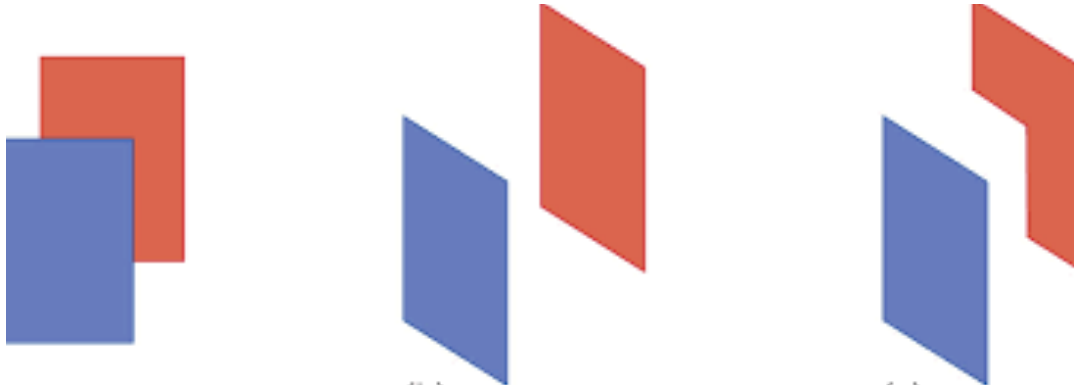
CSE485: Sensation & Sensory Systems

Vinoo Alluri

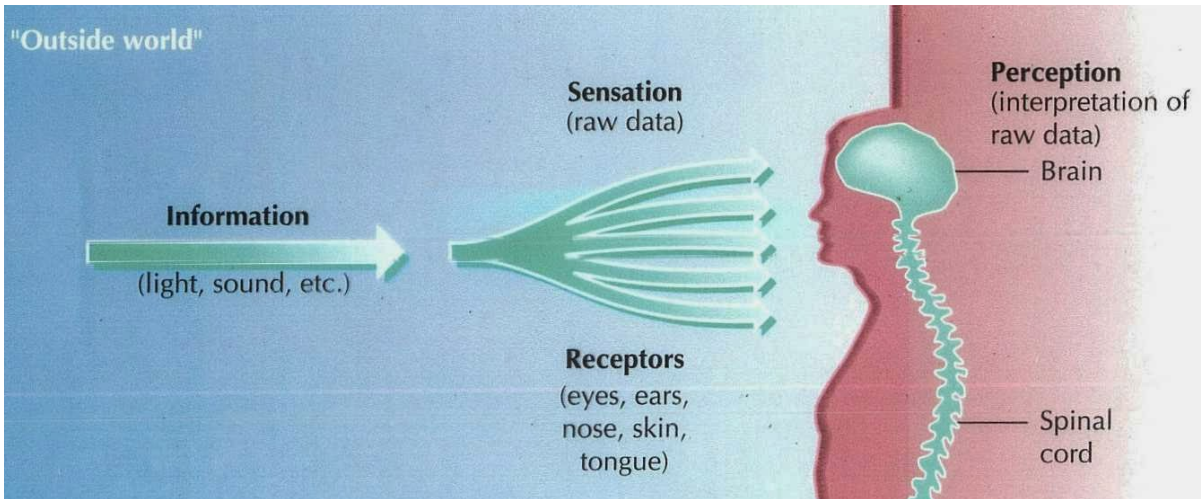
SENSATION



PERCEPTION

SENSATION

- gathering info from the environment via your senses
- senses pick up visual, auditory, and other sensory stimuli and transmit them to the brain
- sensory information registers in the brain but has not been interpreted

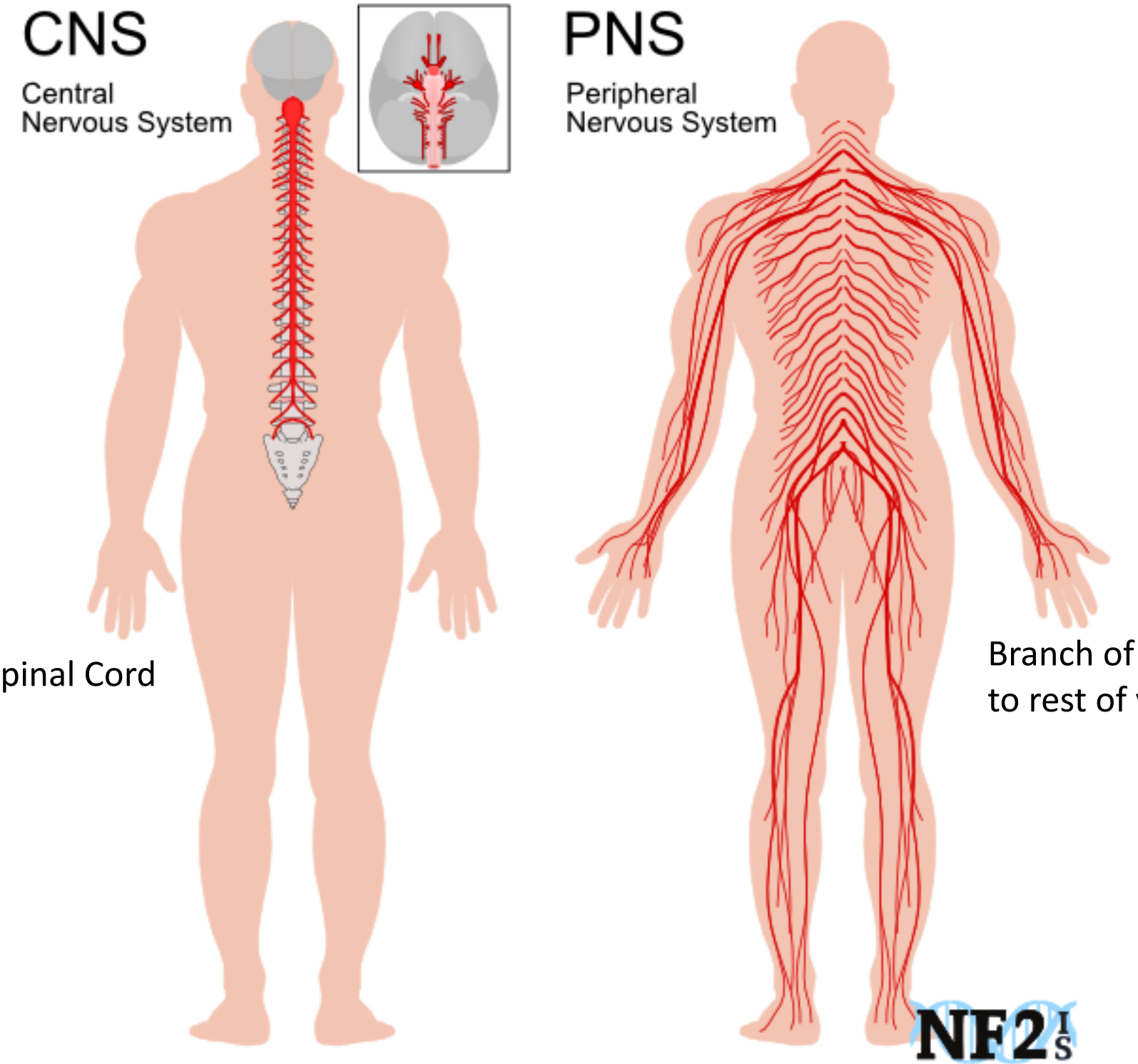


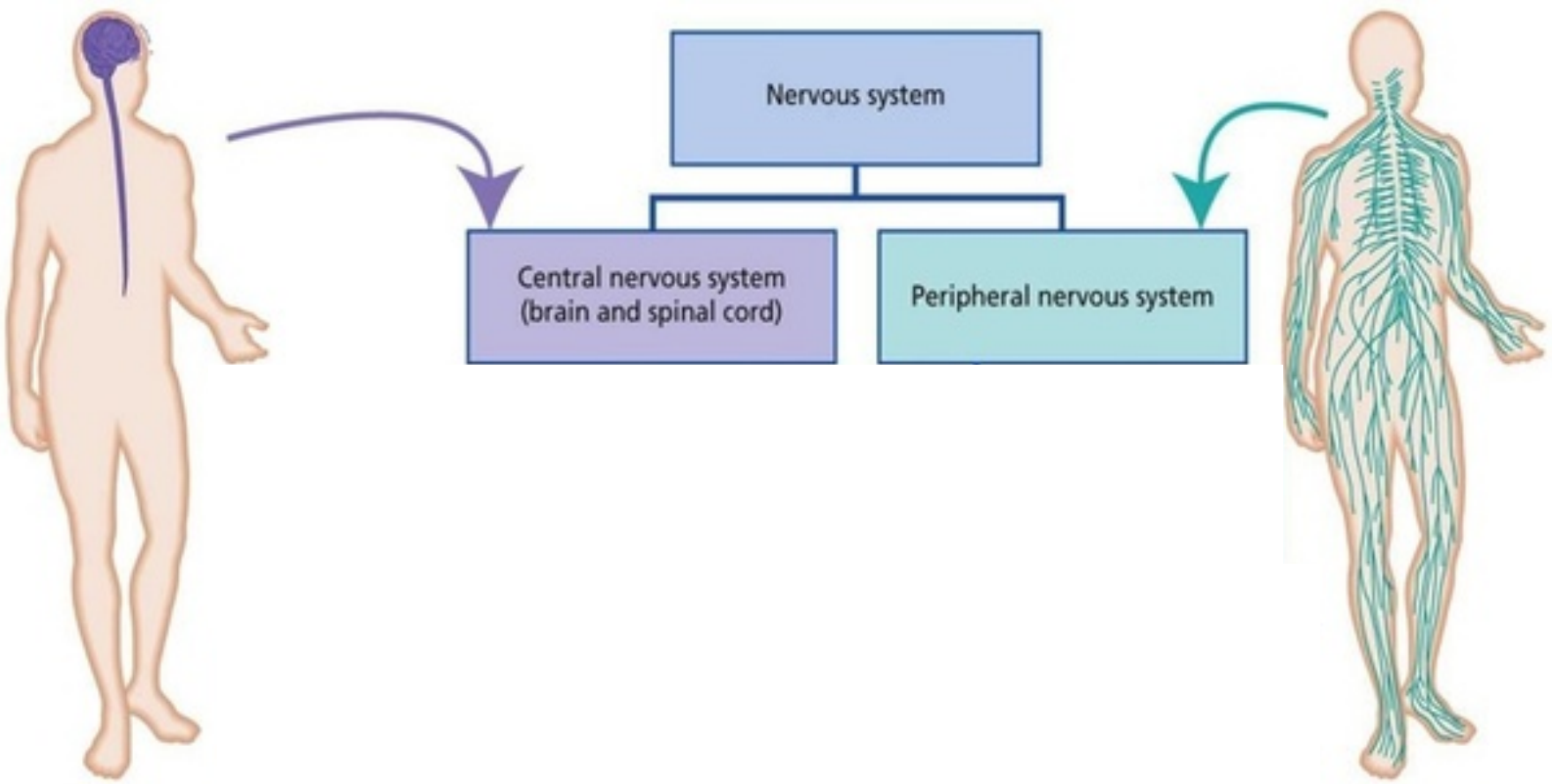
PERCEPTION

the ILLUSION *of* REALITY

- process by which sensory information is actively organized and interpreted by the brain
- understanding what is being sensed
- brain's best guess of the cause of sensory inputs

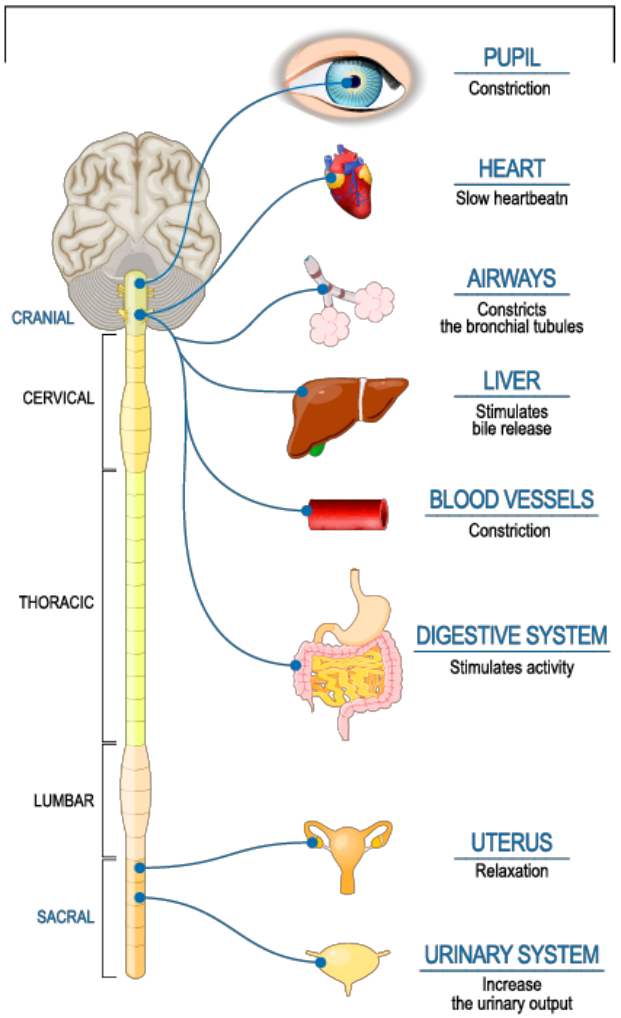
SENSATION

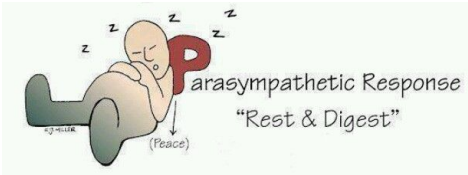

CNS
Central
Nervous System
PNS
Peripheral
Nervous System
Brain & Spinal Cord
Branch of from CNS
to rest of your body
NF2


Nervous system
Central nervous system
(brain and spinal cord)
Peripheral nervous system

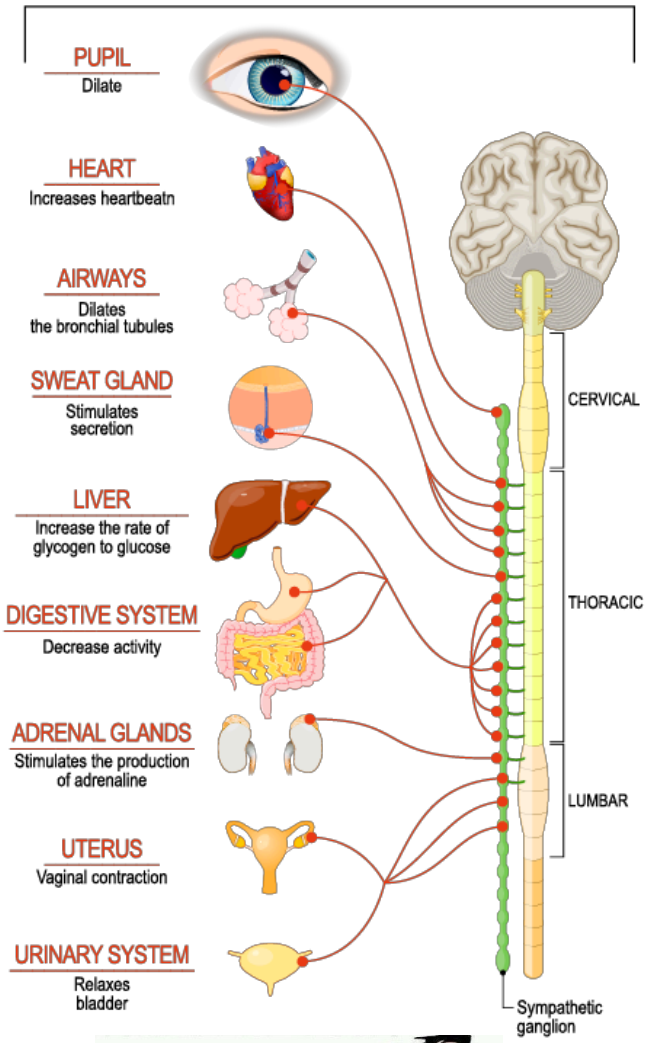
ANS Autonomic Nervous System

Parasympathetic





Sympathetic



Nervous system structure

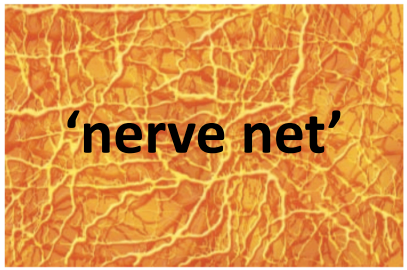
The Nobel Prize in Physiology or Medicine 1906

Camillo Golgi

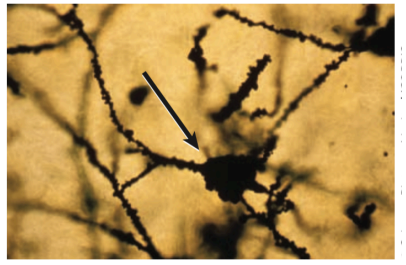
Prize share: 1/2

Santiago Ramón y Cajal

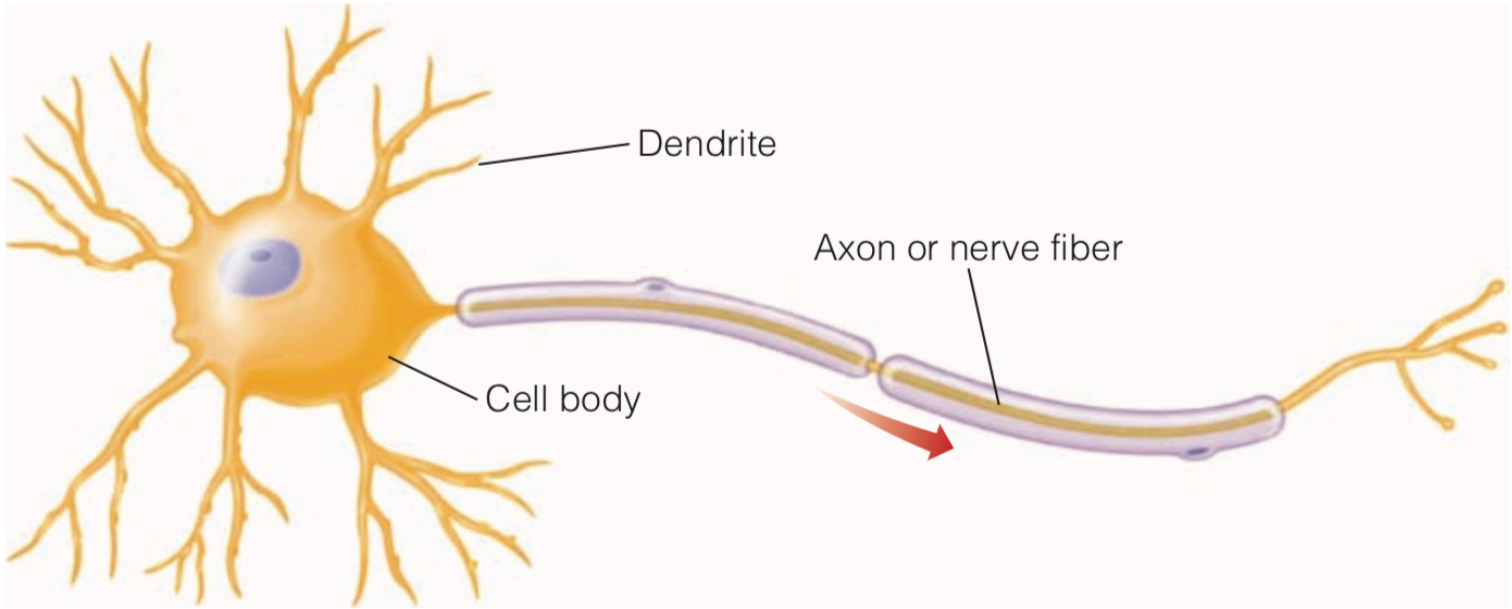
Prize share: 1/2



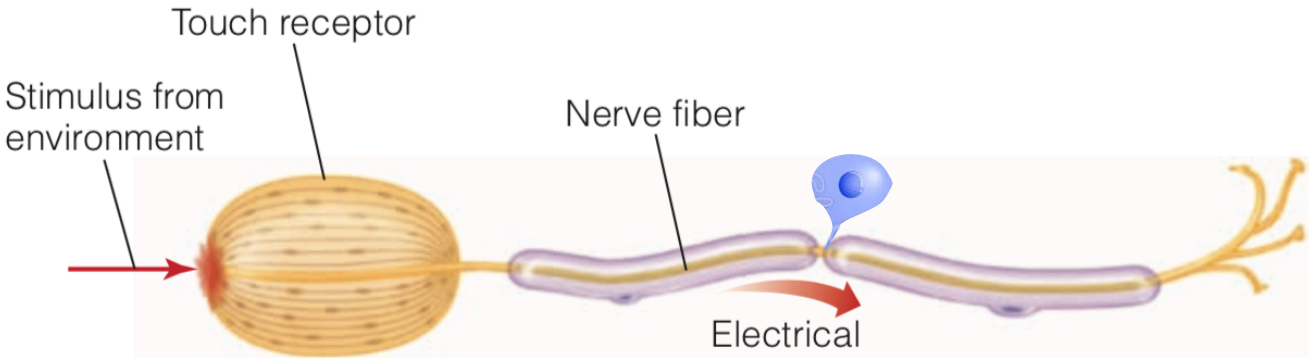
reticular theory vs neuron doctrine



Nervous system structure

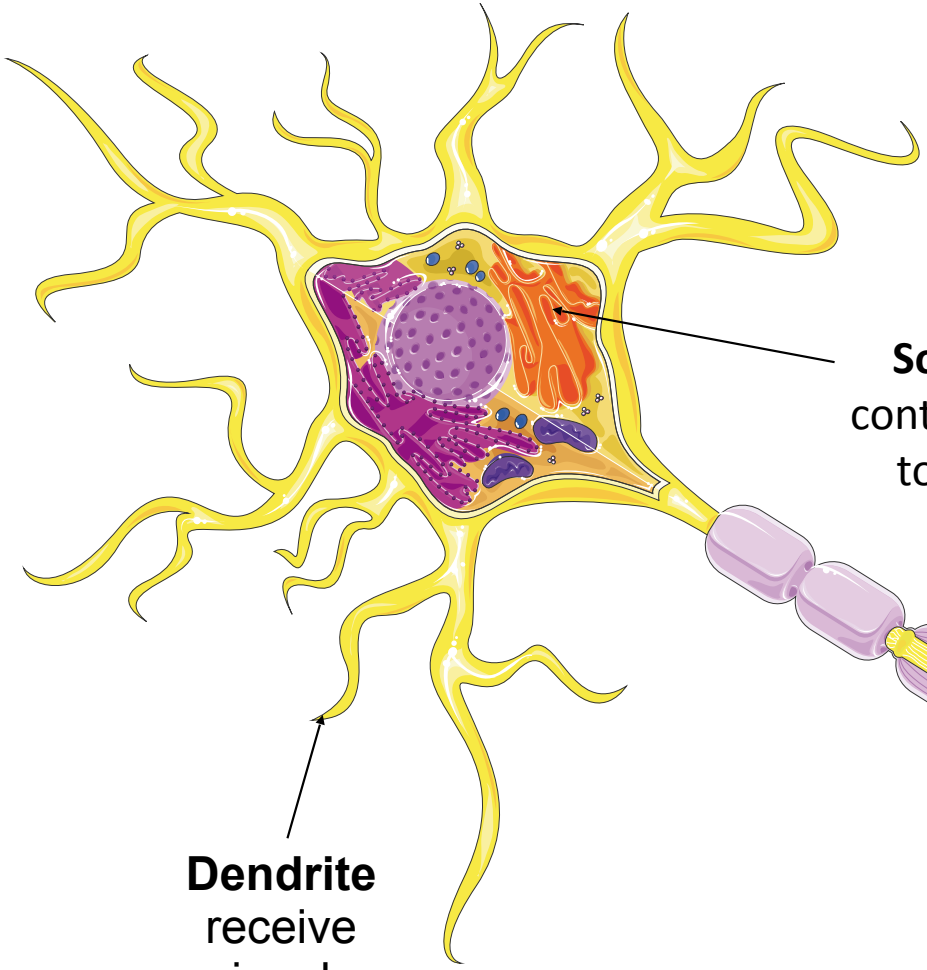


(a)



(b)

Neuron



Soma (cell body)
contains mechanisms to keep cell alive

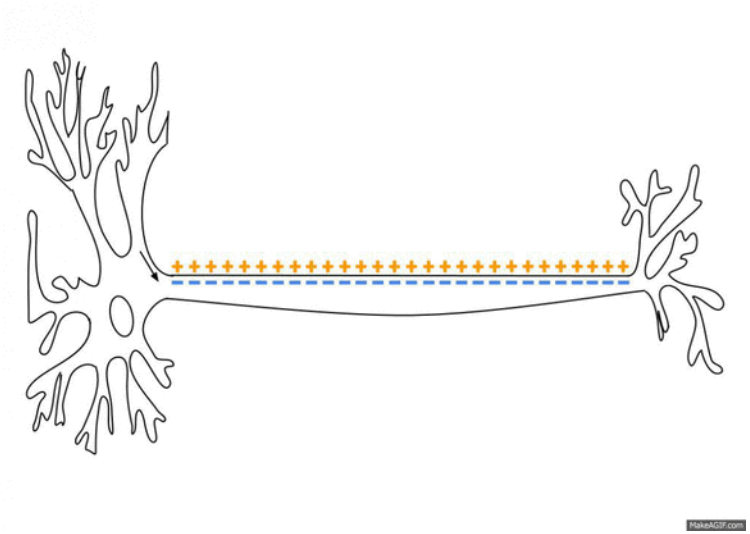
Nodes of Ranvier
uninsulated and highly enriched in ion channels

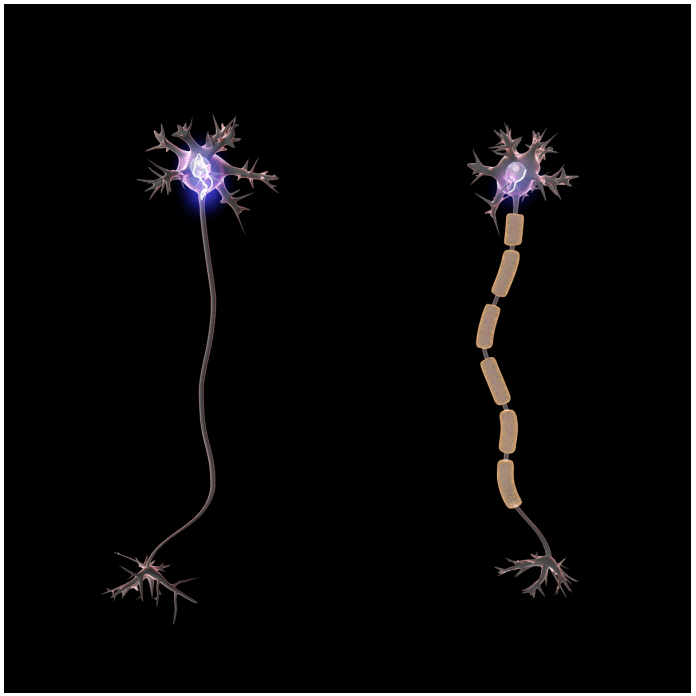
Axon
transmit signals from cell body to other neurons

Dendrite
receive signals from other neurons

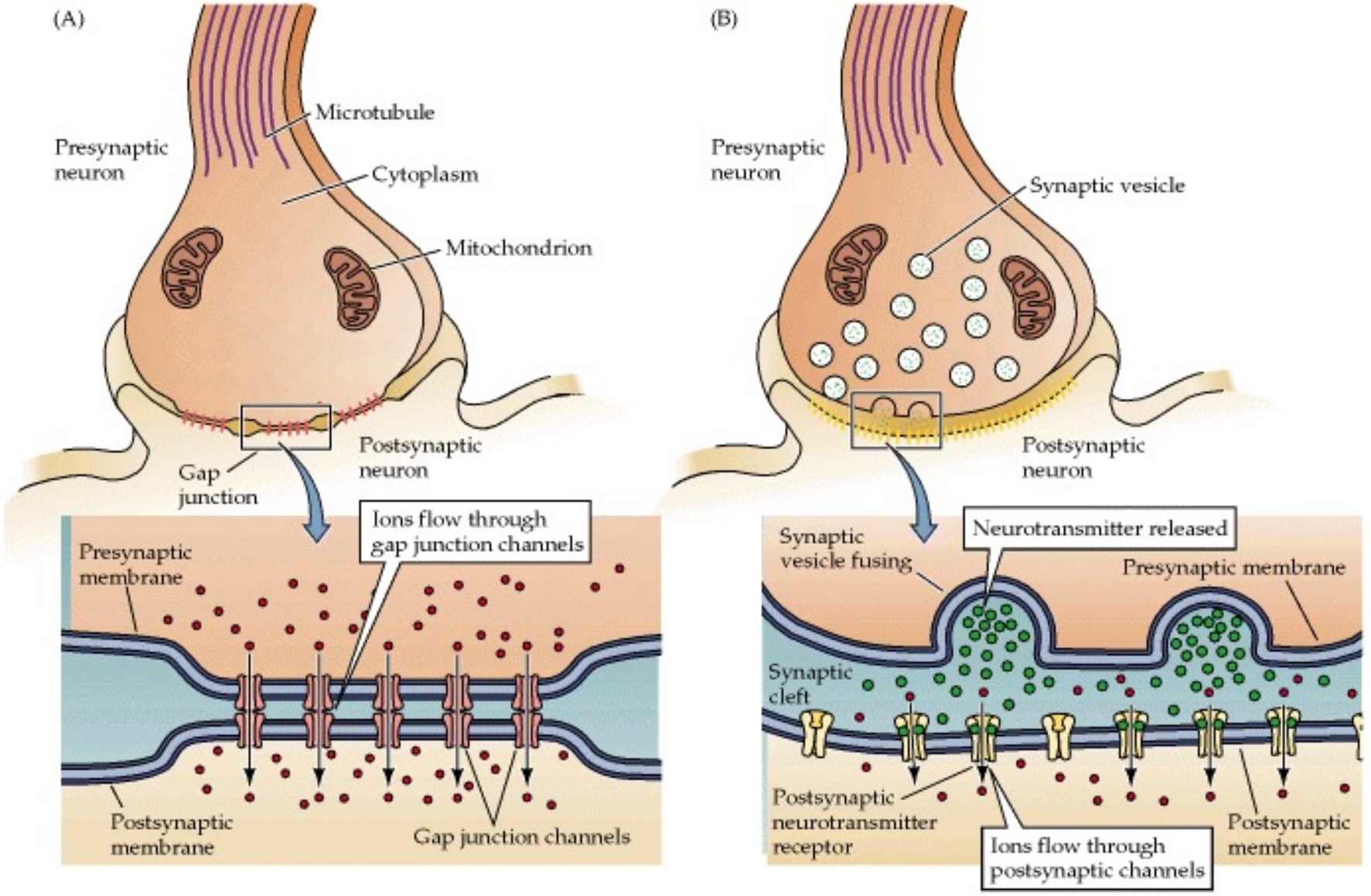
Synapses
gap between end of neuron's axon and dendrites of another neuron

Neuron





Synapse


(A)
Microtubule
Presynaptic neuron
Cytoplasm
Mitochondrion
Postsynaptic neuron
Gap junction
Ions flow through gap junction channels
Presynaptic membrane
Postsynaptic membrane
Gap junction channels
(B)
Presynaptic neuron
Synaptic vesicle
Postsynaptic neuron
Neurotransmitter released
Synaptic vesicle fusing
Presynaptic membrane
Synaptic cleft
Postsynaptic neurotransmitter receptor
Ions flow through postsynaptic channels
Postsynaptic membrane

MENU nature REVIEWS NEUROSCIENCE

Review Article | Published: 12 March 2014

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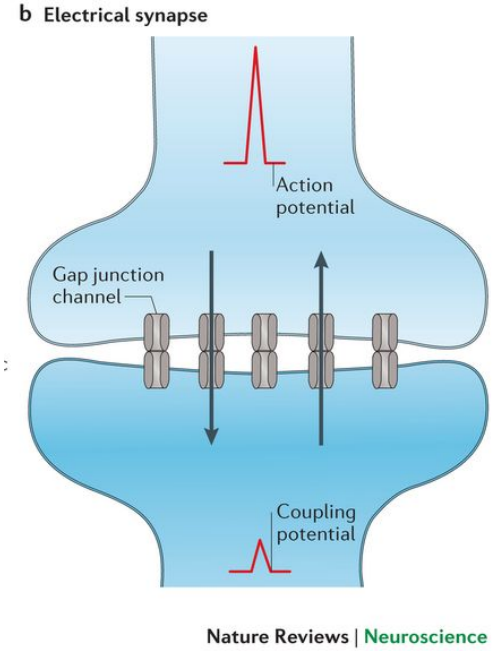
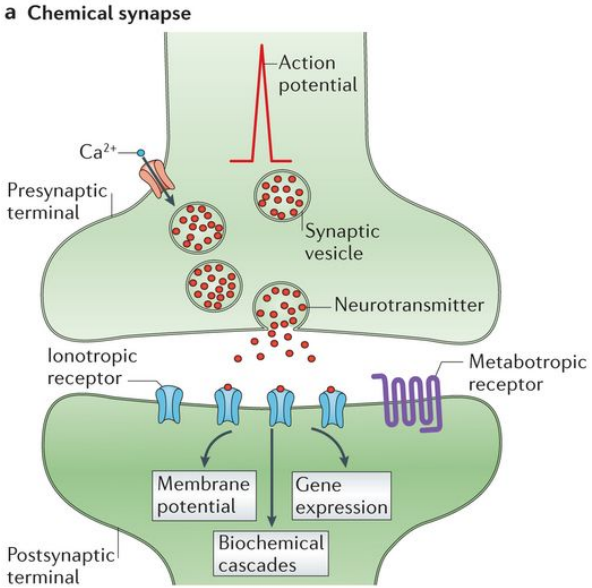
Alberto E. Pereda

Nature Reviews Neuroscience **15**, 250–263 (2014) | Download Citation



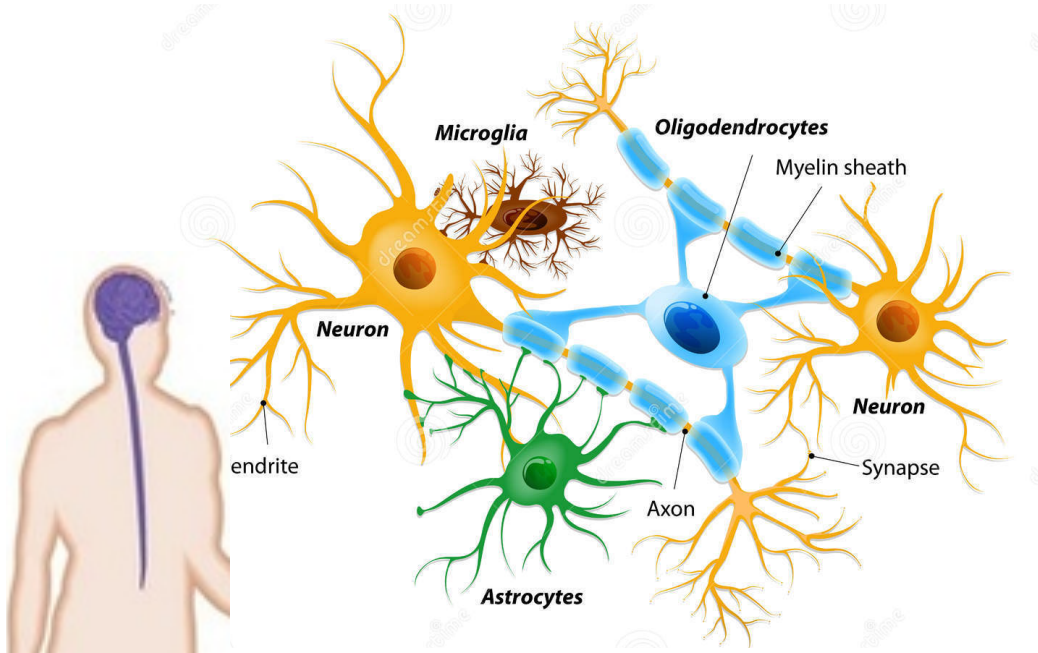


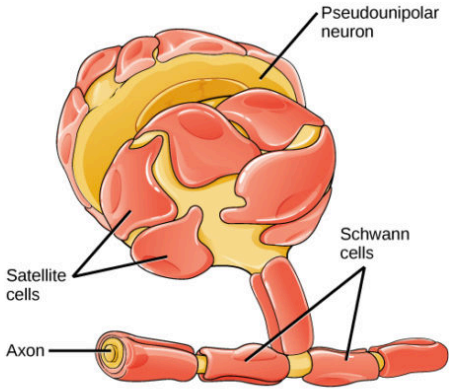
- directly connected by clusters of intercellular channels called gap junctions
- conduct nerve impulses faster; lacks gain (excitatory).
- typically bidirectional
- often found in neural systems that require the fastest possible response (ex: defensive reflexes, heart beat)

- information is transferred through the release of a neurotransmitter from one neuron and detection of the neurotransmitter by an adjacent cell
- conduct nerve impulses slower; gain present (excitatory or inhibitory)
- usually unidirectional

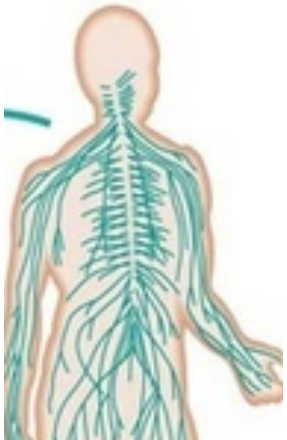
Glial cells

- non-neuronal cells
  - provide support
  - form myelin
  - neuron immunity and maintain homeostasis



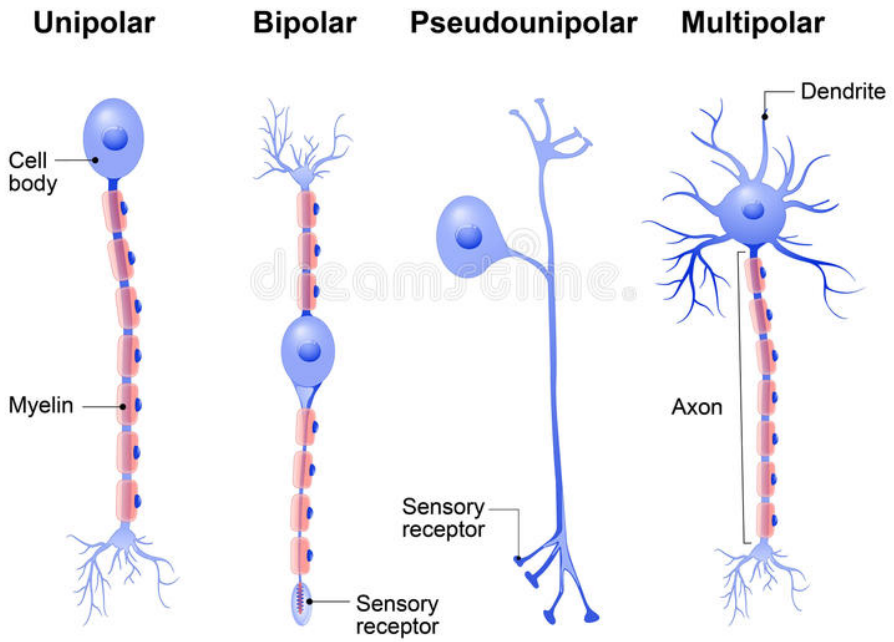


(b) Peripheral nervous system



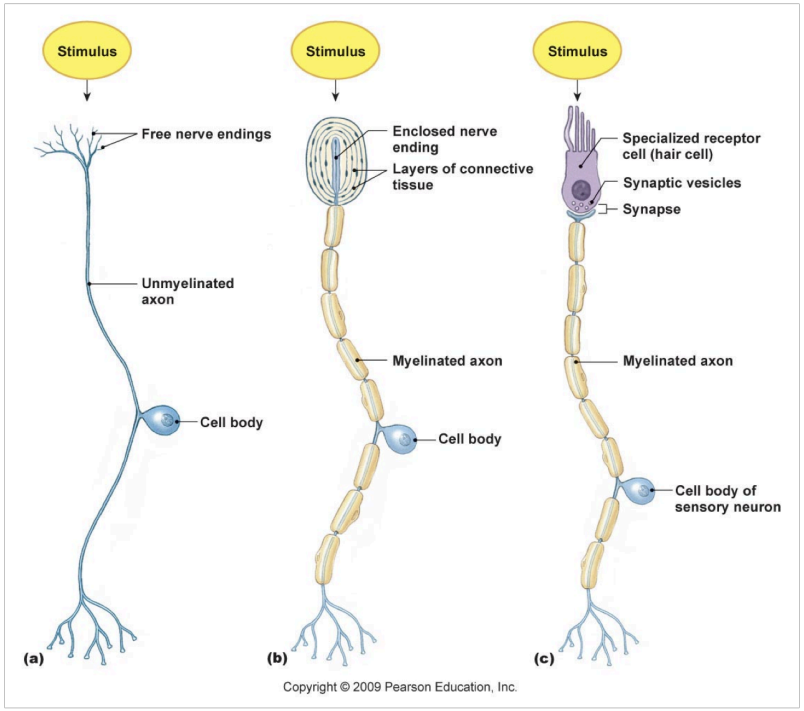
Neurons

- Unipolar (insects) to pseudo-unipolar (humans - **sensory - afferent**)
- Bipolar (rare; specific to olfactory epithelium, the retina of the eye)
- Multipolar - Most common, brain and spinal cord (**motor neurons - efferent; interneurons - association**)

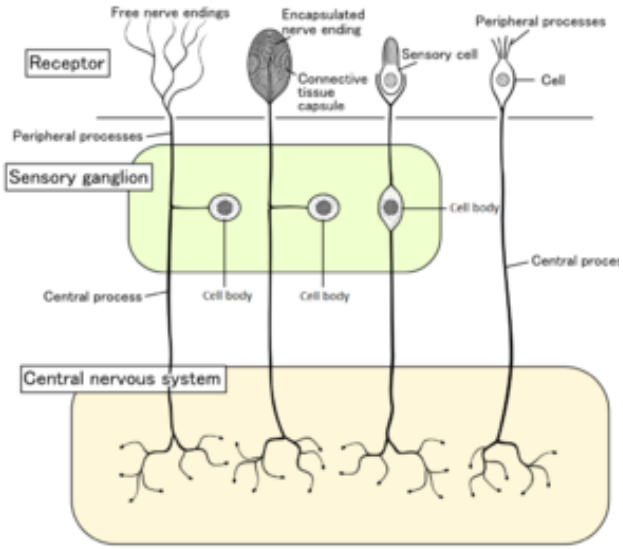


Neurons (Sensory)

- convert a specific type of stimulus, via their **specialised receptors**, into action potentials
- sensory information travels along afferent nerve fibers to the brain via the spinal cord

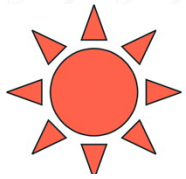


Neurons (Sensory)



- Examples:
  - thermoreceptors

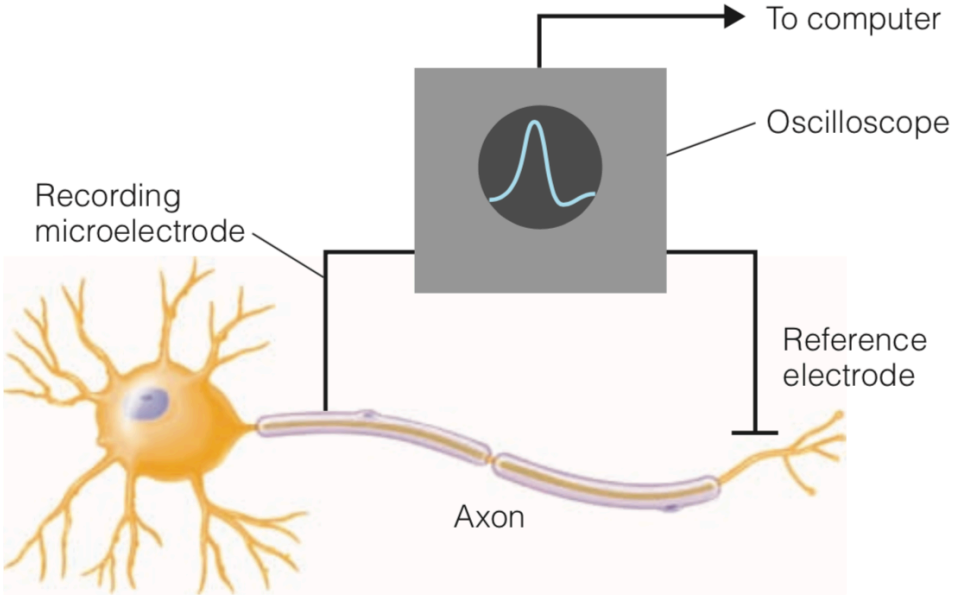
  - photoreceptors

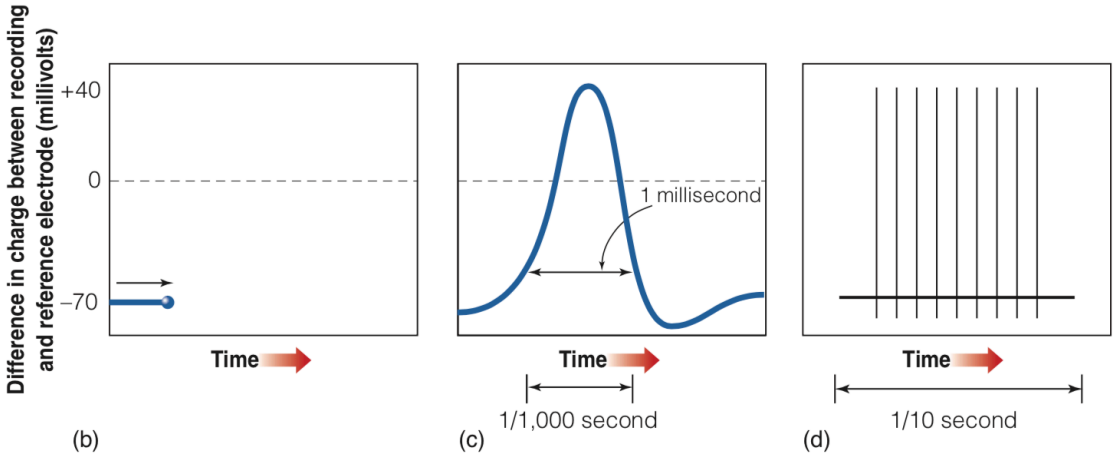


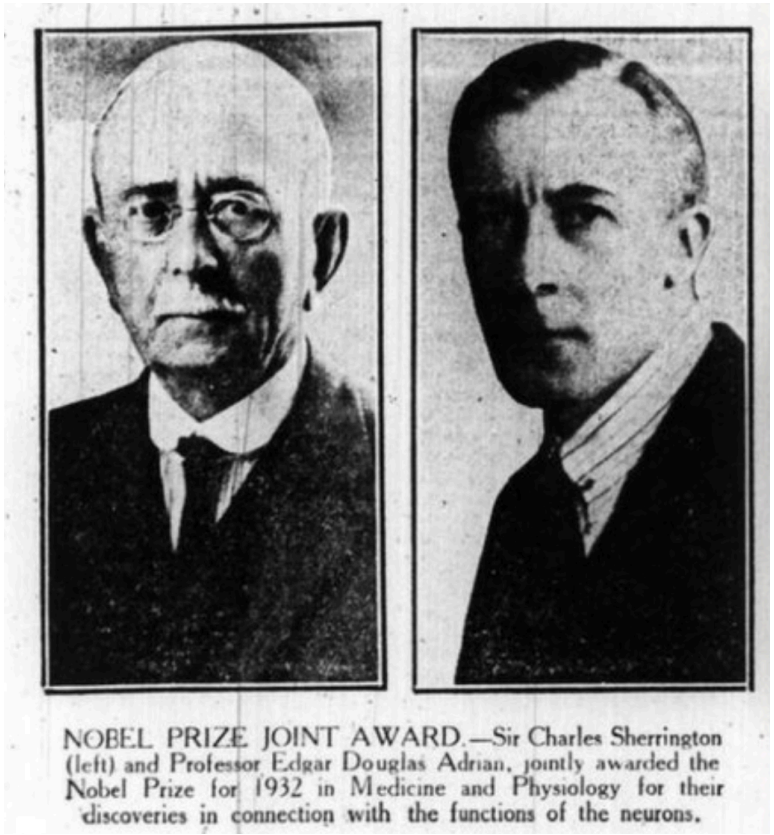
  - chemoreceptors
    - chemicals in mouth (taste), nose (smell) and body fluids

  - mechanoreceptors
    - pressure/deformation
      - ex: nociceptors - pain

Signals in Neurons



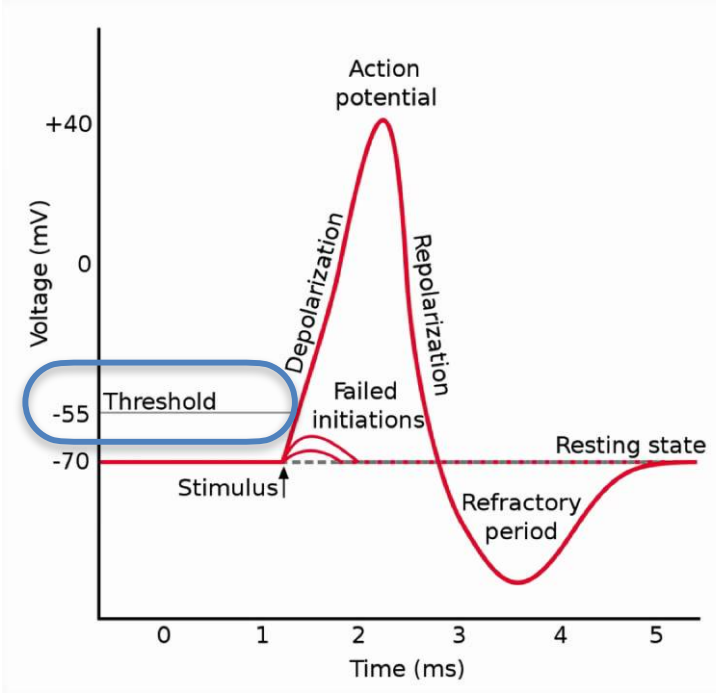




NOBEL PRIZE JOINT AWARD.—Sir Charles Sherrington (left) and Professor Edgar Douglas Adrian, jointly awarded the Nobel Prize for 1932 in Medicine and Physiology for their discoveries in connection with the functions of the neurons.

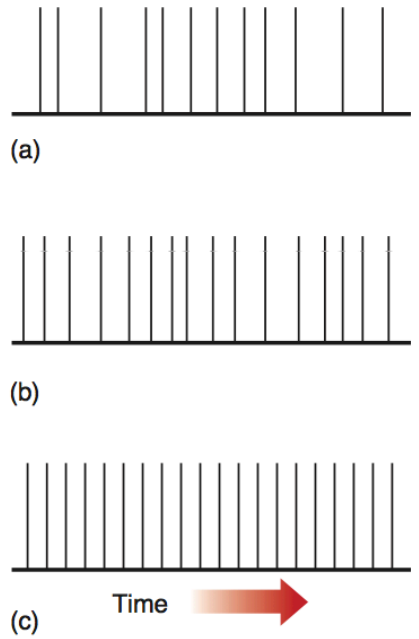
Action Potentials

- nerve impulses
- resting-membrane potential - 70 mV
- a temporary shift (from negative to positive) in the neuron's membrane potential caused by ions suddenly flowing in and out of the neuron



Action Potentials

- Input is analog (membrane potential is continuous valued) and Output is discrete (neuron spikes or not)
- ex: how does firing of a neuron from a receptor in the skin change with increase in pressure applied?



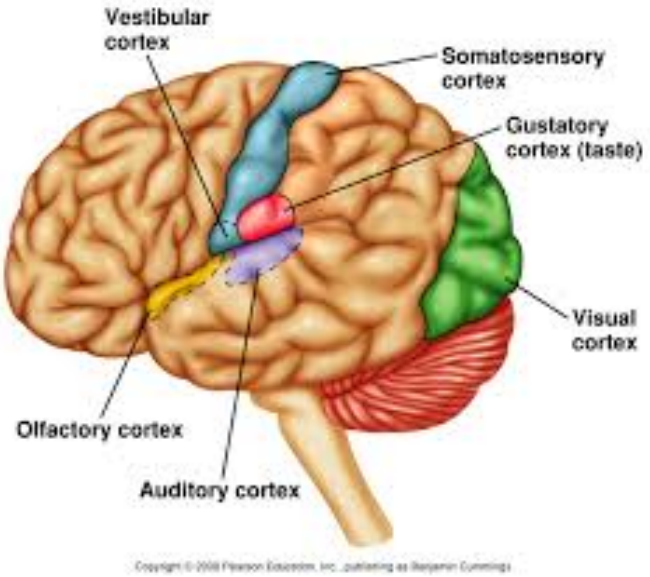
stimulus intensity

=

rate of neural firing

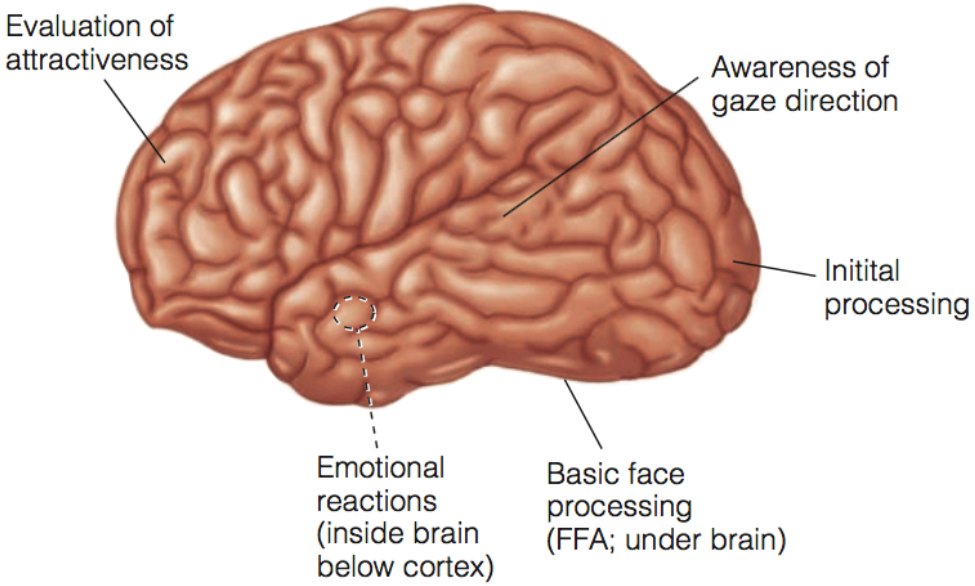
Action Potentials to Perception

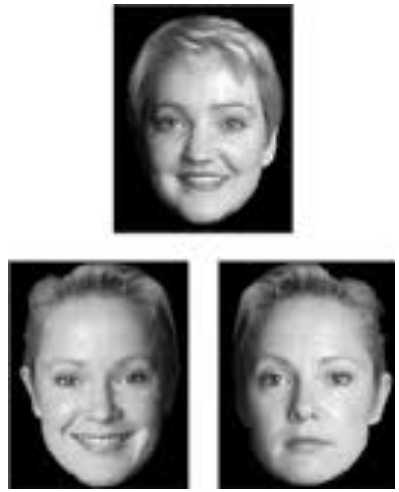
- if output is always binary then how does the brain distinguish stimuli?
- Localization of function/modularity
  - primary receiving areas
    - ex: temporal (auditory), occipital (vision), parietal (touch),etc..
  - specific sensory functional areas
    - ex: Wernicke's area, fusiform face area (in addition to other areas)



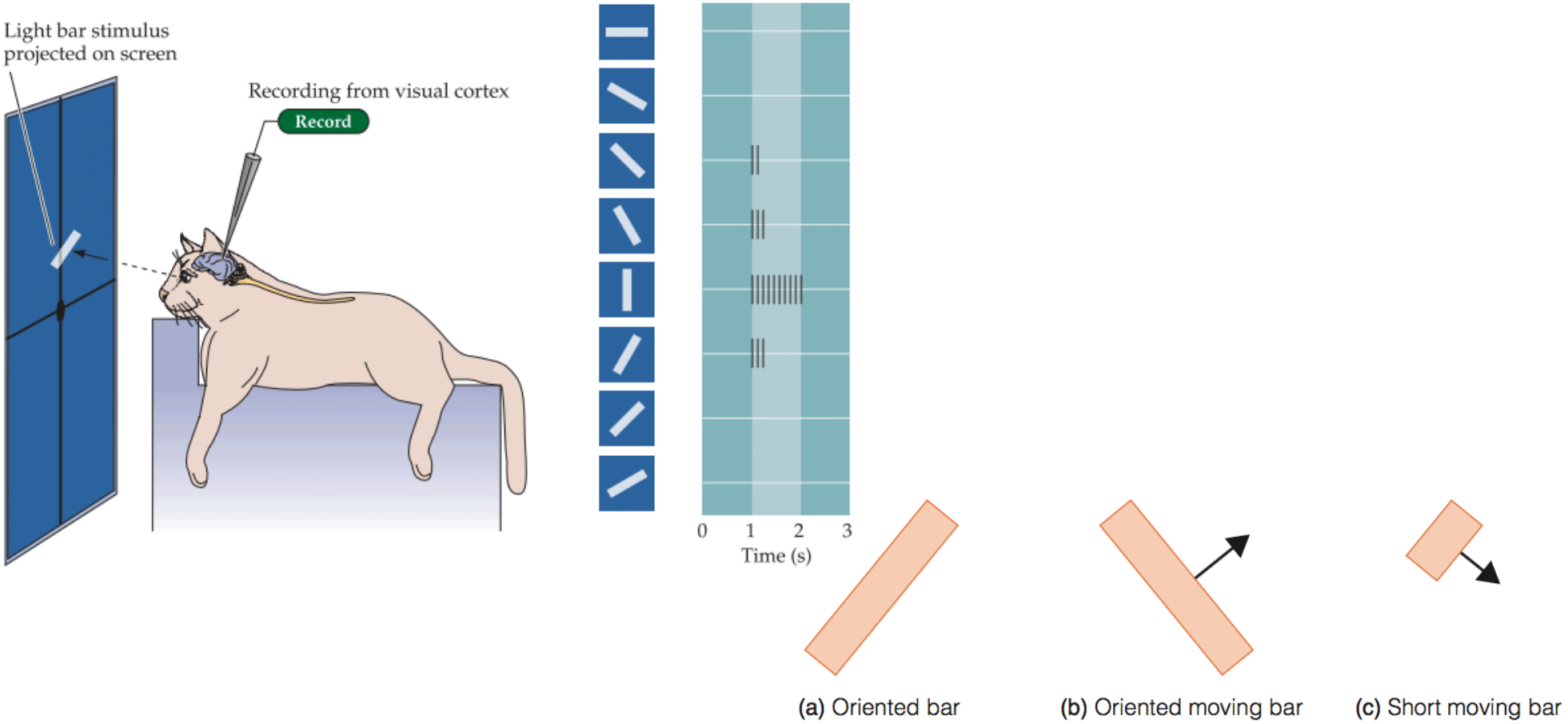
Localization vs distributed processing

- specific functions are processed by many different areas that are associated with ***representation***
  - ex: face perception - ***distributed processing***





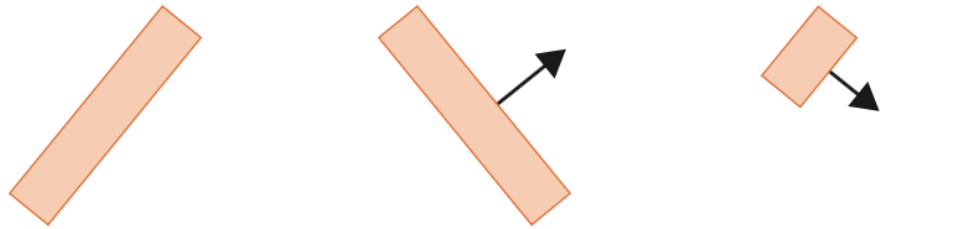
Representation in the Brain



● **FIGURE 2.18** Three types of stimuli that Hubel and Wiesel (1959, 1965) found caused neurons in the cat cortex to respond. They found neurons that responded to bars with a specific orientation, to bars with a specific orientation that were moving in a particular direction, and bars of a particular length that were moving in a particular direction. Neurons that responded to these specific types of stimuli were called feature detectors.

Representation in the Brain

- feature detectors - certain neuronal populations respond to specific type of stimulation or features (ex: edges, lines, angles, etc.)
- patterns of neural firing that represent stimuli known as *neural code*



(a) Oriented bar (b) Oriented moving bar (c) Short moving bar

FIGURE 2.18 Three types of stimuli that Hubel and Wiesel (1959, 1965) found caused neurons in the cat cortex to respond. They found neurons that responded to bars with a specific orientation, to bars with a specific orientation that were moving in a particular direction, and bars of a particular length that were moving in a particular direction. Neurons that responded to these specific types of stimuli were called feature detectors.

Neural Code

- *representation/neural code/schema*
  - specificity coding vs distributed coding

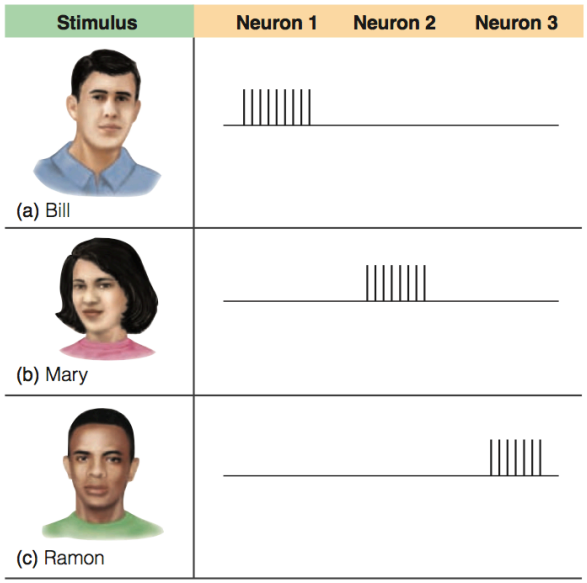


FIGURE 2.21 How faces could be coded by specificity coding. Each faces causes one specialized neuron to respond. (Source: B. Goldstein, *Sensation and Perception* 8th ed., Fig. 2.21, p. 36. Copyright © 2010 Wadsworth, a part of Cengage Learning. Reproduced with permission. www.cengage.com/permissions.)

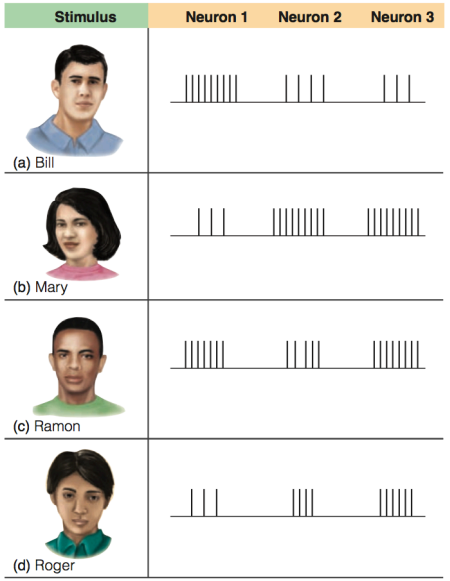


FIGURE 2.22 How faces could be coded by distributed coding. Each face causes all the neurons to fire, but the pattern of firing is different for each face. One advantage of this method of coding is that many faces could be represented by the firing of the three neurons. (Source: B. Goldstein, *Sensation and Perception*, 8th ed., Fig. 2.23, p. 38. Copyright © 2010 Wadsworth, a part of Cengage Learning. Reproduced with permission. www.cengage.com/permissions.)

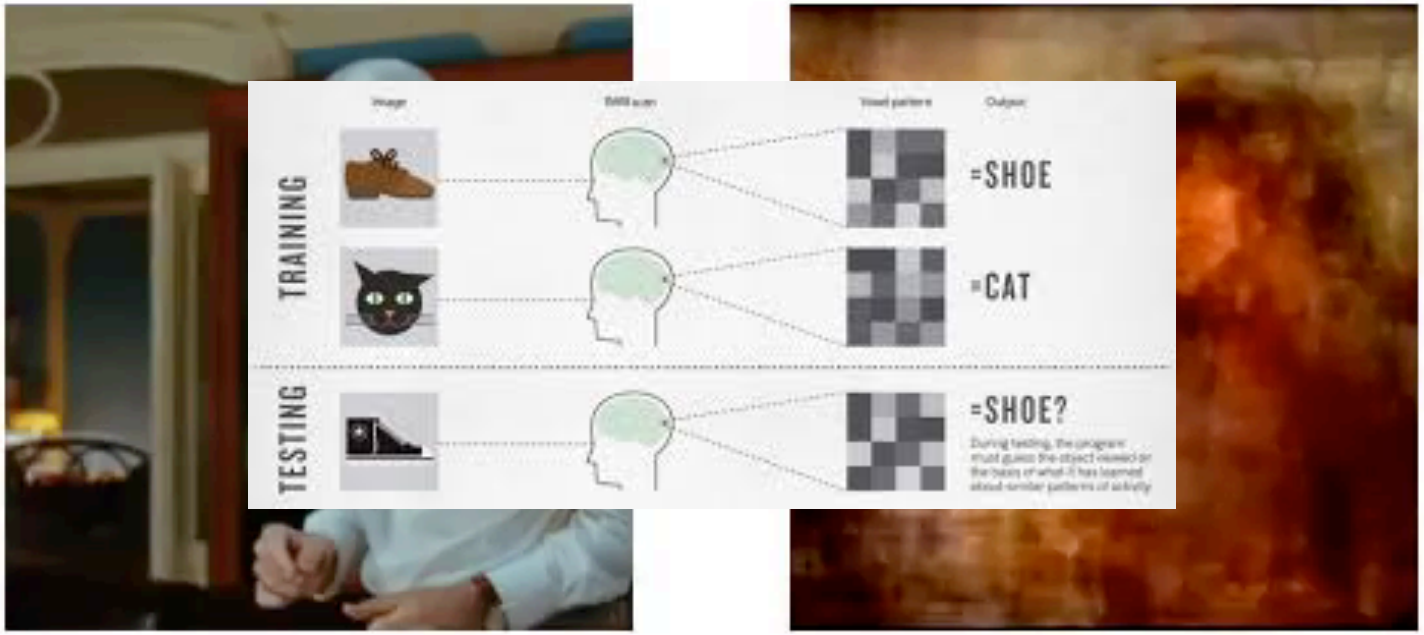
  - distributed coding used for decoding or “mind reading”

The Gallant lab at UC Berkeley
Cognitive, computational and systems neuroscience

decoding

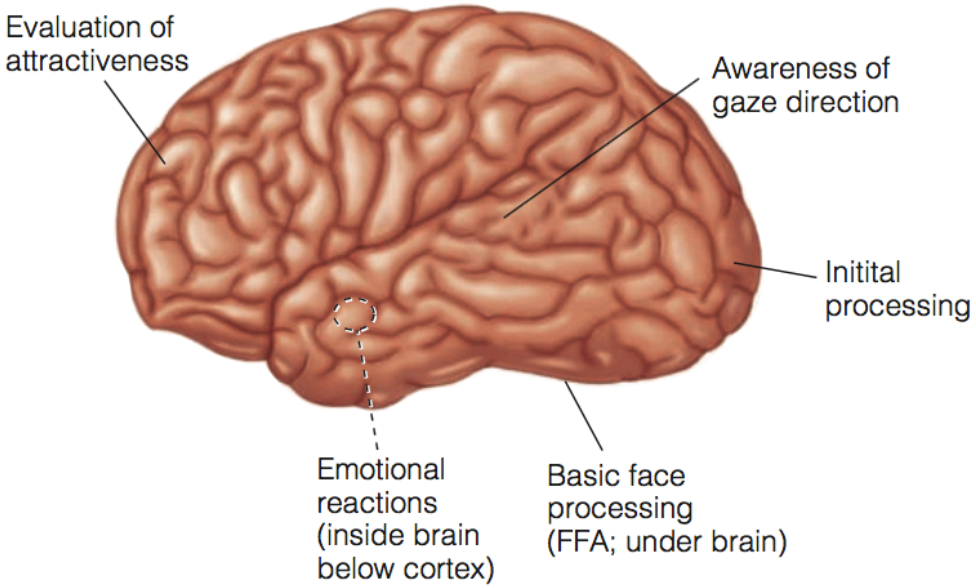
Presented clip

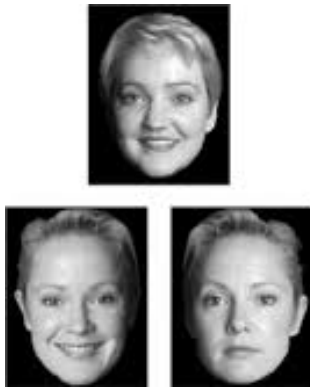
Clip reconstructed from brain activity



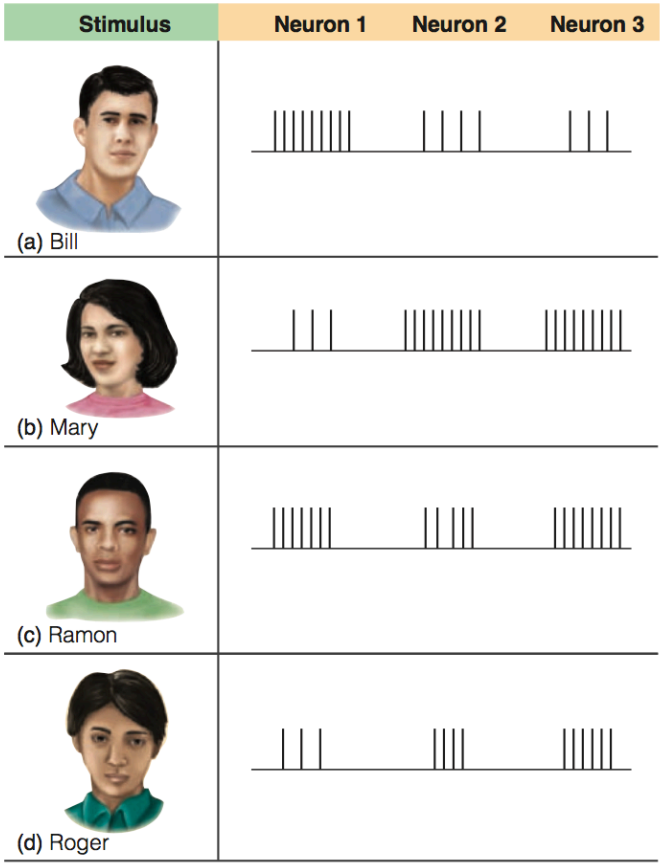
Nishmoto et al 2011. Reconstructing visual experiences from brain activity evoked by natural movies. *Current Biology*

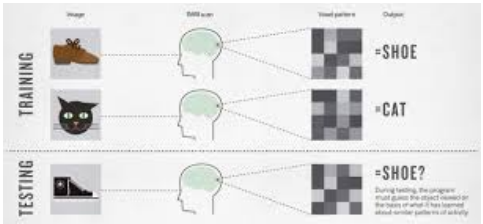
distributed processing



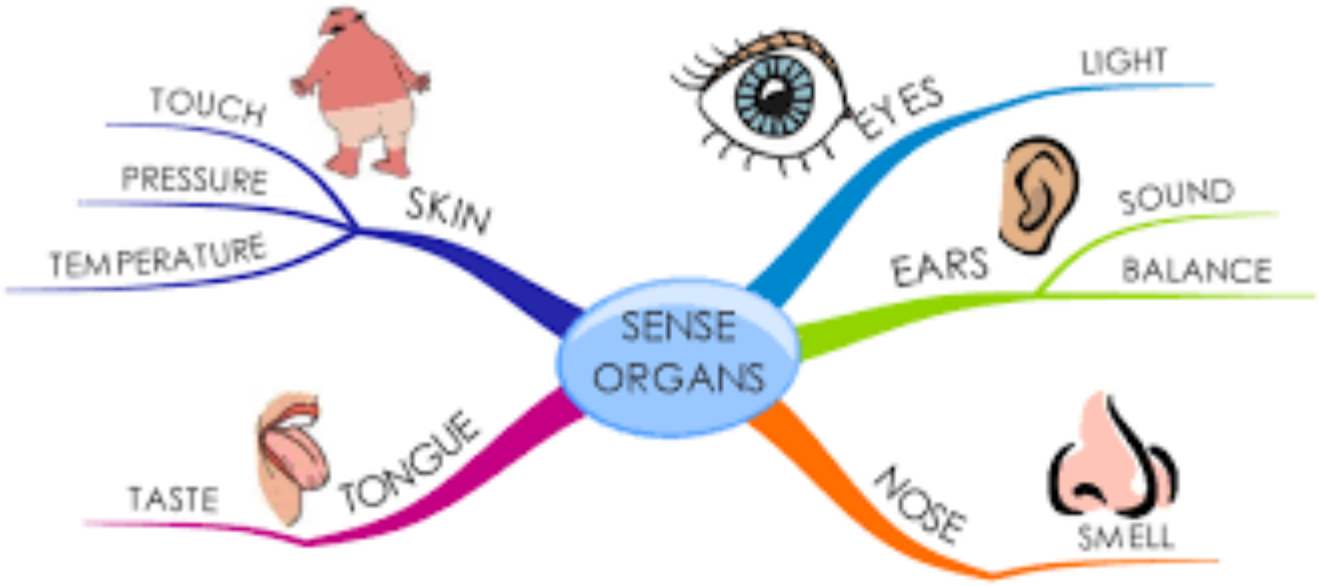


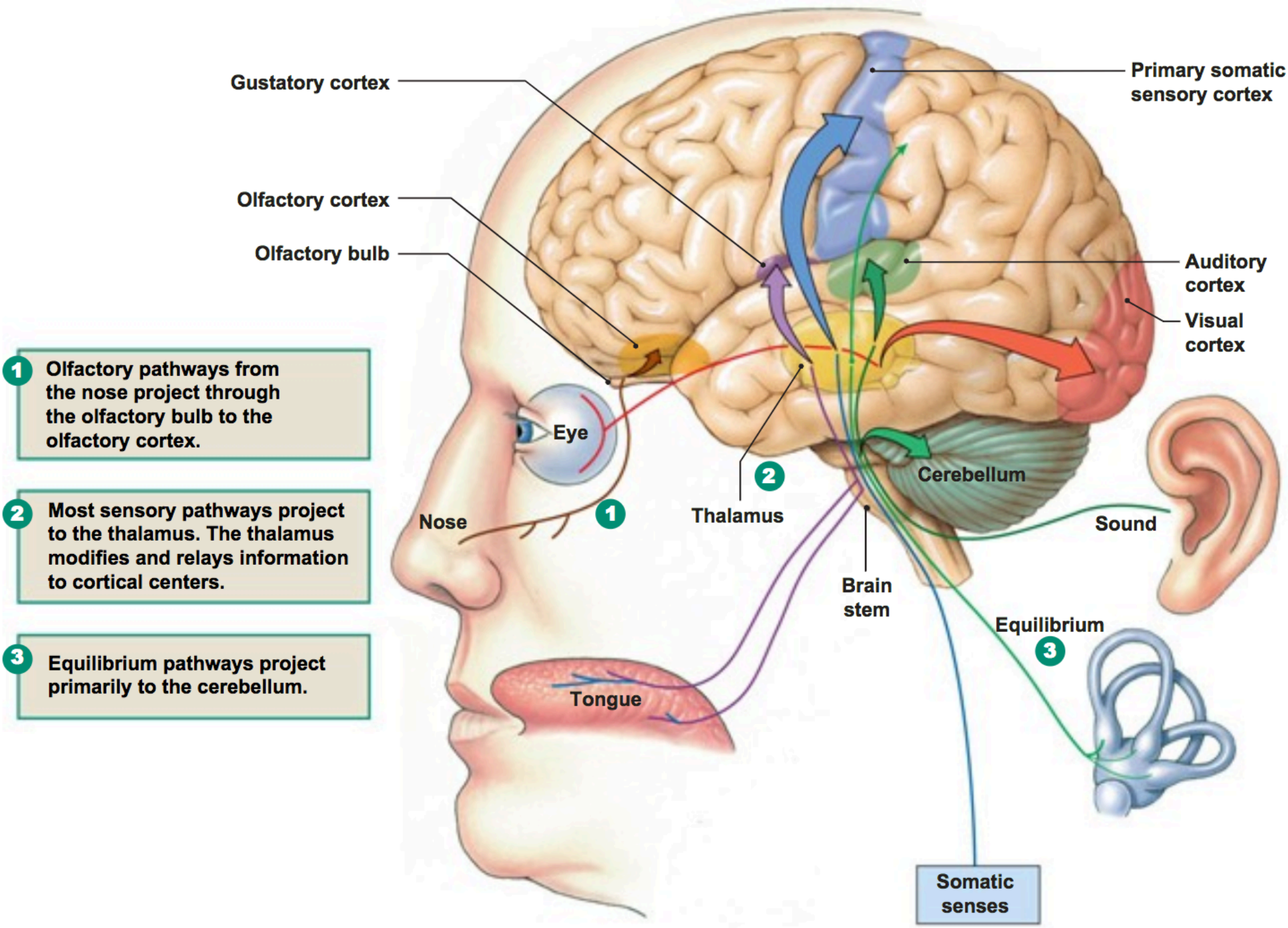
distributed coding





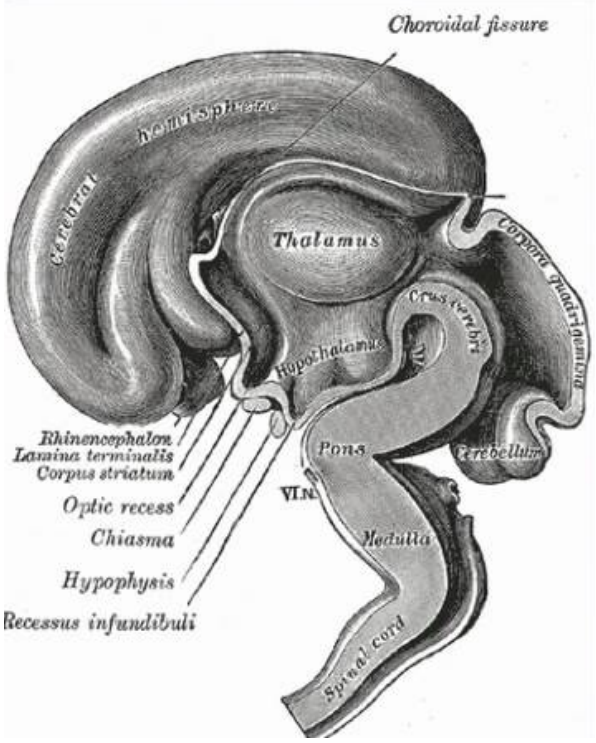
Sensory Systems

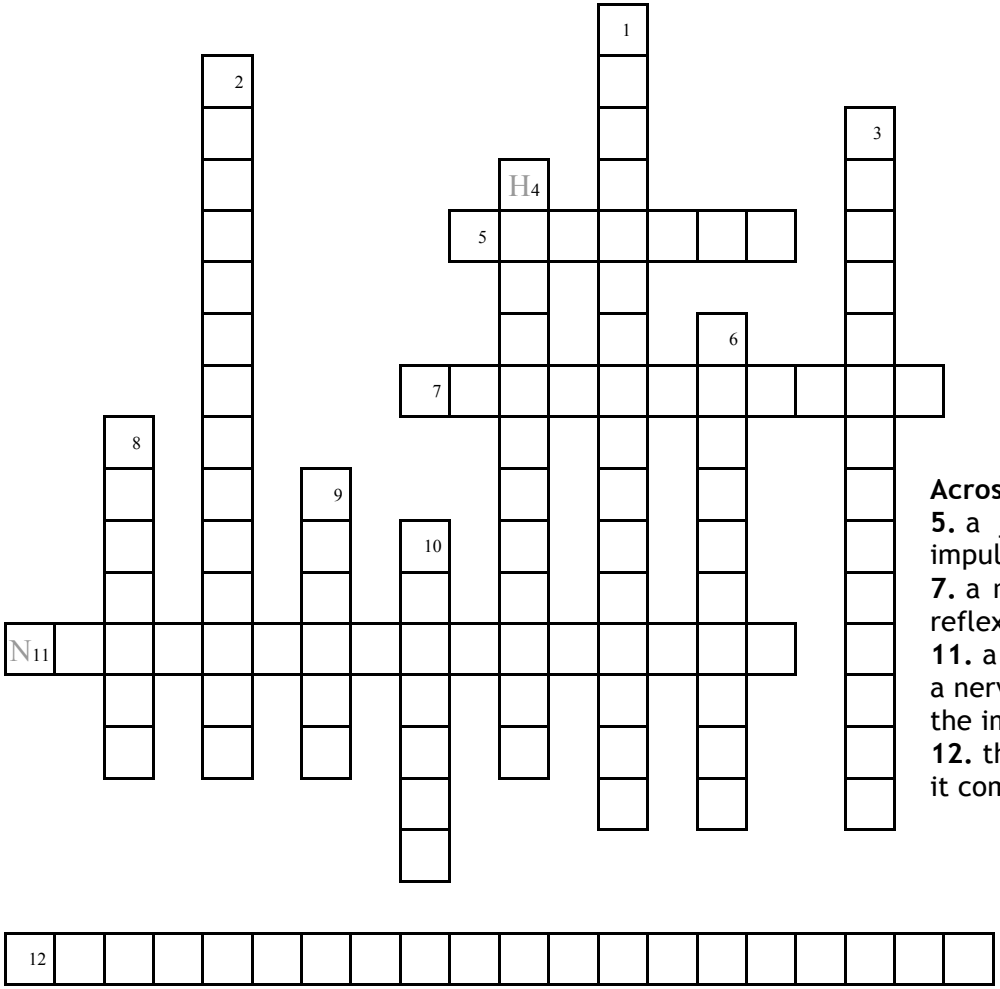



Gustatory cortex
Primary somatic sensory cortex
Olfactory cortex
Olfactory bulb
Auditory cortex
Visual cortex
1 Olfactory pathways from the nose project through the olfactory bulb to the olfactory cortex.
2 Most sensory pathways project to the thalamus. The thalamus modifies and relays information to cortical centers.
3 Equilibrium pathways project primarily to the cerebellum.
Eye
Nose
1
2
Thalamus
Cerebellum
Sound
Brain stem
Equilibrium
3
Tongue
Somatic senses

Thalamus and Hypothalamus

- Thalamus
  - control center for sensory info
  - relay center
- Hypothalamus
  - intermediary between the nervous system and the endocrine system (hormones)
  - control center for ANS
  - regulates basic (insntincts) survival mechanisms (body temp, thirst,hunger, etc.)





Across

5. a junction between two nerve cells, consisting of a minute gap across which impulses pass by diffusion of a neurotransmitter

7. a neuron which transmits impulses between other neurons, especially as part of a reflex arc.

11. a chemical substance which is released at the end of a nerve fibre by the arrival of a nerve impulse and, by diffusing across the synapse or junction, effects the transfer of the impulse to another nerve fibre, a muscle fibre, or some other structure.

12. the complex of nerve tissues that controls the activities of the body. In vertebrates it comprises the brain and spinal cord.

Down

1. a sense organ or cell that responds to mechanical stimuli such as touch or sound.

2. sensory cells responsive to chemical stimuli.

3. a non-specialised sensory receptor, or more accurately the receptive portion of a sensory neuron, that codes absolute and relative changes in temperature, primarily within the innocuous range.

4. a region of the forebrain below the thalamus which coordinates both the autonomic nervous system and the activity of the pituitary.

6. near the surface of the body, with special reference to the circulation and nervous system.

8. A thing or event that evoke a specific functional reaction in the organ or tissue

9. a specialized cell transmitting nerve impulses; a nerve cell.

10. relating to sensation or the physical senses; transmitted or perceived by the senses.