
Topic: Nervous system

Reading: Chapter 38

Main concepts:

- Neurons are the cells that make up nervous tissue and most of the nervous system. Dendrites receive signals, the cell body integrates incoming signals, the axon conducts the signals, and the synaptic terminal passes the signal to the next neuron.
- Neurons: receive information, integrate and interpret information, conduct signals over distances, and transmit signals to receiving organs.
- Nerve signals involve the concentration of potassium and sodium ions on either side of the cell membrane. The signal is conducted when ion channels open briefly in a “wave” down the cell, allowing sodium and potassium to switch sides.
- The synapse is a small gap between two neurons, and is bridged by chemicals called neurotransmitters. These allow fine control of neural signals. Not every signal has to be transmitted.
- Four basic operations for information processing:
 - Type of stimulus (auditory, visual, etc.) is determined by wiring patterns in the brain.
 - Intensity is determined by frequency of signals.
 - Information from the senses may converge from many sources.
 - Divergence of signals from the brain to the body allows complex responses.
- The simplest neural signal is the reflex arc: a signal from sensory organs is directed to motor neurons in the spine and the response carried out before the brain gets the message.
- Other signals travel to the brain first. The brain sorts out sensory signals, may ignore some that are unimportant, and determines the correct response. The brain then sends signals to effectors: muscles, glands, organs.
- Human nervous system is divided into two parts: central nervous system (brain, spine) and peripheral nervous system (nerves, sensory organs).
- Peripheral nervous system (PNS) is divided into:
 - Motor portion
 - somatic system: controls voluntary muscles (though they can be involved in an involuntary response, such as a reflex arc)
 - Autonomic system: controls involuntary responses (though conscious training, such as meditation or relaxation techniques, can allow people to affect the degree of response)
 - Sympathetic division: “fight or flight”
 - Parasympathetic division: “rest and rumination”
 - Sensory portion
 - Sensory receptors collect information: chemoreception, mechanoreception, photoreception, etc.
 - Sensory neurons transmit signals, informing the brain of what is going on in the environment.
- Central nervous system is divided into:
 - Brain
 - Hindbrain made up of medulla, pons, and cerebellum
 - Medulla controls autonomic functions, such as breathing and heart rate.
 - Pons appears to control stages of sleep.
 - Cerebellum stores many motor memories and coordinates body movements.
 - Midbrain contains the reticular formation, which relays and filters sensory information.
 - Forebrain includes thalamus, limbic system, and cerebral cortex.
 - Thalamus channels sensory information to the limbic system and cerebral cortex.
 - Limbic system controls basic emotions, drives, and behaviors.
 - Hypothalamus integrates the nervous and endocrine systems.
 - Amygdala produces sensations of pleasure, fear, or arousal.
 - Hippocampus is involved in emotions, and is critical for storing experiences into memory.
 - Cerebral cortex is divided into regions that process sensory and motor information, store memories, and carry out the most complex thought and reasoning. May be the part of the brain that produces “mind.”

- Sensory organs can be classified by the type of signal that they receive
 - Heat, cold = thermoreception, which is carried out by specialized nerve endings in the skin.
 - Hearing, touch = mechanoreception
 - Outer ear is shaped to catch and channel sound waves into the ear canal.
 - Middle ear (eardrum, ear bones) transmit and amplify signals.
 - Inner ear contains a long membrane (basilar membrane) with sensitive hair cells that respond to certain frequencies of sound. Loud or prolonged noise can damage these cells permanently.
 - Touch receptors in the skin respond to varying pressures, producing the sensation of touch.
 - Sight = photoreception
 - Light enters the eye through the cornea and pupil.
 - Lens focuses the light on the retina on the back of the eye.
 - Retina contains rod and cone cells, which contain light-sensitive pigments. Light causes the pigments to break, releasing energy, which sparks a nerve signal to the brain.
 - The image on the back of the eye is fuzzy and upside-down. The brain interprets the signal and makes meaning of it. Because the brain is capable of “filling in” information, the brain’s interpretation is not always faithful to reality.
 - Rod cells detect light of all wavelengths, and can be active in dim light.
 - Cone cells respond to certain colors of light, and give us color vision.
 - Taste, smell, and pain = chemoreception
 - Taste
 - Chemicals in our food stimulate taste receptors on the tongue.
 - Five types of taste receptors: salty, sweet, sour, bitter, and “umami”
 - “Flavor” is a combination of taste and smell.
 - Smell
 - Chemicals in the air dissolve in the mucous in the nose, stimulating olfactory receptors located in a small area inside the nose.
 - There may be over 1000 different olfactory receptor proteins in the receptors cells.
 - Pain
 - Damage to skin, blood vessels, and small nerves cause the release of potassium ions, stimulating pain receptors.
 - Other chemicals are involved in this response, some of which are blocked by pain medications.
- Synesthesia: What might be called “cross-sensory perception.” The most common forms are letter-color and number-color associations, where an individual experiences specific colors for specific letters or numbers (but the colors are not consistent between synesthetes). Some might have sensations of color when hearing certain sounds, or may perceive certain tastes as “round” or “pointed.” Synesthetes do not choose these associations, nor do they simply imagine them, nor are they learned responses. The responses are involuntary and remain consistent over time. Brain scans show that synesthetes who, for example, associate colors with sounds, have activity in both the auditory and visual parts of the cortex. By contrast, someone who is not synesthetic who imagines such associations does not show similar brain activity. Some studies suggest all human infants are synaesthetic, and that neural “pruning” that goes on in early development sorts out the senses; thus synaesthesia might be the result of incomplete neural pruning. Other studies suggest that this is not the case, so no one yet knows what causes the condition. Rarely is it disabling. Most synesthetes find their condition useful and would rather not be “cured.”

Common misconceptions:

- Many people strongly separate the ideas of “brain” and “mind,” and consider “brain” as something necessary for physical things, while “mind” is what thinks and creates emotion. All functions associated with “mind” are associated with activity in the brain. However, neural science is still very young and we are far from understanding what it is about “brain” that creates “mind” — nor how much “mind” can in turn affect the physical brain.
 - Many people have an “active eye” model of sight, in which light or some type of “vision rays” shoot out from the eye and return with an image of what is seen. Eyes work when light from the environment is reflected off of an object and enters our eyes.
 - Students often believe that humans can “see in the dark.” Even if one is put in a room that has absolutely no light, young students are sometimes convinced that it will just take longer to “get used” to the darkness.
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Eyes only see when there is light in the environment. “Getting used” to “dark” as we often experience it is in reality the eye adjusting to very low levels of light. Few of us have experienced absolute darkness.

- Young students may also have an “active ear” model of hearing, believing that hearing is the result of active listening or paying attention. Ears receive auditory signals all the time. Whether we perceive these depends on our attentiveness.

Reading notes:

- Draw and label the parts of a neuron, and note the function of the parts.
- Define “action potential” and state how it works.
- Define “synapse” and explain what happens at the synapse.
- Read “Drugs, Diseases, and Neurotransmitters” and summarize the connection between neurotransmitters and addictive drugs.
- Distinguish between convergence and divergence of neural signals.
- Explain how a reflex arc works.
- Distinguish between: central and peripheral nervous systems; brain and spinal cord; motor and sensory neurons; somatic and autonomic nervous systems; sympathetic and parasympathetic divisions.
- State the main functions of these brain parts: medulla, pons, cerebellum, midbrain, limbic system, thalamus, hippocampus, cerebral cortex.
- State which parts of the cerebral cortex are involved in visual processing, auditory processing, other sensory processing, memory, speech, motor functions, and higher intellectual functions.
- Summarize the “right brain, left brain” functions, and state why these are simplified interpretations.
- State which parts of the brain seem to be involved in creating memories.
- Explain what parts of the ear are necessary for perceiving sound, and how they work.
- Explain what parts of the eye are necessary for perceiving light, and how they work.
- Explain how chemoreception works in the tongue and the nose, and why both areas of chemoreception are necessary to produce “flavor.”
- Explain how pain, heat, cold, and touch are perceived.
- List some other senses that other animals have that humans do not have.
- Describe what synaesthesia is.

Useful websites:

- “Eye” <http://www.kscience.co.uk/animations/eye.htm> is an animation showing how the eye functions, including the rod cells.
 - “Synapse” <http://www.kscience.co.uk/animations/synapse.htm> is a simplified model of a synaptic gap, with or without drugs.
 - “Action Potential” <http://outreach.mcb.harvard.edu/animations/actionpotential.swf> is a detailed interactive animation that explains how ion channels and active transport are involved in sending neural signals.
 - “Hearing” <http://www.physpharm.fmd.uwo.ca/undergrad/medsweb/L4Aud/m4aud.swf> explains the functions of the ear.
 - “Sense of Taste” http://www.wisc-online.com/objects/index_tj.asp?objID=AP14104 explains how taste buds on the tongue function.
 - “Sense of Smell” http://www.wisc-online.com/objects/index_tj.asp?objID=AP14004 explains how sensory receptors in the nose work, and what smells have to do with emotion.
 - “Touch Receptors” <http://www.physpharm.fmd.uwo.ca/undergrad/sensesweb/L7Touch/L7Touch.swf> is an animation that explains how our sense of touch works.
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