

The Brain: Biological Basis of Behavior

Part II: Neurophysiology—Chemical Events at the Synapse

OBJECTIVES/RATIONALE

Each structure and each chemical produced and used by the brain has a specific function. Disease may cause alteration in the functions of the brain. An understanding of the chemical events occurring at a synapse is fundamental to biological psychology. The student will identify the neurotransmitters and name disorders that can result when there is neurotransmitter dysfunction.

TEKS: 121.26 (c) 1B

TAKS ELA 1
Science 1, 2

KEY POINTS

POWER POINT

- I. Neurons – nerve cells that make up the brain and peripheral nerves
 - A. communicate with each other at **synapses**
 - i. synapse is a functional (not physical) contact between two neurons
 - B. about 100 billion neurons in human brain
 - i. each neuron has about 10,000 synaptic contacts with other neurons
- II. Parts of a Neuron
 - A. **cell body** or **soma** (*soma* – from Greek root meaning *body*)
 - i. contains nucleus (DNA) of the cell
 - ii. soma constitutes “receiving” surface of the neuron (along with dendrites)
 - iii. if a soma is damaged, a neuron will not recover
 - B. **dendrites** (term comes from Greek root work meaning *tree*)
 - i. multiple branches come off the soma
 - ii. branches receive nerve impulses from other neurons
 - iii. dendrite branching is influenced by environment during development, both pre and post natal
 - 1. the more branches, the more receiving sites for a neuron
 - 2. dendrites are few and sparsely branched in certain conditions such as Downs Syndrome and Fetal Alcohol Syndrome
 - 3. lab animals who have received stimulation as infants show more dendritic branching
 - C. **axon** (term comes from Greek word meaning *axis*)
 - i. single fiber that is thicker and longer than dendrites
 - ii. axon may have many branches at its end
 - iii. axons may be very short (1 micron) to very long (1 meter) depending on their destinations in the nervous system
 - iv. damaged neuron may show sprouting of new terminals to fill in spaces vacated by damaged axons
 - v. mature neurons may not have an axon
 - 1. can only convey information to adjacent neurons
 - vi. axon terminals in brain continuously reorganized themselves over life span
 - 1. learning and memory may be represented by these reorganizations

D. myelin sheath

- i. the lipid and protein sheath surrounding the axon
- ii. purpose is to insulate neuron
- iii. the more heavily myelinated the neuron, the faster the electrical impulse can travel down the axon to other neurons
- iv. Multiple Sclerosis (MS) condition where myelin of brain and spinal cord degenerate
 1. nerve impulses unable to travel smoothly and efficiently

III. The Synapse

A. a dynamic region between neurons consisting of:

- i. axon terminal (carries electrical impulses away from soma)
- ii. synaptic cleft (a space between terminal axon and receiving neuron)
- iii. dendrite (or adjacent neuron body) *Remember, both soma and dendrites constitute the receiving surface of a neuron.

IV. The Chemical Messengers: Neurotransmitters

- A. chemicals (hormones) that are made in soma and stored in small synaptic vesicles (“packages”) at the tip to the axon
- B. as electrical impulse travels from soma to axon, neurotransmitters are released into synapse
- C. neurotransmitters stick to receptor proteins in neighboring dendrite and trigger nerve impulse that travels down dendrite, across soma, down axon, etc.
- D. our behavior is consequence of millions of cells “talking” to each other via these electrochemical processes

V. Inactivation of Neurotransmitters

A. action of neurotransmitters can be stopped by four different mechanisms:

- i. **diffusion** – neurotransmitter drifts away out of synaptic cleft where it can no longer act on a receptor
- ii. **enzyme deactivation** – specific enzyme changes structure of neurotransmitter so it is not recognized by receptor
- iii. **glia cells** – astrocytes remove neurotransmitters from synaptic cleft
- iv. **reuptake** – whole neurotransmitter molecule is taken back into axon terminal that released it
 1. this is a common way that action of neurotransmitters norepinephrine, dopamine, and serotonin are stopped

VI. Some of the Better Known Neurotransmitters

A. Acetylcholine (ACh)

- i. contributes to movement, learning, memory processes, and REM sleep
- ii. only transmitter between motor neurons and voluntary muscles
- iii. EXCESS: muscle paralysis or convulsions, sometimes death
- iv. DEFICIT: memory impairment (Alzheimer’s disease)

B. Dopamine (DA)

- i. used by neurons that control voluntary movements
- ii. also used by neurons that are important for learning, attention, thought, and emotion
- iii. EXCESS: irrational thought, delusion, and/or hallucinations (Schizophrenia)
- iv. DEFICIT: tremors, muscular rigidity (Parkinson’s disease)

C. Serotonin and Norepinephrine

- i. serotonin plays prominent role in regulation of mood, sleep, impulsivity, aggression, and appetite
- ii. norepinephrine plays role in eating, sleep, and mood
- iii. lower level of activity in serotonin and norepinephrine is related to depression
- iv. DEFICIT in serotonin may lead to increased aggressive behavior and suicide
- v. some antidepressant drugs act to block reuptake of serotonin or norepinephrine

- D. Gamma-Aminobutyric Acid (GABA)
 - i. Appears to have inhibitory effects at synapses
 - ii. contributes to regulation of anxiety
 - iii. lower levels of activity related to anxiety
 - iv. anti-anxiety drugs (tranquilizers such as Valium) facilitate GABA synapses and thereby reduce anxiety
 - v. abnormality in GABA neurons may cause epilepsy
- E. Endorphins (“endogenous morphine”)
 - i. opiate-like substances produced in the body
 - ii. provide relief from pain and produce feelings of pleasure and well-being
 - iii. drugs such as opium, morphine, and heroin bind with receptors for endorphins
 - iv. endorphins may explain “runners-high” experienced by long-distance runners

ACTIVITIES

- I. View video *The Brain Body Connection*.
- II. Create clay model of a synapse. (See POWER POINT guidelines.)

MATERIALS NEEDED

Presentation Rubric

Films for the Humanities & Sciences, *Psychology & Mental Health*, 800-257-5126, www.films.com - *The Brain-Body Connection*, #DPM10589 (wonderful video source)

<http://www.csuchico.edu/psy/BioPsych/neurotransmission.html> - overview of entire process of neurotransmission with explanations of all components involved; great page for starting out!

<http://serendip.brynmawr.edu/bb/> - awesome site for interactive online brain games

<http://www.williams.edu:803/imput/> - excellent site describing the four steps in synaptic transmission; supporting movie clips (requires *QuickTime* 3.0 or greater)

<http://salmon.psy.plym.ac.uk/year1/neurotr.htm#overview> - on-line study and learning materials from University of Plymouth’s Department of Psychology; includes Loewi’s experiment on vagal nerve stimulation and electron microscope pictures of synapses

http://serendip.brynmawr.edu/gen_beh/ - Genes, Brains, Behavior: A Work in Progress (worth a visit)

<http://faculty.washington.edu/chudler/introb.html> - “Must see” brain and spinal cord site—Includes pronunciation of neuro terms, divisions of brain, functions, and gender differences.

An Anthropologist on Mars, Oliver Sacks, ISBN # 0-679-75697-3 (short stories on real-life case histories of patients with neurological disorders; this is a great read and a good resource for enrichment activities.) Another good book by Oliver Sacks: *The Man Who Mistook His Wife For A Hat and Other Clinical Tales*, ISBN 0-684-85394-9 (Both available on www.amazon.com)

ASSESSMENT

Successful completion of the Presentation Rubric.

ACCOMMODATIONS

For reinforcement, the student will read an assigned chapter from *An Anthropologist on Mars*.

For enrichment, the student will present his/her clinical case from *An Anthropologist on Mars*.

REFLECTIONS

Presentation Assessment Rubric

Student: _____

Date: _____

Title of Clinical Case: _____

Scoring Criteria	5	4	3	2
	Excellent	Good	Needs Improvement	Poorly Prepared
Clearly and effectively communicates introduction of presentation.				
Clearly and effectively communicates content throughout presentation.				
Integrated a variety of multi-media resources to create a professional presentation.				
Presentation holds audience attention and relates a clear message.				
Timing between slides is appropriate for viewer to read content.				
Each image and font size is legible for entire audience.				

Scale:

- 26-30 A Excellent
- 21-25 B Good
- 16-20 C Needs Improvement
- 15 or below Poorly Prepared

Total = _____