PHGY 210,2,4 - Physiology

SENSORY PHYSIOLOGY

Martin Paré

Associate Professor of Physiology & Psychology

pare@biomed.queensu.ca

http://brain.phgy.queensu.ca/pare

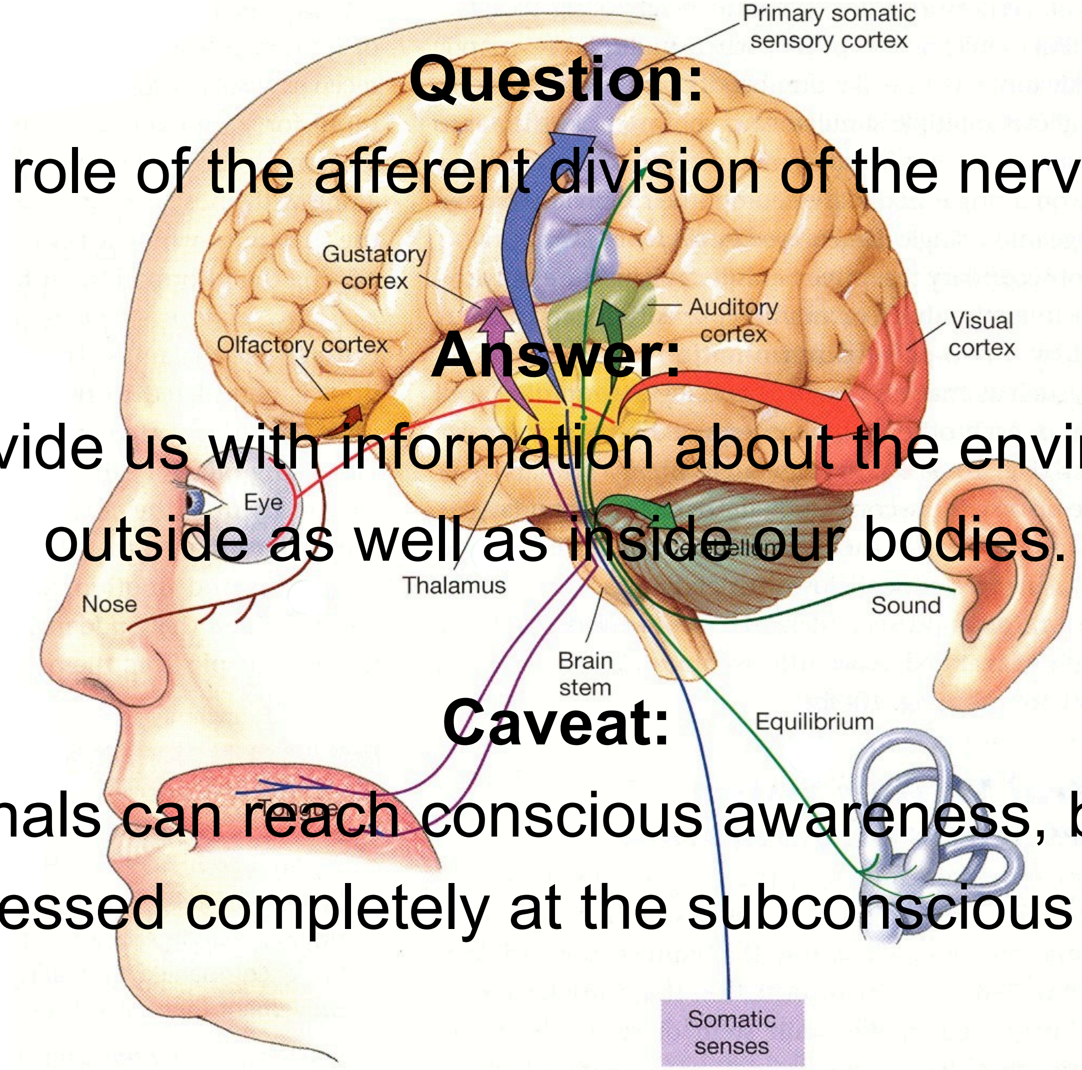
SENSORY PHYSIOLOGY

Reading

Rhoades & Pflanzer (4th edition)

Chapter 8

Sensory Systems



Question:

What is the role of the afferent division of the nervous system?

Answer:

To provide us with information about the environment outside as well as inside our bodies.

Caveat:

Sensory signals can reach conscious awareness, but others are processed completely at the subconscious level.

Sensory Systems

Conscious

Special senses
Vision
Hearing
Taste
Smell
Equilibrium

Somatic senses
Touch/pressure
Temperature
Pain
Proprioception

Subconscious

Visceral stimuli
Blood pressure
pH/oxygen content in blood
pH of cerebrospinal fluid
Lung inflation
Osmolarity of body fluids
Blood glucose

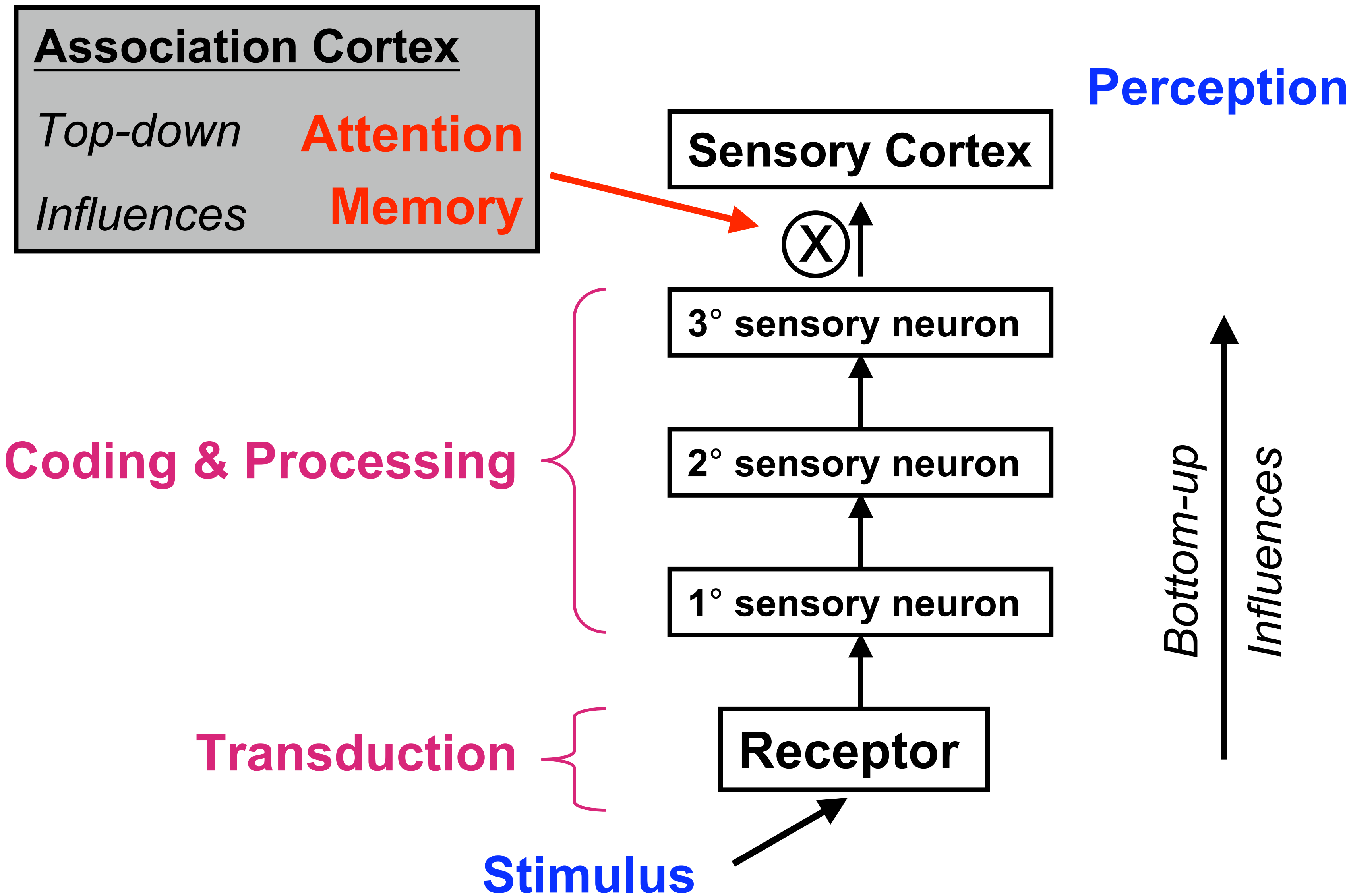
Somatic stimuli
Muscle length and tension

Sensory Systems

All sensory pathways begin with a stimulus,
which acts on sensory receptors,
which convert the stimulus in neural signals,
which are transmitted by sensory neurons to the brain,
where they are integrated.

Question:
How are sensory signals transduced, coded, and processed?

From Stimulus to Perception



From Stimulus to Perception

From Stimulus to Perception

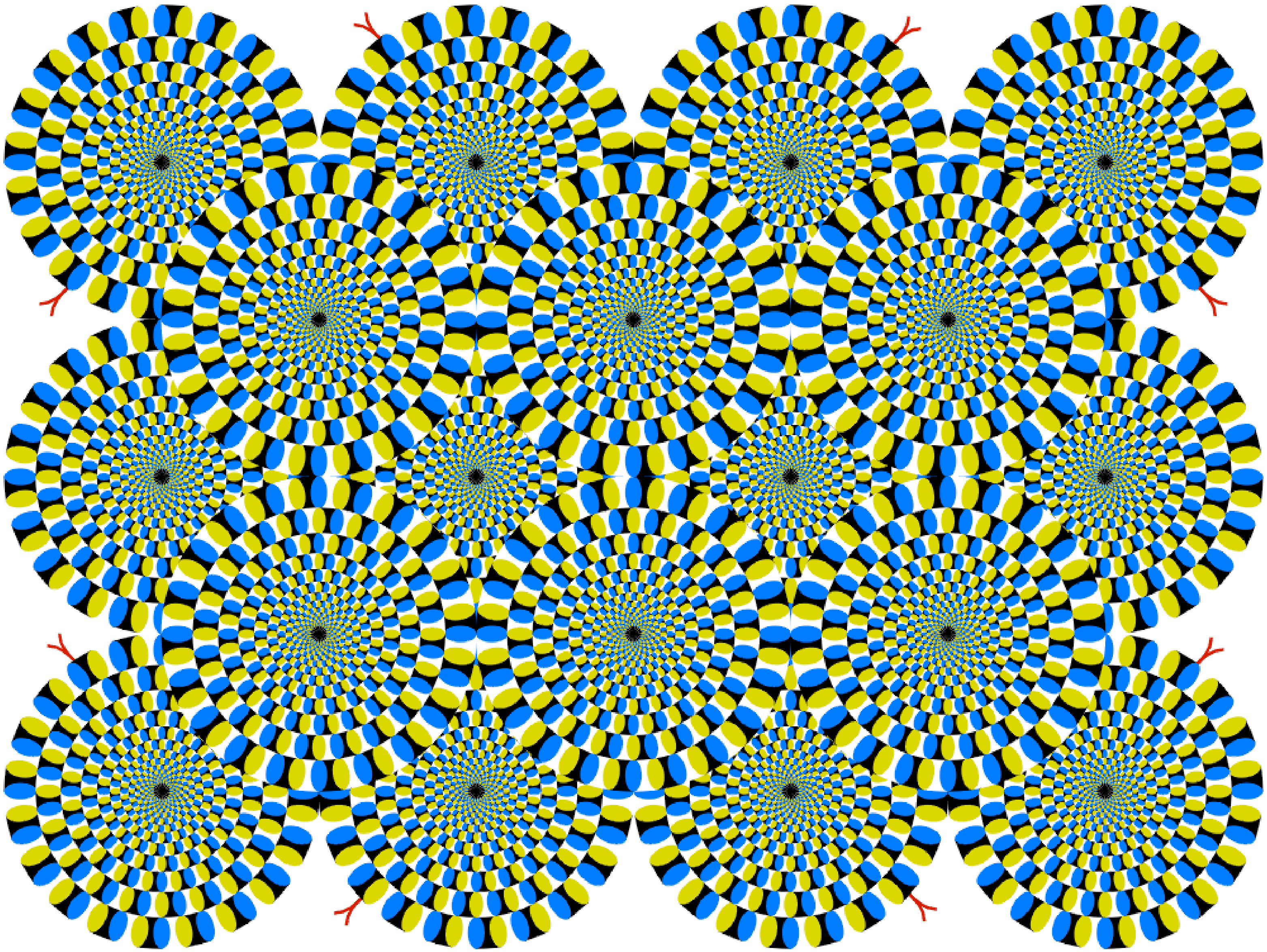
You might think that our sense organs would be shape to give us a ‘*true*’ picture of the world as it ‘*really*’ is.

It is safer to assume that they have been shaped to give us a useful picture of the world, to help us survive. In a way what sense organs do is assist our brain to construct a useful model of the world, and it is this model that we move around in.

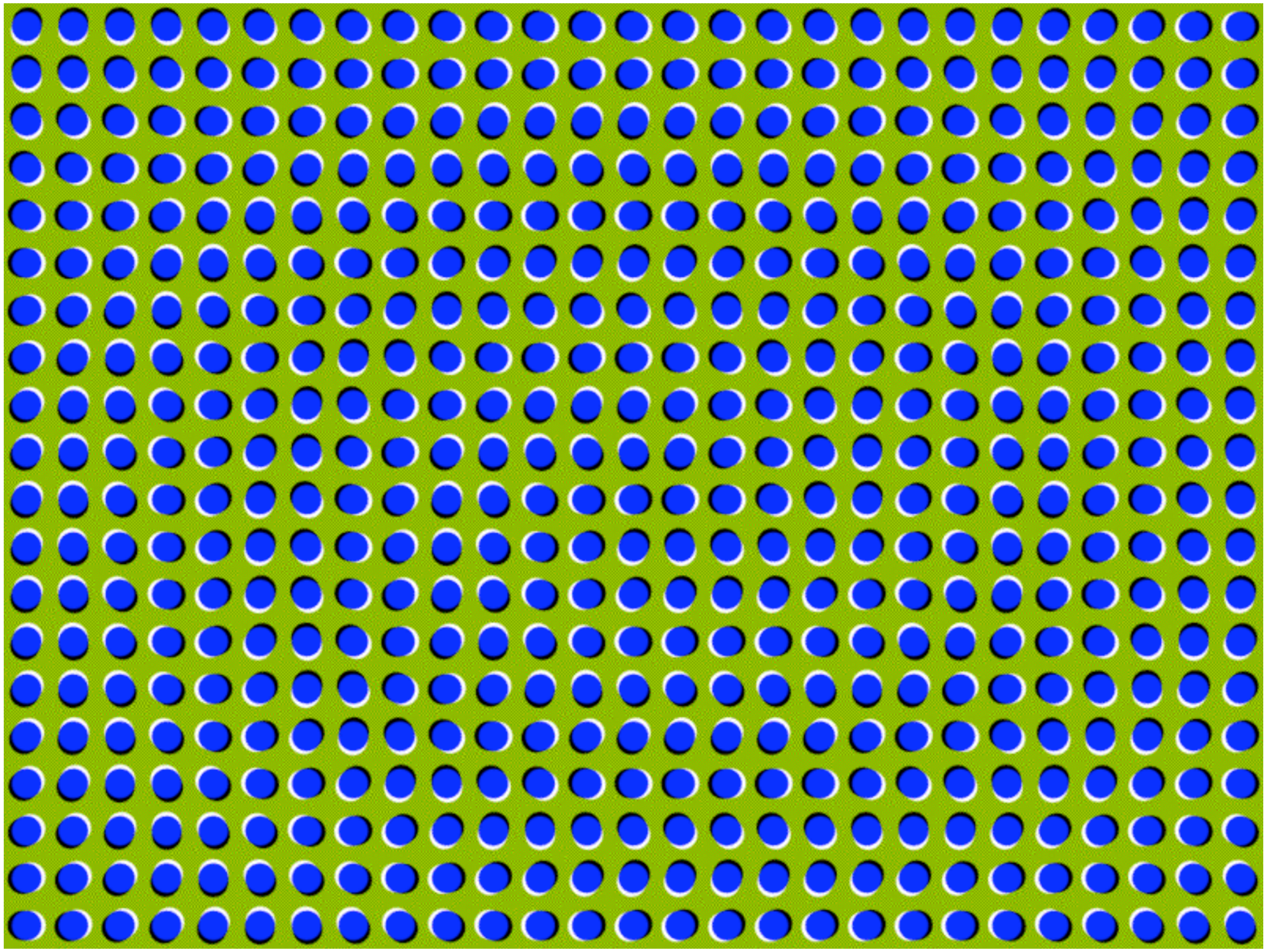
It is a kind of ‘*virtual reality*’ simulation of the real world.

Richard Dawkins (A Chaplain’s Devil)

From Stimulus to Perception



From Stimulus to Perception



Sensory Receptors

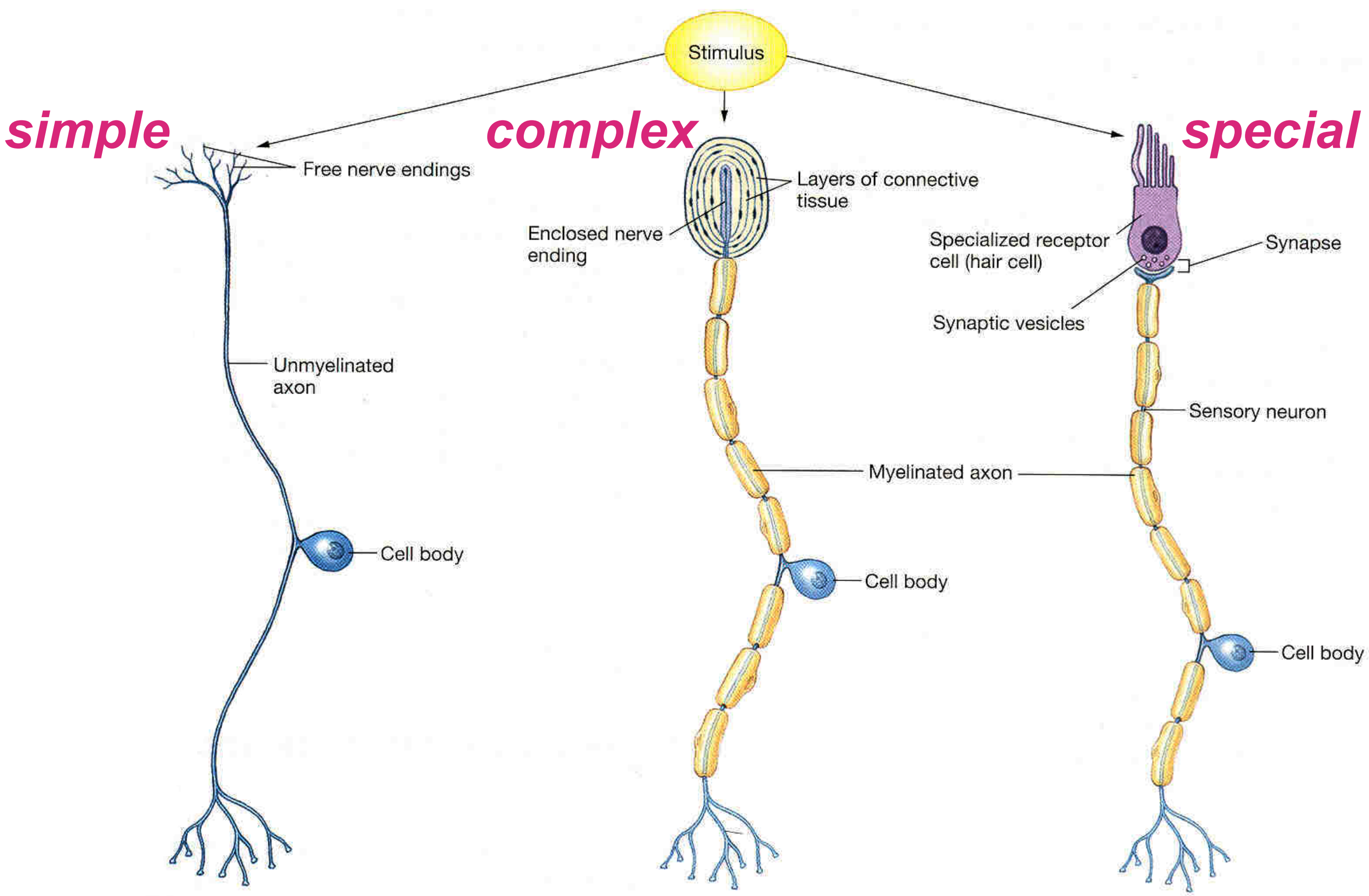
Sensory receptors are divided into five major groups:

Chemoreceptors	*pH, O_2, organic molecules*
Mechanoreceptors	*vibration, acceleration, sound*
Photoreceptors	*light*
Thermoreceptors	*temperature*
Nociceptors	*tissue damage (pain)*

The specificity of a receptor for a particular type of stimulus is called **the law of specific nerve energies (Muller's Law)**

Sensory Receptors

The complexity of sensory receptors ranges from free nerve endings to specialized nerve endings and receptor cells.



Sensory Transduction

Question:

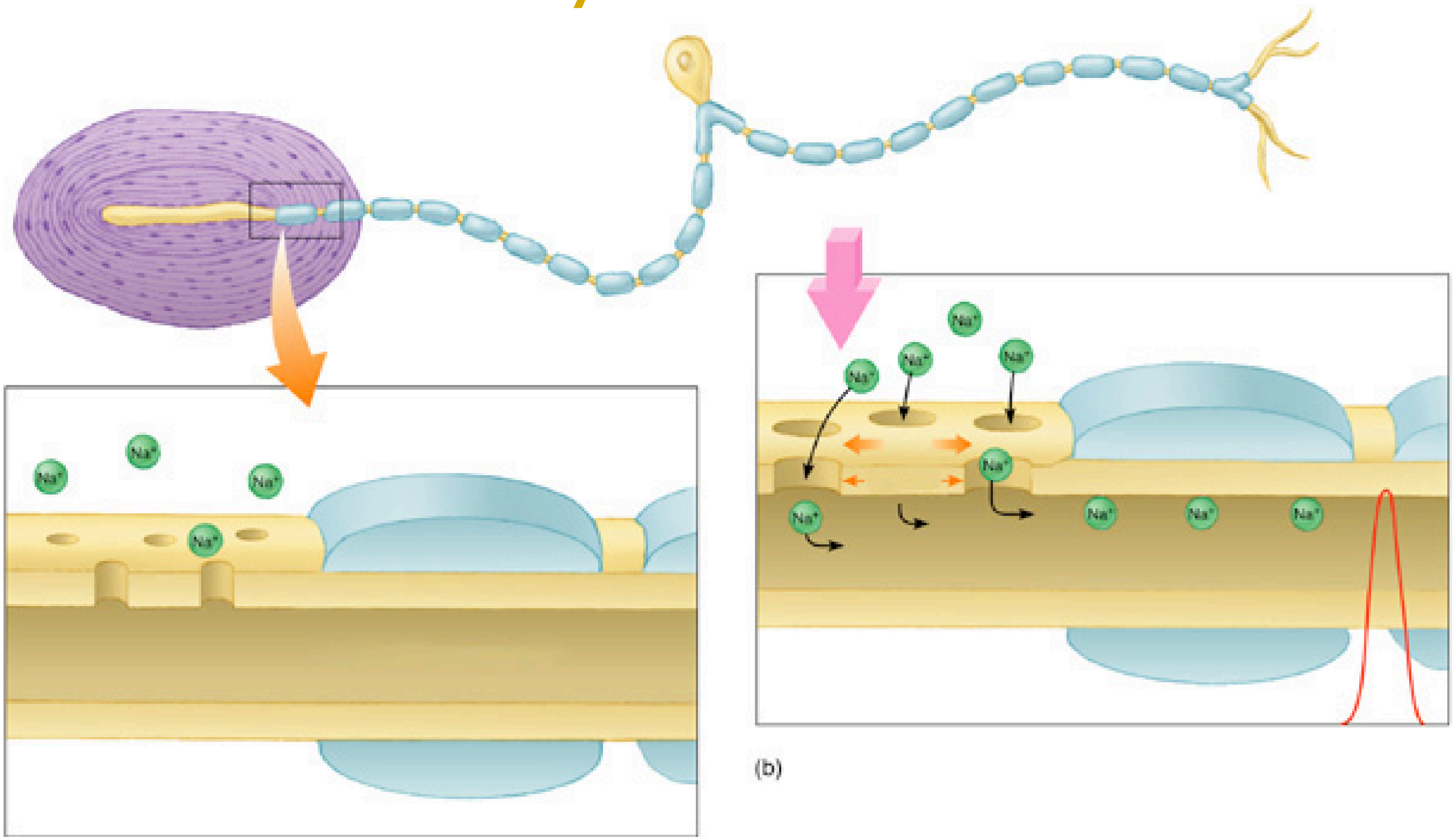
How is a stimulus converted into a neural signal?

Answer:

The stimulus opens ion channels in the receptor membrane, either directly or indirectly (through a second messenger).

In most cases, channel opening results in net influx of Na^+ into the receptor, causing a **depolarization** of the membrane.

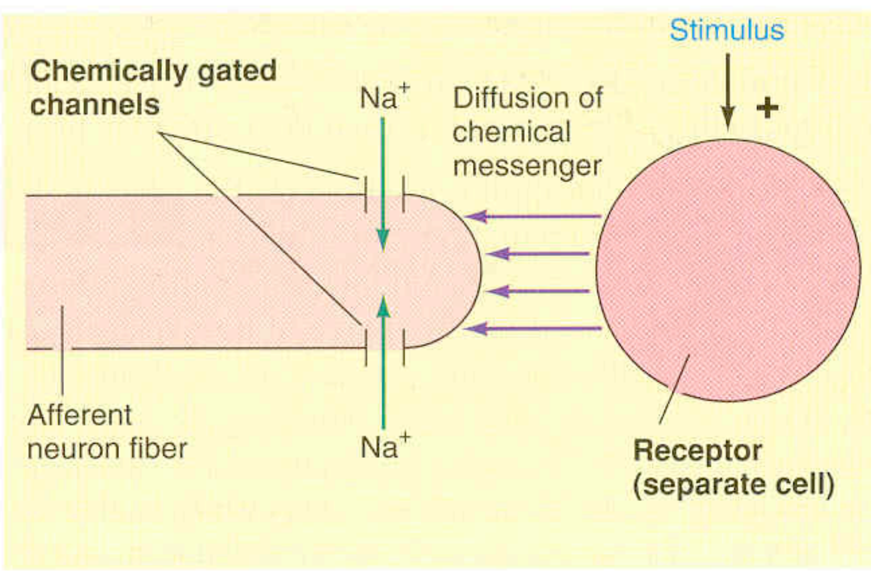
Sensory Transduction



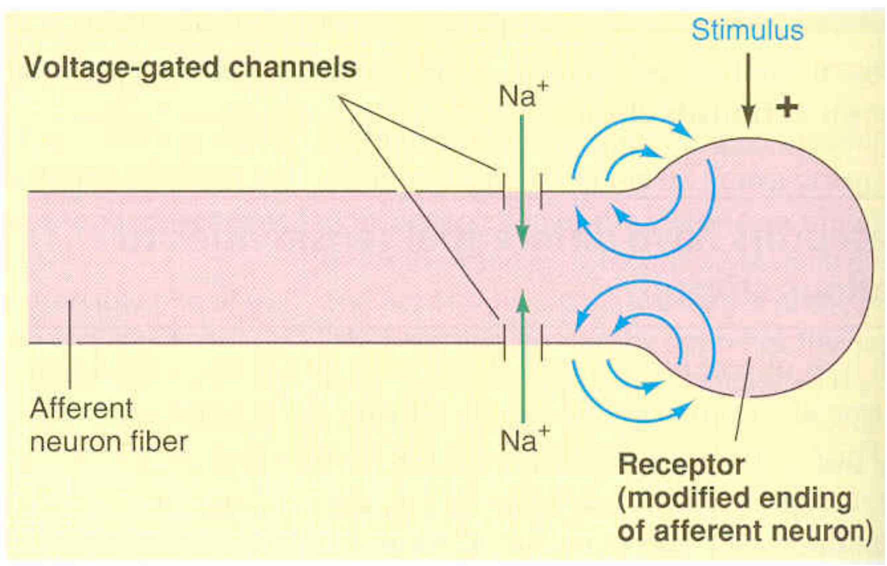
In most cases, channel opening results in net influx of Na^+ into the receptor, causing a **depolarization** of the membrane.

Sensory Transduction

Sensory transduction converts stimuli into graded potentials. Such changes in receptor membrane potential are known as the **receptor potential** and the **generator potential**.



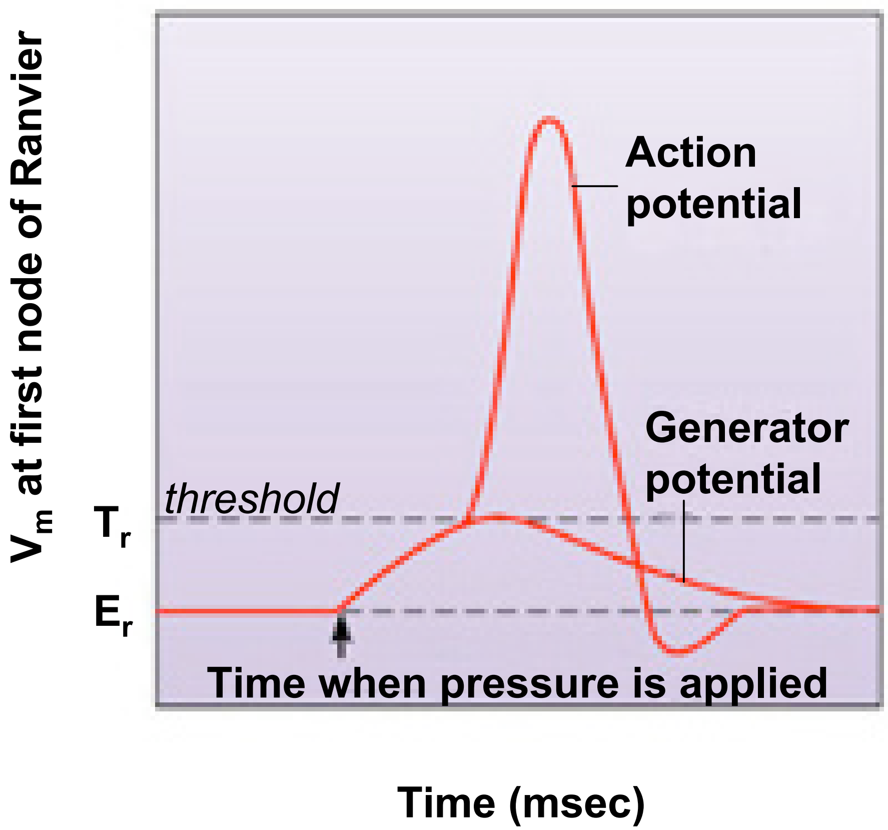
special sense receptors



somatic sense receptors

Sensory Transduction

Sensory transduction converts stimuli into graded potentials, but action potentials transmit the information to the brain.



Sensory Representations

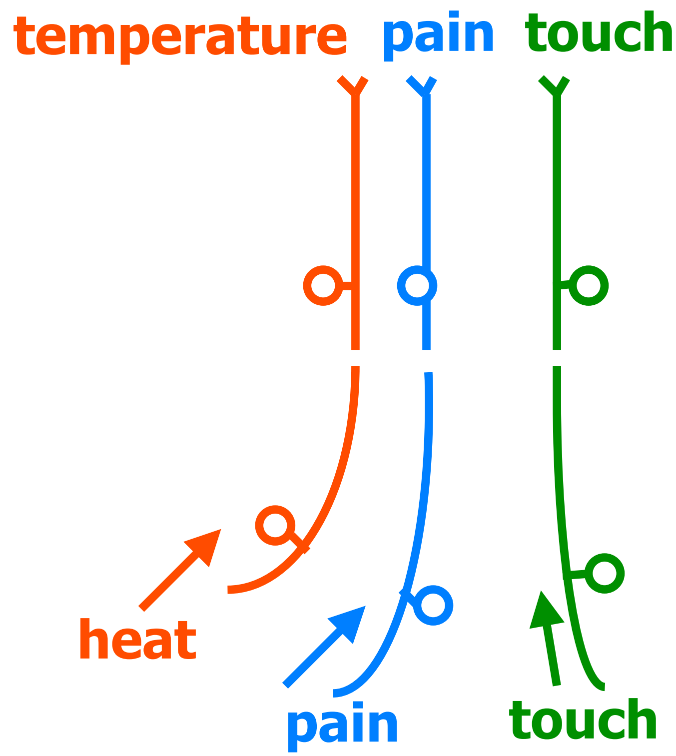
To create an accurate neural representation of sensory stimuli, the brain must distinguish FOUR stimulus properties:

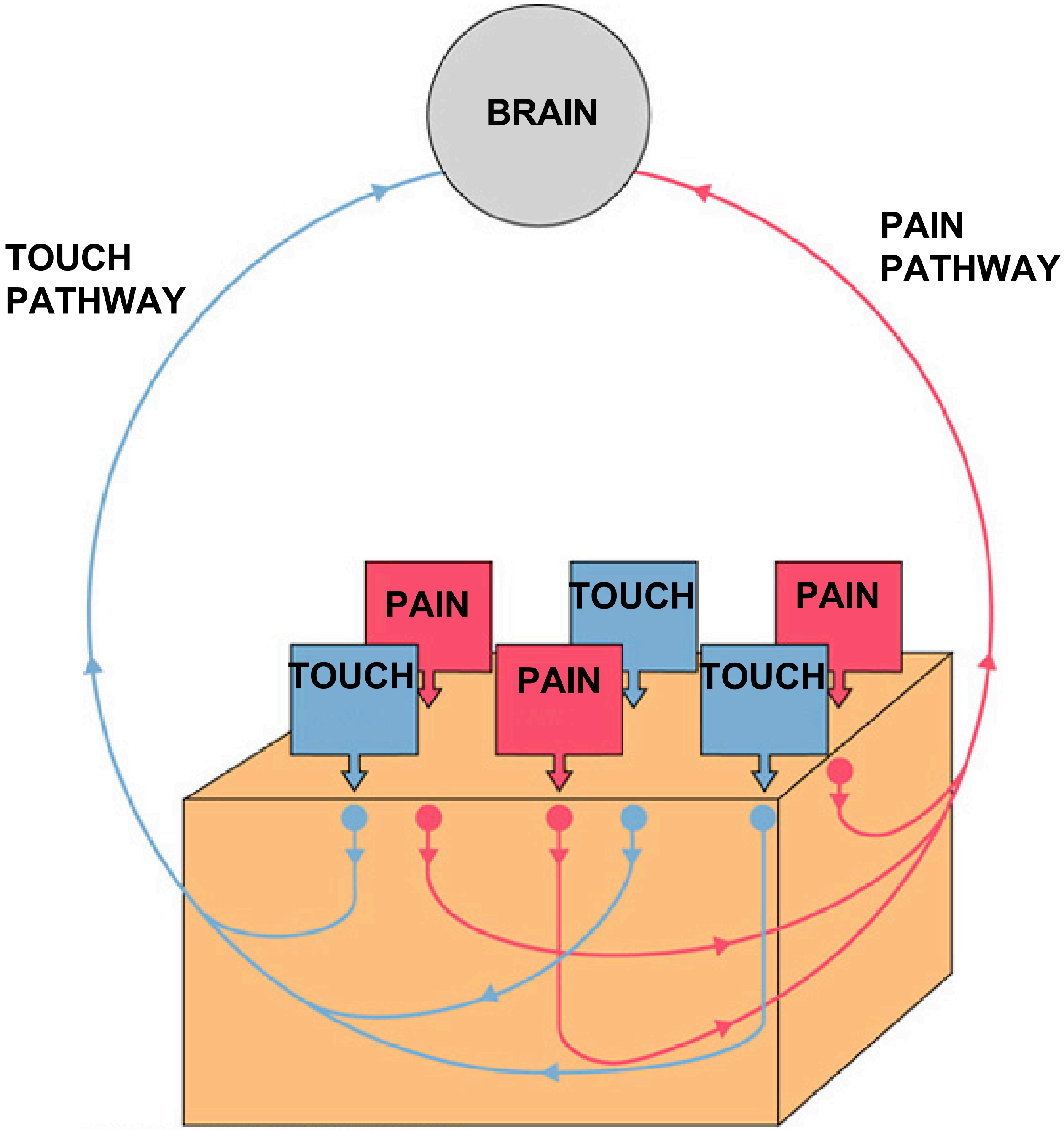
1) stimulus **modality**
2) stimulus **location**
3) stimulus **intensity**
4) stimulus **duration**

Stimulus Modality

Each receptor type is most sensitive to a particular type of stimulus. The brain thus associates a signal coming from a specific group of receptors with a specific modality.

This direct association between a receptor and a sensation is called the **labeled line coding**.




BRAIN
TOUCH PATHWAY
PAIN PATHWAY
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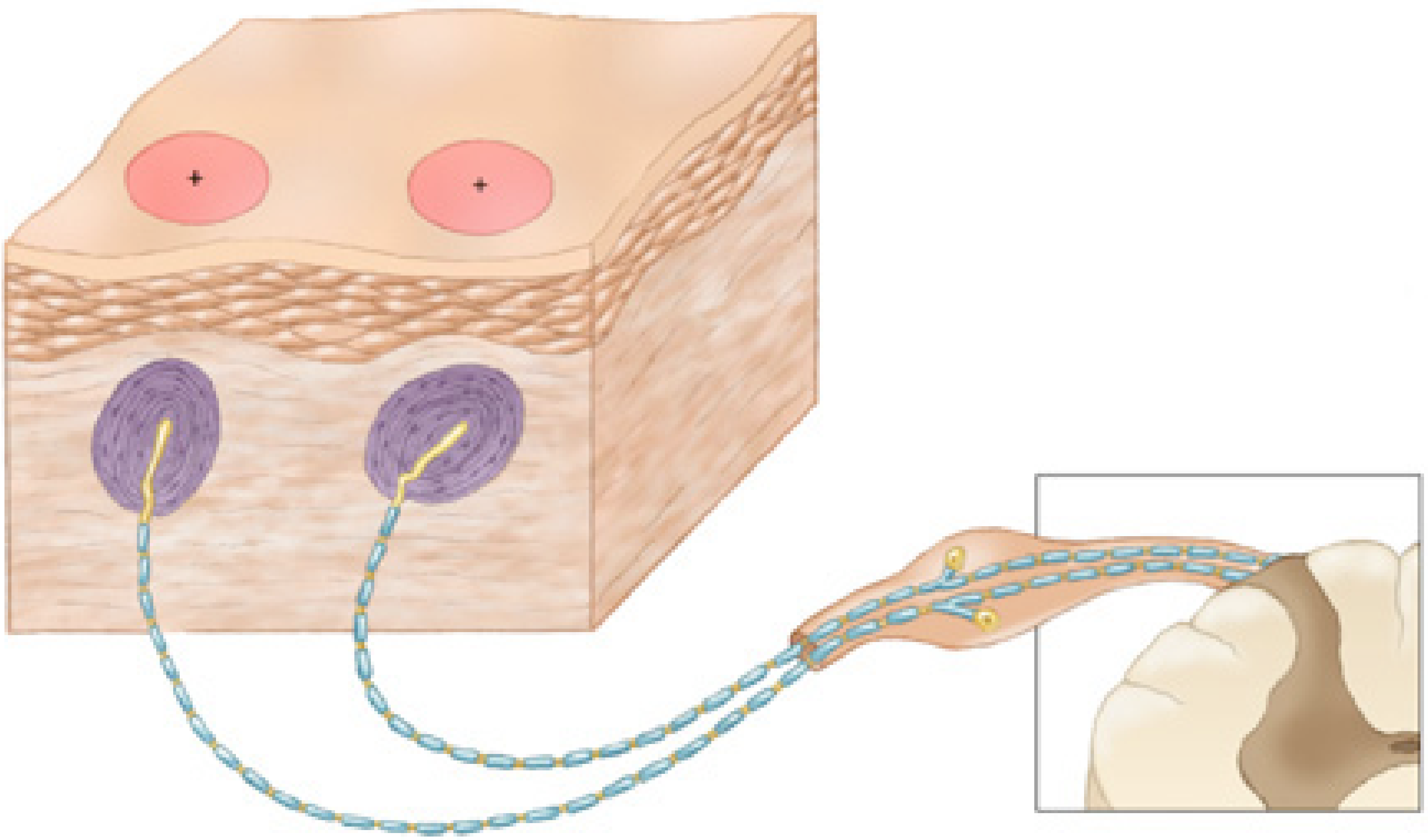
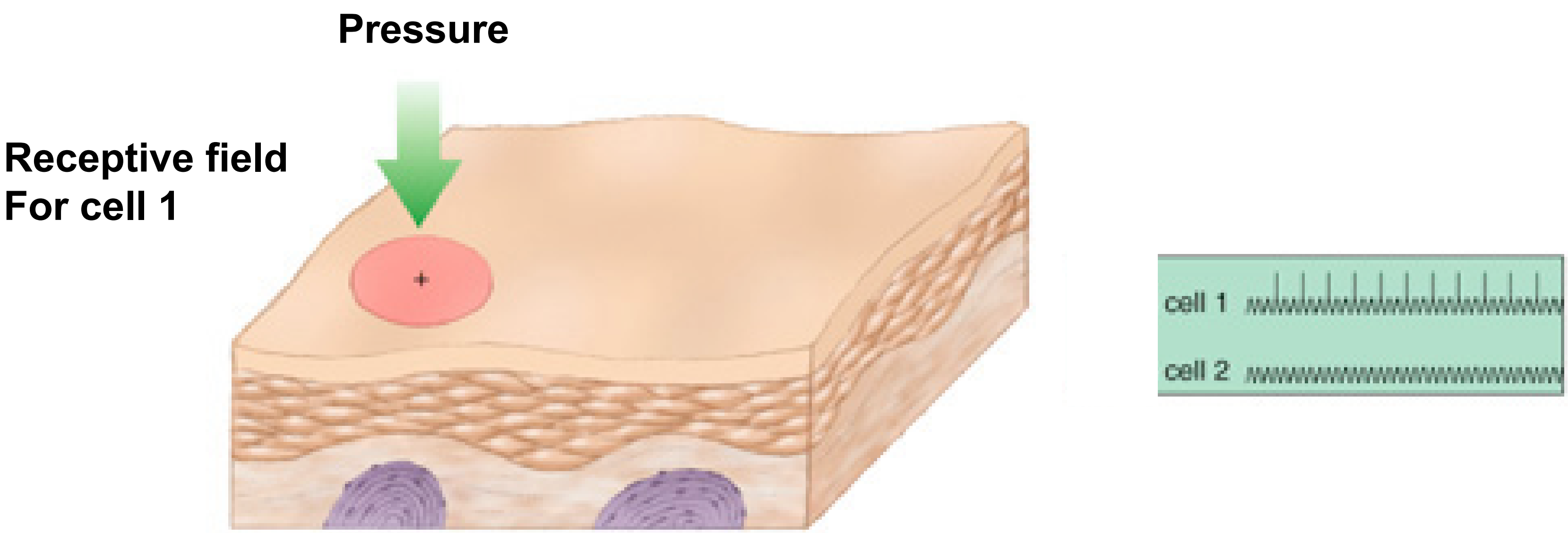
Stimulus Location

Each sensory receptor is most sensitive to stimulation of a specific area, which defines the receptor's **receptive field**.



Stimulus Location

Each sensory receptor is most sensitive to stimulation of a specific area, which defines the receptor's **receptive field**. When action potentials are elicited from a sensory neuron, the neuron's receptive field codes the stimulus location.



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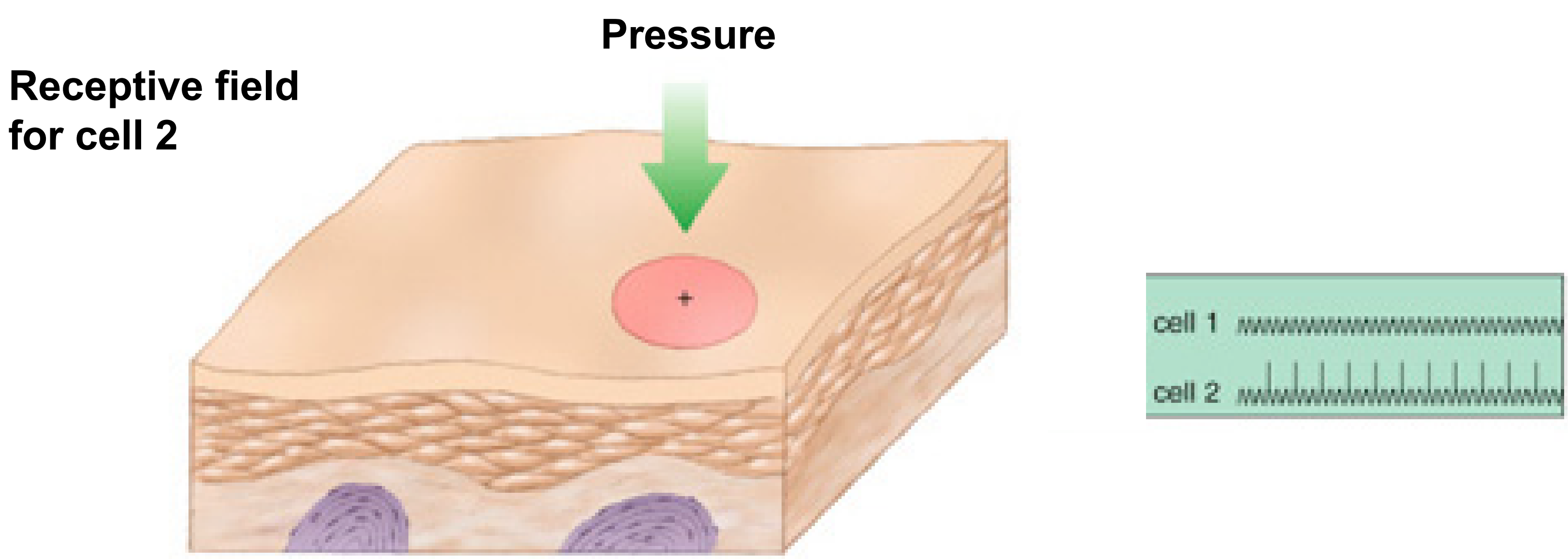
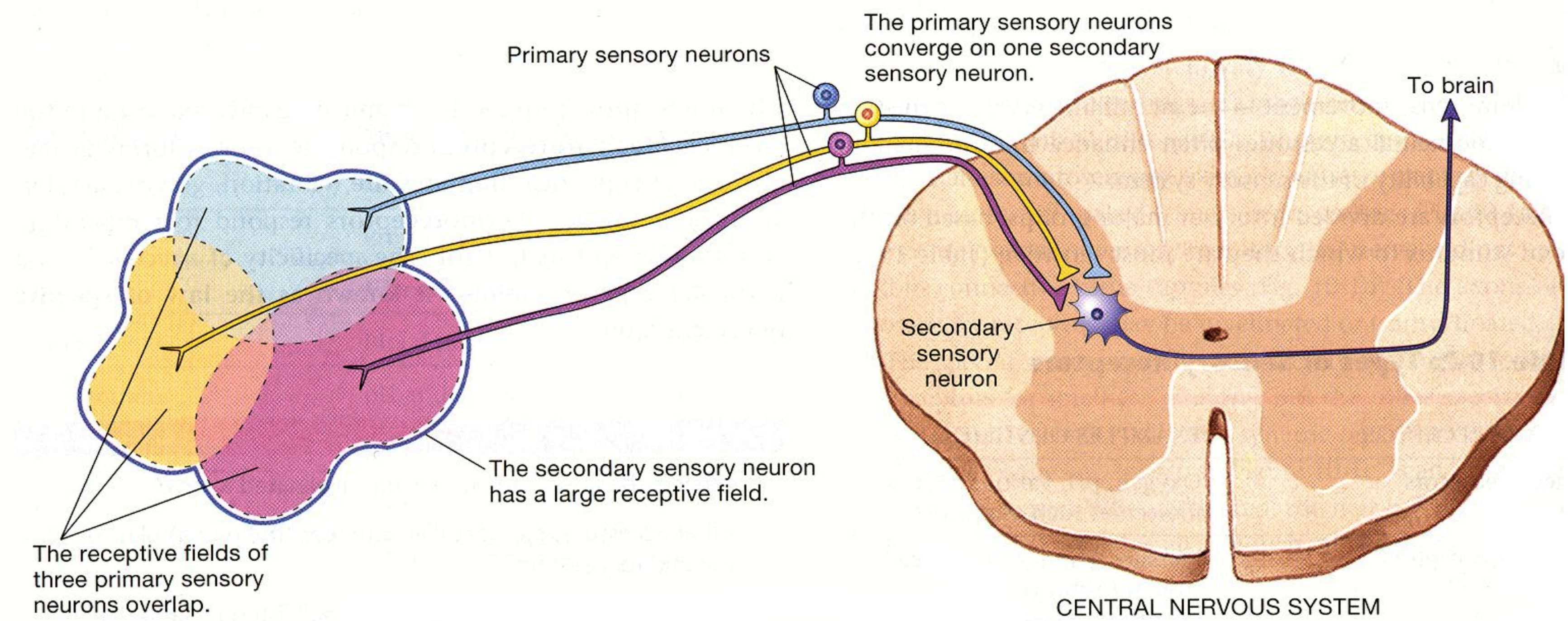


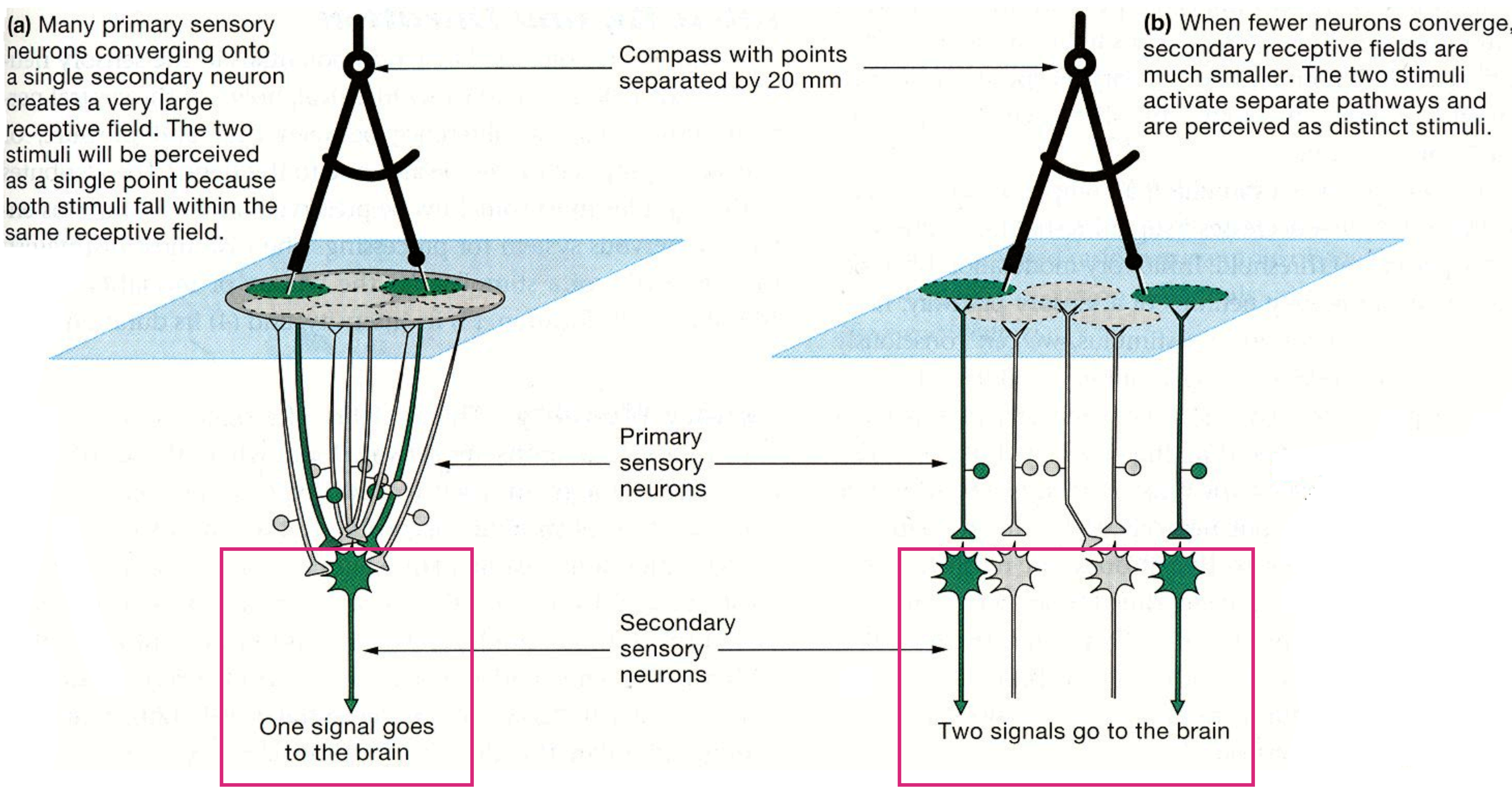
Stimulus Location

Sensory receptive fields vary in size and frequently overlap. **Convergence of inputs** onto a single sensory neuron enhances that neuron's sensitivity, but reduces its spatial resolution.



Stimulus Location

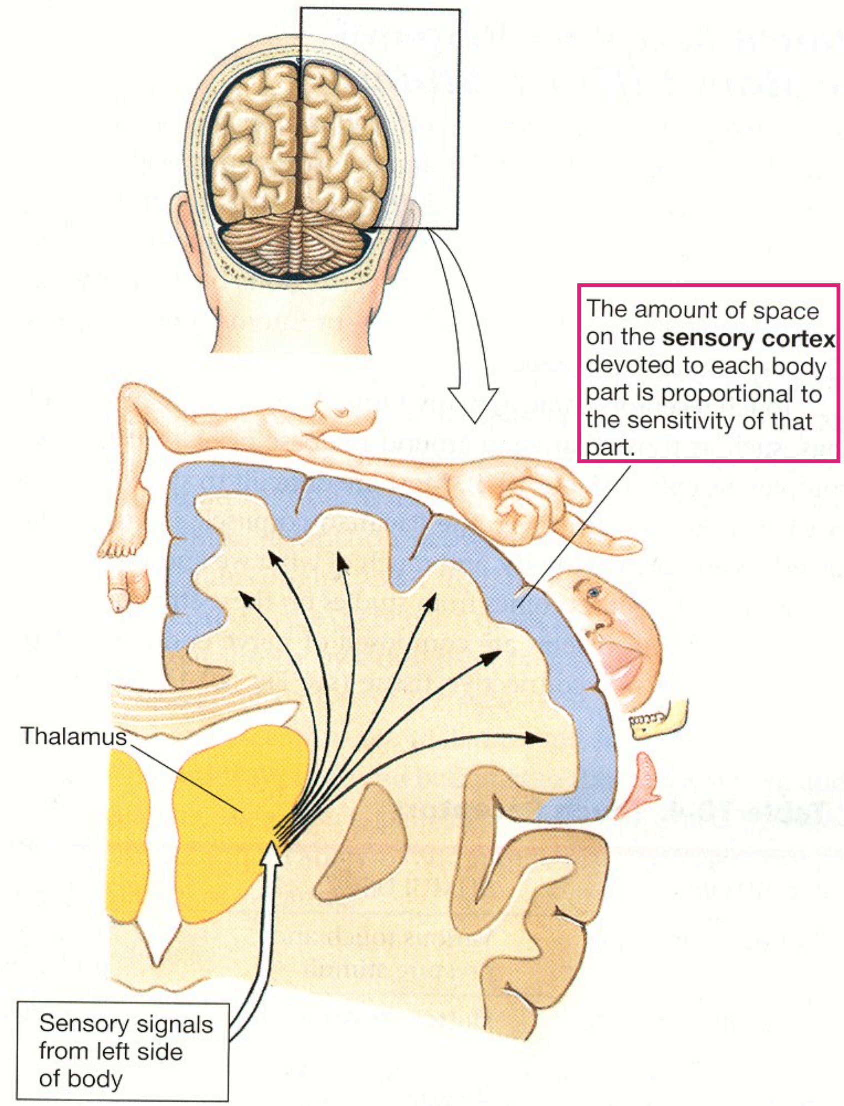
The size of neuronal receptive fields representing a given area determines our **capacity to discriminate** stimuli in this area.



Stimulus Location

Sensory neuronal receptive fields are orderly organized in cortical sensory areas to form **topographical maps**.

The location of a stimulus is coded according to which group of neurons is active.

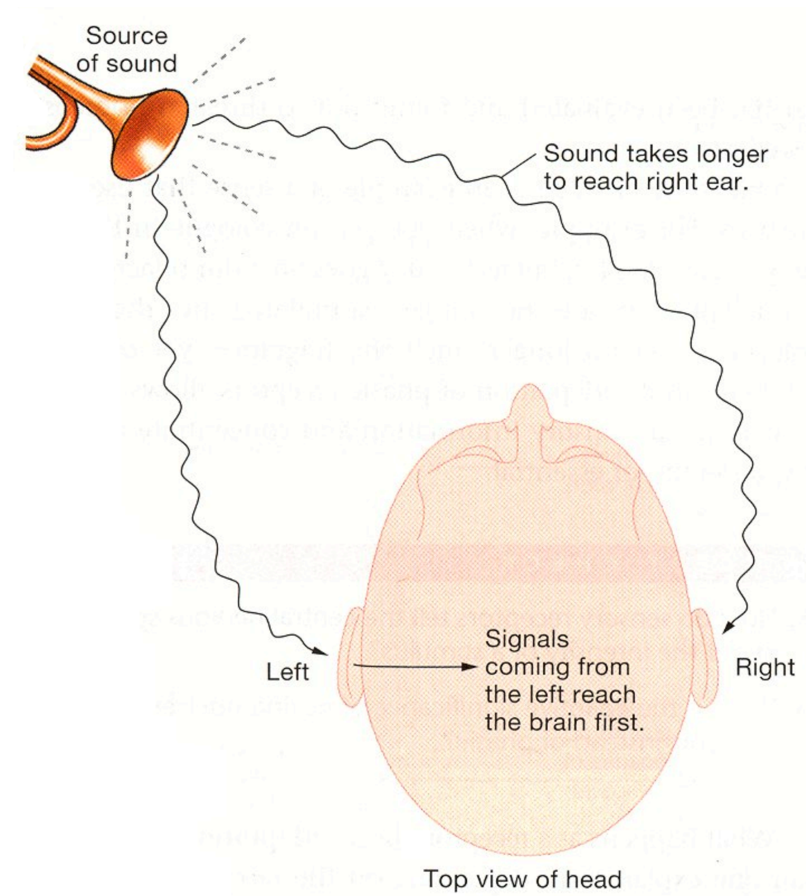


Cross section of the right cerebral hemisphere and sensory areas of the cerebral cortex

Stimulus Location

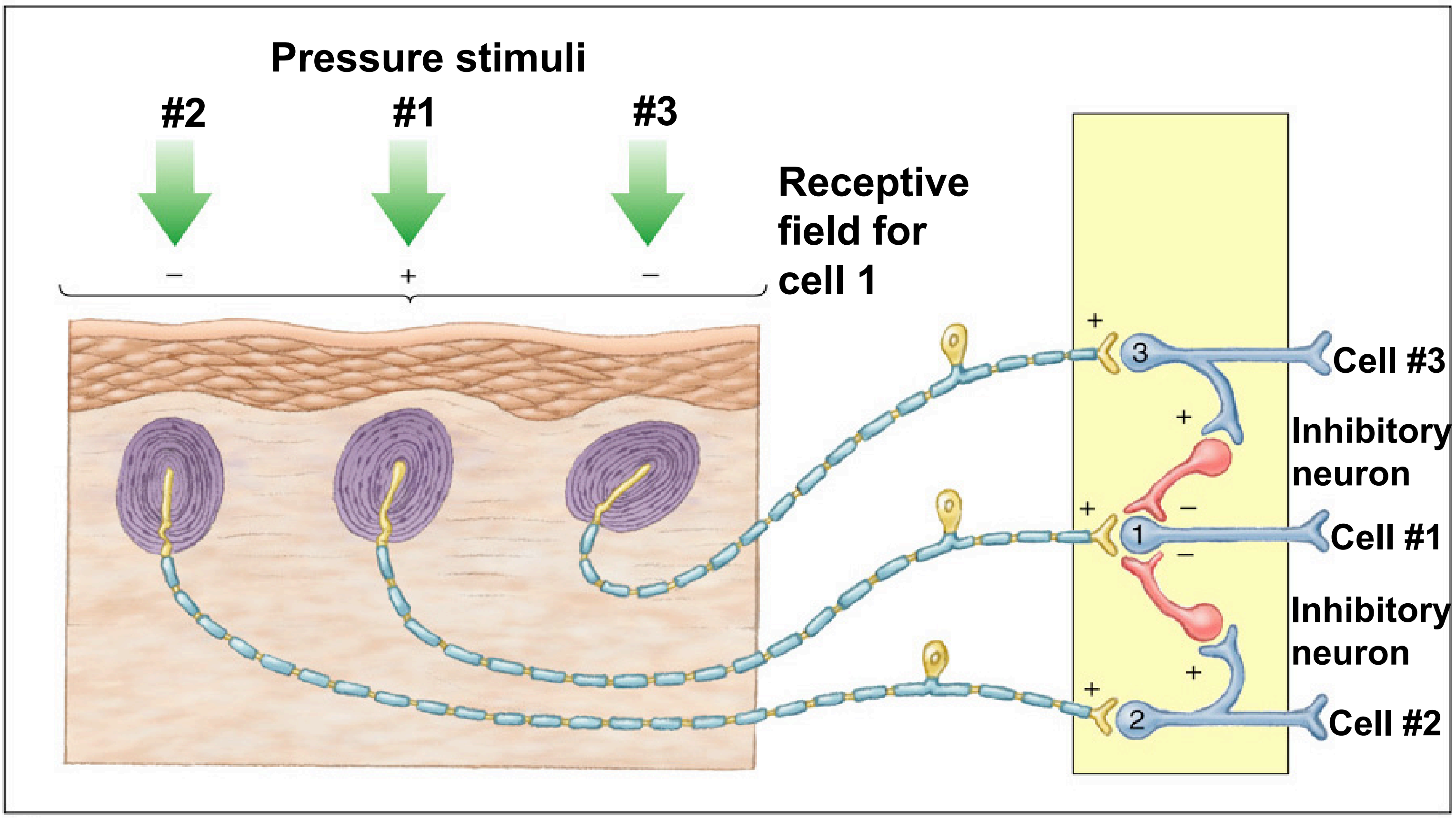
Auditory and olfactory information is the exception to the topographical localization rule.

For these sensory modalities, the brain uses the **timing difference** in receptor activation to compute the source location of sounds or odors.



Stimulus Location

Lateral inhibition enhances the contrast between the stimulus and its surrounding, facilitating its perception and localization.



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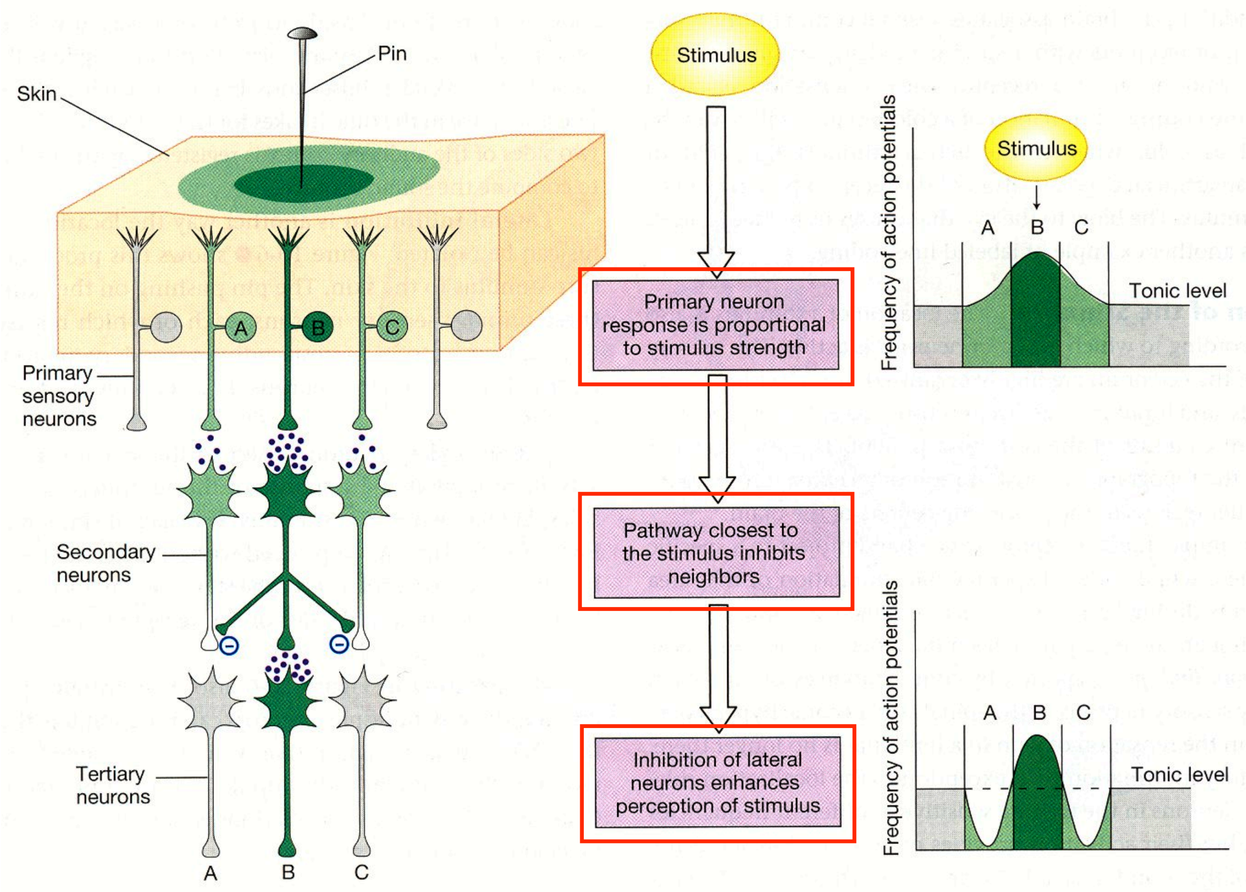
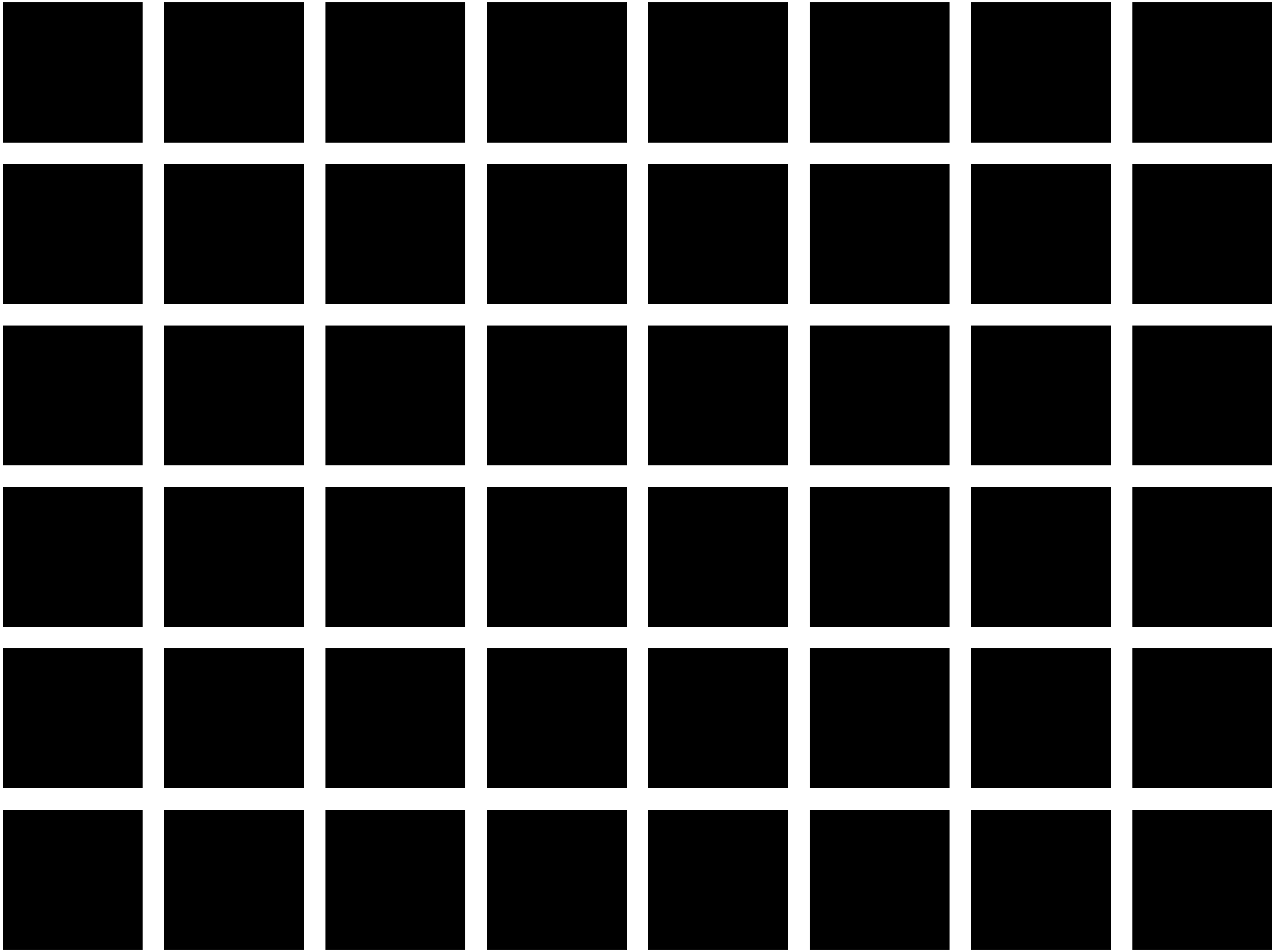
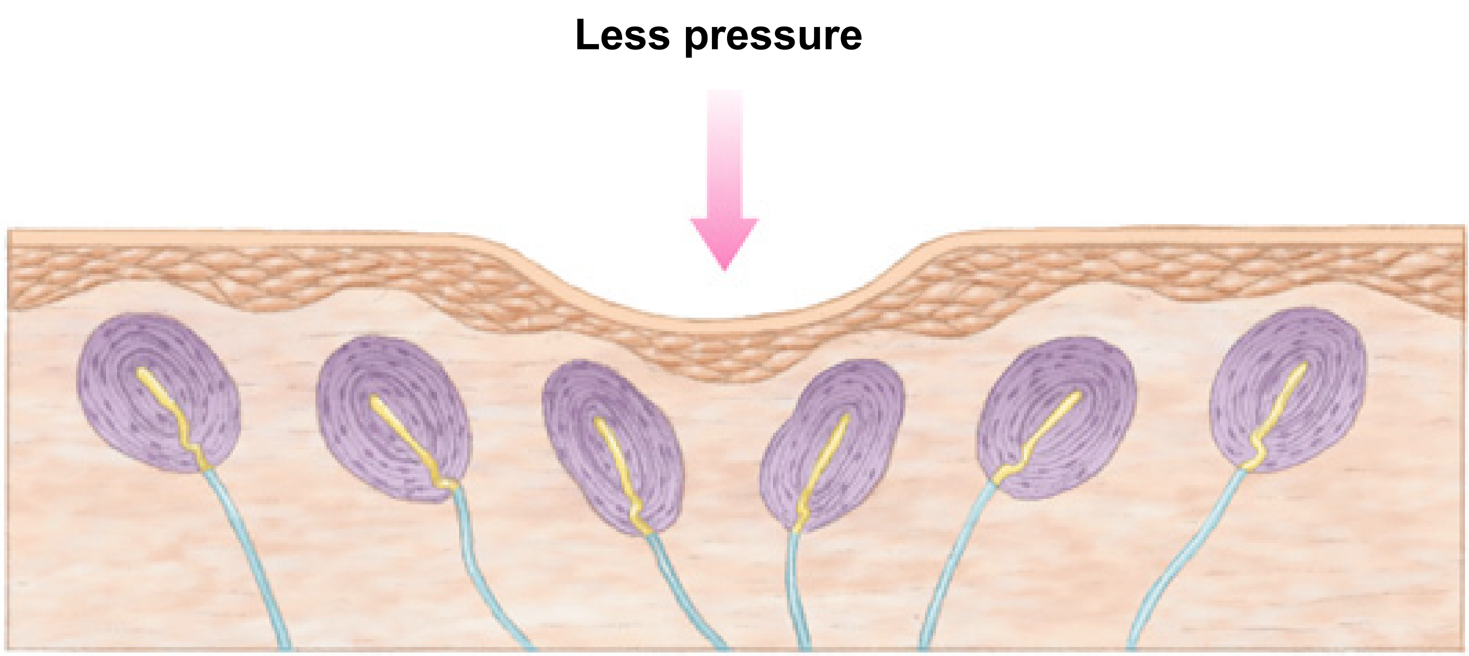




Stimulus Intensity

Stimulus intensity is coded by:

1) the number of receptors activated (**population coding**).



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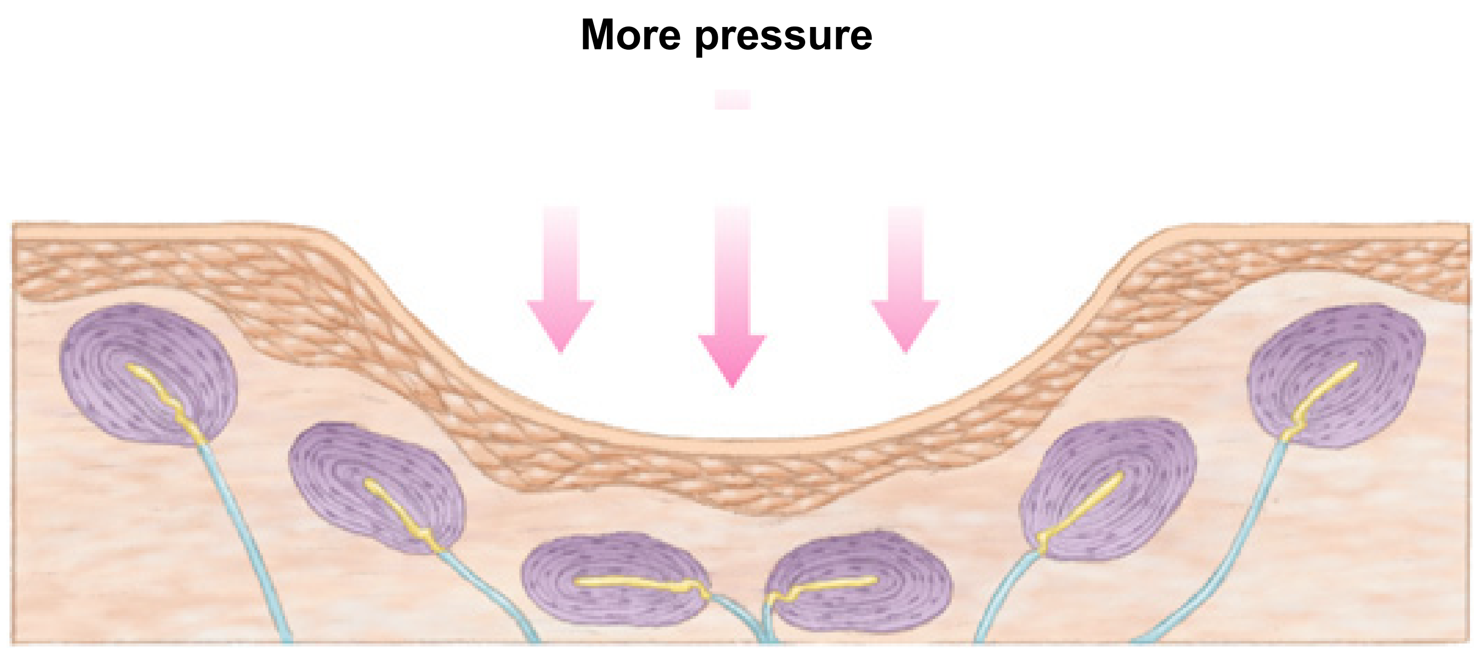

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Stimulus intensity is coded by:

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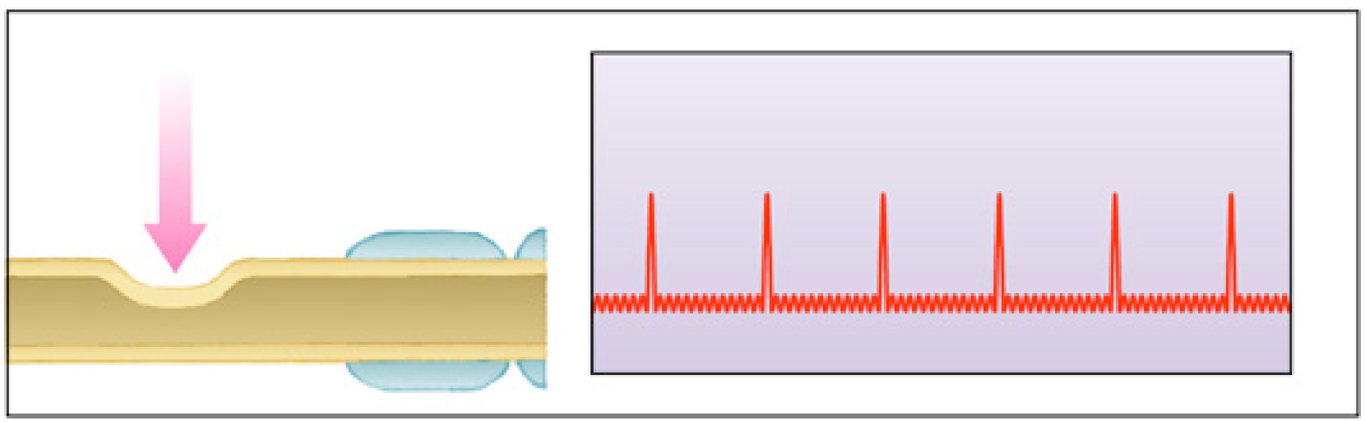
2) the frequency of action potentials (**frequency coding**).



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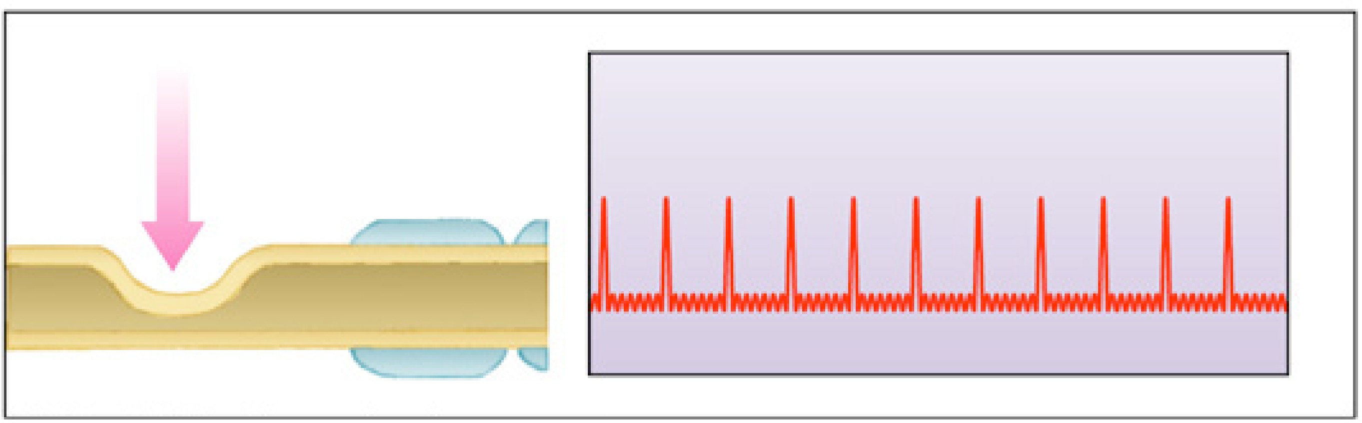
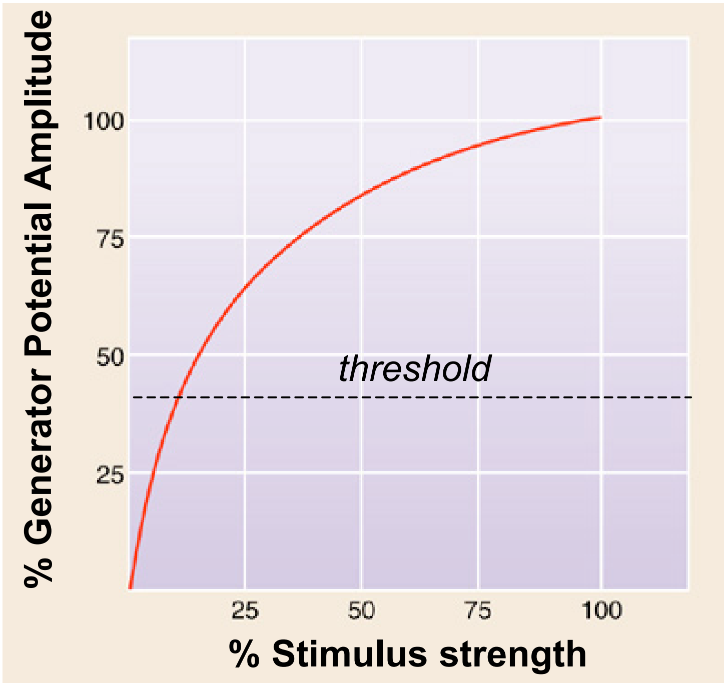


Stimulus Intensity

Stimulus intensity is coded by:

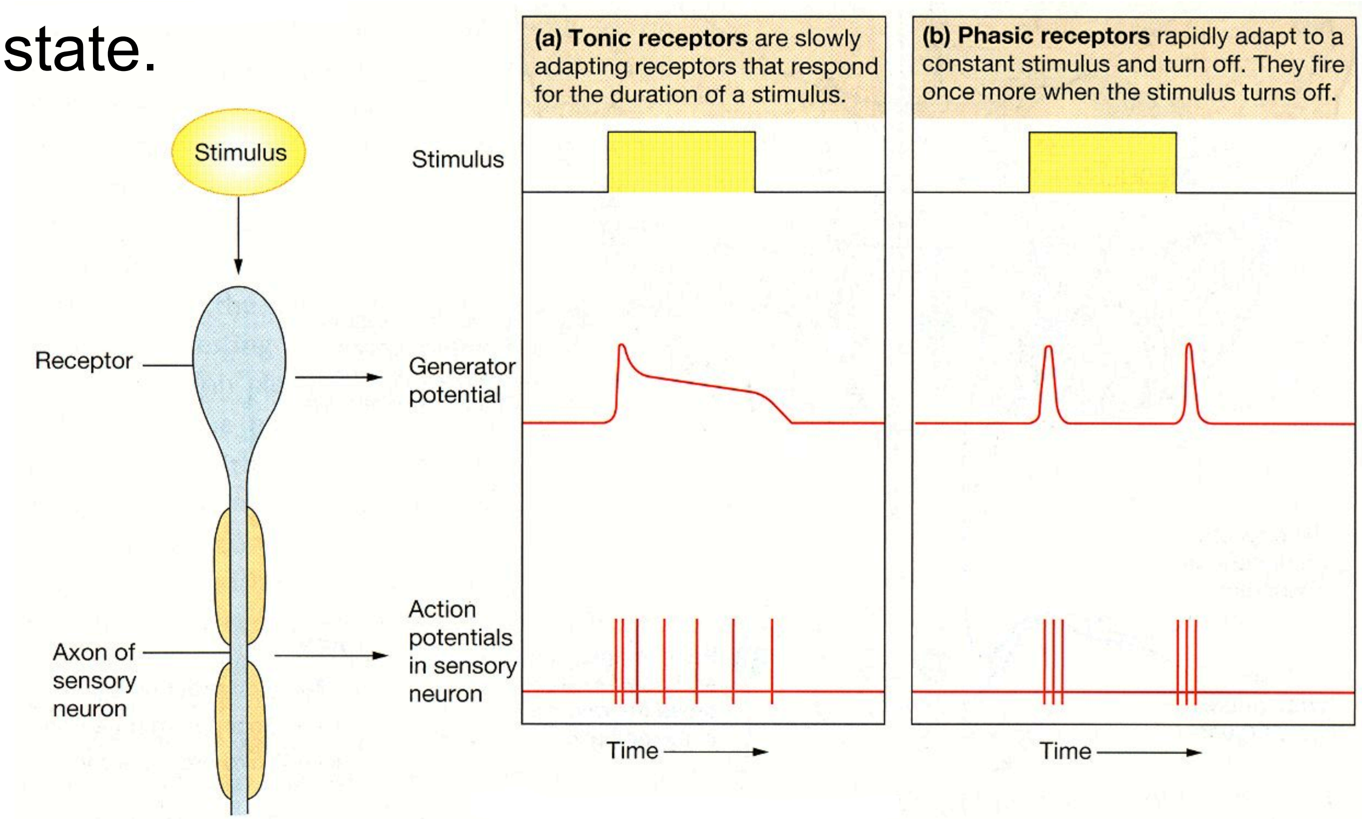
1) the number of receptors activated (**population coding**).

2) the frequency of action potentials (**frequency coding**), following not a linear but a power relationship.



Stimulus Duration

Stimulus duration can be coded by the spike train duration, but not many sensory receptors can sustain their responses. The neural code best reflects the **change in stimulation**, not the steady state.



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2) stimulus **location**

    receptive field, input convergence, topographical maps, lateral inhibition

3) stimulus **intensity**

    population & frequency coding

4) stimulus **duration**

    best reflect changes in stimulation