Invitation to Psychology 7th edition Wade Solutions Manual

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Chapter 2 *Neurons, Hormones, and the Brain*

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I. THE NERVOUS SYSTEM: A BASIC BLUEPRINT

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- *Activity 2.1 - Building a Robot*
- *REVEL Multimedia*
- *MyPsychLab Multimedia*

Learning Objective 2.1.A - Describe the primary functions of the central nervous system, and name its two main structures.

A. The central nervous system
  1. Functions--receives, processes, interprets, and stores incoming information; sends out messages to muscles, glands, internal organs
  2. Parts--brain and spinal cord (an extension of the brain)

Learning Objective 2.1.B - List the major structures and major divisions of the peripheral nervous system, and describe their primary functions.

B. The peripheral nervous system--nervous system outside brain and spinal cord
  1. Functions
     a. Sensory nerves--bring input from skin, muscles, and organs
     b. Motor nerves--carry output to muscles, glands, and organs
  2. Divisions
     a. Somatic nervous system
        (1) Nerves connected to sensory receptors
        (2) Nerves connected to skeletal muscles--voluntary action
     b. Autonomic nervous system--works automatically
        (1) Functions--regulates blood vessels, glands, organs
        (2) Divisions
           (a) Sympathetic--mobilizes the body for action
           (b) Parasympathetic--enables body to conserve and store energy

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II. COMMUNICATION IN THE NERVOUS SYSTEM

- *Lecture Launcher 2.2 - Neurotransmitters: Chemical Communicators of the Nervous System*
- *Lecture Launcher 2.3 - Exceptions to the Rules*
- *Lecture Launcher 2.4 - The Glue of Life: Neuroglial Cells*
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- *Activity 2.2 - Using Dominoes to Understand the Action Potential*
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- *Activity 2.7 - Reaction Time and Neural Processing*

- *REVEL Multimedia*
- *MyPsychLab Multimedia*

Learning Objective 2.2.A - Compare the functions of neurons and glial cells.

A. Types of cells
   1. Glial cells--hold neurons in place, nourish, insulate neurons
   2. Neurons--cells that communicate to, from, or within the CNS

Learning Objective 2.2.B - Describe each of the three main parts of a neuron, and explain their functions.

B. The structure of the neuron
   1. Dendrites--receive messages from other neurons, transmit to cell body
   2. Cell body--keeps the neuron alive, determines whether to fire
   3. Axon--transmits messages away from cell body to other neurons
      a. Ends in branches or axon terminals
      b. Many axons are insulated by fatty material called a *myelin sheath*
      c. Bundles of axons in the peripheral nervous system form nerves

Learning Objective 2.2.C - Explain how stem cells contribute to the process of neurogenesis.

C. Neurogenesis
   1. Discovery of neurogenesis has reshaped the thinking of many brain scientists
   2. Stem cell research offers an abundance of promising avenues

Learning Objective 2.2.D - Outline the process by which neurons communicate with each other, and explain the basic functions of the synapse, action potential, synaptic vesicles, and neurotransmitters.

D. How neurons communicate
   1. Synapse = axon terminal + synaptic cleft (small space between one axon and next dendrite) + covering membrane of receiving dendrite or cell body
      a. Many thousands of neurons may communicate at a synapse
      b. Synaptic connections continue to change throughout life
   2. How neurons communicate
      a. Wave of electric voltage, called action potential, moves down axon to end of axon terminal, called synaptic end bulb
      b. Action potentials travel more rapidly in myelinated axons than in unmyelinated axons
      c. Synaptic end bulb releases chemical neurotransmitters (transmitters) which have been stored in synaptic vesicles (sacs in the end bulb)
      d. Transmitters cross the synaptic cleft and briefly lock onto receptor sites on the receiving dendrites
      e. They can increase or decrease the likelihood that the receiving neuron will generate an action potential
      f. Receiving neuron averages the excitatory and inhibitory incoming messages to determine if it reaches firing threshold
      g. Neurons either fire or do not fire (all or none); the strength of firing does not vary

Learning Objective 2.2.E - Summarize the effects of some of the main neurotransmitters in the brain, and list four hormones that influence behavior.

E. Chemical messengers in the nervous system
   1. Neurotransmitters: Versatile couriers
      a. Many have been identified, more are being found
      b. Neurotransmitters exist throughout the body
      c. Better understood neurotransmitters and some of their effects
         (1) *Serotonin*--sleep, mood, eating
         (2) *Dopamine*--movement, learning, memory, emotion [pleasure]
         (3) *Acetylcholine*--muscle action, memory, emotion
         (4) *Norepinephrine*--heart rate, learning, memory

(5) *GABA*--major inhibitory neurotransmitter in the brain
(6) Glutamate—major excitatory neurotransmitter
d. Levels that are too high or too low may produce problems
(1) Low levels of serotonin and norepinephrine associated with depression
(2) Abnormal GABA levels associated with sleep and eating disorders and convulsive disorders
(3) Loss of cells that produce acetylcholine associated with Alzheimer's disease
e. Each neurotransmitter plays many roles and functions overlap
f. Cause and effect between neurotransmitters and behavior unclear
2. Hormones: Long-distance messengers
a. Substances produced in one part of the body but affect another
b. Originate primarily in endocrine glands that release hormones into the bloodstream, which carries them to other organs and cells
c. A chemical may act as either a neurotransmitter or a hormone, depending where it is located
d. Hormones of particular interest to psychologists
(1) *Melatonin*--secreted by the pineal gland, regulates biological rhythms
(2) *Oxytocin*--secreted by the pituitary gland
(3) *Adrenal hormones*
(a) Involved in stress and emotional responses
(b) Produced by the adrenal glands
(c) Cortisol, epinephrine, and norepinephrine are produced and activate the sympathetic nervous system and enhance memory
(4) *Sex hormones*--three major types; all three types occur in both sexes
(a) *Androgens* (e.g., testosterone)--masculinizing, influence sexual arousal in both sexes
(b) *Estrogen*--feminizing, influence menstrual cycle, may contribute to improved learning and memory
(c) *Progesterone*--maintenance of uterine lining
3. Neuromodulators: The brain's volume control
a. Endorphins are endogenous opioid peptides
b. Produce effects similar to natural opiates; reduce pain, promote pleasure, as well as playing a role in other functions
c. Most act as neuromodulators--influence actions of neurotransmitters
d. Work by binding to receptors in brain
e. Levels increase during stress or fear response
f. Release of endorphins may also be linked to the pleasures of social contact

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III. MAPPING THE BRAIN

- *Lecture Launcher 2.6 - Psychophysiological Measurement*
- *Lecture Launcher 2.7 - Berger's Wave*
- *Lecture Launcher 2.8 - Lie Detectors 2.0*

- *REVEL Multimedia*
- *MyPsychLab Multimedia*

Learning Objective 2.3.A - Describe three techniques researchers use for manipulating the brain and observing the behavior that results.

A. Manipulating the brain and observing behavior
1. Researchers study the brains of those who have experienced disease or injury
2. Lesion method involves damaging or removing section of brain in animals and then observing the effects
3. Transcranial magnetic stimulation (TMS) – brain cells are manipulated through the

application of a large electrical current
4. Transcranial direct current stimulation (tDCS) applies a very small current to stimulate or suppress activity in the cortex

Learning Objective 2.3.B - Describe five techniques researchers use for manipulating behavior and observing the effects on the brain.

B. Manipulating behavior and observing the brain
   1. Electroencephalogram (EEG) involves brain wave recording; not very specific
   2. Event-related potentials (ERPs) isolate neural activity associated with a specific stimulus
   3. Positron-Emission Tomography (PET)
      a. Records biochemical changes in the brain as they occur
      b. Utilizes a radioactive glucose-like substance
      c. Used to diagnose abnormalities or to learn about normal brain activity
   4. Magnetic Resonance Imaging (MRI) uses magnetic fields and radio frequencies
   5. Functional Magnetic Resonance Imaging (fMRI) allows a glimpse at brain activity as it occurs
   6. Have caution: Imaging the brain and thinking critically about brain structure and function need to go hand in hand, so to speak

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IV. A TOUR THROUGH THE BRAIN

- *Lecture Launcher 2.9 - Handedness, Eyedness, Footedness, Facedness*
- *Lecture Launcher 2.10 -* Brain Metaphors
- *Lecture Launcher 2.11- Brain's Bilingual Broca*
- *Lecture Launcher 2.12 - The Importance of a Wrinkled Cortex*
- *Lecture Launcher 2.13 - A New Look at Phineas Gage*
- *Lecture Launcher 2.14- Freak Accidents and Brain Injuries*

- *Activity 2.8 - Football and Brain Damage*

- *REVEL Multimedia*
- *MyPsychLab Multimedia*

Learning Objective 2.4.A - List and describe three main structures in the brain stem, explain the primary functions each structure performs, and discuss the processes controlled by the cerebellum.

A. The brain stem--located at base of skull; old part of brain
   1. *Pons*--involved in sleeping, waking, and dreaming
   2. *Medulla*--regulates breathing and heart rate; automatic functions
   3. *Reticular activating system [RAS]*--network of neurons, extends upward and connects with higher brain areas; screens information, responsible for arousal and alertness

B. *Cerebellum*--regulates balance and coordination of movement; also involved in remembering certain skills and acquired reflexes

Learning Objective 2.4.B - Describe the structure, function, and location of the thalamus.

C. *Thalamus*--directs incoming sensory messages (except olfactory) to higher centers

Learning Objective 2.4.C - Describe the structure, function, and location of the hypothalamus and pituitary gland.

D. *Hypothalamus*--associated with drives, such as hunger, thirst, emotion, sex and reproduction, body temperature, and the autonomic nervous system

E. *Pituitary gland*--"master gland" governed by hypothalamus

Learning Objective 2.4.D - Describe the structure, function, and location of the amygdala.

F. *Amygdala*--evaluates sensory information to determine its importance, involved in mediating anxiety and depression

Learning Objective 2.4.E - Describe the structure, function, and location of the hippocampus.

G. *Hippocampus*--"gateway to memory" that enables us to form new memories

Learning Objective 2.4.F - Describe the structure of the cerebrum, and explain the function of the corpus callosum.

H. *Cerebrum*--responsible for higher forms of thinking--divided into two halves or cerebral hemispheres
   1. Connected by band of fibers called corpus callosum
   2. Right hemisphere in charge of left side of the body
   3. Left hemisphere in charge of right side of the body
   4. Lateralization--each hemisphere has somewhat different tasks and talents

Learning Objective 2.4.G - Sketch the location of each of the lobes of the cerebral cortex, and explain the major functions each lobe performs, with particular reference to the prefrontal cortex.

   5. Cerebrum is covered by layer of densely packed cells--*cerebral cortex*
      a. Grayish appearance = gray matter
         i Made up of cell bodies of nerve cells
         ii "White" matter beneath cortex is formed by myelinated axons
      b. Contains three-fourths of all cells in the brain
      c. Divided into four regions
         i *Occipital lobes*--contain the visual cortex
         ii *Parietal lobes*--contain somatosensory cortex, that receives information about pressure, pain, touch, and temperature from all over the body
         i *Temporal lobes*--contain auditory cortex
         ii *Frontal lobes*--contain the motor cortex; responsible for making plans, taking initiative, and thinking creatively
      e. *Prefrontal cortex* involved in personality
         i Case of Phineas Gage shows the outcomes of damage to the prefrontal cortex
         ii Involved in social judgment, rational decision making, and the ability to set goals and make and carry through plans
         iii Involved in determining the proper order of behaviors and knowing when to stop

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V. THE TWO HEMISPHERES OF THE BRAIN

- *Lecture Launcher 2.15 - The Results of a Hemispherectomy*
- *Lecture Launcher 2.16 - En Garde: Dualism versus Monism*

- *Activity 2.9 - Hemispheric Communication and the Split Brain*
- *Activity 2.10 - Hemispheric Lateralization*
- *Activity 2.11 - Left or Right?*

- *REVEL Multimedia*
- *MyPsychLab Multimedia*

Learning Objective 2.5.A - Discuss the basic format of a split-brain experiment and what such results reveal about the functioning of the cerebral hemispheres.

A. Split brains: A house divided
   1. *Corpus callosum*, which connects the cerebral hemispheres in normal brains, is severed
   2. This surgery has been performed in animal studies and for some human conditions such as severe epilepsy
   3. Effects
      a. Split-brain patients are able to lead normal lives
      b. Effects on perception and memory are observable under experimental conditions
   4. The work of Sperry and colleagues is described

Learning Objective 2.5.B - Describe why the two hemispheres of the brain are allies rather than opposites.

B. The two hemispheres: Allies or opposites?
   1. Left hemisphere handles language for nearly all right-handed people and a majority of left-handers
   2. Left side more active than right during some logical, symbolic, and sequential tasks, such as math
   3. Many researchers believe the left side is dominant because cognitive skills, including rational and analytic abilities, originate here
   4. Others point to abilities of the right hemisphere: superior visual-spatial abilities, facial recognition, appreciation of art and music; some researchers claim it is holistic and intuitive
   5. In real life, the two hemispheres cooperate automatically in most activities

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VI. THE FLEXIBLE BRAIN

➢ *REVEL Multimedia*
➢ *MyPsychLab Multimedia*

Learning Objective 2.6.A - Define neural plasticity, and summarize some of the main evidence that the brain has the ability to change in response to new experiences.

A. Experience and the brain
   1. Accumulating evidence for neural plasticity gives cause for rethinking some old tenets of brain research
      a. The brain is a dynamic organ, rather than a static storehouse of information
      b. Experiences and environments can modify the brain
      c. Applications to rehabilitation of all sorts look promising

Learning Objective 2.6.B - Discuss the relationship between cultural forces and brain function.

B. Culture and the brain
   1. Cultural neuroscience examines the links between culture and brain functioning
      a. Bilingualism and literacy provide examples

Learning Objective 2.6.C - Summarize cautions surrounding the conclusion that sex differences in the brain are linked to sex differences in behavior.

C. Are there “his” and “her” brains?
   1. Efforts to identify male-female differences have reflected biases of the times
   2. Two questions must be asked:
      a. *Are male and female brains physically different?*
         i Sex differences have been found in animal brains
         ii Human sex differences are more elusive
            - Many changing findings, many contradictory findings
            - Many different conclusions drawn

  - Both right and left hemisphere areas are activated during a rhyming task in women; only left hemisphere areas are activated in men--evidence of a possible sex difference in lateralization

b. If there are brain differences, what do they mean for the behavior of women and men in real life?
   i Many supposed sex differences are stereotypes
   ii Brain differences do not necessarily produce behavioral differences
   iii Brain differences do not account for behavior differences across situations
   iv Sex differences in the brain could be the result rather than the cause of behavioral differences
   v Replicate, replicate, replicate!

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▼Learning Objectives

LO 2.1.A - Describe the primary functions of the central nervous system, and name its two main structures.

LO 2.1.B - List the major structures and major divisions of the peripheral nervous system, and describe their primary functions.

LO 2.2.A - Compare the functions of neurons and glial cells.

LO 2.2.B - Describe each of the three main parts of a neuron, and explain their functions.

LO 2.2.C - Explain how stem cells contribute to the process of neurogenesis.

LO 2.2.D - Outline the process by which neurons communicate with each other, and explain the basic functions of the synapse, action potential, synaptic vesicles, and neurotransmitters.

LO 2.2.E - Summarize the effects of some of the main neurotransmitters in the brain, and list four hormones that influence behavior.

LO 2.3.A - Describe three techniques researchers use for manipulating the brain and observing the behavior that results.

LO 2.3.B - Describe five techniques researchers use for manipulating behavior and observing the effects on the brain.

LO 2.4.A - List and describe three main structures in the brain stem, explain the primary functions each structure performs, and discuss the processes controlled by the cerebellum.

LO 2.4.B - Describe the structure, function, and location of the thalamus.

LO 2.4.C - Describe the structure, function, and location of the hypothalamus and pituitary gland.

LO 2.4.D - Describe the structure, function, and location of the amygdala.

LO 2.4.E - Describe the structure, function, and location of the hippocampus.

LO 2.4.F - Describe the structure of the cerebrum, and explain the function of the corpus callosum.

LO 2.4.G - Sketch the location of each of the lobes of the cerebral cortex, and explain the major functions each lobe performs, with particular reference to the prefrontal cortex.

LO 2.5.A - Discuss the basic format of a split-brain experiment and what such results reveal about the functioning of the cerebral hemispheres.

LO 2.5.B - Describe why the two hemispheres of the brain are allies rather than opposites.

LO 2.6.A - Define neural plasticity, and summarize some of the main evidence that the brain has the ability to change in response to new experiences.

LO 2.6.B - Discuss the relationship between cultural forces and brain function.

LO 2.6.C - Summarize cautions surrounding the conclusion that sex differences in the brain are linked to sex differences in behavior.

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►Rapid Review

Chapter 2 discusses the brain and nervous system. The central nervous system, composed of the brain and spinal cord, receives incoming messages from the senses, processes that information, and sends messages to the muscles and organs. The nerves in the rest of the body make up the peripheral nervous system. This system, in turn, is composed of the somatic nervous system, which regulates sensation and voluntary actions, and the autonomic nervous system, which regulates glands, internal organs, and blood vessels. The autonomic nervous system is composed of the sympathetic nervous system, which mobilizes the body for action, and the parasympathetic nervous system, which conserves energy. The nervous system is made up of neurons; the key components of neurons are dendrites, the cell body, and an axon, which ends in axon terminals. A neural message goes from dendrites to axon via an electrical impulse, and neurons communicate with other neurons through chemicals called neurotransmitters that are released into synapses. A variety of methods for mapping the brain, such as EEG, tDCS, TMS, PET, MRI, and fMRI, are discussed. Different brain structures and their functions are explained, along with general issues about how the brain processes information. Research on split-brain patients, who have had the corpus callosum severed, provides insight into hemispheric specialization. Discussion of some challenging issues—how experience shapes the brain, the link between culture and brain functioning, and whether men and women have substantially different types of brains—reveals myths and truths on these subjects.

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▼LECTURE LAUNCHERS AND DISCUSSION TOPICS

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Lecture Launcher 2.1 - The Cranial Nerves

The textbook discusses various divisions of the nervous system. You may want to add a description of the cranial nerves to your outline of the nervous system. Although the function of the cranial nerves is not different from that of the sensory and motor nerves in the spinal cord, they do not enter and leave the brain through the spinal cord. There are 12 cranial nerves (numbered 1 to 12 and ordered from the front to the back of the brain) that primarily transmit sensory information and control motor movements of the face and head. The 12 cranial nerves are:

1. *Olfactory*. A sensory nerve that transmits odor information from the olfactory receptors to the brain.

2. *Optic*. A sensory nerve that transmits information from the retina to the brain.

3. *Oculomotor*. A motor nerve that controls eye movements, the iris (and therefore pupil size), lens accommodation, and tear production.

4. *Trochlear*. A motor nerve that is also involved in controlling eye movements.

5. *Trigeminal*. A sensory and motor nerve that conveys somatosensory information from receptors in the face and head and controls muscles involved in chewing.

6. *Abducens*. Another motor nerve involved in controlling eye movements.

7. *Facial*. Conveys sensory information and controls motor and parasympathetic functions associated with facial muscles, taste, and the salivary glands.

8. *Auditory-vestibular*. A sensory nerve with two branches, one of which transmits information from the auditory receptors in the cochlea and the other conveys information concerning balance from the vestibular receptors in the inner ear.

9. *Glossopharyngeal*. This nerve conveys sensory information and controls motor and parasympathetic functions associated with the taste receptors, throat muscles, and salivary glands.

10. *Vagus*. Primarily transmits sensory information and controls autonomic functions of the internal organs in the thoracic and abdominal cavities.

11. *Spinal accessory*. A motor nerve that controls head and neck muscles.

12. *Hypoglossal*. A motor nerve that controls tongue and neck muscles.

As is their custom, medical students have developed several mnemonics for memorizing the cranial nerves. Some of the family-friendly ones include:

On Old Olympus' Tiny Tops, A Friendly Viking Grew Vines And Hops
Oh Once One Takes The Anatomy Final Very Good Vacations Are Heavenly
One Of Our Two Timing Adults Found Very Good Values At Home
On Occasion Our Trusty Truck Acts Funny. Very Good Vehicle Any How
Orlando's Overweight Octopuses Try To Avoid Fuddrucker's And Grabbing Vienna Sausage Hamburgers
On Our Overseas Trip To Argentina Found Very Grand Villas And Huts

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Lecture Launchers 2.2 - Neurotransmitters: Chemical Communicators of the Nervous System

In 1921, Otto Loewi put two living hearts in a fluid bath that kept them beating. He stimulated the vagus nerve of one of the hearts. This is a bundle of neurons that serves the parasympathetic nervous system and causes a reduction in the heart's rate of beating. A substance was released by the nerve of the first heart and was transported through the fluid to the second heart. The second heart reduced its rate of beating. The substance released from the vagus nerve of the first heart was later identified as *acetylcholine*, one of the first neurotransmitters to be identified. Although many other neurotransmitters have now been identified, we continue to think of acetylcholine as one of the most important neurotransmitters. For example, curare is a poison that was discovered by South American Indians, who put it on the tips of the darts they shoot from their blowguns. Curare blocks acetylcholine receptors, and paralysis of internal organs results. The victim is unable to breathe and eventually dies. As another example, a substance in the venom of black widow spiders stimulates release of acetylcholine at synapses. More commonly, botulism toxin, found in improperly canned foods, blocks release of acetylcholine at the synapses and has a deadly effect. It takes less than one millionth of a gram of this toxin to kill a person. Finally, a deficit of acetylcholine is associated with Alzheimer's disease, which afflicts a high percentage of older adults.

Many neurotransmitters have been identified in the years since 1921, and there is increasing evidence of their importance in human behavior. Psychoactive drugs affect consciousness because of their effects on synaptic transmission. For example, cocaine and the amphetamines prolong the action of certain neurotransmitters and opiates imitate the action of natural neuromodulators called endorphins. It appears that the neurotransmitters dopamine, norepinephrine, and serotonin are associated with some of the most severe forms of mental illness.

Loewi, O. (1921). Über humorale übertragbarkeit der herznervenwirkung. [About humoral transmissibility of the heart nervous system] *Pflüger's Archiv für die gesamte Physiologie des Menschen und der Tiere*, [Pflüger's Archive for the Whole Physiology of Man and Animals], *189*(1), 239-242.
Loewi, O. (1960). An autobiographic sketch. *Perspectives in Biology and Medicine*, *4*(1), 3-25.

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Lecture Launcher 2.3 - Exceptions to the Rules

In an introductory psychology class, students learn the basic rules that generally govern neuronal communication. In many cases, however, the exceptions to these rules may be as important as the rules themselves. Several of these exceptions are described below.

Rule #1: Neuron to neuron signaling is chemical, not electrical.
Exception: Gap junctions

Although it is generally the case that a neuron's electrical signal must first be converted to a chemical signal in order excite or inhibit another neuron, this is not always the case. Some neurons have gap junctions, which connect their intracellular fluids. This means that the electrical signal can flow directly from one neuron to another. Unlike chemical synapses, most electrical synapses formed by gap junctions are bi-directional, meaning that electrical signals can travel in both directions through the gap junctions. Gap junctions also contain gates, which can be closed to prevent the electrical signal from being passed to the neighboring neuron.

Rule #2: Axons always synapse on dendrites.
Exception: Axo-axonic and axosomatic synapses

Axons can form synapses on all parts of a postsynaptic neuron. Synapses located on the soma (i.e., cell body) of a neuron are often inhibitory. In other words, transmitters released at these axosomatic synapses make it harder for the postsynaptic neuron to reach the threshold for generating an action potential. When an axon synapses on the axon of another neuron, it is called an axo-axonic synapse. Because these synapses usually occur near the end of the axon, they have no effect on whether the post synaptic cell generates an axon potential or not. Instead, axo-axonic synapses usually modulate how much neurotransmitter is released from the postsynaptic neuron.

Rule #3: Action potentials only travel in one direction.
Exception: Back-propagating action potentials

Action potentials begin at the axon hillock, where the axon emerges from the soma. From there, the action potential travels down the axon, and away from the soma. At the same time however, a back-propagating action potential can travel from the axon hillock, through the soma, and into the dendrites. Back-propagating action potentials are thought to affect the functioning of receptors located in the soma and dendrites.

Kandel, E., Schwartz, J., & Jessell, T. (2012). *Principles of neural science* (5th ed.). New York, NY: McGraw-Hill.

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Lecture Launcher 2.4 - The Glue of Life: Neuroglial Cells

Glia is derived from the Greek word for glue and is an appropriate name for the cells that surround all neurons, sealing them together. Glial cells outnumber neurons ten to one, and, although tiny in size, still make up half of the brain's bulk. Unlike neurons, glia do not possess excitable membranes and so cannot transmit information in the way neurons do. Yet so many thousands of cells must be there for some purpose.

Researchers studying the brain have suggested that glia can take up, manufacture, and release chemical transmitters, and so may help to maintain or regulate synaptic transmission. Other researchers suggest that glia can manufacture and possibly transmit other kinds of molecules, such as proteins. The anatomy of some glial cells is striking in this regard, for they seem to form a conduit between blood vessels and neurons, and so may bring nourishment to the neurons. It is thought that these cells may have important functions during prenatal development and recovery from brain injury. One role of the glia is known definitely: certain kinds of glia, called by the tongue-twisting name of *oligodendroglia,* form the myelin sheath that insulates central nervous system axons and speeds conduction of the nerve impulse. A counterpart called a Schwann cell performs the same role for the neurons that make up peripheral nerves.

The study of glia is difficult because these tiny cells are inextricably entwined with neurons. As the most numerous type of cell in the brain, their potential importance is vast, and investigation of their function seems likely to yield exciting results in the near future.

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Lecture Launcher 2.5 - Hormone Imbalances

Various problems are caused by imbalances within the endocrine system. The following disorders and medical problems are associated with abnormal levels within the pituitary, thyroid, and adrenal glands.

<u>Pituitary malfunctions</u>

Hypopituitary Dwarfism
If the pituitary secretes too little of its growth hormone during childhood, the person will be very small, although normally proportioned.

Giantism
If the pituitary gland over-secretes the growth hormone while a child is still in the growth period, the long bones of the body in the legs and other areas grow very, very long—a height of 9 feet is not unheard of. The organs of the body also increase in size, and the person may have health problems associated with both the extreme height and the organ size.

Acromegaly
If the over-secretion of the growth hormone happens after the major growth period is ended, the person's long bones will not get longer, but the bones in the face, hands, and feet will increase in size, producing abnormally large hands, feet, and facial bone structure. The famous wrestler/actor, Andre the Giant (Andre Rousimoff), had this condition, as did the great actor Rondo Hatton.

<u>Thyroid malfunctions</u>

Hypothyroidism
In hypothyroidism, the thyroid does not secrete enough thyroxin, resulting in a slower than normal metabolism. The person with this condition will feel sluggish and lethargic, have little energy, and tend to be obese.

Hyperthyroidism
In hyperthyroidism, the thyroid secretes too much thyroxin, resulting in an overly active metabolism. This person will be thin, nervous, tense, and excitable. He or she will also be able to eat large quantities of food without gaining weight (oh, if only we came equipped with thyroid control knobs!).

<u>Adrenal Gland Malfunctions</u>

Among the disorders that can result from malfunctioning of the adrenal glands are Addison's Disease (which is caused by adrenal insufficiency) and Cushing's Syndrome (caused by elevated levels of cortisol). In the former, fatigue, low blood pressure, weight loss, nausea, diarrhea, and muscle weakness are some of the symptoms, whereas for the latter, obesity, high blood pressure, a "moon" face, and poor healing of skin wounds is common. John F. Kennedy, Helen Reddy, and (perhaps) Osama bin Laden were well-known Addisonians.

If there is a problem with over-secretion of the sex hormones in the adrenals, virilism and premature puberty are possible problems. Virilism results in women with beards on their faces and men with exceptionally low, deep voices. Premature puberty, or full sexual development while still a child, is a result of too many sex hormones during childhood. (Puberty is considered premature if it occurs before the age of 8 in girls and 9 in boys.) Treatment is possible using hormones to control the appearance of symptoms, but must begin early in the disorder.

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Lecture Launcher 2.6 - Psychophysiological Measurement

There are various strategies for measuring activity in the brain, especially recently developed techniques such as PET, TMS, or MRI. There are, of course, other bodily systems and other techniques for measuring them, many of which rely on the electrophysical activity of the body.

■ *EMG—Electromyography*. An electromyogram records the action potential given off by contracting muscle fibers. A common example is the recording of facial EMG, in which either inserted electrodes or surface electrodes record the activity of muscles as they pose various expressions.

■ *EGG—Electrogastrography*. Electrogastrograms provide a record of smooth muscle activity in the abdomen. The contractions of the stomach or intestines, for example, can be measured by comparing the readings from a surface electrode attached to the abdomen with those of an electrode attached to the forearm. In the special case of measuring contractions in the esophagus, surface electrodes are attached to a balloon, which is "swallowed" by the person being measured. EGG may be used successfully to gain information about fear, anxiety, or other emotional states.

■ *EOG—Electrooculography*. Readings from electrodes placed around the posterior of the eyes are the basis for EOG. Electrical signals result from small saccadic eye movements as well as more gross movements that can be directly observed. EOG can be used for measuring rapid eye movements during sleep.

■ *EKG—Electrocardiography*. EKG records changes in electrical potential associated with the heartbeat. Electrodes are placed at various locations on the body, and their recordings yield five waves that can be analyzed: P-waves, Q-waves, R-waves, S-waves, and T-waves. EKG may be used by psychologists to supplement observations relevant to stress, heart disease, or Type A behavior patterns.

■ *EDA—Electrodermal activity*. Formerly called *galvanic skin response*, *skin resistance*, and *skin conductance*, EDA refers to the electrical activity of the skin. As activity in the sympathetic nervous system increases it causes the eccrine glands to produce sweat. This activity of the eccrine glands can be measured by EDA, regardless of whether or not sweat actually rises to the skin surface. The folklore of "sweaty palms" associated with a liar might be measured using this technique.

■ *EEG—Electroencephalography*. As discussed in the text, EEG provides information about the electrical activity of the brain, as recorded by surface electrodes attached to the scalp. EEG has been used in a variety of ways to gather information about brain activity under a wide range of circumstances.

■ *Pneumography*—Pneumographs measure the frequency and amplitude of breathing, and are obtained through a relatively straightforward procedure. A rubber tube placed around the chest expands and contracts in response to the person's inhalations and exhalations. These changes can then be recorded with either an ink pen or electrical signal.

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Lecture Launcher 2.7 - Berger's Wave

Ask if anyone knows what is meant by the term *Berger's wave*. Explain that the study of electrical activity in the brain was once limited to studies in which different kinds of measuring devices were attached to the exposed brains of animals. Studies involving humans were rare; researchers could only measure the electrical activity of the living human brain in individuals who had genetic defects of their skull bones that caused the skin of their scalps to be in direct contact with the surfaces of their brains. Yuck!

All this changed when a German physicist named Hans Berger, after several years of painstaking research, discovered that it was possible to amplify and measure the electrical activity of the brain by attaching special electrodes to the scalp which, in turn, sent impulses to a machine that graphed them. In his research, Berger discovered several types of waves, one of which he called the "alpha" wave for no other reason than being the first one he discovered ("alpha" is the first letter of the Greek alphabet). He kept his research a secret until he published an article about it in 1929. The alpha wave is also sometimes called *Berger's wave* in honor of Berger's discovery.

Obviously, Berger achieved one of the most important discoveries in the history of neuroscience. However, his life was not a happy one. Shortly after his article was published, the Nazis rose to power in Germany, which greatly distressed him. In addition, his work wasn't valued in Germany; he was far better known in the United States. As a result, Berger fell into a deep depression in 1941 and hanged himself.

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Lecture Launcher 2.8 - Lie Detectors 2.0

A staple of police and lawyer television shows is the "lie detector scene," in which the suspect is connected to a polygraph and asked a series of questions about a crime. As the questions are asked, the needles on the machine record the suspect's heart rate, breathing, skin conductance, and other physiological responses to the questions. Polygraphs have been used in this way by various law enforcement agencies for many years. The principle behind the test is that the act of lying causes an involuntary change in the autonomic nervous system, which can be detected by the polygraph. The accuracy of polygraphs, however, is controversial, and in many courts they are inadmissible evidence. More recently, some researchers have tried to create a new generation of lie detectors, which can measure activity in the brain directly. These techniques look for patterns in the brain that, at least in theory, correlate with lying.

One technique that might be adapted to lie detection is electroencephalography, more commonly referred to as EEG. During an EEG recording, electrodes are placed at various locations on the scalp. These electrodes are capable of measuring the electrical activity produced by neurons located in different parts of the brain. Although the activity of individual neurons cannot be identified, the patterns of electrical activity produced by thousands of neurons working together can be a sign that the brain is functioning in a particular way. One way EEGs may be useful as lie detectors is by identifying event-related potentials (ERPs). An ERP is a brief electrical change that occurs at a reliable time point relative to a specific event. For example, it has been found that 300 to 500 ms after a person has been shown something that is unexpected or novel, there is a brief electrical change in that person's EEG. Theoretically, this ERP could be used to determine if a subject has previous knowledge of a piece of evidence. For instance, an ERP occurring 300 ms after being shown a picture of the murder weapon might indicate that the suspect had not seen the murder weapon before.

More recently, fMRIs have been suggested as potential lie detectors. fMRI, or functional magnetic resonance imaging, works by detecting the increase in blood flow to more active regions in the brain. This is not to be confused with structural MRIs, which can only create an image of tissues, bones, and so on. When a person performs a task in an fMRI machine (adding two numbers together for example), the brain regions required to perform the task will become active. This activity will cause a change in blood flow, which the fMRI can detect. It is possible that, because different brain regions are involved in recounting an actual event than are involved in making up a story, an fMRI is capable of determining whether someone is lying or telling the truth. Some researchers have found that, even if a lie is well rehearsed, it nonetheless appears to activate different brain regions than telling the truth does.

Despite media interest in new forms of lie detection, many experts agree that the EEG and fMRI approaches currently suffer from the same issues that polygraphs do. For example, although the newer techniques measure brain activity much more directly, there is concern about their reliability. Although certain brain activity might suggest that a person is lying, unless the technology can be made almost 100% accurate, innocent people may be accused of crimes they did not commit. Also, it is unclear whether people could find ways to "trick" the machines by performing certain mental tasks during testing. Until these questions can be answered, it is unlikely that the polygraph will be replaced any time soon.

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Lecture Launcher 2.9 -
Handedness, Eyedness, Footedness, Facedness

Although the title sounds like a Dr. Seuss rhyme, it actually denotes something sensible to neuropsychologists. Most people are familiar with the concept of handedness. The human population is distributed across many people who are adept at using their right hands for most tasks, some who have greater skill using the left hand, and a smaller proportion of those who are equally skilled using either hand (or who alternate hands for certain tasks). The concepts of footedness, leggedness, eyedness, and facedness may be less familiar to the layperson, although they stem from the same principle as handedness.

The basis of these distinctions lies in the concept of laterality. Just as the cerebral hemispheres show specialization (e.g., left hemisphere language functions, right hemisphere visual–spatial functions), so too are there preferences or asymmetries in other body regions. The concept of eyedness, then, refers to the preference for using one eye over another, such as when squinting to site down the crosshairs of a rifle or to thread a needle. Footedness and leggedness similarly refer to a preference for one limb over the other; drummers and soccer players will attest to the importance of being equally adept at using either foot and to the difficulty in achieving that. Finally, facedness refers to the strength with which information is conveyed by the right or left side of the face. It has been suggested that verbal information shows a right-face bias, whereas emotional expressions are more strongly shown on the left side of the face, although these conclusions remain somewhat controversial.

Why are these distinctions useful? They play their largest role in the areas of sensation and perception, engineering psychology, and neuropsychology. Studies of reaction time, human–machine interaction, ergonomic design, and so on take into account the preferences and dominance of some body systems over others. In the case of facedness and emotional expression, researchers are working to illuminate the link between facial expressions and cerebral laterality. Given the right hemisphere's greater role in emotional activities, the contralateral control between the right hemisphere and the left hemiface becomes an important proving ground for investigating both brain functions and the qualities of expression.

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Lecture Launcher 2.10 - Brain Metaphors

Metaphors are a toolbox of handiness in psychology, because they help us to understand systems that aren't directly observable through reference to things that are more familiar and perhaps better understood (Weiner, 1991). Our understanding of the human brain and its activity has been helped through a reliance on metaphor. The metaphors used, however, have changed over time.

■ *Hydraulic models*. Thinkers such as Galen and Descartes described the brain as a pneumatic/hydraulic system, relying on the "new-fangled" plumbing systems dominant during their lifetimes. Galen, for example, believed that the liver generated "spirits" or gases that flowed to the brain, where they then formed "animal spirits" that flowed throughout the nervous system. Descartes expanded on this view, adding that the pineal gland (the supposed seat of the soul) acted on the animal spirits to direct reasoning and other behaviors. In short, the brain was a septic tank; storing, mixing, and directing the flow of spirit gases throughout the body for the purposes of behavior and action.

■ *Mechanical and telephone models*. With the advent of new technology came new metaphors for the brain. During the Industrial Revolution machine metaphors dominated, and in particular the brain was conceived as a complex mechanical apparatus involving (metaphorical) levers, gears, trip hammers, and pulleys. During the 1920s, the brain developed into a slightly more sophisticated machine resembling a switchboard; the new technology of the telephone provided a new metaphor. Inputs, patch cords, outputs, and busy signals (though no "call waiting") dominated explanations of brain activity. This metaphor, however, faltered by viewing the brain as a system that shut down periodically, as when no one was dialing a number. We now know, of course, that the brain is continually active.

■ *Computer models*. Starting in the late 1950's, metaphors for the brain relied on computer technology. Input, output, memory, storage, information processing, and circuitry were all terms that seemed equally suited to talking about computer chips or neurons. Although perhaps a better metaphor than plumbing or telephones, the computer model eventually showed its shortcomings. As a descriptive device, however, this metaphor can at least suggest limits in our understanding and point the way to profitable areas of research.

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Lecture Launcher 2.11 - Brain's Bilingual Broca

Se potete parlare Italiano, allore potete capire questa sentenza. Of course, if you only speak English, you probably only understand *this* sentence. If you speak both languages, then by this point in the paragraph you should be really bored.

Bilingual speakers who come to their bilingualism in different ways show different patterns of brain activity. Joy Hirsch (now at the Yale School of Medicine) and her colleagues at Memorial Sloan-Kettering Cancer Center in New York monitored the activity in Broca's area in the brains of bilingual speakers who acquired their second language starting in infancy and compared it to the activity of bilingual speakers who adopted a second language in their teens. Participants were asked to silently recite brief descriptions of an event from the previous day, first in one language and then in the other. An fMRI was taken during this task. All of the 12 adult speakers were equally fluent in both languages, used both languages equally often, and represented speakers of English, French, and Turkish, among other tongues.

Hirsch and her colleagues found that among the infancy-trained speakers, the same region of Broca's area was active, regardless of the language they used. Among the teenage-trained speakers, however, a different region of Broca's area was activated when using the acquired language. Similar results were found in Wernicke's area in both groups. Although the full meaning of these results is a matter of some debate (do they reflect sensitivity in Broca's area to language exposure or pronounced differences in adult versus childhood language learning?), they nonetheless reveal an intriguing link between la testa e le parole.

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Lecture Launcher 2.12 - The Importance of a Wrinkled Cortex

At the beginning of your lecture on the structure and function of the brain, ask students to explain why the cerebral cortex is wrinkled. There are always a few students who correctly answer that the wrinkled appearance of the cerebral cortex allows it to have a greater surface area while fitting in a relatively small space (i.e., the head). To demonstrate this point to your class, hold a plain, white sheet of paper in your hand and then crumple it into a small, wrinkled ball. Note that the paper retains the same surface area, yet is now much smaller and is able to fit into a much smaller space, such as your hand. You can then mention that the brain's actual surface area, if flattened out, would be roughly the size of a newspaper page. Laughs usually erupt when the class imagines what our heads would look like if we had to accommodate an unwrinkled, newspaper-sized cerebral cortex!

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Lecture Launcher 2.13 - A New Look at Phineas Gage

For over 30 years, Jack and Beverly Wilgus had a daguerreotype portrait—a type of early photograph—of a well-dressed young man with one eye closed. Because the photo showed the young man holding what appeared to be part of a harpoon, the Wilguses believed that the man was a 19th-century whaler who had lost his eye, perhaps in a whaling accident. It was only after a copy of the portrait was posted online that the couple was told that the object in the man's hands did not appear to be a harpoon. Then, in 2008, a person viewing the image online posted a comment that the young man may be Phineas Gage, making the "harpoon," the infamous tamping rod that was blasted through his skull and brain. By carefully examining the rod in the daguerreotype, and by comparing the young man's face to the cast made of Gage's head after his death, the Wilguses were able to confirm that the portrait is almost certainly that of Phineas Gage, made sometime after his accident. Importantly, this is the only known photograph of the man who became one of the most famous case studies in psychology.

One of the consequences of the portrait's discovery has been a renewed debate about how Gage's injuries affected his personality and behavior. Many psychology textbooks explain that the accident left Gage a permanently changed man following the accident, with his once well-balanced, gregarious, and hard-working personality replaced with profane, inconsiderate, and impulsive behavior for the rest of his life. This, however, is not necessarily supported by the few original sources researchers have to go on. For example, although the evidence clearly indicates that Gage had major psychological changes for a period after his accident, we also know that Gage later spent many years driving stagecoaches before he died in 1860, 12 years after the accident. Many have questioned whether the post-accident Phineas Gage commonly described in introductory psychology classes could have performed the tasks required to drive a stagecoach, interact with passengers, and be reliable enough to maintain employment for long periods at a time. Does this indicate that many of the psychological changes Gage suffered were temporary? Certainly the newly discovered daguerreotype of a healthy-looking and well-kept Phineas Gage lends further support to the idea that Phineas was able to largely recover from his accident, both physically and mentally. If true, this may mean that the case of Phineas Gage may be as much a story about the incredible plasticity of the brain and its ability to compensate for the loss of specific brain regions, as it is about the localization of specific functions.

The newly discovered portrait of Phineas Gage can be found at: brightbytes.com/phineasgage or by searching the Internet for "Phineas Gage daguerreotype."

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Lecture Launcher 2.14 - Freak Accidents and Brain Injuries

Students may be interested in the unusual cases of individuals who experience bizarre brain injuries due to freak accidents with nail guns. The most fascinating example involved Isidro Mejias, a construction worker in Southern California, who had six nails driven into his head when he fell from a roof onto his coworker who was using a nail gun. (X-ray images of the embedded nails can be found at several sites on the Internet.) Incredibly, none of the nails caused serious damage to Mejia's brain. One nail lodged near his spinal cord, and another came very close to his brain stem. Immediate surgery and treatment with antibiotics prevented deadly infections that could have been caused by the nails. In a similar accident, a construction worker in Colorado ended up with a nail lodged in his head due to a nail gun mishap. Unlike Mejia, Patrick Lawler didn't realize he had a nail in his head for six days. The nail was discovered when he visited a dentist due to a "toothache." It appears that Lawler fired a nail into the roof of his mouth. The nail barely missed his brain and the back of his eye.

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Lecture Launcher 2.15 - The Results of a Hemispherectomy

When Matthew was 6 years old, surgeons removed half of his brain.

His first three years of life were completely normal. Just before he turned 4, however, Matthew began to experience seizures, which did not respond to drug treatment. The seizures were both life threatening and frequent (as often as every 3 minutes). The eventual diagnosis was Rasmussen's encephalitis, a rare and incurable condition of unknown origin.

The surgery, a hemispherectomy, was performed at Johns Hopkins Hospital in Baltimore. A few dozen such operations are performed each year in the United States, usually as a treatment for Rasmussen's and for forms of epilepsy that destroy the cortex but do not cross the corpus callosum. After surgeons removed Matthew's left hemisphere, the empty space quickly filled with cerebrospinal fluid.

The surgery left a scar that runs along one ear and disappears under his hair; however, his face has no lopsidedness. The only other visible effects of the operation are a slight limp and limited use of his right arm and hand. Matthew has no right peripheral vision in either eye. He undergoes weekly speech and language therapy sessions. For example, a therapist displays cards that might say "fast things" and Matt must name as many fast things as he can in 20 seconds. He does not offer as many examples as other children his age. However, he is making progress in the use of language, perhaps as a result of fostering and accelerating the growth of dendrites.

The case of Matthew indicates the brain's remarkable plasticity. Furthermore, it is interesting to note that Matt's personality never changed through the seizures and surgery.

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find more hemispherectomy stories and information at: http://hemifoundation.intuitwebsites.com/

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Lecture Launcher 2.16 - En Garde! Dualism versus Monism

Rene Descartes certainly didn't lack for credentials. As the "Father of Rationalism," "Father of Modern Philosophy," (father of Francine, by the way), and originator of Cartesian geometry, he had more than enough interests to fill his spare time. But his role as "Father of Skepticism" helped popularize a major change in thinking about the nature of human experience. Dualism, or the doctrine that mind and body are of two distinct natures, is one of the key philosophical problems inherited by psychology. In both philosophy and psychology there have been several attempts to reconcile the mind and body.

On the dualism side of the argument, *psychophysical parallelism* and *psychophysical interactionism* have been advanced as explanations for the workings of mind and body. Parallelism has it that mental and physical events are independent of one another but occur simultaneously. Philosophers such as Leibnitz, for example, held that the activities of the mind and body were predetermined, and that both simply ran their course in a carefully orchestrated, synchronized, yet independent fashion. Interactionists, on the other hand, hold that mental and physical events are related in a causal way, such that the mind can influence the body and vice-versa. Descartes championed this idea with his notion that humans are "pilots in a ship;" mental beings who guide physical bodies through the world. Both psychophysical parallelism and psychophysical interactionism agree that the mind and body are of two different natures, and disagree over how closely those natures may interact.

Monists, by comparison, argue that there is one nature to things, although they disagree about whether it is primarily mental or primarily physical. *Subjective idealism* (or "mentalism," as it is often called), argues that there is only the mental world, and that the reality of the physical world is suspect. George Berkeley, for example, provided numerous arguments as to why the essence of existence is to be perceived; when not in direct perception the physical world cannot support the claim of its existence. (Berkeley, by the way, apparently hated walks in the forest, for fear of all those falling trees that he may or may not have heard.) In contrast, *materialistic monism* takes the position that there is only physical "stuff" to the world, such that ideas, thoughts, and images are actually physical events in the body. Many modern biological scientists would agree with this form of monism, arguing that the brain is primary while the "mind" is either illusory or epiphenomenal.

Add to this mix a handful of specialty doctrines and you've got quite an argument. But why all the fuss? As research on mind and behavior grows to embrace evidence gathered in the neurosciences, what once was a stuffy philosophical issue takes on a new importance. Many thinkers, especially those in the materialist camp, would claim that we are closer and closer to identifying the neural connections and chemical actions that produce our experience of "an idea." Fueled by the boom in neural network modeling, the notion that the circuitry of the brain can be mapped to identify where thoughts, images, memories, creativity, and similar "mental activities" originate seems more like science and less like science fiction. Whether dualism will be completely resolved to everyone's satisfaction seems doubtful, but biopsychologists and neuropsychologists continue to contribute data to address this philosophical puzzle.

Wegner, D. M., & Gray, K. (2016). *The mind club: Who thinks, what feels, and why it matters.* New York: Penguin.

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▼CLASSROOM ACTIVITIES, DEMONSTRATIONS, AND EXERCISES

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Activity 2.1 - Building a Robot

In this activity students apply their knowledge about the brain and nervous system to the design of a robot with human capabilities. The handout for this exercise is included as **Handout Master 2.1**.

This is an opportunity for students to be creative. Answers should be evaluated for thoughtfulness and understanding of concepts in the chapter, rather than for specific details. The answers below are not the only ones possible.

1. A list including all the functions the robot would need to perform exactly like a human being would be impossible to compose; it would have to contain entries such as “chew gum,” “roller skate,” and “drive a car.” Also, some functions are components of others (e.g., “turn on ignition” is a component of “drive a car”).

2. The autonomic nervous system might be less important for a robot, because a robot would probably not need most of the internal organs regulated by that system (the bladder, heart, stomach, etc.). The autonomic nervous system also regulates emotional “ups and downs.” Perhaps the robot can do without emotions.

3. If the robot’s energy system is simpler than that of humans (it might, for example, run on rechargeable batteries), it would not need brain mechanisms to control such functions as respiration, digestion, elimination, cardiovascular functions, and sleep. Perhaps the analogs of the medulla and pons could be smaller in the robot. Also, since the robot will not need to eat, drink, or have sex, the area devoted to functions of the hypothalamus can be smaller.

4. The reticular activating system would be important because the robot must be able to monitor environmental stimuli and make decisions concerning what is relevant to its ongoing behavior. The cerebellum would be important because the robot needs coordination and balance. (It might be easier to build a robot that has four legs or wheels than one with two legs.) The hippocampus would be important because the memory function is essential in a robot. The cerebrum would be important because the robot would need many megabytes of memory to be able to adapt its behavior to an endless variety of situations, would need to be able to learn from its interactions with the environment, and would need to make judgments, plans, and decisions. However, perhaps the size of the cerebrum, where memories are stored, can be reduced somewhat by editing the contents of memory periodically. There is probably no need for a robot to remember old telephone numbers or jingles from TV commercials.

5. We still do not fully understand the neural and biochemical basis of perception and cognition, and even with miniaturized computer circuits, we do not yet have the technology to build a human-like nervous system that could fit into a human-sized robot body. Also, the sheer complexity of the human nervous system exceeds that of any existing computer system.

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Activity 2.2 - Using Dominoes to Understand the Action Potential

Walter Wagor suggests using real dominoes to demonstrate the so-called "domino effect" of the action potential as it travels along the axon. For this demonstration, you'll need a smooth table-top surface (at least 5 feet long) and one or two sets of dominoes. Set up the dominoes beforehand, on their ends and about an inch apart, so that you can push the first one over and cause the rest to fall in sequence. Proceed to knock down the first domino in the row and students should clearly see how the "action potential" is passed along the entire length of the axon. You can then point out the concept of refractory period by showing that, no matter how hard you push on the first domino, you will not be able to repeat the domino effect until you take the time to set the dominoes back up (i.e., the resetting time for the dominoes is analogous to the refractory period for neurons). You can then demonstrate the all-or-none characteristic of the axon by resetting the dominoes and by pushing so lightly on the first domino that it does not fall. Just as the force on the first domino has to be strong enough to knock it down before the rest of the dominoes will fall, the action potential must be there in order to perpetuate itself along the entire axon. Finally, you can demonstrate the advantage of the myelin sheath in axonal transmission. For this demonstration, you'll need to set up two rows of dominoes (approximately 3 or 4 feet long) next to each other. The second row of dominoes should have foot-long sticks (e.g., plastic rulers) placed end-to-end in sequence on top of the dominoes. By placing the all-domino row and the stick-domino row parallel to each other and pushing the first domino in each, you can demonstrate how much faster the action potential can travel if it can jump from node to node rather than having to be passed on sequentially, single domino by single domino. Ask your students to discuss how this effect relates to myelinization.

Wagor, W. F. (1990). Using dominoes to help explain the action potential. In V. P. Makosky, C. C. Sileo, L. G. Whittemore, C. P. Landry, & M. L. Skutley (Eds.), *Activities handbook for the teaching of psychology: Vol. 3* (pp. 72-73). Washington, DC: American Psychological Association.

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Activity 2.3 - Stemming the Tide of Misinformation

Although there's a lot of promise in stem cell research, it comes with a lot of controversy as well. Consider these statements from various political figures over the years:

"While we must devote enormous energy to conquering disease, it is equally important that we pay attention to the moral concerns raised by the new frontier of human embryo stem cell research. Even the most noble ends do not justify any means."

GEORGE W. BUSH, speech, Aug. 9, 2001

"I think we can do ethically guided embryonic stem cell research. We have 100,000 to 200,000 embryos that are frozen in nitrogen today from fertility clinics. These weren't taken from abortion or something like that. They're from a fertility clinic, and they're either going to be destroyed or left frozen. And I believe if we have the option, which scientists tell us we do, of curing Parkinson's, curing diabetes, curing, you know, some kind of a ... you know, paraplegic or quadriplegic or, you know, a spinal cord injury — anything — that's the nature of the human spirit. I think it is respecting life to reach for that cure."

JOHN KERRY, presidential debate, Oct. 8, 2004

"The best that can be said about embryonic stem cell research is that it is scientific exploration into the potential benefits of killing human beings."

TOM DeLAY, *Washington Post,* May 25, 2005

"I am pro-life. I believe human life begins at conception. I also believe that embryonic stem cell research should be encouraged and supported."

BILL FRIST, speech, Jul. 29, 2005

"I'm very grateful that President Obama has lifted the restrictions on federal funding for embryonic stem cell research."

NANCY REAGAN, commentary, March 8, 2009

"The majority of Americans - from across the political spectrum, and of all backgrounds and beliefs - have come to a consensus that we should pursue this research. That the potential it offers is great, and with proper guidelines and strict oversight, the perils can be avoided."

BARACK OBAMA, executive order, March 9, 2009

Unfortunately, there's also a lot of misinformation about stem cells and stem cell research…in fact, one might question the scientific credentials of Mr. DeLay, whose noteworthy accomplishments (apart from a chequered political career) include running a pest control business and competing on *Dancing With the Stars*.

Encourage your students to examine the evidence and decide for themselves. Ask them to prepare a brief report on some aspect of stem cell research -- it's current legal status in the United States and worldwide; options for gathering stem cells; potential cures indicated by the current scientific evidence, and so on. You might ask different groups of students to tackle different issues, or ask all students to investigate a small set of issues. Similarly, you might structure this as a brief discussion exercise, or you might want to stage it as a more formal debate. There are many possible ways to implement this exercise. The important underlying aspect, however, is to get students to think critically and discuss openly the facts associated with stem cell research.

http://stemcells.nih.gov/research/pages/current.aspxhttp://www.tellmeaboutstemcells.org/
http://www.stemcells.com/view/0/index.html
http://www.physorg.com/news172072614.html
http://www.wilsoncenter.org/index.cfm?event_id=161696&fuseaction=topics.event_summary&topic_id=116811
http://www.biotech.ucdavis.edu/TBCWebsites/TBC07/StemCells&TissueEngineering/Li-MiraLoma/Biotech%20Website%20Design/index.html
http://www.notable-quotes.com/s/stem_cells_quotes.html

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Activity 2.4 - Environmental Influences on the Brain

You might want to remind students that brain function and structure are subject to environmental influences. Ask students to identify the behaviors that are important for keeping the brain healthy and functioning well. The following are some possibilities:

Good nutrition, especially during childhood Adequate nutrition is vital for proper brain development. Even in adults, diet may influence brain function. Studies are showing that although high levels of cholesterol may be bad for your heart, low levels of cholesterol may be bad for the brain. Low cholesterol may be associated with low levels of the neurotransmitter serotonin, that can result in higher levels of aggression and depression.

Mental stimulation High levels of stimulation help to form neural connections that in turn enhance brain function.

Physical fitness Studies have shown that aerobic fitness has an impact on the density of capillaries in the brain. More capillaries result in greater blood flow to the brain.

Maternal health during pregnancy The uterine environment can have an enormous impact on the brain development of a fetus. Women who do not have adequate nutrition, or drink, smoke, or do drugs, and who are exposed to certain environmental toxins are more likely to have children with lower IQs and learning disabilities.

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Activity 2.5 - Demonstrating Neural Conduction: The Class as a Neural Network

In this engaging exercise (suggested by Paul Rozin and John Jonides), students in the class simulate a neural network and get a valuable lesson in the speed of neural transmission. Depending on your class size, arrange 15 to 40 students so that each person can place his or her right hand on the right shoulder of the person in front of them. Note that students in every other row will have to face backwards in order to form a snaking chain so that all students (playing the role of individual neurons) are connected to each other. Explain to students that their task as a neural network is to send a neural impulse from one end of the room to the other. The first student in the chain will squeeze the shoulder of the next person, who, upon receiving this "message," will deliver (i.e., "fire") a squeeze to the next person's shoulder and so on, until the last person receives the message. Before starting the neural impulse, ask students (as "neurons") to label their parts; they typically have no trouble stating that their arms are axons, their fingers are axon terminals, and their shoulders are dendrites.

To start the conduction, the instructor should start the timer on a stopwatch while simultaneously squeezing the shoulder of the first student. The instructor should then keep time as the neural impulse travels around the room, stopping the timer when the last student/neuron yells out "stop." This process should be repeated once or twice until the time required to send the message stabilizes (i.e., students will be much slower the first time around as they adjust to the task). Next, explain to students that you want them to again send a neural impulse, but this time you want them to use their ankles as dendrites. That is, each student will "fire" by squeezing the ankle of the person in front of them. While students are busy shifting themselves into position for this exercise, ask them if they expect transmission by ankle-squeezing to be faster or slower than transmission by shoulder-squeezing. Most students will immediately recognize that the ankle-squeezing will take longer because of the greater distance the message (from the ankle as opposed to the shoulder) has to travel to reach the brain. Repeat this transmission once or twice and verify that it indeed takes longer than the shoulder squeeze.

This exercise -- a student favorite -- is highly recommended because it is a great ice-breaker during the first few weeks of the semester, and it also makes the somewhat dry subject of neural processing come alive.

Rozin, P., & Jonides, J. (1977). Mass reaction time measurement of the speed of the nerve impulse and the duration of mental processes in class. *Teaching of Psychology, 4*, 91-94.

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Activity 2.6 - The Dollar Bill Drop

After engaging in the neural network exercise, follow it up with the "dollar bill drop" (Fisher, 1979), which not only delights students but also clearly illustrates the speed of neural transmission. Ask students to get into pairs and to come up with one crisp, flat, one-dollar bill (or something larger, if they trust their fellow classmates!) between them. First, each member of the pair should take turns trying to catch the dollar bill with their nondominant (for most people, the left) hand as they drop it from their dominant (typically right) hand. To do this, they should hold the bill vertically so that the top, center of the bill is held by the thumb and middle finger of their dominant hand. Next, they should place the thumb and middle finger of their nondominant hand around the dead center of the bill, as close as they can get without touching it. When students drop the note from one hand, they should be able to easily catch it with the other before it falls to the ground.

Now that students are thoroughly unimpressed, ask them to replicate the drop, only this time one person should try to catch the bill (i.e., with the thumb and middle finger of the nondominant hand) while the other person drops it (i.e., from the top center of the bill). Student "droppers" are instructed to release the bill without warning, and "catchers" are warned not to grab before the bill is dropped. (Students should take turns playing dropper and catcher). There will be stunned looks all around as dollar bills whiz to the ground. Ask students to explain why it is so much harder to catch it from someone other than themselves. Most will instantly understand that when catching from ourselves, the brain can simultaneously signal us to release and catch the bill, but when trying to catch it from someone else, the signal to catch the bill can't be sent until the eyes (which see the drop) signal the brain to do so, which is unfortunately a little too late.

Fisher, J. (1979). *Body magic*. Briarcliff Manor, NY: Stein and Day.

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Activity 2.7 - Reaction Time and Neural Processing

Yet another exercise that illustrates the speed of neural processing is suggested by E. Rae Harcum. The point made by this simple but effective exercise is that reaction times increase as more response choices become available (i.e., because more difficult choices in responses involve more neuronal paths and more synapses, both of which slow neural transmission). Depending on your class size, recruit two equal groups of students (10 to 20 per group is ideal) and have each group stand together at the front of the room. First, explain that all subjects are to respond as quickly as possible to the name of a U.S. president. Then give written instructions to each group so that neither group knows the instructions given to the other. One group should be instructed to raise their right hands if the president served before Abraham Lincoln and to raise their left hands if the president served after Lincoln. The other group should be instructed simply to raise their left hands when they hear a president's name. Ask participants and audience members to note which group reacts more quickly. When all students are poised and ready to go (i.e., hands level with shoulders and ready to raise), say "Ready" and then "Reagan." The group with the simpler reaction time task should be faster than the group whose task requires a choice.

Harcum, E. R. (1988). Reaction time as a behavioral demonstration of neural mechanisms for a large introductory psychology class. *Teaching of Psychology, 4*, 208-209.

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Activity 2.8 - Football and Brain Damage

Coaches and medical experts have known for a while that the severe hits that football players take on the field can lead to concussions, blacking out, and even permanent damage. More recently, however, there has been increasing concern that the effects of repeated hits to the head may not manifest themselves until decades later. Early studies suggest that former NFL players suffer high rates of memory and other cognitive problems years after retiring, and that they also may develop these problems earlier than non-football players do. NFL players may also be vulnerable to higher rates of depression and Alzheimer's disease.

To investigate this problem, groups like the Sports Legacy Institute have begun to encourage former NFL players to donate their brains to science when they die. Already, the brains of a handful of players have been examined, with shocking results. Almost all of the brains show high levels of a protein called *tau,* which is suspected of being involved in several neurodegenerative disorders, including Alzheimer's disease. The presence of high levels of tau may explain why football players have a tendency to develop cognitive impairments long after their playing days are over. More disturbing still, high levels of tau have also been found in the brain of an 18 year-old high school football player who died.

After introducing students to this issue, have the class discuss the possible implications for social and sports policy. Should football playing be stopped? Should the rules of the game be changed to eliminate hard hitting? If necessary, pose the following additional questions to stimulate discussion: Everyone knows football is dangerous, but does the fact that these cognitive impairments may take decades to develop make them somehow different? Is the risk of permanent cognitive disability somehow different than the risk of permanent physical disability? Wrestlers, soccer players, boxers, and other types of athletes are also at risk for long term brain damage. Should these sports be changed of banned?

After discussing the issue in class, have students respond to the following writing prompt.

Writing Prompt: Describe a longitudinal and then a cross-sectional study that could be used to determine if professional football players show higher than normal rates of cognitive impairment. Explain some of the advantages and disadvantages of the two designs.

Sample answer: *A longitudinal study might choose a few football players and then test them every 10 years using the same cognitive tests to see how their abilities change over time. A cross-sectional study, on the other hand, might find a group of 65 year old retired football players and compare their cognitive functioning to 65-year-olds who did not play football. The longitudinal study would provide a more complete view of how cognitive function might decline, but would take decades to complete, and may suffer from attrition. The cross-sectional study would be a lot easier to perform, but would only offer a "snap-shot" of cognitive function. You could not tell, for example, if football players develop cognitive impairment earlier than non-football players typically do.*

Miller, G. (2009). A late hit for pro football players. *Science, 7*, 670–672.

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Activity 2.9 - Hemispheric Communication and the Split Brain

Even after reading the textbook and listening to your lecture, many students may have difficulty conceptualizing the effects of a split-brain operation on an individual's behavior. Morris (1991) described five activities designed to simulate the behavior of split-brain patients. All of the activities have the same basic setup. You will need to solicit two right-handed volunteers and seat them next to each other at a table, preferably in the same chair. The volunteer on the left represents the left hemisphere, and the other student is the right hemisphere. The students are instructed to place their outer hand behind their back and their inner hands on the table with their hands crossed, representing the right and left hands of the split-brain patient. Finally, the student representing the right hemisphere is instructed to remain silent for the remainder of the activity. In one of the activities described by Morris, both students are blindfolded and a familiar object (Morris suggested a retractable ball-point pen) is placed in the left hand of the "split-brain patient" (the hand associated with the right hemisphere). Then ask the "right hemisphere" student if he or she can identify the object, reminding him or her that they must do so nonverbally. Next, ask the "right hemisphere" to try to communicate, without using language, what the object is to the "left hemisphere." Your more creative volunteers may engage in behaviors that attempt to communicate what the object is through sound or touch. If your "right hemisphere" has difficulty in figuring out how to communicate, ask the class for suggestions. This demonstration can be used to elicit discussion about why only the "left hemisphere" student can talk, the laterality of the different senses, and how split-brain patients are able to adjust their behavior to accommodate. You should refer to Morris's original article for descriptions of the other activities.

Morris, E. J. (1991). Classroom demonstration of behavioral effects of the split-brain operation. *Teaching of Psychology, 18*, 226-228.

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Activity 2.10 - Hemispheric Lateralization

Hemispheric lateralization results in eyedness, handedness, footedness, earedness, facedness, and other silly-sounding words with important implications (see the related Lecture Launcher in this chapter). Lateralization results from the specialization of each hemisphere for different tasks, such as reading facial expressions, speaking, solving spatial problems, or performing analytic tasks. Although neuropsychologists use sophisticated measures to determine these lateralization, this simple exercise allows students to gauge their own brain organization.

With both eyes open, have students hold up their right thumbs at arm's length under an object across the room directly in front of them. As they alternately close their left and right eyes, their thumbs should appear to jump to the right or to the left with respect to the distant object. For those who are right-eyed, their thumbs should jump to the right when they close their right eyes, but stay as is when they close their left eyes. The opposite pattern should occur among those who are left-eyed. Students who see little or no jumping are among the 41% of the population who are neither strongly left-eyed nor right-eyed.

As a second test, ask for a volunteer. Present the student with the first paragraph of this exercise (or any suitable short passage) to memorize, a broom, a clock with a second hand, a pencil, and a pad of paper. First, time how long the volunteer can balance the broom on the tip of his or her right index finger while standing on the right foot. Next, measure the time as the volunteer balances the broom on his or her left index finger while standing on the left foot. Finally, repeat these tests while the volunteer recites the memorized passage. Speech will be localized on the side of the brain opposite the hand that is most disrupted by the memorization task.

Another demonstration, suggested by Morton Ann Gernsbacher, requires students to move their right hand and right foot simultaneously in a clockwise direction for a few seconds. Next ask that the right hand and left foot be moved in a clockwise direction. Then, have students make circular movements in opposite directions with right the hand and the left foot. Finally, have students attempt to move the right hand and right foot in opposite directions. This generally produces laughter as students discover that this procedure is most difficult to do even though they are sure – before they try it – that it would be no problem to perform. A simple alternative activity is to ask students to pat their heads and to rub their stomachs clockwise and then switch to a counterclockwise motion. The pat will show slight signs of rotation as well.

The brain is lateralized to some extent, and this makes some activities difficult to perform. Challenge your students to explain why activities of these types are difficult to execute. This will generally lead to interesting discussions and the assertion by some students that this type of behavior is no problem. Generally students who have been trained in martial arts, dance and/or gymnastics have less difficulty completing these activities due to their rigorous physical training.

Haseltine, E. (1999, June). Brain works: Your better half. *Discover,* 112.
Kemble, E. D. (1987). Cerebral lateralization. In V. P. Makosky, L. G. Whittemore, and A. M. Rogers (Eds.). *Activities handbook for the teaching of psychology* (Vol. 2) (pp. 33–36). Washington, D.C.: American Psychological Association.
Kemble, E. D., Filipi, T., & Gravlin, L. (1985). Some simple classroom experiments on cerebral lateralization. *Teaching of Psychology, 12*, 81–83.

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Activity 2.11 - Left or Right?

In this exercise, students determine which hemisphere of the brain is functioning during a child's responses to a complex test. The handout for this exercise is included as **Handout Master 2.2**. Suggested answers are as follows: 1-Both, 2-Left, 3-Right, 4-Left.

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▼ HANDOUT MASTERS

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Handout Master 2.1 — Building a Robot

Imagine that you are part of a scientific team studying the feasibility of building a robot that can pass for human. Other team members are responsible for the hair and skin, the muscles and joints, an energy system, and various internal works. Your task is to design the nervous system.

1. One approach might be to start by listing all the functions the robot would have to perform to behave like a human being. What's wrong with this approach?

2. Which subdivision of the human nervous system would be less important for a robot than for a human being, and why? Hint: Think of Mr. Spock from *Star Trek*.

3. Assume that the robot's brain will have all the same parts that a human being's brain does (the pons, cerebellum, hippocampus, etc.). Which parts might you make smaller to save space because they are less important for a robot than for a person? Explain.

4. Which brain parts do you think would be especially important for a robot, and why?

5. What might be particularly problematic about trying to design a robot with a human-like brain and nervous system?

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Handout Master 2.2 Left or Right?

The cerebrum is divided into two integrated cerebral hemispheres. Messages are freely and instantly exchanged between these two areas across a structure known as the corpus callosum. In a sense, the hemispheres receive information about the world in duplicate: information within the right hemisphere is immediately flashed to a corresponding area in the left and vice versa. However, the two hemispheres are not identical twins. While information is duplicated, it may not be processed in the same way. Each hemisphere controls the opposite side of the body and has its own specialized functions. In the examples below, identify whether the abilities being measured are related to the functioning of the right hemisphere, the left hemisphere, or both.

1. A nine-year-old with several problems, but who is thought to be gifted, has been referred for testing by his teacher. One portion of the test assesses his ability to read and apply detailed instructions regarding geometrical forms, for example, "Put the red trapezoid inside the blue hexagon under the orange parabola." To the delight of his teacher, he performs these tasks perfectly.

2. Another portion of the test taken by this child requires him to read simple sentences aloud. This proves exceedingly difficult for the child; the words are garbled and typically stated in an improper sequence.

3. A third portion of the test requires the child to remember and reproduce sequences of photographs after they are scrambled. There are four sets of photographs, each set containing five pictures of a person posed identically except for facial expression. The child performs perfectly.

4. The last portion of the test assesses manual dexterity in the nondominant arm and hand. Because the boy is left-handed, he is required to perform all sorts of mechanical tasks with his right hand. He fails this part of the test miserably, not completing a single task.

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Interactive: Central Nervous System
Interactive: Divisions of the Nervous System
Interactive: Mapping the Brain
Interactive: An Event-Related Potential
Interactive: Scanning the Brain
Interactive: Emotional Faces and the Amygdala
Interactive: Divided View
Interactive: Right-Brained / Left-Brained
Interactive: Getting Connected
Interactive: Sex Differences in the Brain?

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Thinking Critically Journal Writing Prompts 2.1 – 2.6

Shared Writing Prompt: Let's assume that you would like to find a way to improve your brain and cognitive functioning. Of the potential methods described above—cognitive training, physical exercise, medication, neurostimulation—which one would you choose and why? Defend your answer.

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▼MyPsychLab Multimedia Resources

MyPsychLab features a variety of content to enhance your course. To access these resources, go to www.MyPsychLab.com, and select **Videos**, **Simulations**, or **Writing Space**.

Chapter 2 Videos

Video: The Basics: How the Brain Works, Part 1 (5:04)
Find out about neurons: their parts, how they communicate, and their function in the brain.

Video: The Basics: How the Brain Works, Part 2 (6:11)
Find out about the nervous system: how it's divided and processes information, the significance of each brain structure, and how neuronal transmission works.

Video: The Big Picture: My Brain Made Me Do It. (4:59)
Learn about the function of different parts of the nervous system and how it integrates multiple signals to create experience.

Video: In the Real World: Neurotransmitters (3:10)
Learn about the neurotransmitter dopamine and what happens when there is an imbalance of dopamine as a result of natural causes or drugs.

Video: Special Topics: The Plastic Brain (7:04)
Learn specifics about how the human brain grows and develops throughout the lifespan and how the brain can remarkably repair itself or compensate after being damaged.

Video: Thinking Like a Psychologist: The Pre-Frontal Cortex (3:28)
See how certain areas of the brain contribute to different behaviors, and how both biological and environmental factors can lead a person to become a violent criminal later in life.

Video: What's In It For Me? Your Brain on Drugs (3:51)
Neurotransmitter imbalances can occur from chemicals that we willingly ingest, such as drugs or alcohol.

Chapter 2 Simulations

Simulation: Hemispheric Specialization
Judge whether a string of letters in your peripheral vision is a real word and test whether language functions are lateralized in the brain.

Survey: Do You Fly or Fight?
Participate in a survey to discover if you flee or fight under stressful conditions.

Writing Space

Writing Practice prompts within Writing Space offer immediate automated feedback. Each student submission receives feedback based on the following characteristics: Development of Ideas, Organization, Conventions, Voice, Focus and Coherence. Instructors can provide additional feedback and can adjust the auto-generated grade.

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▼Practice Quizzes and *Test Yourself* Answer Keys

Quiz for Module 2.1

1. d; 2. b; 3. a; 4. c; 5. c.

Quiz for Module 2.2

1. b; 2. d; 3. d; 4. d; 5. a.

Quiz for Module 2.3

1. a; 2. d; 3. a; 4. b; 5. d.

Quiz for Module 2.4

1. c; 2. d; 3. a; 4. d; 5. a.

Quiz for Module 2.5

1. a; 2. d; 3. a; 4. b; 5. b.

Quiz for Module 2.6

1. b; 2. a; 3. d; 4. b; 5. d.

Chapter 2 Quiz

1. d; 2. b; 3. d; 4. a; 5. c; 6. a; 7. b; 8. a; 9. c; 10. a;
11. c; 12. a; 13. d; 14. c; 15. a; 16. d; 17. c; 18. b; 19. a; 20. d.

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