BMD ENG 301Quantitative Systems Physiology (Nervous System)

Introduction to Sensory Systems

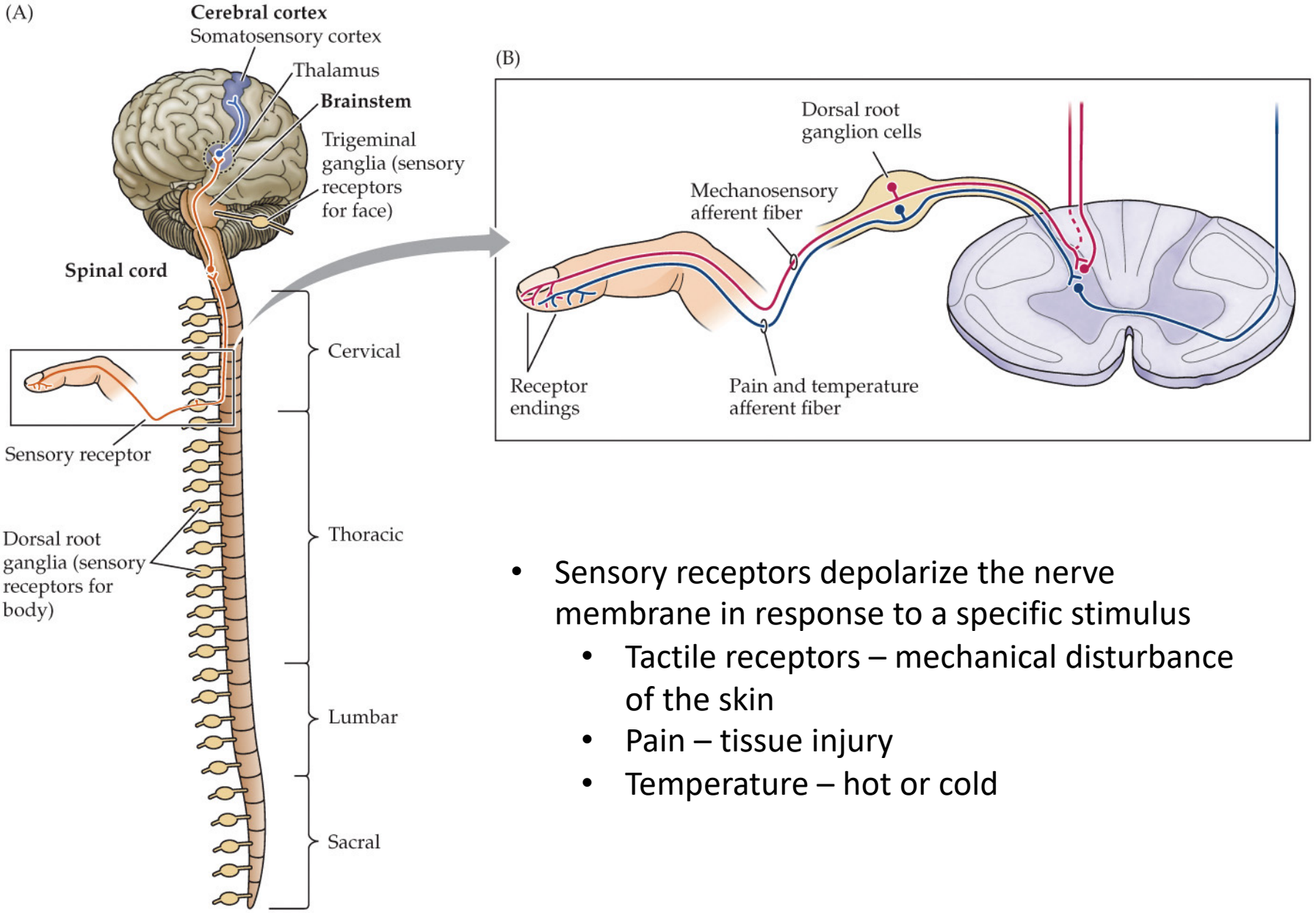
Professor Malcolm A. MacIver

Sensory reception

- **What is the purpose of sensory reception?**
  - **To inform us about the environment in which we operate (external & internal)**
  - **To convert information into a form that the nervous system can interpret**
    - **Bioelectric signals**

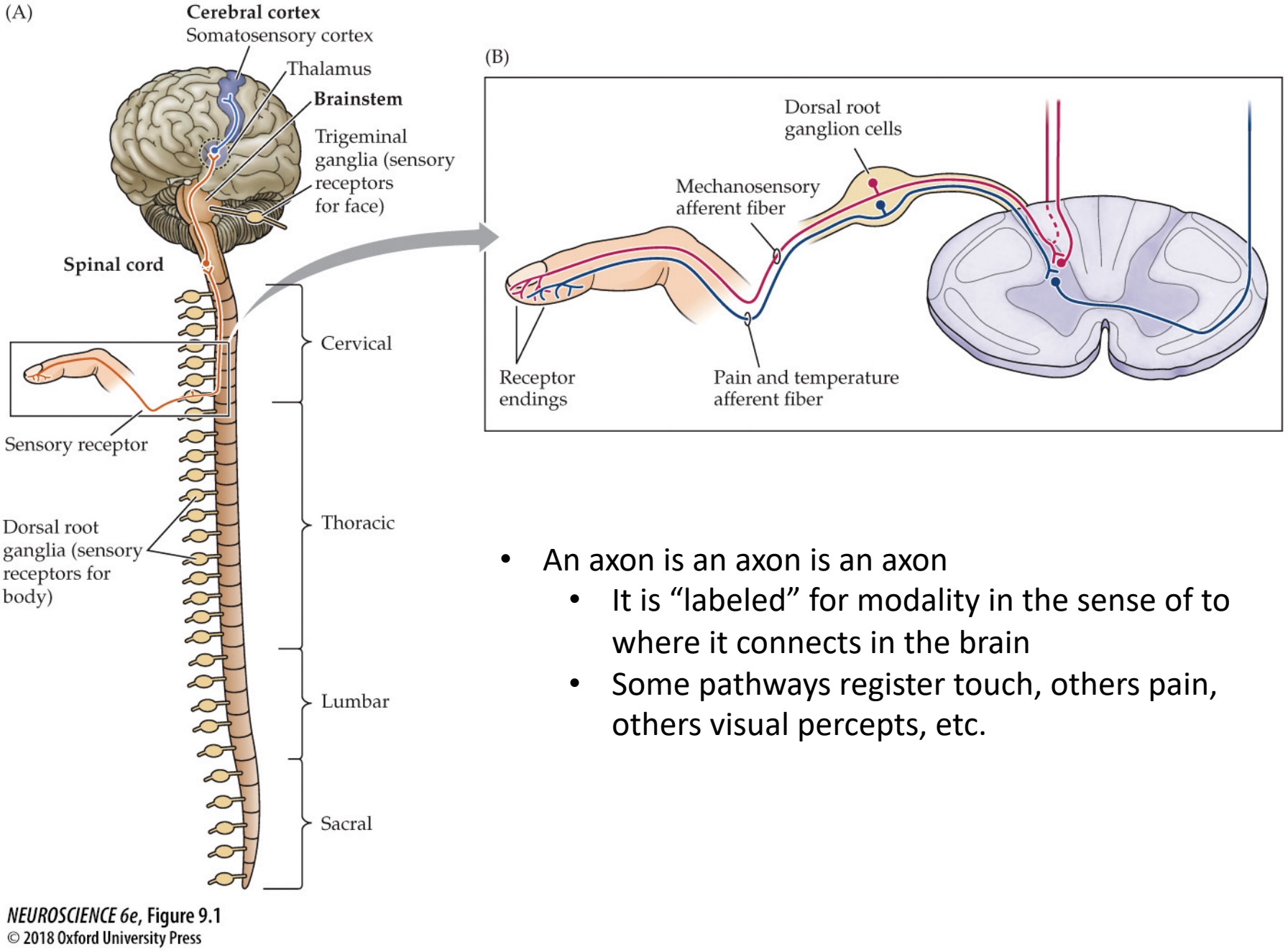
Overview of Sensory Systems

- Exteroceptive
  - Sensory input linked to a network which represents some aspect of the external world
- Interoceptive
  - Sensory input linked to a network that is responsible for representing the physiological condition of the body
- Proprioceptive
  - Sensory input linked to a network that is responsible for representing the position of parts of the body and the strength of effort employed in movement



NEUROSCIENCE 6e, Figure 9.1

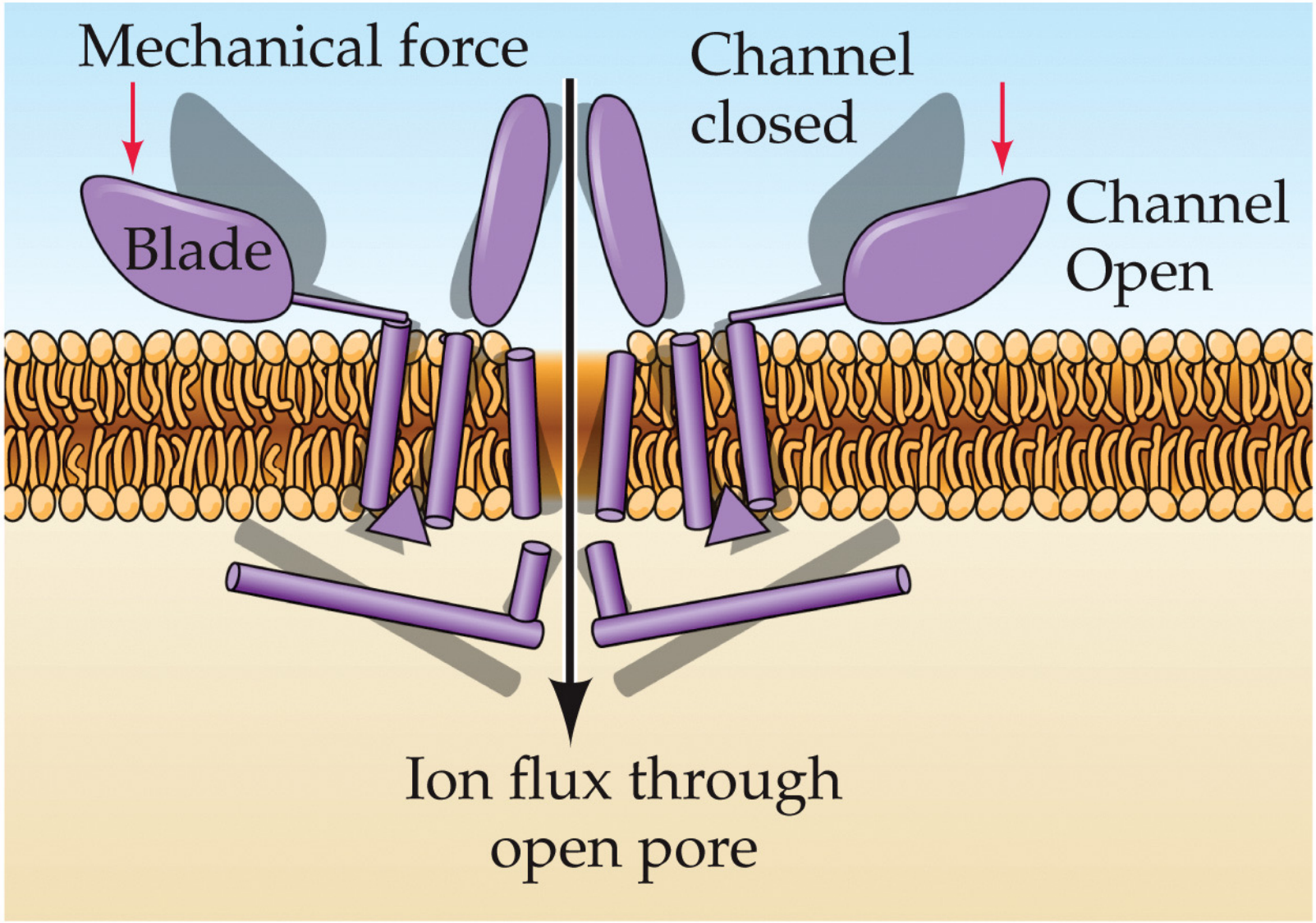
- Sensory receptors depolarize the nerve membrane in response to a specific stimulus
  - Tactile receptors – mechanical disturbance of the skin
  - Pain – tissue injury
  - Temperature – hot or cold



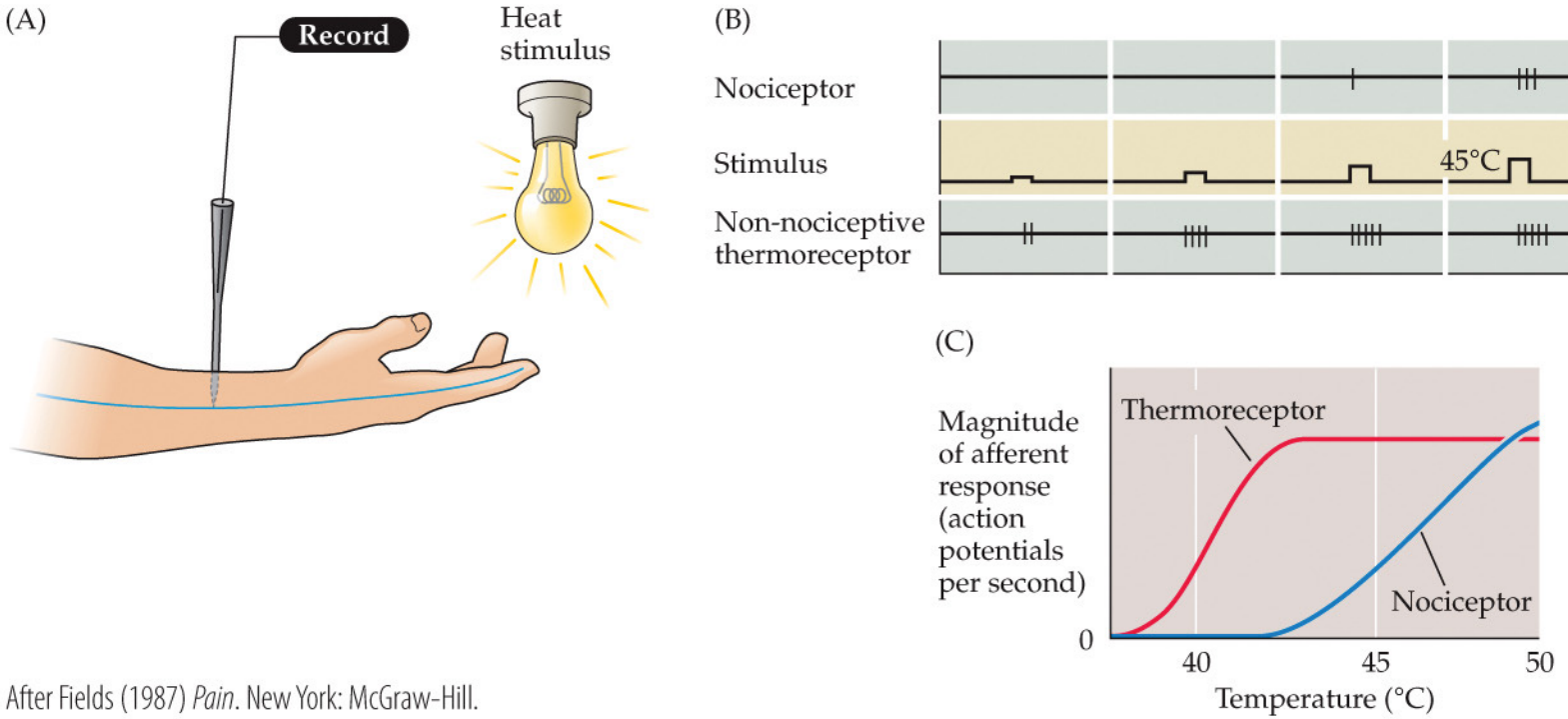
NEUROSCIENCE 6e, Figure 9.1

- An axon is an axon is an axon
  - It is "labeled" for modality in the sense of to where it connects in the brain
  - Some pathways register touch, others pain, others visual percepts, etc.

(D)



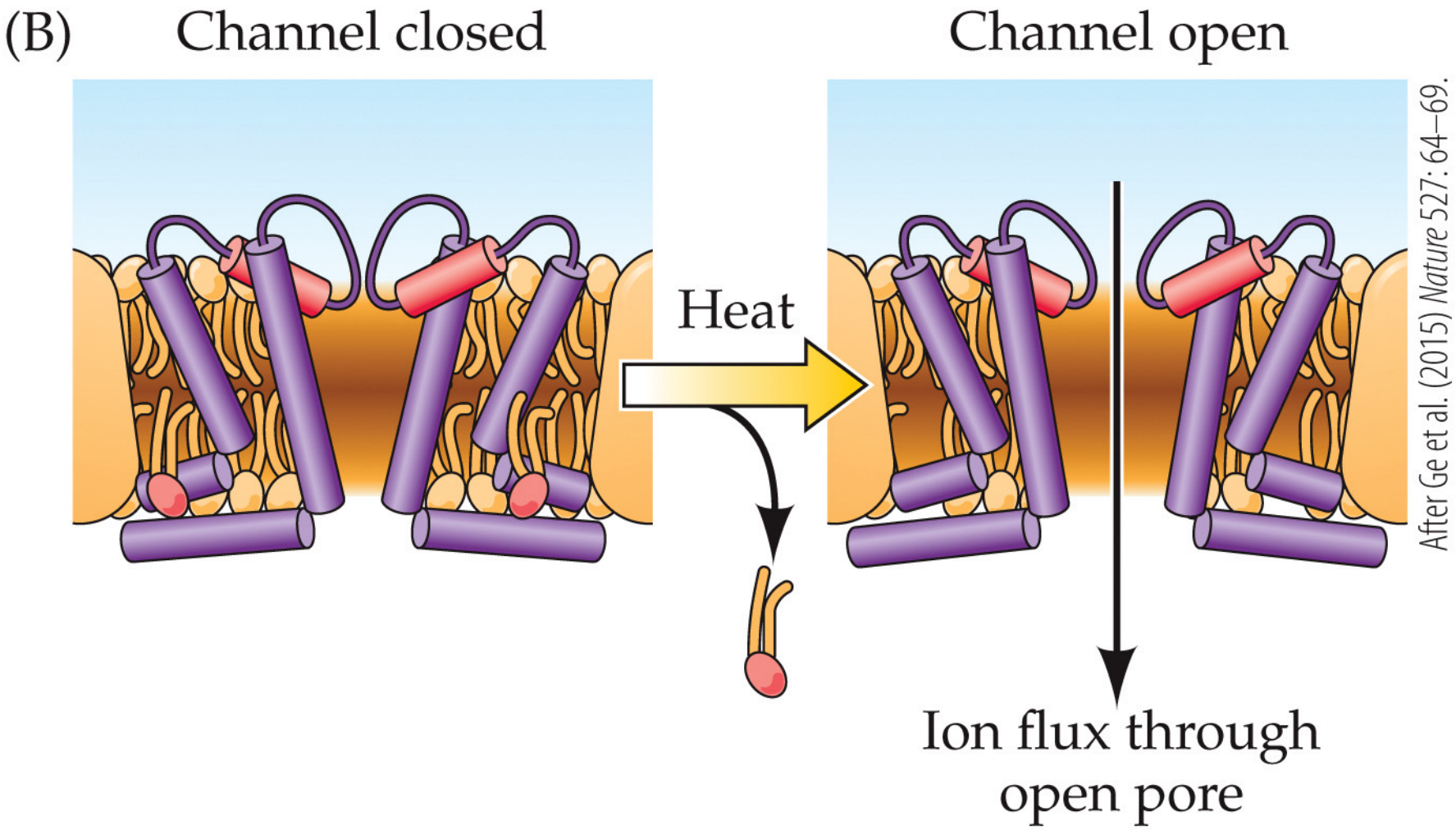
NEUROSCIENCE 6e, Figure 4.9 (Part 4)



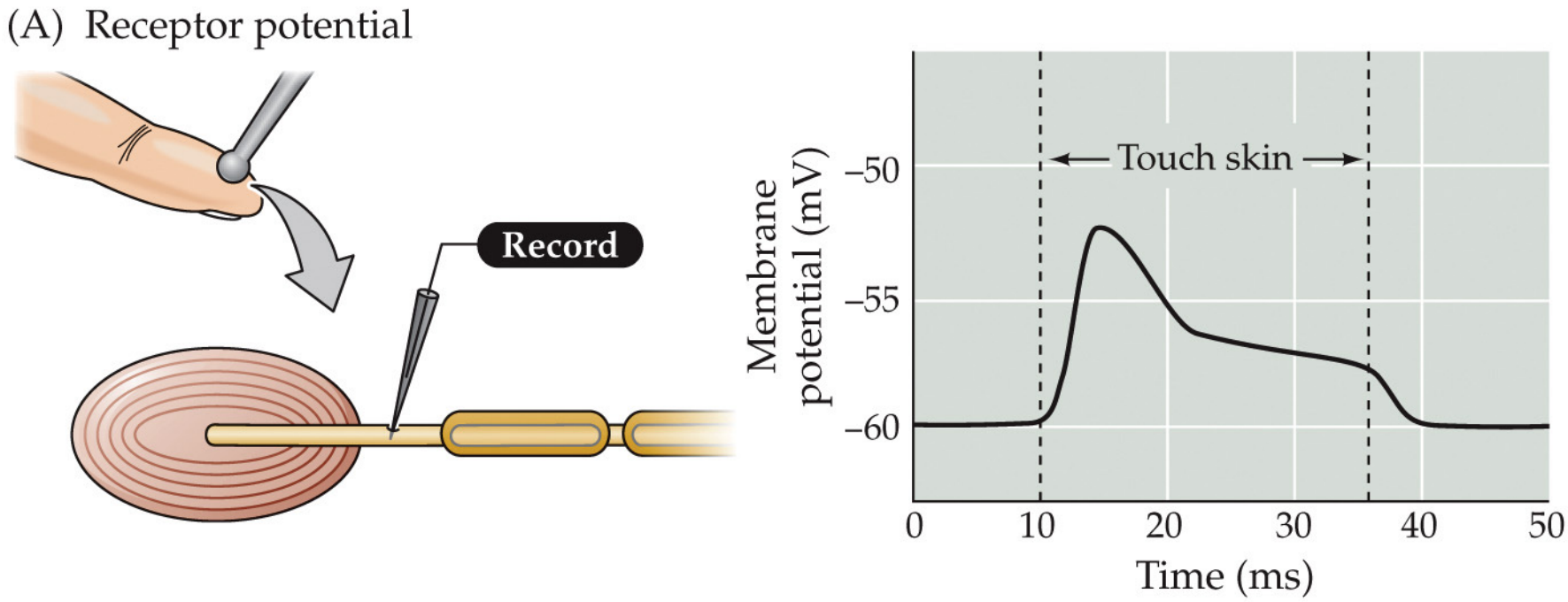
After Fields (1987) *Pain*. New York: McGraw-Hill.

***NEUROSCIENCE 6e*, Figure 10.1**

Firing of the nociceptor signals temperatures that can cause tissue damage

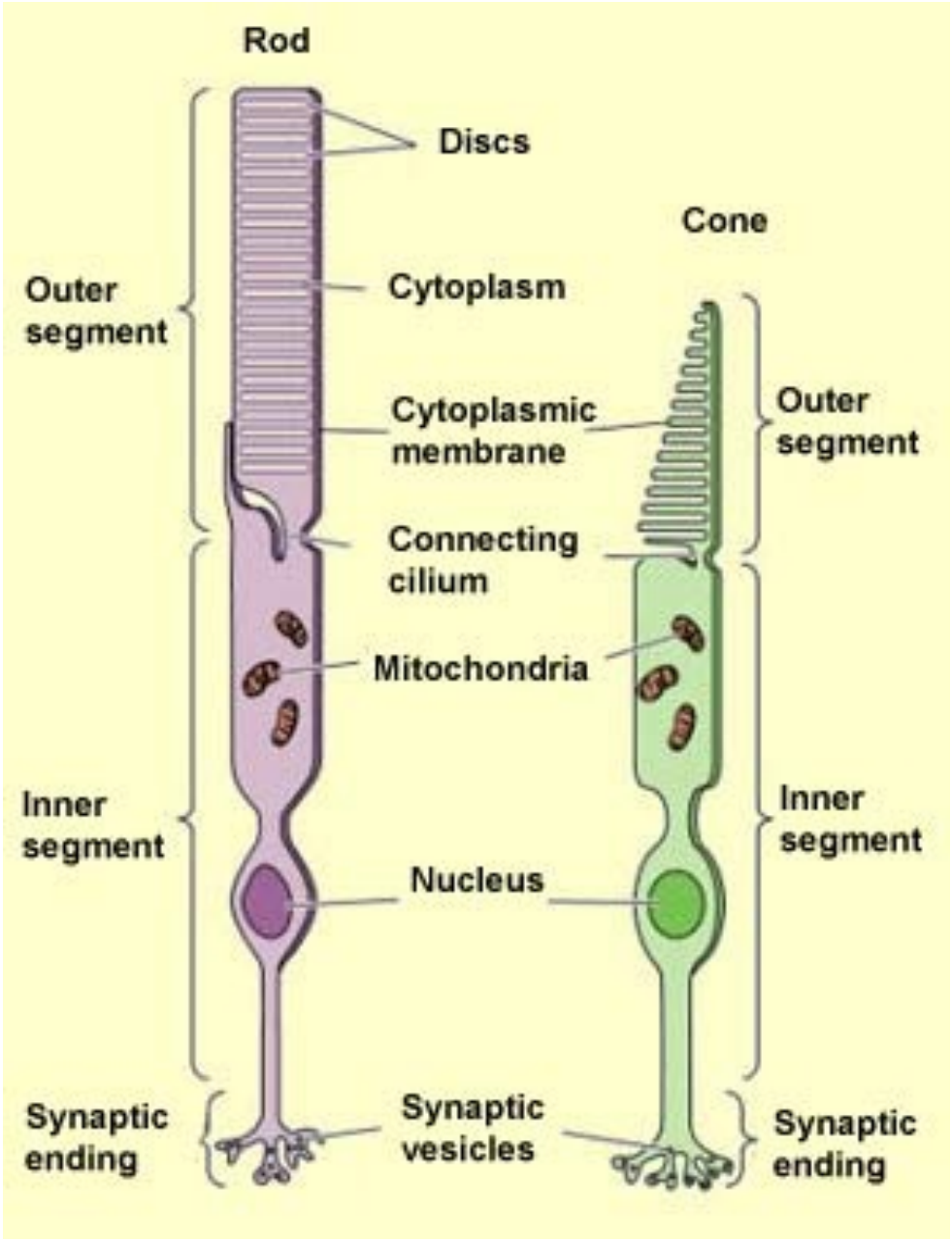


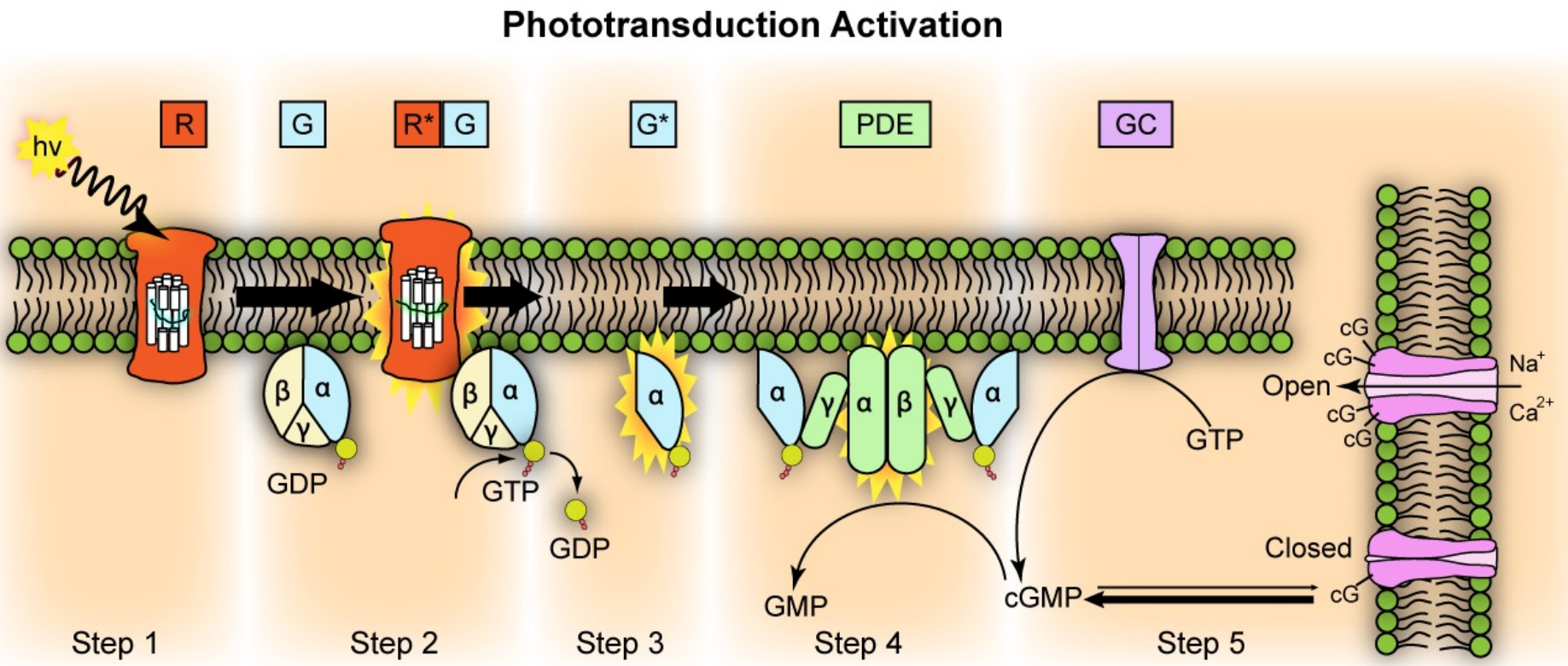
NEUROSCIENCE 6e, Figure 4.9 (Part 2)



NEUROSCIENCE 6e, Figure 2.1 (Part 1)

When sensory reception is far from the CNS and action potential propagation is required to register a signal there, sensory reception must result in membrane depolarization


Rod
Discs
Cone
Outer segment
Cytoplasm
Cytoplasmic membrane
Outer segment
Connecting cilium
Mitochondria
Inner segment
Inner segment
Nucleus
Synaptic ending
Synaptic vesicles
Synaptic ending



Activation Cascade

R: Rhodopsin

R*: Activated Rhodopsin (Retinal in all trans)

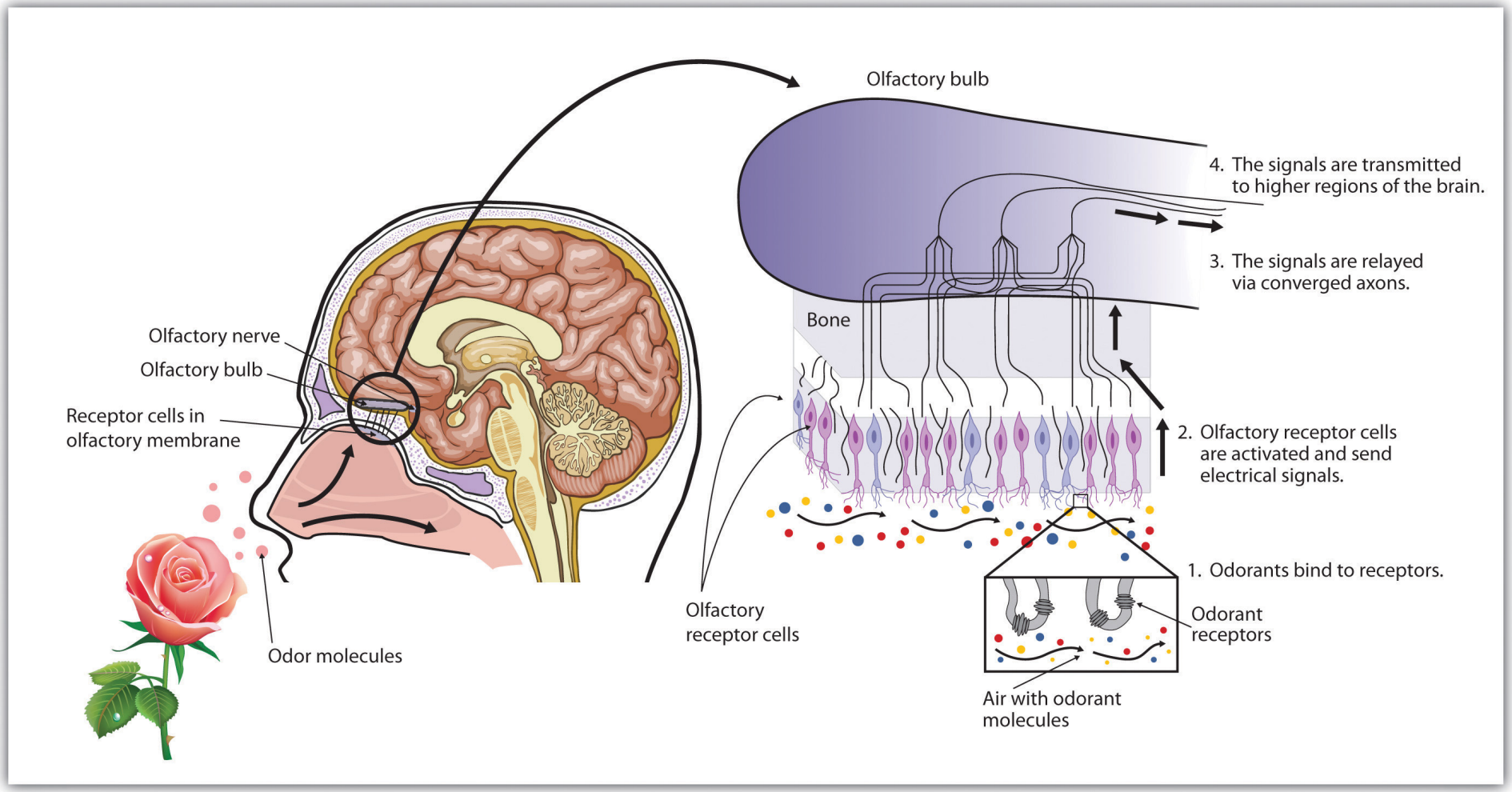
G: Transducin

G*: Activated alpha subunit of Transducin

PDE: cGMP Phosphodiesterase

Adaptation

GC: Guanylyl Cyclase


Olfactory bulb
4. The signals are transmitted to higher regions of the brain.
3. The signals are relayed via converged axons.
Bone
Olfactory nerve
Olfactory bulb
Receptor cells in olfactory membrane
2. Olfactory receptor cells are activated and send electrical signals.
1. Odorants bind to receptors.
Odorant receptors
Air with odorant molecules
Olfactory receptor cells
Odor molecules

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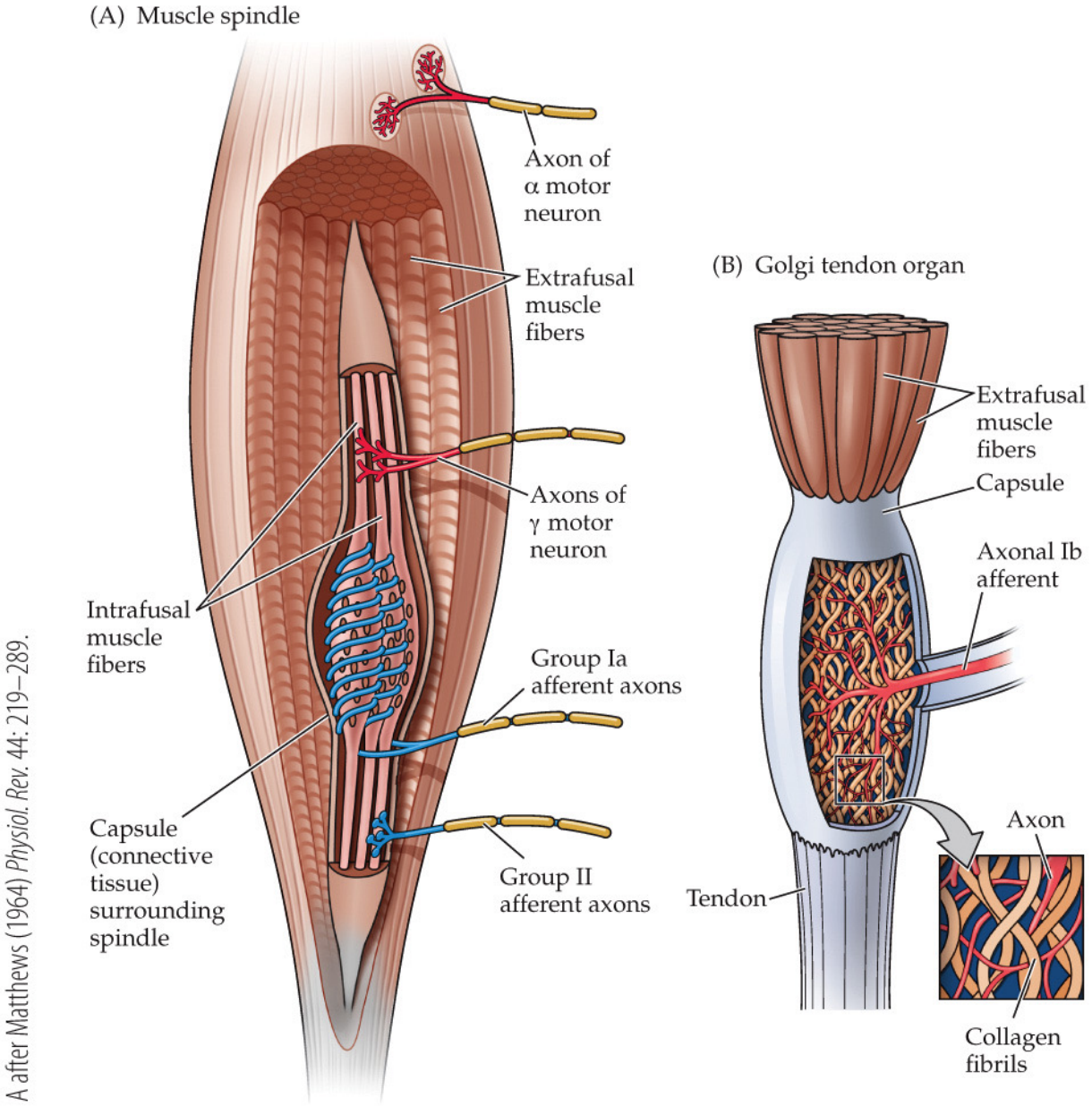
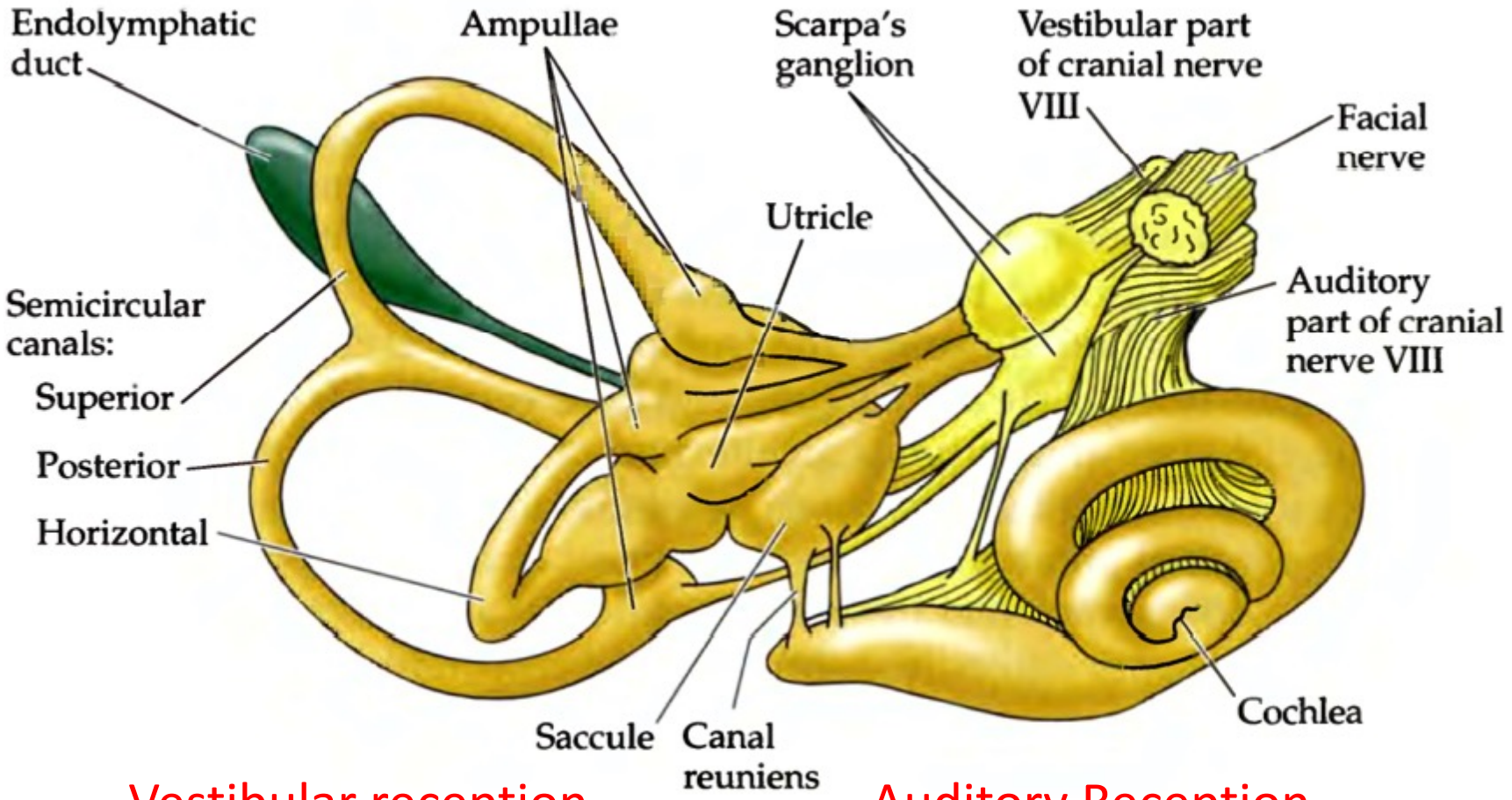


NEUROSCIENCE 6e, Figure 9.7

Muscle spindle
Changes in muscle contraction – steady change and rate of change

Golgi tendon organ
Change in muscle tension (force)

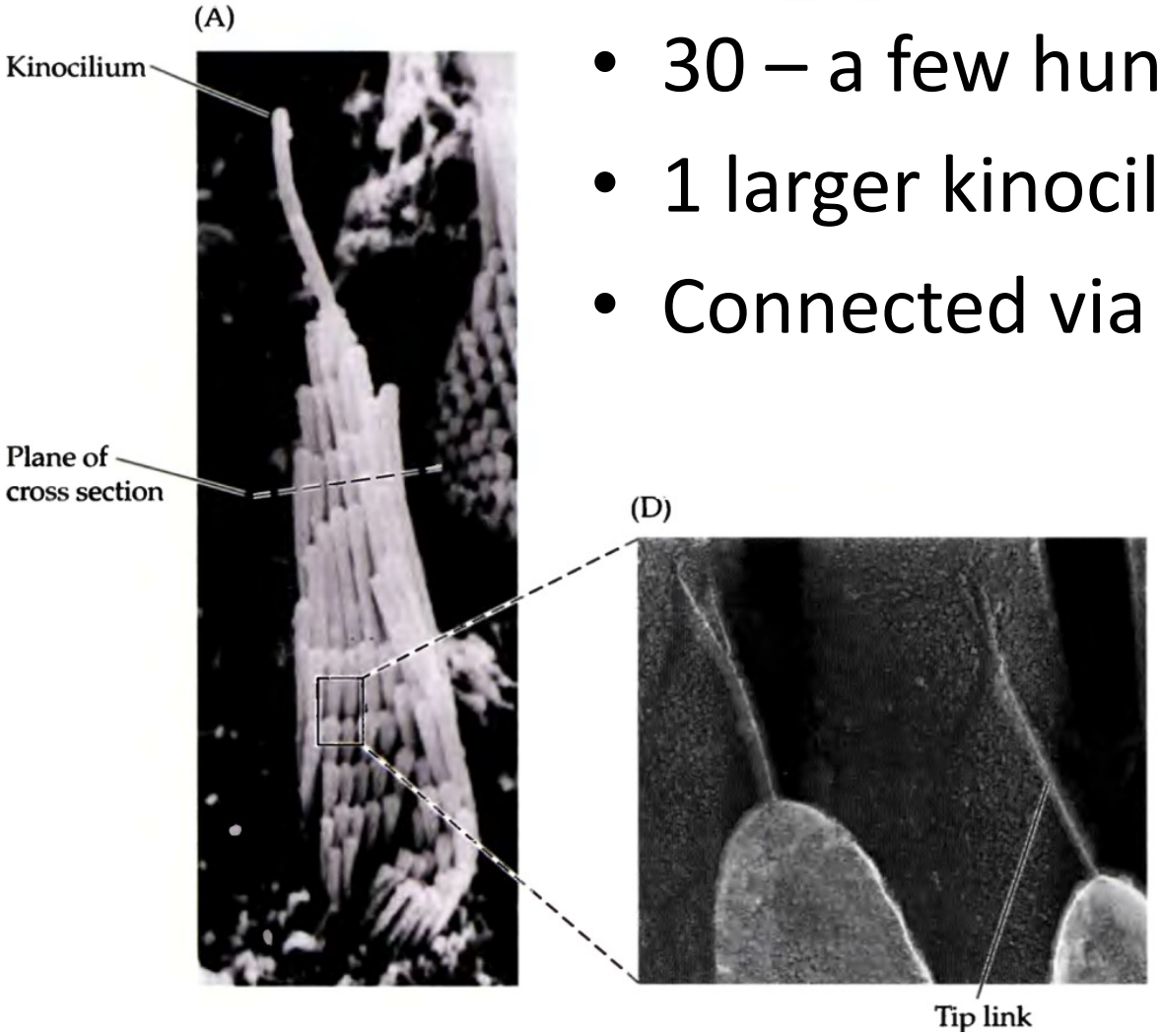
Inner Ear



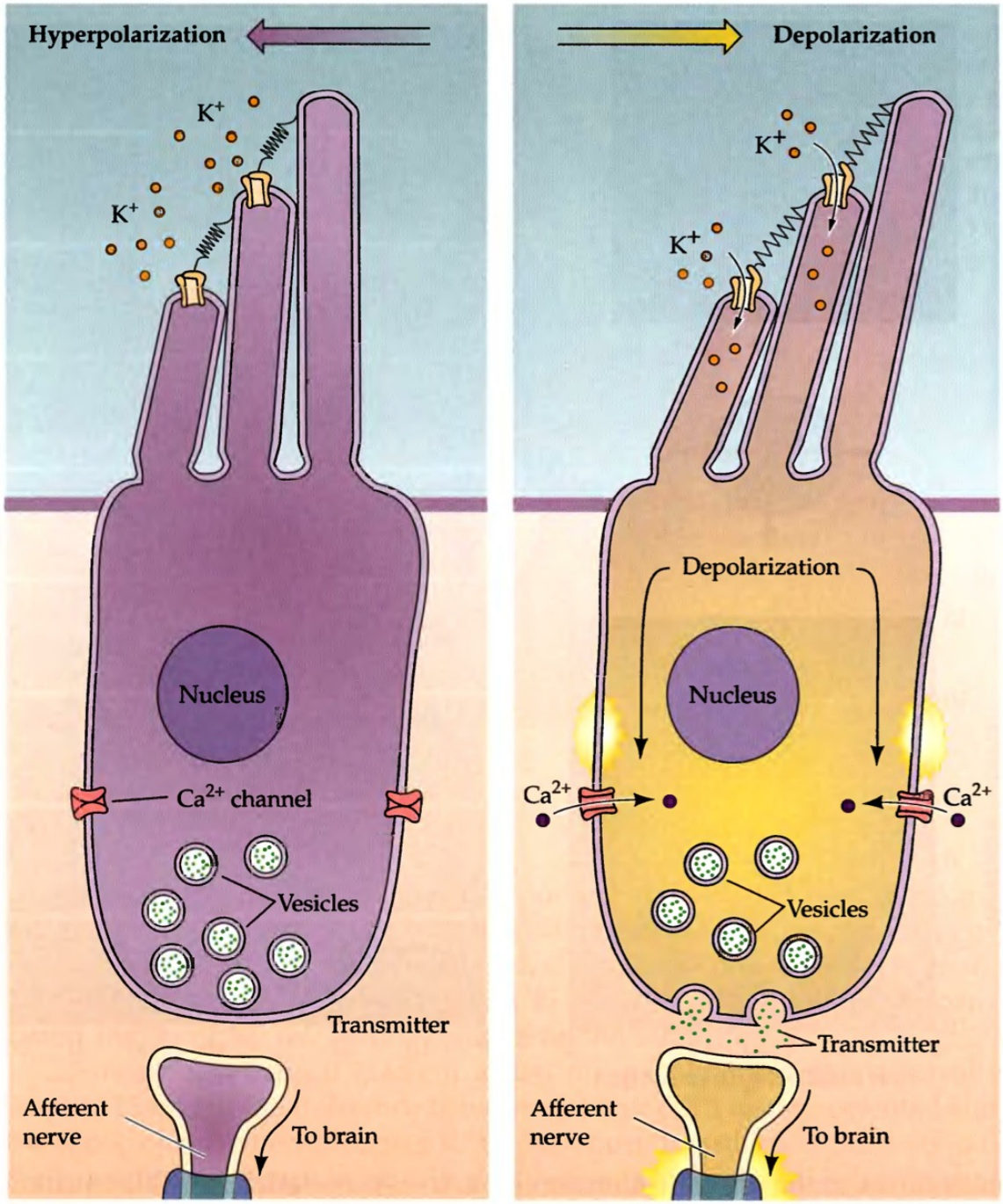
Vestibular reception

Auditory Reception

Hair Cells



- 30 – a few hundred stereocilia
- 1 larger kinocilium
- Connected via tip links



Endolymph

Unusually high $[K^+]$

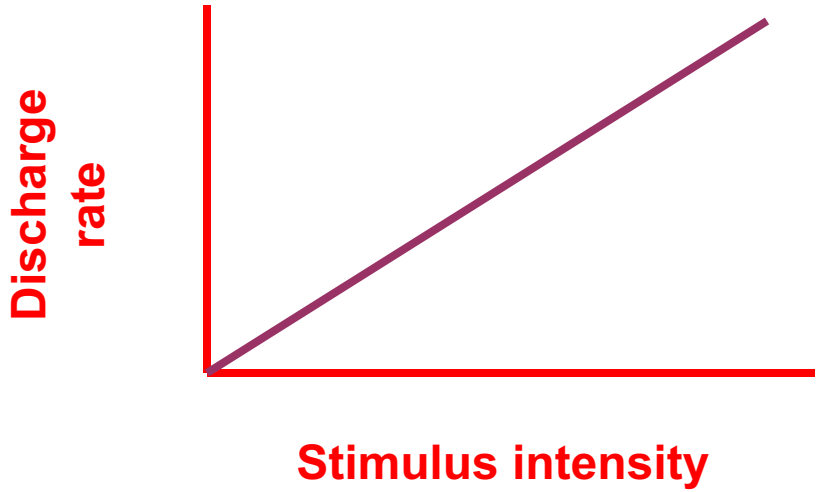
E_K is depolarizing from V_R

Coding in Sensory Systems

- **Stimulus intensity**
  - **Signal strength increases with stimulus strength**
- **Stimulus modality**
  - **Labeled lines**
- **Stimulus position**
  - **Topographic organization**
- **Stimulus time-course**
  - **Modulation of signal over time reflects modulation of stimulus over time**

Breaking the neural code

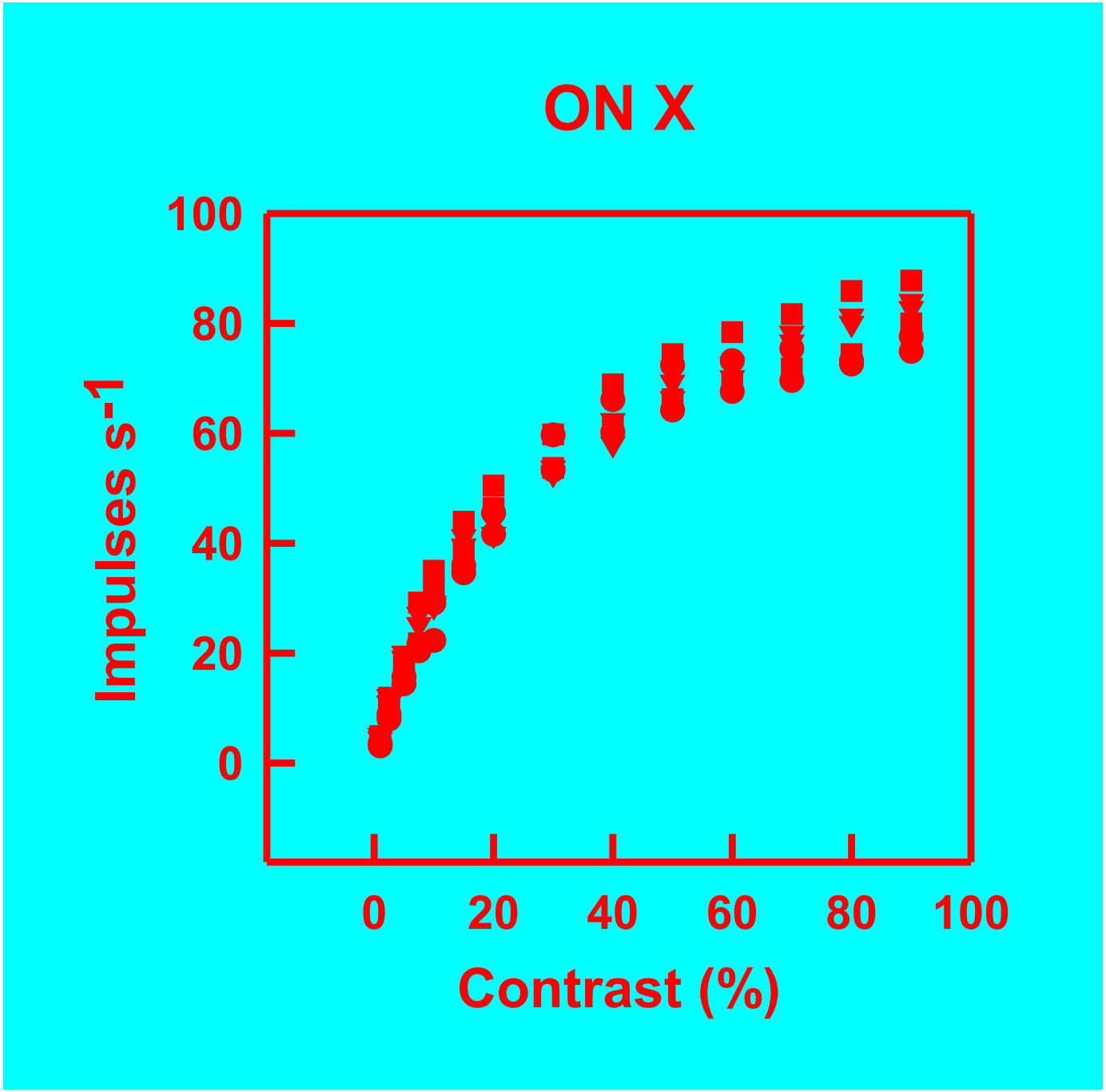
Neural messages are encoded as the rate of action potentials discharged (Adrian)



Mountcastle et al. (1968)
sensory nerve

Do not clutter the brain with what it does not need to know

1. Eliminate noise
2. Eliminate redundancy
3. Concentrate on what has changed
4. Encode what is useful


ON X
100
80
60
40
20
0
Impulses s-1
0
20
40
60
80
100
Contrast (%)