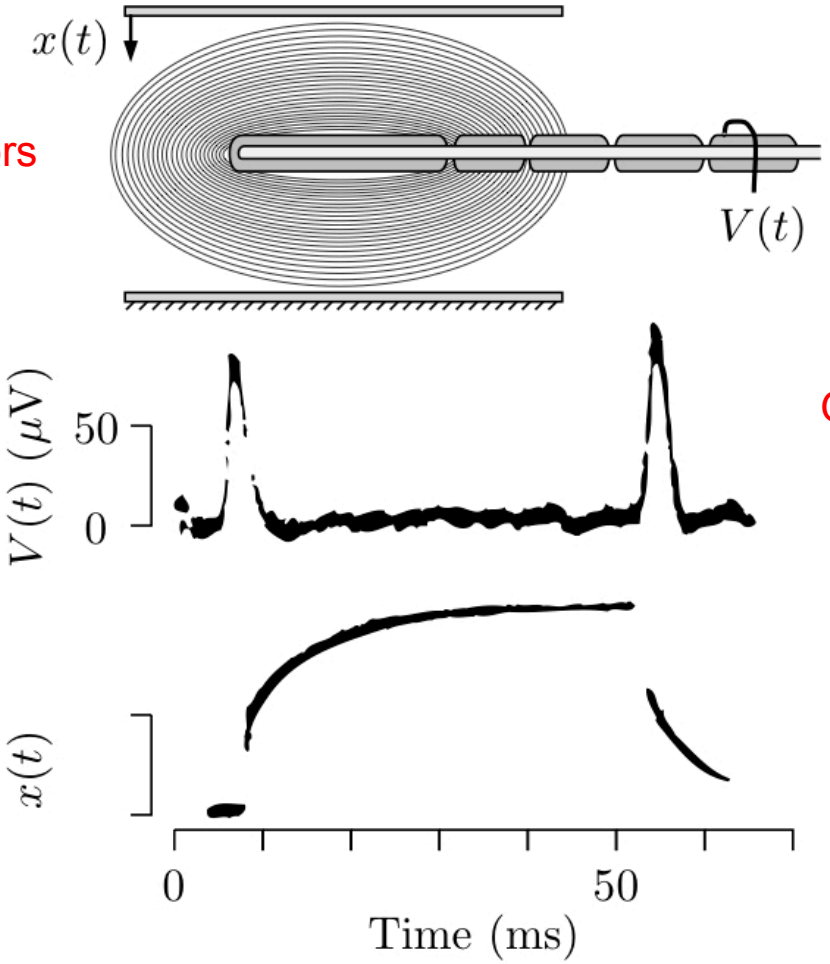


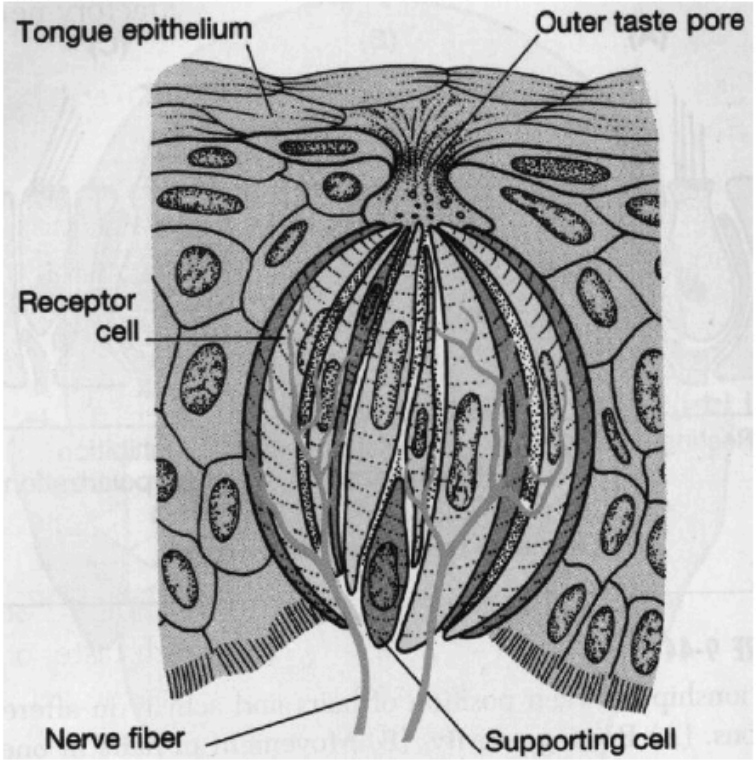
Figure 1.4

Graded potential (w/ adaptation)

(not an action potential)

Electrical Responses in Sensory Systems

Chemoreceptors (taste)



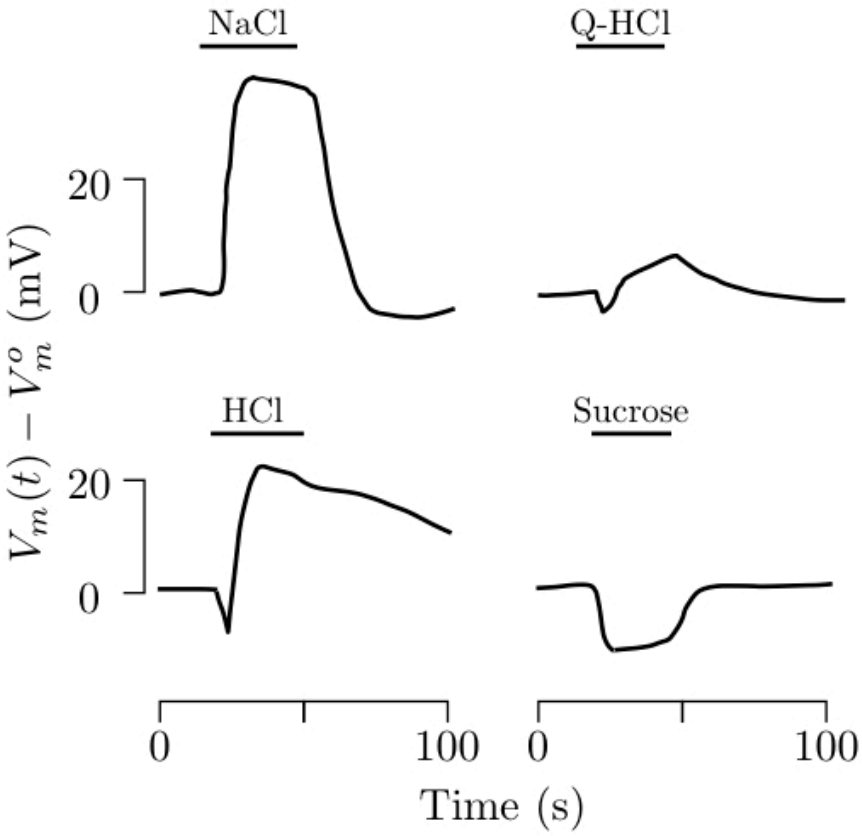


Figure 1.6

Electrical Responses in Sensory Systems

Chemoreceptors (chemical synapse) → "Neurotransmitters"

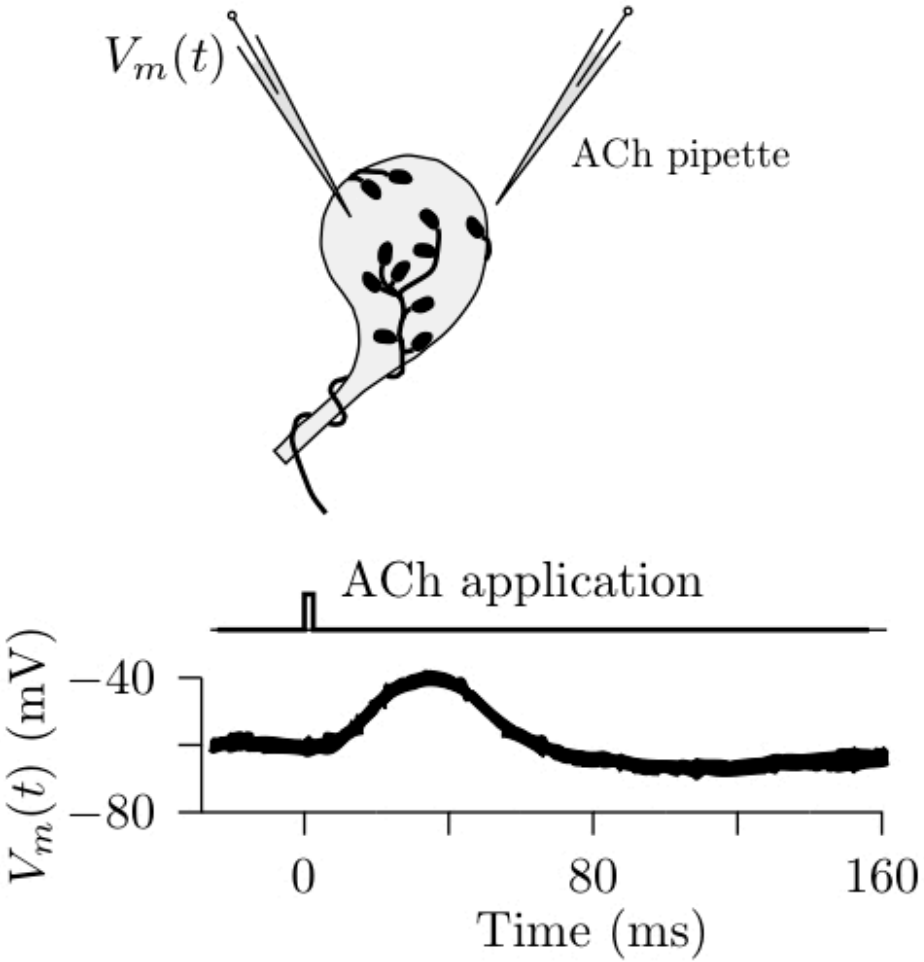


Figure 1.7

Action Potentials

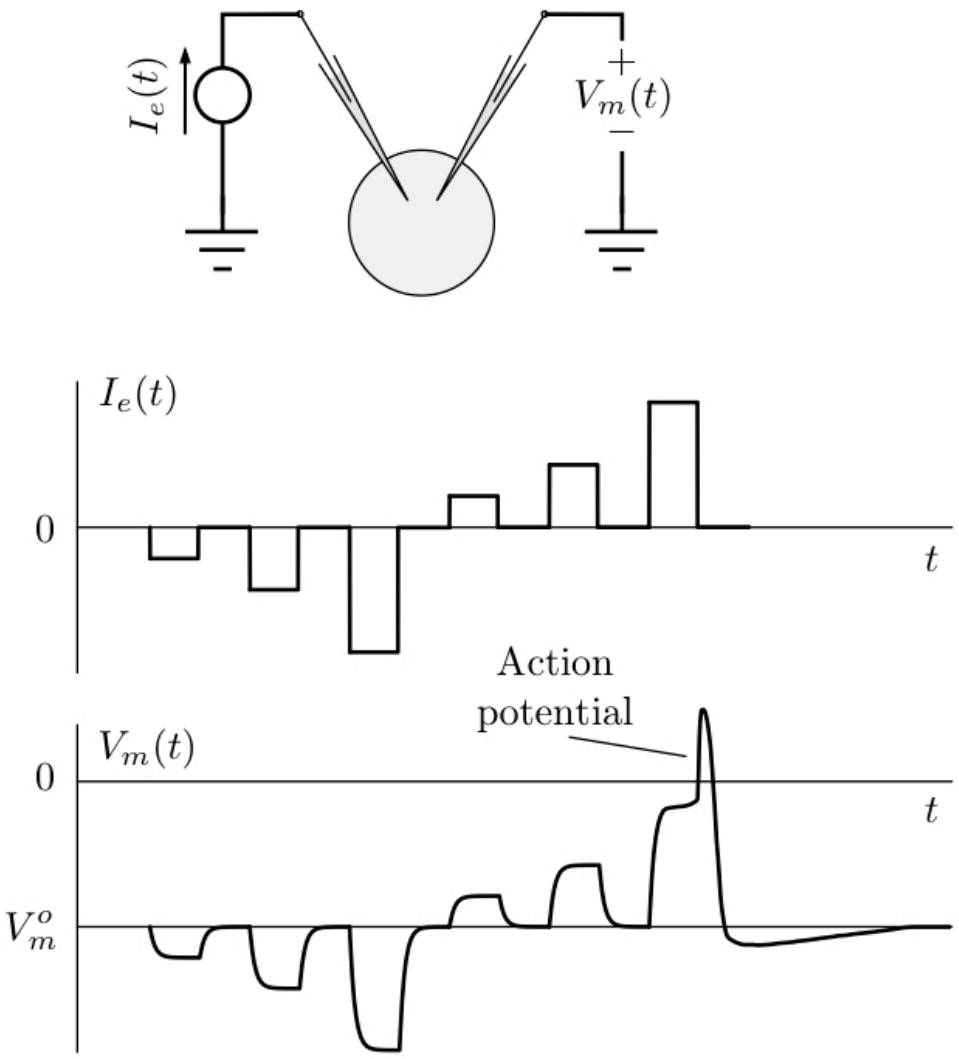


Figure 1.8

Not a graded potential!

(nonlinear; there is a *threshold*)

Graded vs Action Potentials

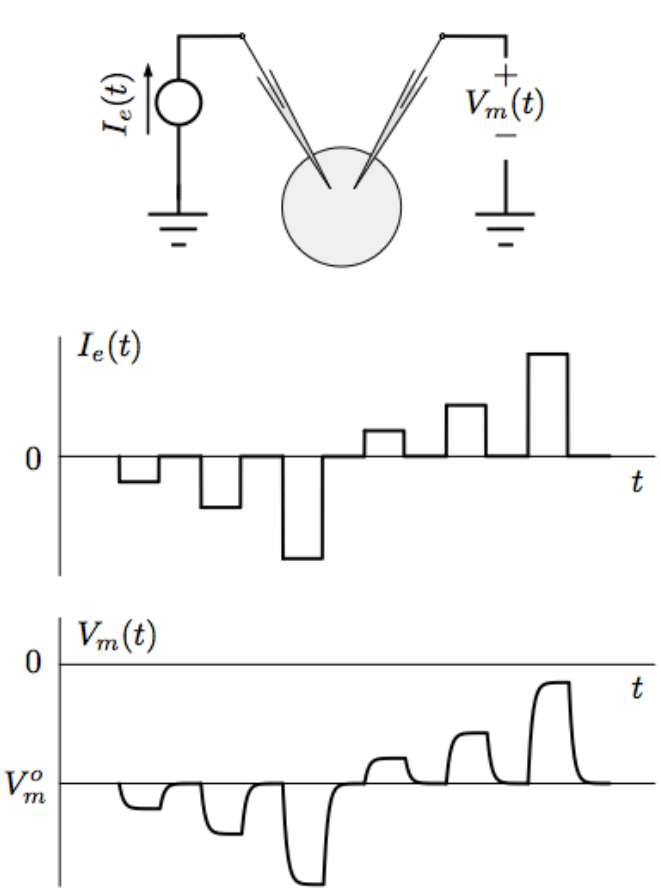


Figure 1.1

Electrically inexcitable cell

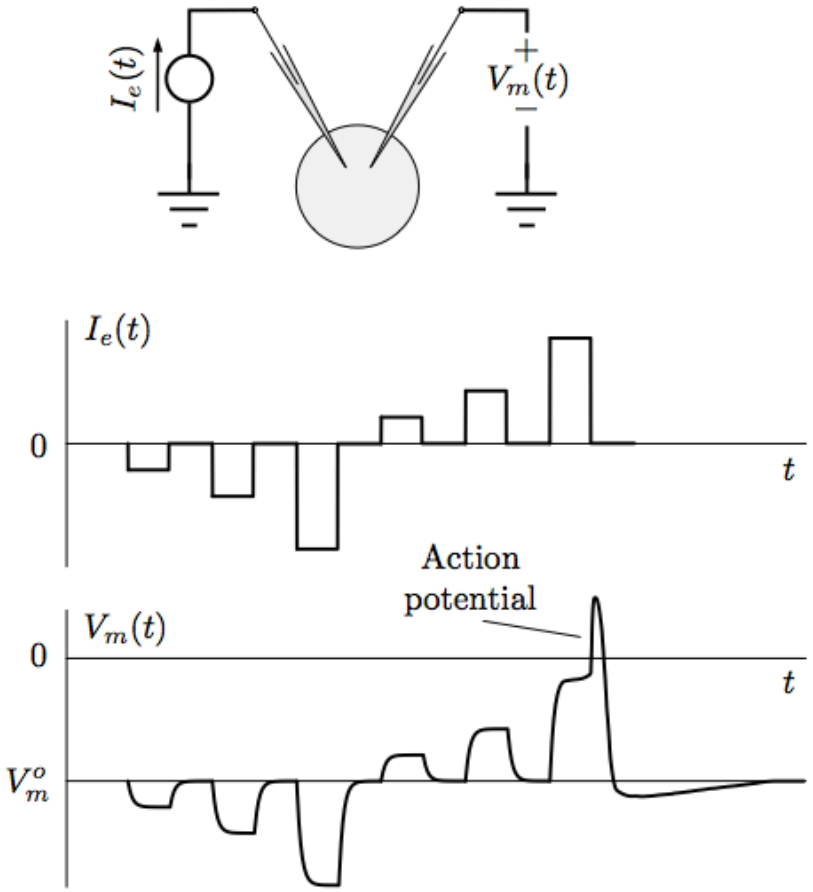


Figure 1.8

Electrically excitable cell

Action Potentials & Neurons

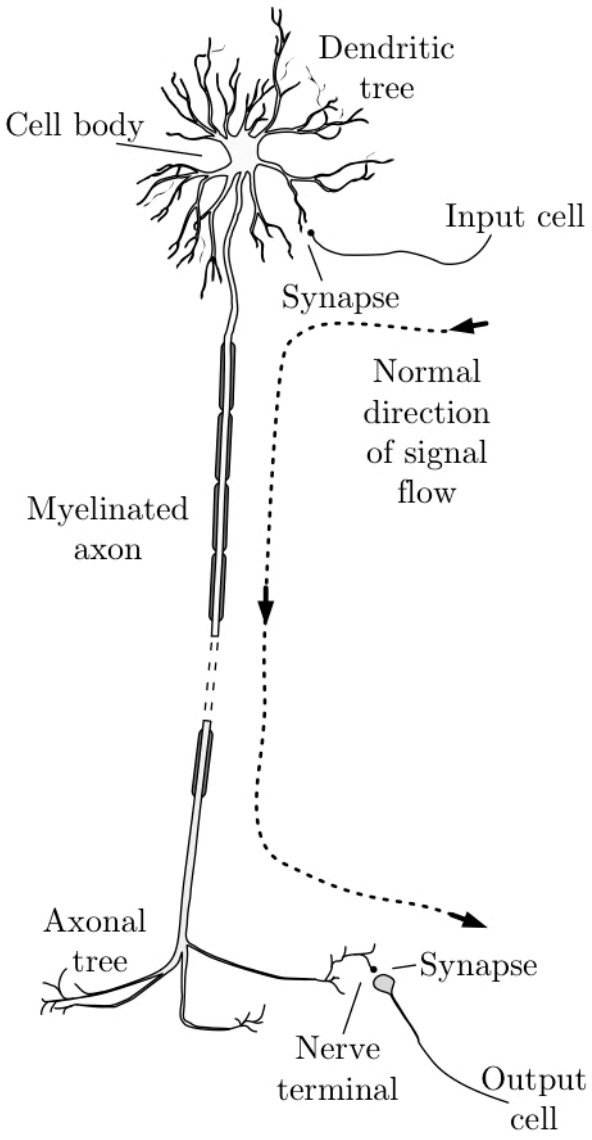


Figure 1.22

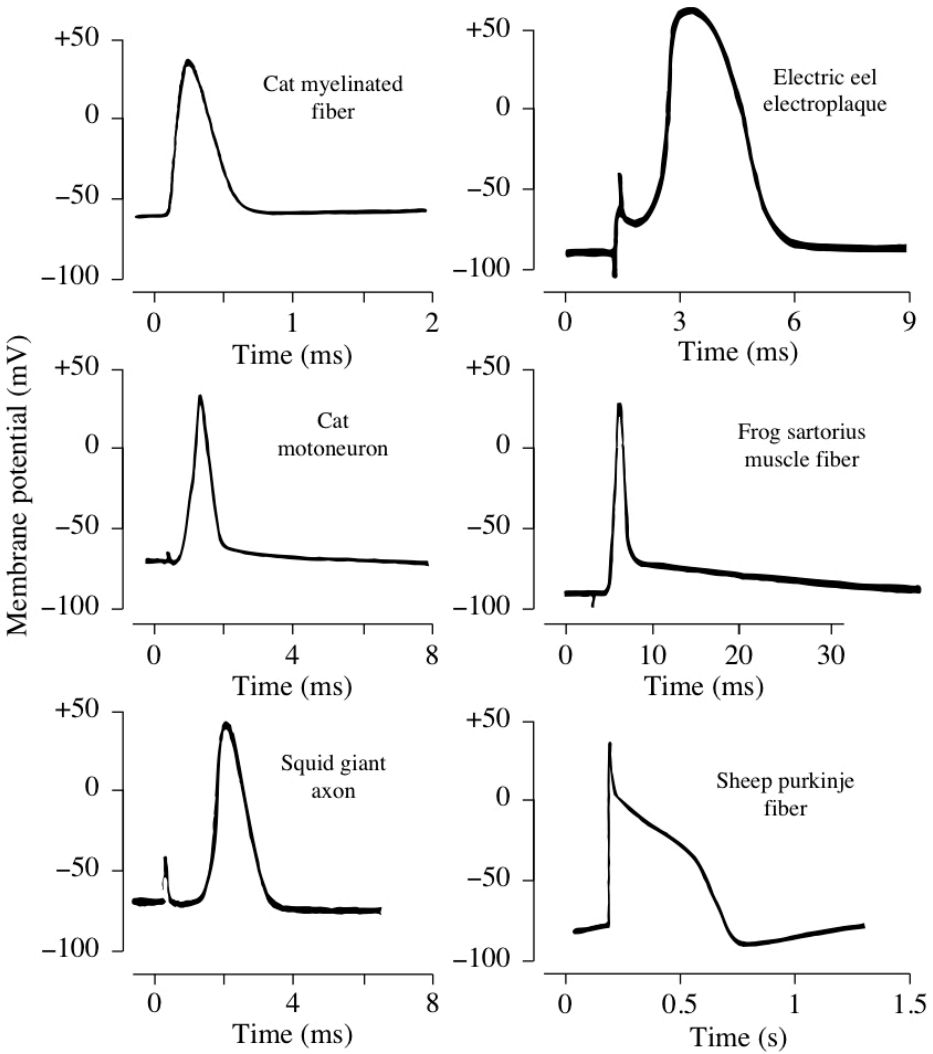


Figure 1.9

Action Potentials

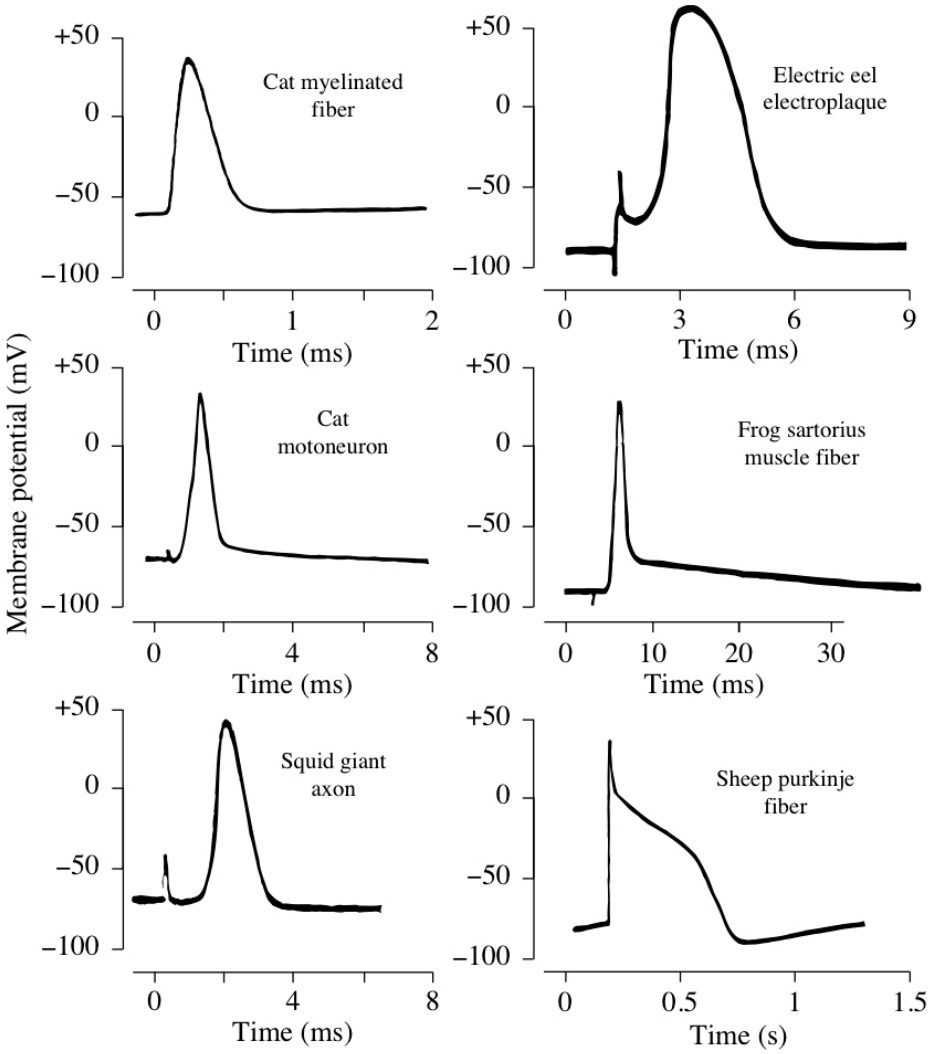


Figure 1.9

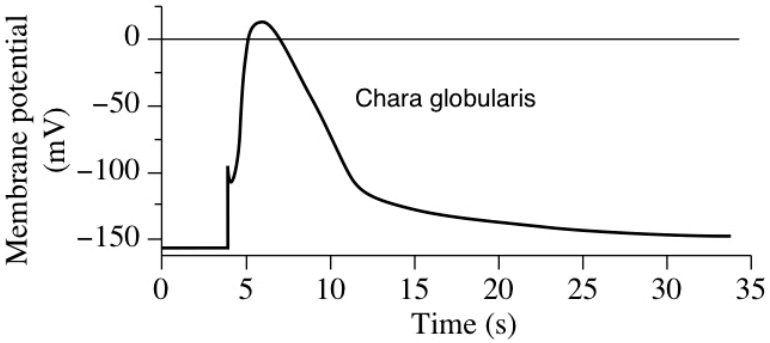
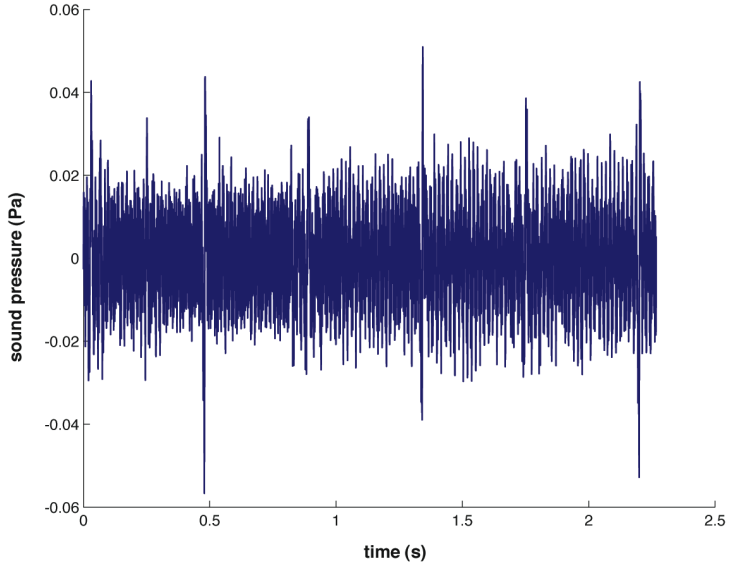


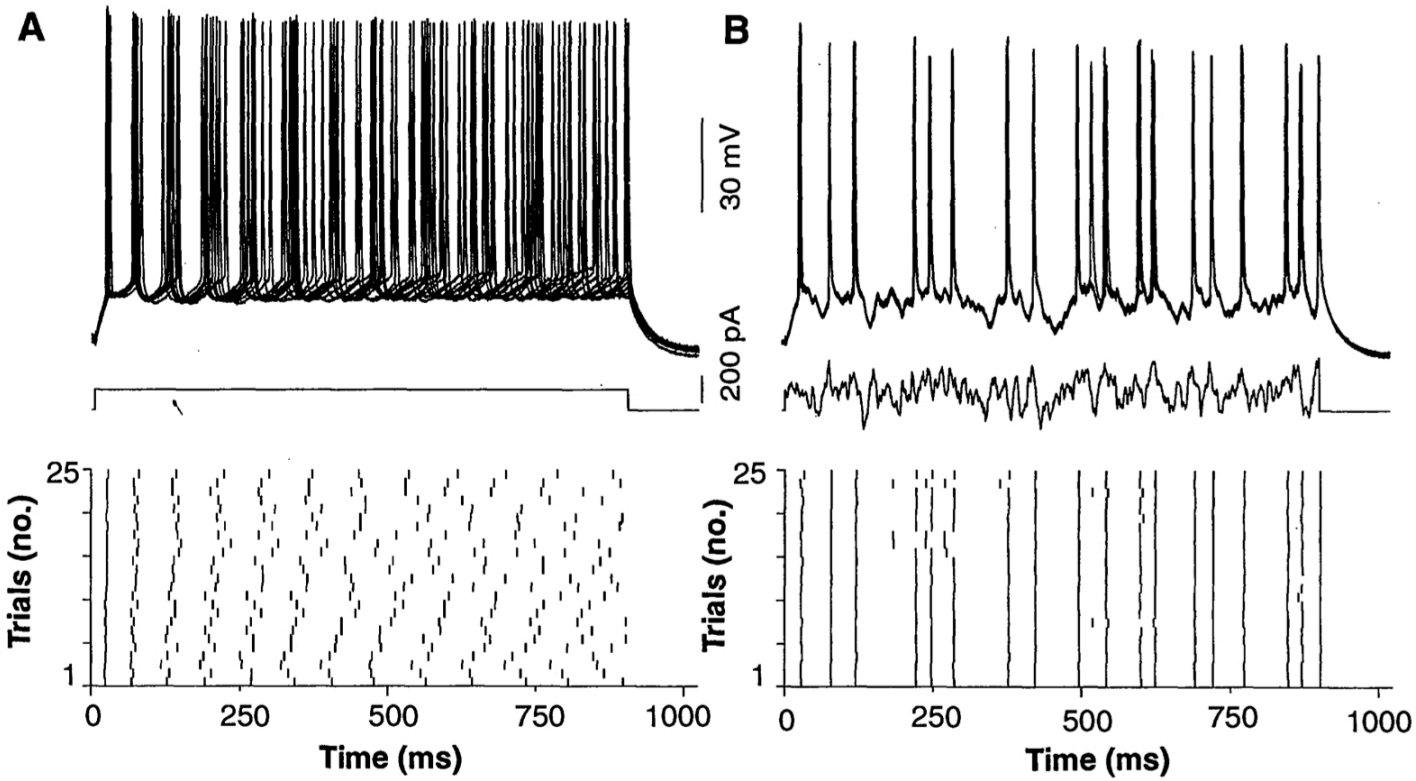
Figure 1.10

→ Wide range of timescales for an action potential 'firing'

Ex. “Spike reliability”

“frozen noise”

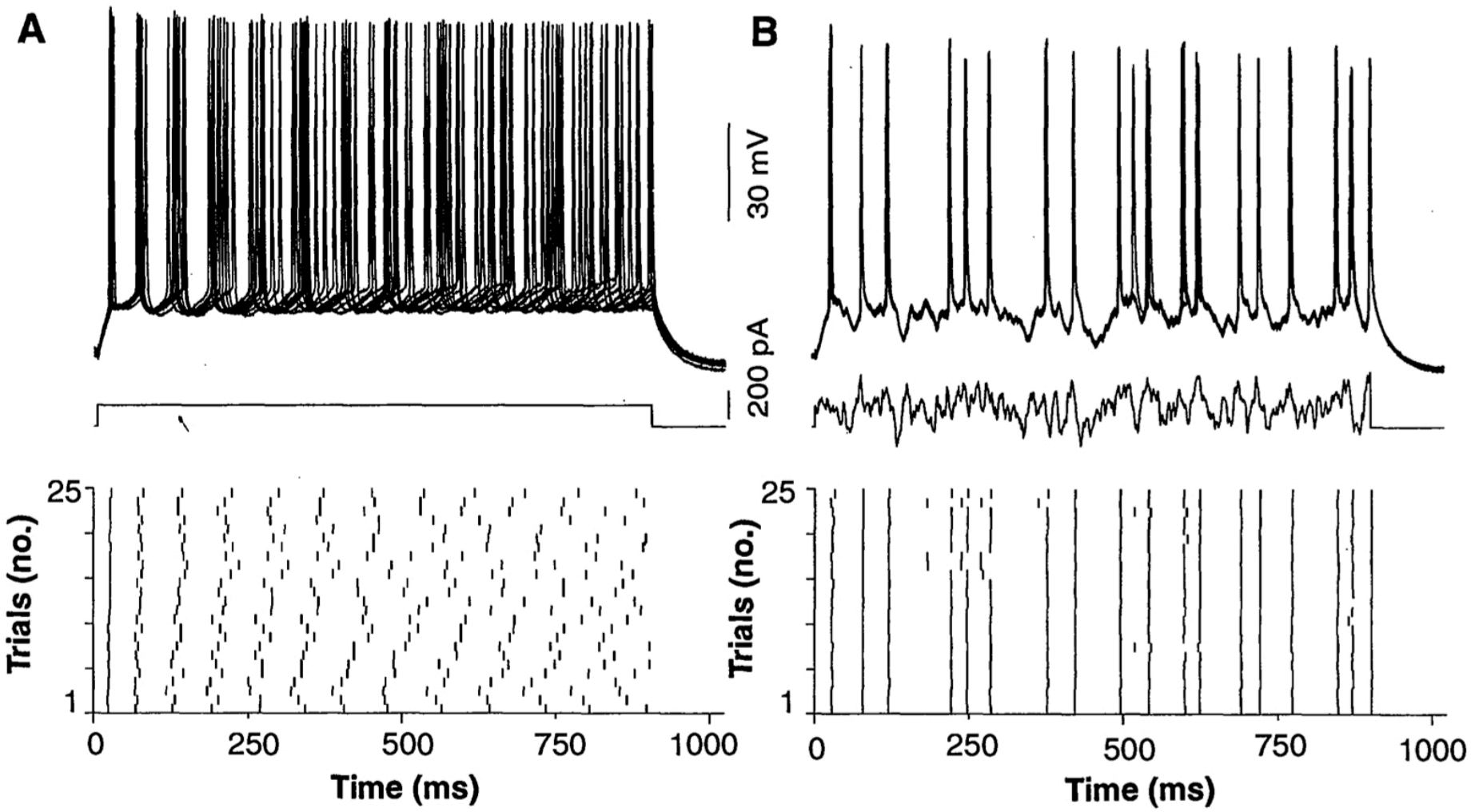




“spike reliability”

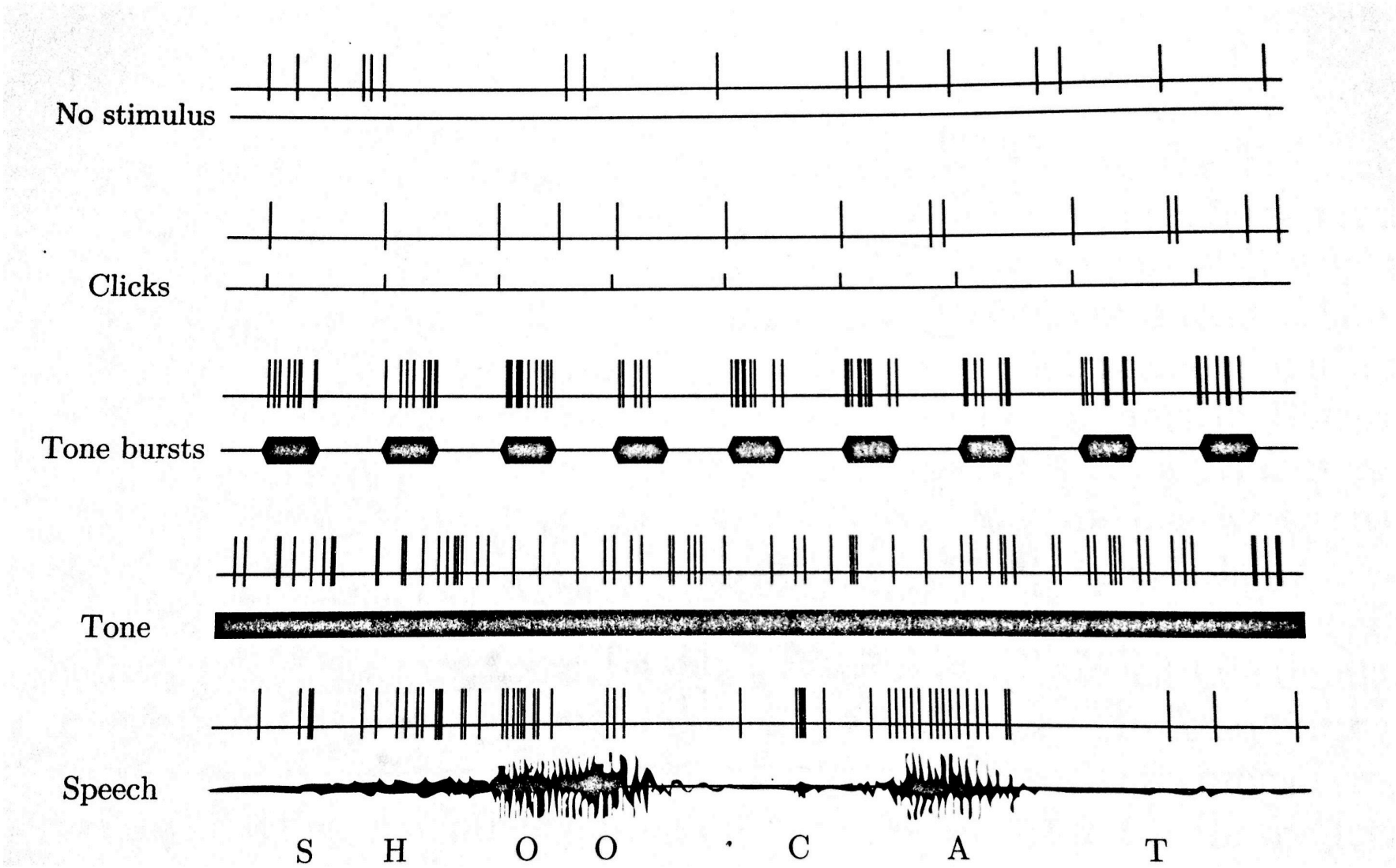
Mainen & Sejnowski (1995)

Ex. “Spike reliability”



Mainen & Sejnowski (1995)

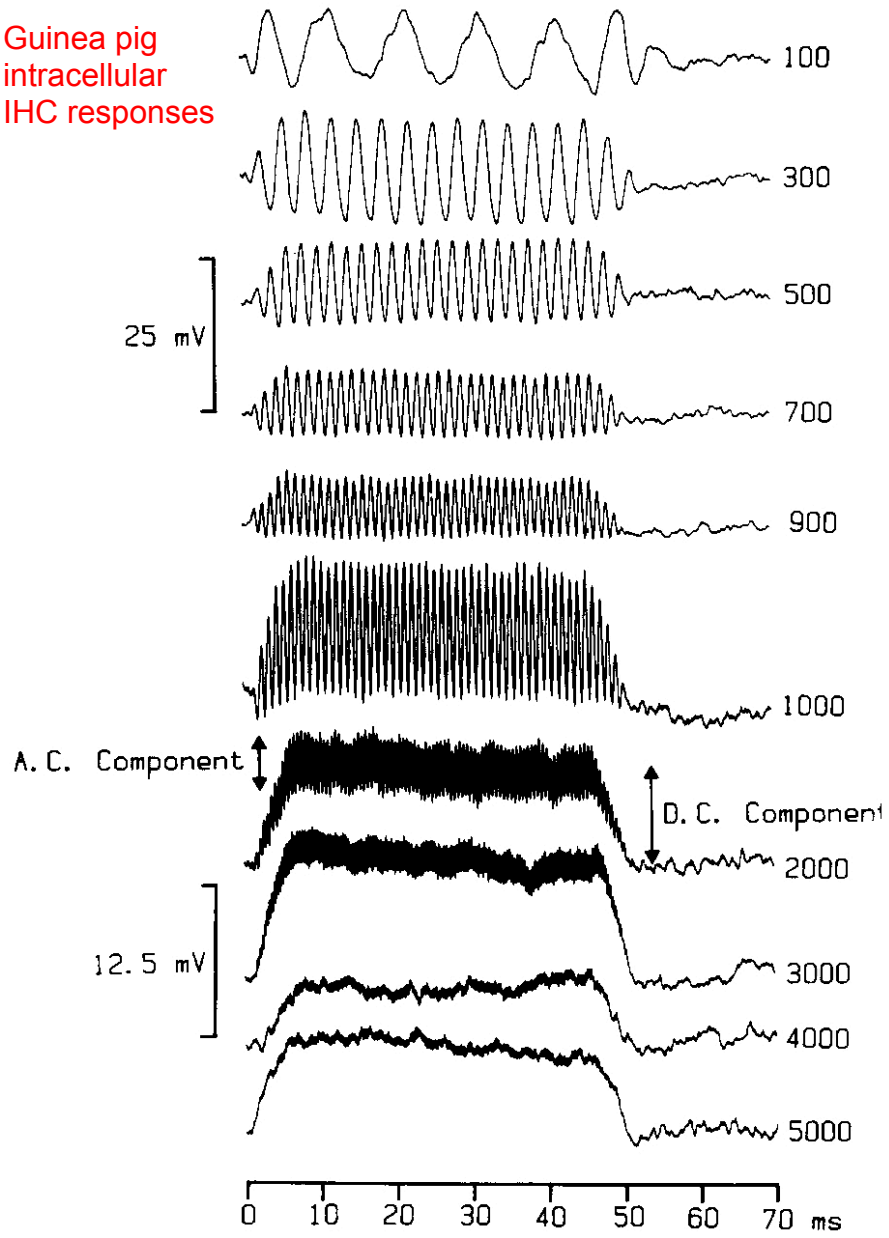
Ex. Neural coding of auditory stimuli

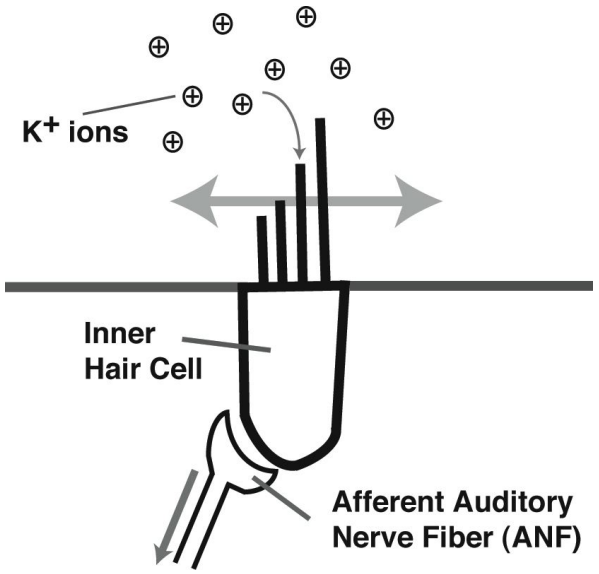


Kiang (1975)

Ex. Neural coding of auditory stimuli

Guinea pig intracellular IHC responses



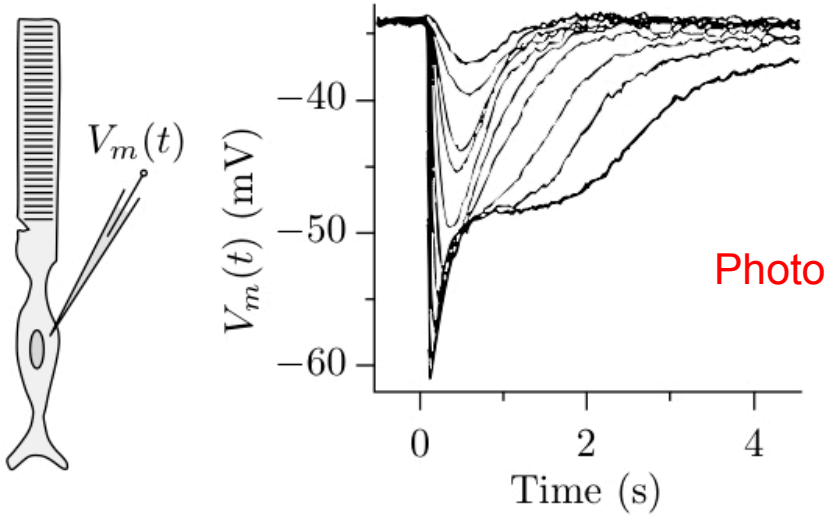


Transduction is nonlinear

- Hair cells act as low-pass filters (due to membrane capacitance)

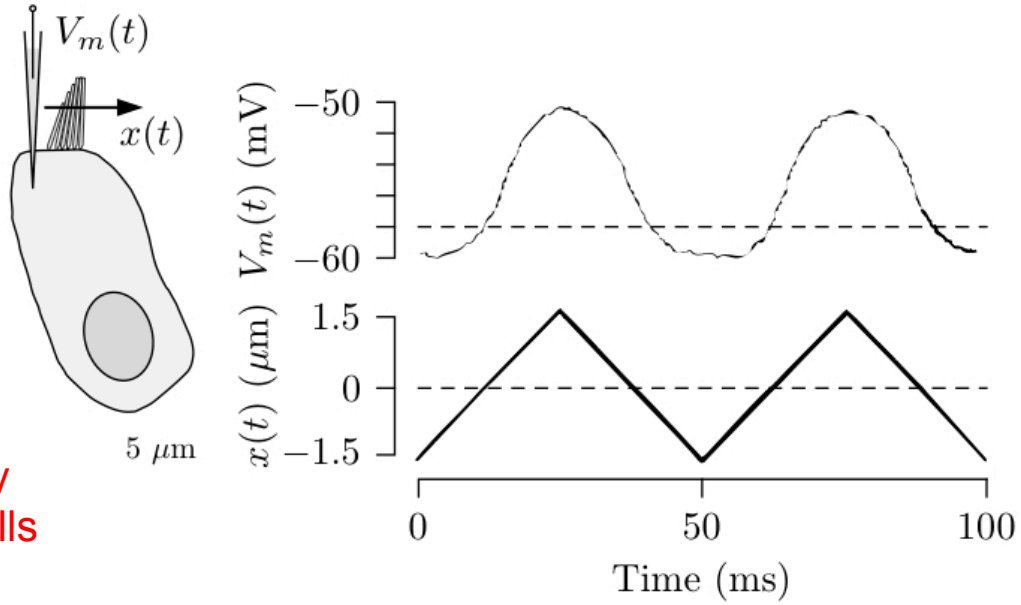
→Hair cells (graded potentials) act as front end to auditory neurons (action potentials)

Palmer & Russell (1986)



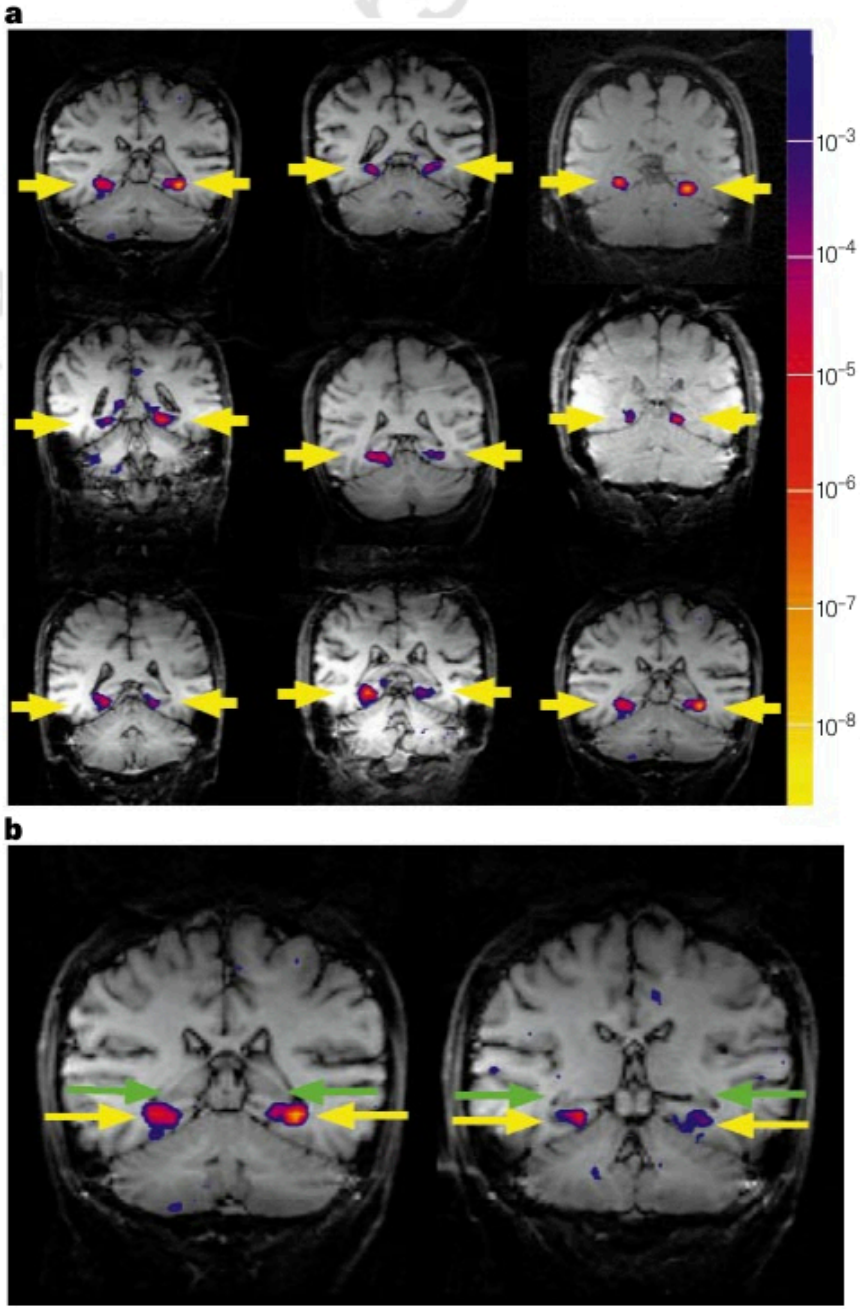
Photoreceptors

Figure 1.3



Auditory Hair Cells

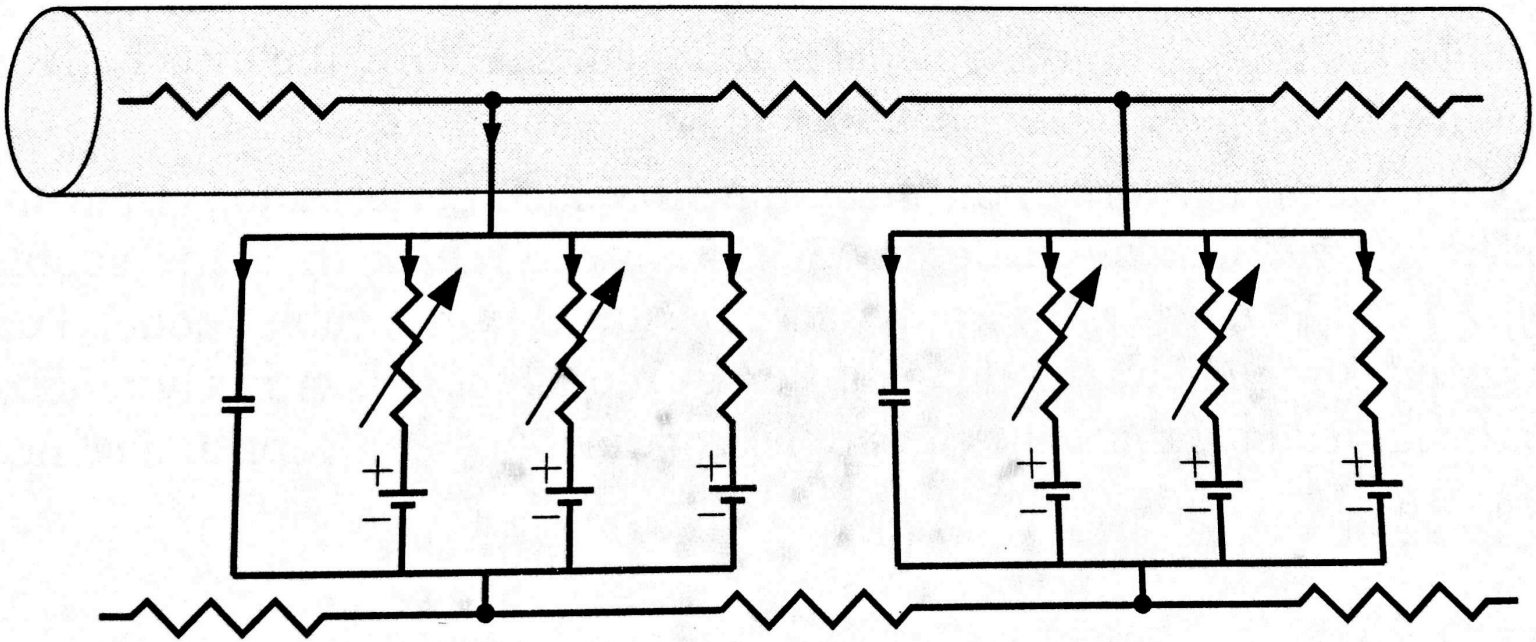
Figure 1.5



Epstein & Kanwisher (1998)

Looking Ahead: Hodgkin-Huxley network

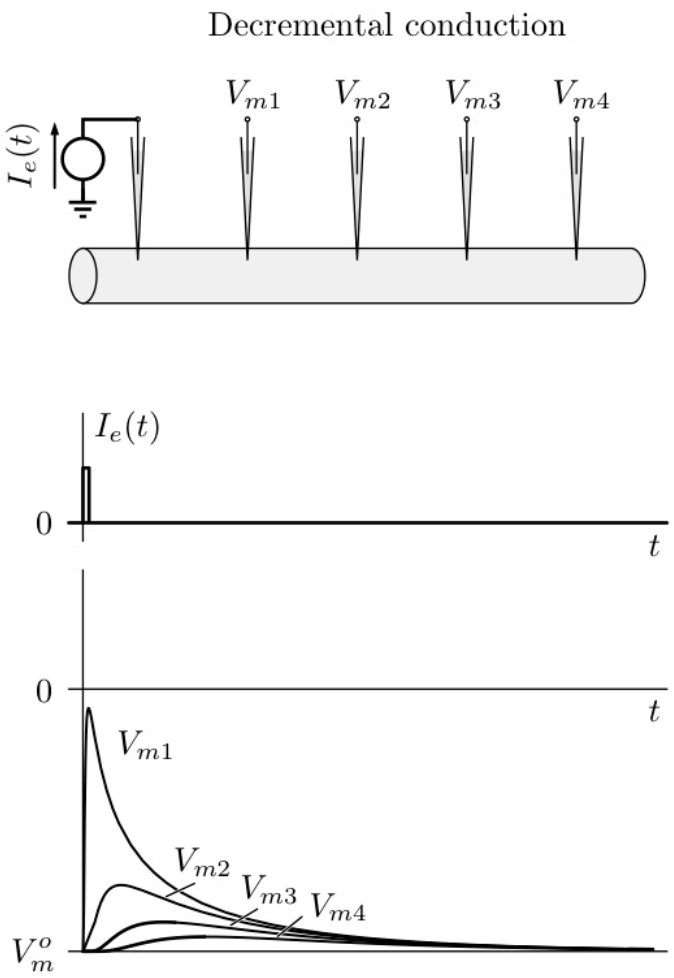
Figure 4.7 (vol.2)



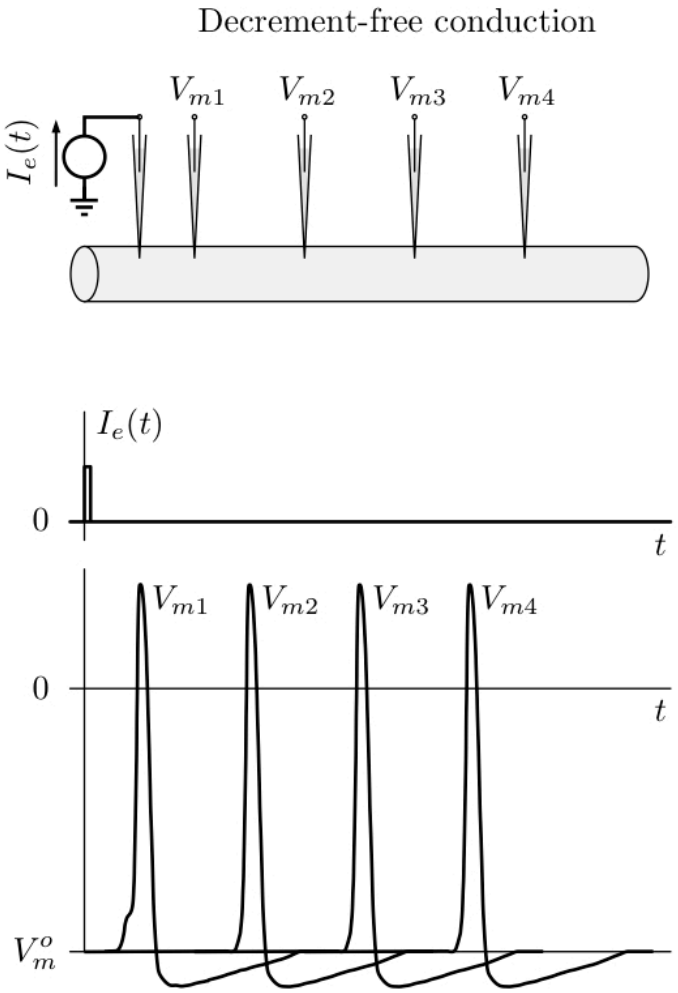
Two main ingredients:

- "sections" of membrane behaving like parallel circuit w/ variable conductances & a capacitor → action potentials
- successive elements spatially arranged like a "transmission line" → propagation

Spatial Conduction → Propagation



Electrically inexcitable cell



Electrically excitable cell