2/ THE BIOLOGICAL PERSPECTIVE

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LECTURE GUIDE

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2.1 What are the nervous system, neurons, and nerves, and how do they relate to one another? (text p. 42)
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  - The brain is made up of two types of cells, neurons and glial cells.
  - Neurons have dendrites, which receive input, a soma or cell body, and axons, which carry the neural message to other cells.
  - Glial cells separate, support, and insulate the neurons from each other and make up 90% of the brain.
  - Myelin insulates and protects the axons of neurons that travel in the body.
  - These axons bundle together in "cables" called nerves. Myelin also speeds up the neural message.
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  - A neuron contains charged particles called ions. When at rest, the neuron is negatively charged on the inside and positively charged on the outside (the resting potential). When stimulated, this reverses the charge by allowing positive sodium ions to enter the cell. The action potential is the sequence of electrical charges moving down the cell.
  - Neurons fire in an all-or-nothing manner. It is the speed and number of neurons firing that tells researchers the strength of the stimulus.

2.2 How do the neurons use neurotransmitters to communicate with each other and with the body? (text p. 47)

- Sending the Message to Other Cells: The Synapse
  - Synaptic vesicles in the end of the axon terminal release neurotransmitter chemicals in to the synapse, or gap, between one cell and the next.
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- The Spinal Cord
  - The spinal cord serves two functions: the outer part of the cord transmits messages to and from the brain, while the inner part controls life-saving reflexes such as the pain response.
  - Spinal cord reflexes involve sensory neurons, interneurons, and motor neurons, forming a simple reflex arc.
  - Great strides are being made in spinal cord repair and the growth of new neurons in the central nervous system.
  - The central nervous system consists of the brain and the spinal cord.

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- The Autonomic Nervous System
  - The autonomic nervous system consists of the parasympathetic division and the sympathetic division.
  - The sympathetic division is our fight-or-flight system, reacting to stress.
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  - Hormones are secreted directly into the bloodstream, influencing the activity of the muscles and organs.
- The Pituitary Gland
  - The pituitary gland is found in the brain just below the hypothalamus. It has two parts, the anterior and the posterior.
  - It controls the levels of salt and water in our system and, in women, the onset of labour and lactation.
  - It also controls the secreting of growth hormones and influences the activity of the other glands.
- The Pineal Gland
  - The pineal gland is located near the back of the brain.
  - It secretes the hormone melatonin, which regulates the sleep-wake cycle.
- The Thyroid Gland
  - The thyroid gland is located inside the neck and controls metabolism (the burning of energy) by secreting thyroxin.
- The Pancreas
  - The pancreas controls the level of sugar in the blood by secreting insulin and glucagons.
  - Too much insulin produces hypoglycaemia, while too little causes diabetes.
- The Gonads
  - The gonads are the ovaries in women and testes in men.
  - They secrete hormones to regulate sexual growth, activity, and reproduction.
- The Adrenal Glands
  - The adrenal glands, one on top of each kidney, control our stress reaction through the adrenal medulla's secretion of epinephrine and norepinephrine.
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- Brain Stimulation
  - Disrupting or enhancing brain functioning with electrical stimulation
  - Stimulation can take place internally via invasive means or external, noninvasive techniques.
- Mapping Structure
  - CT scans are computer-aided X-rays of the brain and show a great deal of brain structure.
  - MRI scans use a magnetic field and a computer to give researchers an even more detailed look at the structure of the brain.
- Mapping Function
  - The EEG machine allows researchers to look at the activity of the surface of the brain through the use of microelectrodes placed on the scalp and connected to an amplifier and a computer for data recording and analysis.
  - PET scans use a radioactive sugar injected into the bloodstream to track the activity of brain cells, which is enhanced and colour-coded by a computer.
  - By tracking changes in the oxygen levels of the blood, functional MRI (fMRI) can tell researchers what areas of the brain are active.

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2.7 What are the different structures of the bottom part of the brain, and what do they do? (text p. 65)

- The Hindbrain
  - The medulla is at the very bottom of the brain and top of the spinal column. It controls life-sustaining functions such as breathing and swallowing. The nerves from each side of the body also cross over in this structure to opposite sides.
  - The pons is above the medulla and acts as a bridge between the lower part of the brain and the upper part. It influences sleep, dreaming, arousal, and coordination of movement on the left and right sides of the body.
  - The reticular formation runs through the medulla and the pons, and controls our selective attention and arousal.
  - The cerebellum is found at the base and back of the brain, and coordinates fine, rapid motor movement, learned reflexes, posture, and muscle tone.

2.8 What are the structures of the brain that control emotion, learning, memory, and motivation? (text p. 66)

- Structures Under the Cortex
  - The thalamus is the switching station that sends sensory information to the proper areas of the cortex.
  - The hypothalamus controls hunger, thirst, sleep, sexual behaviour, sleeping and waking, and emotions. It also controls the pituitary gland.
  - The limbic system consists of the thalamus, hypothalamus, hippocampus, amygdala, and the fornix.
  - The hippocampus is the part of the brain responsible for storing memories and remembering locations of objects.
  - The amygdala controls our fear responses and memory of fearful stimuli.
  - The cingulate cortex plays an important role in emotional and cognitive processing.
  - The fornix connects the hippocampus to the mammillary bodies.
- The Cortex
  - The cortex is about one tenth of an inch in thickness. Its wrinkles, or corticalization, allow for greater surface area and are associated with human's greater intelligence as compared with other animals.

2.9 What parts of the cortex control the different senses and the movement of the body? (text p. 69)

  - The cortex is divided into two cerebral hemispheres connected by a thick band of neurons called the corpus callosum.
  - The occipital lobes at the back and base of each hemisphere process vision and contain the primary visual cortex.

  - The parietal lobes at the top and back of the cortex contain the somatosensory area, which processes our sense of touch, temperature, and body position. Taste is also processed in this lobe.
  - The temporal lobes contain the primary auditory area and are also involved in understanding language.
  - The frontal lobes contain the motor cortex, which controls the voluntary muscles, and are also where all the higher mental functions occur, such as planning and complex decision making. In the left frontal lobe is an area for producing speech.

2.10 What parts of the cortex are responsible for higher forms of thought, such as language? (text p. 71)

- The Association Areas of the Cortex
  - The association areas are particularly found in the frontal lobes. These areas help people make sense of the information they receive from the lower areas of the brain.
  - An area called Broca's area in the left frontal lobe is responsible for producing fluent, understandable speech. If damaged, the person has Broca's aphasia in which words will be halting and pronounced incorrectly.
  - An area called Wernicke's area in the left temporal lobe is responsible for the understanding of language. If damaged, the person has Wernicke's aphasia in which speech is fluent but nonsensical. The wrong words are used.
  - Spatial neglect comes from damage to the association areas on one side of the cortex, usually the right side. A person with this condition will ignore information from the opposite side of the body or the opposite visual field.

2.11 How does the left side of the brain differ from the right side? (text p. 73)

  - Studies with split-brain patients, in which the corpus callosum has been severed to correct epilepsy, reveal that the left side of the brain seems to control language, writing, logical thought, analysis, and mathematical abilities. The left side also processes information sequentially.
  - The right side of the brain processes globally, and controls emotional expression, spatial perception, recognition of faces, patterns, melodies, and emotions.
  - The left hemisphere controls spoken language in most individuals.

APPLYING PSYCHOLOGY TO EVERYDAY LIFE: PAYING ATTENTION TO THE CAUSES OF ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (TEXT P. 75)

- The brain areas in attention-deficit/hyperactivity disorder (ADHD) are divided into those responsible for regulating attention and those responsible for alertness and motivation.
- A combination of assessment techniques, including neuroimaging, is being used to search for causal factors.
- Current research is looking at a variety of areas and environmental factors that may be causes.

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CHAPTER 2
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2.1 What are the nervous system, neurons, and nerves, and how do they relate to one another?
2.2 How do neurons use neurotransmitters to communicate with each other and with the body?
2.3 How do the brain and spinal cord interact?
2.4 How do the somatic and autonomic nervous systems allow people and animals to interact with their surroundings and control the body's automatic functions?
2.5 How do the hormones released by glands interact with the nervous system and affect behaviour?
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2.7 What are the different structures of the bottom part of the brain and what do they do?
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CHAPTER 2
Rapid Review
(From Ciccarelli/White *Psychology: An Exploration Study Guide and Concept Notes* by Natalie Ceballos ISBN 0205260551)

The **nervous system** is made up of a complex network of cells throughout your body. Because psychology is the study of behaviour and mental processes, understanding how the nervous system works provides fundamental information about what is going on inside your body when you engage in a specific behaviour, feel a particular emotion, or have an abstract thought. The field of study that deals with these types of questions is called **biological psychology or behavioural neuroscience**. The role of the nervous system is to carry information. Without your nervous system, you would not be able to think, feel, or act. The cells in the nervous system that carry information are called **neurons**. Information enters a neuron at the **dendrites**, flows through the cell body (or **soma**) and down the **axon** in order to pass the information on to the next cell. Although, neurons are the cells that carry the information, most of the nervous system (about 90%) consists of **glial cells**. Glial cells provide food, support, and insulation to the neuron cells. The insulation around the neuron is called **myelin** and works in a way very similar to the plastic coating of an electrical wire. Bundles of myelin-coated axons are wrapped together in cable like structures called **nerves**.

Neurons use an electrical signal to send information from one end of its cell to the other. At rest, a neuron has a negative charge inside and a positive charge outside. This is due to both electrostatic pressure and **diffusion**, the process of molecules moving from areas of high concentration to areas of low concentration. When a signal arrives, gates in the cell wall next to the signal open and the positive charge moves inside. The positive charge inside the cell causes the next set of gates to open and those positive charges move inside. In this way, the electrical signal makes its way down the length of the cell. The movement of the electrical signal is called an **action potential**. After the action potential is over, the positive charges get pumped back out of the cell and the neuron returns to its negatively charged state. This condition is called the **resting potential**. A neuron acts in an **all-or-none** manner. This means the neuron either has an action potential or it does not. The neuron indicates the strength of the signal by how many action potentials are produced or "fired" within a certain amount of time.

Neurons pass information on to target cells using a chemical signal. When the electrical signal travels down the axon and reaches the other end of the neuron called the **axon terminal**, it enters the very tip of the terminal called the **synaptic knob** and causes the **neurotransmitters** in the **synaptic vesicles** to be released into the fluid-filled space between the two cells. This fluid-filled space is called the **synapse** or the **synaptic gap**. The neurotransmitters are the chemical signals the neuron uses to communicate with its target cell. The neurotransmitters fit into the **receptor sites** of the target cell and create a new electrical signal that then can be transmitted down the length of the target cell.

Neurotransmitters can have two different effects on the target cell. If the neurotransmitter increases the likelihood of an action potential in the target cell, the connection is called an **excitatory synapse**. If the neurotransmitter decreases the likelihood of an action potential, the connection is called an **inhibitory synapse**. **Agonists** and **antagonists** are chemicals that are not naturally found in our body but that can fit into the receptor sites of target cells when they get into our nervous system. Agonists lead to a similar response in the target cell as the neurotransmitter itself, while antagonists block or reduce the action of the neurotransmitter on the target cell. There are at least 50–100 different types of neurotransmitters in the human body. Acetylcholine was the first to be discovered; it is an excitatory neurotransmitter that causes your muscles to contract and has a role in cognition, particularly memory. Gamma amino butyric acid (GABA) is an inhibitory neurotransmitter that decreases the activity level of neurons in your brain. Serotonin is both an excitatory and inhibitory neurotransmitter and has been linked with sleep, mood, and appetite. Low levels of the neurotransmitter dopamine have been found to cause Parkinson's disease and increased levels of dopamine have been linked to the psychological disorder known as schizophrenia. Endorphin is a special neurotransmitter called a neural regulator that controls the release of other neurotransmitters. When endorphin is released in the body, they neurons transmitting information about pain are not able to fire action potentials. All the different types of neurotransmitters are cleared out of the synaptic gap through the process of **reuptake**, **diffusion**, or **enzymatic degradation**.

The **central nervous system (CNS)** is made up of the brain and the **spinal cord**. The spinal cord is a long bundle of neurons that transmits messages between the brain and the body. The cell bodies or somas of the neurons are located along the inside of the spinal cord and the cell axons run along the outside of the spinal cord. **Afferent (sensory) neurons** send information from our senses to the spinal cord. For example, sensory neurons would relay information about a sharp pain in your finger. **Efferent (motor) neurons** send commands from the spinal cord to our muscles, such as a command to pull your finger back. **Interneurons** connect sensory and motor neurons and help to coordinate the signals. All three of these neurons act together in the spinal cord to form a **reflex arc**. The ability of the brain and spinal cord to change both in structure and function is referred to as **neuroplasticity**. **Stem cells** are one type of cell that facilitates these changes.

The **peripheral nervous system (PNS)** is made up of all the nerves and neurons that are NOT in the brain or spinal cord. This includes all the nerves that connect to your eyes, ears, skin, mouth, and muscles. The PNS is divided into two parts, the **somatic nervous system** and the **autonomic nervous system (ANS)**. The somatic nervous system consists of all the nerves coming from our sensory systems, called the **sensory pathway**, and all the nerves going to the skeletal muscles that control our voluntary movements, called the **motor pathway**. The autonomic nervous system is made up of the nerves going to and from our organs, glands, and involuntary muscles and is divided into two parts: the **sympathetic division** and the **parasympathetic division**. The sympathetic division turns on the body's fight-or-flight reactions, which include responses such as increased heart rate, increased breathing, and dilation of your pupils. The parasympathetic division controls your body when you are in a state of rest to keep the heart beating regularly, to control normal breathing, and to coordinate digestion. The parasympathetic division is active most of the time.

The **endocrine glands** represent a second communication system in the body. The endocrine glands lack ducts and secrete chemicals called **hormones** directly into the bloodstream. Compared to neuronal communication, the hormonal system generally results in slower, more widespread effects on the body and/or behaviour. The **pituitary gland** is located in the brain and secretes the hormones that control milk production, salt levels, and the activity of other glands. The **pineal gland** is also located in the brain and secretes **melatonin**. This hormone helps to track day length and contributes to the regulation of the sleep cycle in humans. The **thyroid gland** is located in the neck and releases a hormone that regulates metabolism. The **pancreas** controls the level of blood sugar in the body, while the **gonad** sex glands — called the **ovaries** in females and the **testes** in males — regulate sexual behaviour and reproduction. The **adrenal glands** play a critical role in regulating the body's response to stress.

Researchers have used animal models to learn a great deal about the human brain. Two of the most common techniques used in animals involve either destroying a specific area of the brain (deep lesioning) or stimulating a specific brain area (electrical stimulation of the brain or ESB) to see the effect. In work with humans, researchers have developed several methods to observe the structure and activity of a living brain. If a researcher wants a picture of the structure of the brain, she might choose a **CT scan** or an **MRI**. Computed tomography (CT) scans use x-rays to create images of the structures within the brain. Magnetic resonance images (MRIs) use a magnetic field to "take a picture" of the brain. MRIs provide much greater detail than CT scans. On the other hand, if a researcher wanted to record the activity of the brain, he might select an **EEG**, **fMRI**, **PET scan, or SPECT scan**. An **electroencephalogram** (EEG) provides a record of the electrical activity of groups of neurons just below the surface of the skull. A functional magnetic resonance image (fMRI) uses magnetic fields in the same way as an MRI, but goes a step further and pieces the pictures together to show changes over a short period of time. A positron emission tomography (PET) scan involves injecting a person with a low dose of a radioactive substance and then recording the activity of that substance in the person's brain. The **single photon emission computed tomography** (SPECT) scan functions similarly to the PET scan but uses a somewhat different radiotracer technique.

The brain can be roughly divided into three sections: the brainstem, the cortex, and the structures under the cortex. The brainstem is the lowest part of the brain that connects to the spinal cord. The outer wrinkled covering of the brain is the **cortex**, and the structures under the cortex are essentially everything between the brainstem and the cortex. The brainstem contains four important structures: The **medulla**, controls life-sustaining functions such as heart beat, breathing, and swallowing. The **pons** influences sleep, dreaming, and coordination of movements. The **reticular formation** plays a crucial role in attention and arousal, and the **cerebellum** controls all of the movements we make without really "thinking" about it.

One main group of structures under the cortex is the **limbic system**. The limbic system includes the **thalamus**, **olfactory bulbs**, **hypothalamus**, **hippocampus**, and **amygdala**. The thalamus receives input from your sensory systems, processes it, and then passes it on to the appropriate area of the cortex. (The **olfactory bulbs**, just under the front part of the brain, receive signals from the neurons in the sinus cavity to provide the sense of smell. The sense of smell is the only sense that cannot be affected by damage to the thalamus.) The hypothalamus interacts with the endocrine system to regulate body temperature, thirst, hunger, sleeping, sexual activity, and mood. It appears that the hippocampus is critical for the formation of long-term memories and for memories of the locations of objects. The amygdala is a small almond-shaped structure that is involved in our response to fear.

The outer part of the brain, or **cortex**, is divided into right and left sections called **cerebral hemispheres**. The two hemispheres communicate with each other through a thick band of neurons called the **corpus callosum**. Each cerebral hemisphere can be roughly divided into four sections. These sections are called lobes. The **occipital lobes** are at the back of the brain and process visual information. The **parietal lobes** are located at the top and back half of the brain and deal with information regarding touch, temperature, body position, and possibly taste. This area contains the **somatosensory cortex**, an area of neurons running down the front of the parietal lobes on either side of the brain. The **temporal lobes** are just behind your temples and process auditory information. The **frontal lobes** are located at the front of your head and are responsible for higher mental functions such as planning, personality, and decision-making, as well as language and motor movements. Motor movements are controlled by a band of neurons located at the back of the frontal lobe called the **motor cortex**. **Mirror neurons**, neurons that fire when you perform an action and also when you see someone else perform that action, may explain a great deal of the social learning that takes place in humans from infancy on. Recent studies suggest that humans have mirror neurons in areas of the brain associated with movement, vision, and memory.

Association areas are the areas within each of the lobes that are responsible for "making sense" of all the incoming information. Broca's area is located in the left frontal lobe in most people and is responsible for the language production. A person with damage to this area would have trouble producing the words that he or she wants to speak. This condition is referred to as **Broca's aphasia**. The comprehension of language takes place in Wernicke's area located in the left temporal lobe. If this area of the brain is damaged, individuals are often still able to speak fluently, but their words do not make sense. This type of language disorder is referred to as **Wernicke's aphasia**. Damage to the right parietal and occipital lobes can cause a condition known as **unilateral spatial neglect** where the individual ignores objects in their left visual field.

The **cerebrum** is made up of the two cerebral hemispheres and the structures connecting them. The **split-brain research** studies of Roger Sperry helped scientists to figure out that the two cerebral hemispheres are not identical. The left hemisphere is typically more active when a person is using language, math, and other analytical skills, while the right hemisphere shows more activity during tasks of perception, recognition, and expression of emotions. This split in the tasks of the brain is referred to as lateralization.

LECTURE LAUNCHERS AND DISCUSSION TOPICS

Lecture/Discussion: Leading Off the Chapter

Your students may find the presence of a chapter on "biology" puzzling in a psychology textbook. An effective lead off for the chapter is to point out our tendency to take for granted the integrity and normal functioning of the nervous system. Only when there is damage through stroke, disease, or brain trauma do we realize its importance. If there is an example from your personal life that is apropos here, such as a family member with a neurological disease, consider sharing it with your students. Students may add their own stories as well to highlight the importance of studying "biology" in a psychology class.

Lecture/Discussion: Critical Thinking About the Brain

Students are given a couple minutes to answer a question posed by the instructor. These assignments can be used in a variety of ways – to verify attendance, to start discussion, to assess student knowledge, and to provide opportunities for critical thinking. Sample assignments are provided below:

1. **Brain function**. If you could enhance the function of one structure in your brain, what would it be? Suppose a television network wanted to create a superhero with your brain capabilities. What would you name the superhero?

2. **Hemisphere Dominance.** Would you consider yourself a right-brain or left-brain thinker? Why? Give examples to support your answer.

3. **Autonomic System.** Think of a time when you were very frightened. What sorts of bodily symptoms did you experience? Think of a time when you were very calm and relaxed. What sorts of bodily symptoms did you experience? List them.

4. **Heredity**. Are there any physical characteristics in your family tree that appear to be dominant – eye colour, shape or size of the nose, height, hair colour, dimples, etc.? List these dominant traits.

5. **Brain damage.** Do you know anyone who has had damage to their brain? What caused the damage – an illness, a trauma, a birth defect? What symptoms does the person have? Is the brain damage permanent?

Marin, A.J. (2011). *Interactive Learning Companion.* Boston: Pearson Education, Inc.

Lecture/Discussion: Neurotransmitters: Chemical Communicators of the Nervous System

In 1921, a scientist in Austria put two living, beating 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. Curare is a poison that was discovered by South American Indians. They put it on tips of the darts they shoot from their blowguns. Curare blocks acetylcholine receptors; paralysis of internal organs results. The victim is unable to breathe, and dies. A substance in the venom of black widow spiders stimulates release of acetylcholine at the synapses. Botulism toxin found in improperly canned foods, blocks release of acetylcholine at the synapses and has a deadly effect. It takes less that one millionth of a gram of this toxin to kill a person. 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 behaviour. 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 the endorphins. It appears that the neurotransmitters dopamine, norepinephrine, and serotonin are associated with some of the most severe forms of mental illness.

There are probably only a few ounces of these substances in the body, but they may have a profound effect on mood, memory, perception, and behaviour. Could intelligence be primarily a matter of having plenty of the right neurotransmitter at the right synapses?

Lecture/Discussion: Neurotransmitters

Using the expert jigsaw technique, each team member is assigned to a different neurotransmitter. Students may be asked to complete their research outside of class, or you may give students 5 minutes in class to look up the information in their textbook. Students meet in expert groups to make sure they have the correct information on their assigned neurotransmitter. Students return to their teams and present information on their neurotransmitter.

Marin, A.J. (2011). *Interactive Learning Companion.* Boston: Pearson Education, Inc.

Lecture/Discussion: Synaptic Transmission and Neurotransmitters

Point out to students that neurons do not touch each other. Instead, two neurons are connected through a small space called a *synapse*, into which flow substances called *neurotransmitters* that either enhance or impede impulses moving from one neuron to the next. During the first half of the 1900s, there was controversy over whether synaptic transmission was primarily chemical or electric. By the 1950s, it was apparent that the communication between the neurons was chemical. During this period, some synapses showed what was termed *gap junction* or electrical transmission between neurons at the synapse. Recent research has shown that electrical synaptic transmission may be more frequent than neuroscientists once believed (Bennett, 2000). Even though the transmission of information between neurons at the synapses is primarily chemical, some electrical synapses are known to exist in the retina, the olfactory bulb, and the cerebral cortex (Bennett, 2000).

Use "The Wave," an activity at sports arenas, as an analogy for the action potential. Like "The Wave," the action potential travels the length of the neuron; the neuron doesn't experience the action potential all at once. To extend the analogy, mention that right after people stand up in "The Wave," they are somewhat tired and must recover (i.e., refractory period) to be prepared for the next go-round (i.e., action potential).

Lecture/Discussion: Exceptions to the Rules

In an introductory psychology class, students usually 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 signalling is chemical, not electrical.
Exception: gap junctions

While it is generally the case that a neuron's electrical signal must first be converted to a chemical signal in order to 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 bidirectional, 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 neighbouring 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 postsynaptic cell generates an axon potential or not. Instead, axo-axonic synapses usually modulate how many neurotransmitters are 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. (2000). *Principles of neural science* (4th ed.). New York, NY: McGraw-Hill.

Lecture/Discussion: The Perception of Phantom Pain

The idea of pain sensation means different things to different people. Many students are aware of phantom pain sensations and are actually very curious as to what it is. Medical professionals have recorded many cases of what has come to be called "phantom limbs." Phantom limb phenomenon occurs when a person who has had an amputation of some body part, such as an arm or leg, reports "feeling" sensations from the now-missing limb. Phantom limb refers to the subjective sensory awareness of an amputated body part, and may include numbness, itchiness, temperature, posture, volume, or movement. For example, one man whose left arm was amputated just above the elbow during a horrific car accident claimed that he could still feel the arm as a kind of ghostly presence. He could feel himself wiggling non-existent fingers and "grabbing" objects that would have been in his reach had his arm still been there (Ramachandran & Blakeslee, 1998). Phantom sensations may take years to fade, and usually do so from the end of the limb up to the body—in other words, one's phantom arm seems to get shorter and shorter until it can no longer be felt. In addition to legs and arms there have been cases of phantom breasts, bladders, rectums, vision, hearing, and internal organs.

Phantom limb pain refers to the specific case of painful sensations that appear to reside in the amputated body part. Patients have variously reported pins-and-needles sensations, burning sensations, shooting pains that seem to travel up and down the limb, or cramps, as thought the severed limb was in an uncomfortable and unnatural position. Many amputees often experience several types of pain; others report that the sensations are unlike other pain they've experienced. Unfortunately, some estimates suggest that over 70 percent of amputees still experience intense pain, even 25 years after amputation. Most treatments for phantom limb pain (there are over 50 types of therapy) help only about 7 percent of sufferers.

What causes these phantom sensations? A recent study has shed light on the causes of phantom limb sensations. Researchers at Humboldt University in Berlin suggest that the most severe type of this pain occurs in amputees whose brains undergo extensive sensory reorganization. Magnetic responses were measured in the brains of 13 arm amputees in response to light pressure on their intact thumbs, pinkies, lower lips, and chins. These responses were then mapped onto the somatosensory cortex controlling that side of the body. Because of the brain's contralateral control over the body, the researchers were able to estimate the location of the somatosensory sites for the missing limb. They found that those amputees who reported the most phantom limb pain also showed the greatest cortical reorganization. Somatosensory areas for the face encroached into regions previously reserved for the amputated fingers.

Renowned neuroscientist Dr. V. S. Ramachandran has investigated many cases of phantom limb sensations in his career. He believes that examination of people, who experience these phenomena, using the non-invasive techniques of magnetoencephalograms and functional MRIs, can teach us much about the relationship between sensory experience and consciousness. Researchers have long known that touching certain points on the stump of the amputation (and in some cases on the person's face) can produce phantom sensations in a missing arm or fingers (Ramachandran & Hirstein, 1998). Older explanations of phantom limb sensations have called it an illusion brought on by the irritation of the nerve endings in the stump due to scar tissue. But using anaesthesia on the stump does not remove the phantom limb sensations or the pain experienced by some patients in the missing limb, so that explanation is not adequate. Ramachandran and colleagues suggest instead that phantom limb sensations may occur because areas of the face and body near the stump "take over" the nerve functions that were once in the control of the living limb, creating the false impression that the limb is still there, feeling and moving. This "remapping" of the limb functions, together with the sensations from the neurons ending at the stump and the person's mental "body image" work together to produce phantom limb sensations.

Although these findings do not by themselves solve the riddle of phantom limb pain, they do offer avenues for future research. For example, damage to the nervous system may cause a strengthening of connections between somatosensory cells and the formation of new ones. Phantom limb pain may result due to an imbalance of pain messages from other parts of the brain. As another possibility, pain may result from a remapping of somatosensory areas that infringes on pain centres close by.

Boas, R. A., Schug, S. A., & Acland, R. H. (1993). Perineal pain after rectal amputation: A 5-year follow-up. *Pain, 52,* 67–70.
Bower, B. (1995). Brain changes linked to phantom-limb pain. *Science News, 147,* 357.
Brena, S. F., & Sammons, E. E. (1979). Phantom urinary bladder pain – Case report. *Pain, 7,* 197–201.
Bressler, B., Cohen, S. I., & Magnussen, F. (1955). Bilateral breast phantom and breast phantom pain. *Journal of Nervous and Mental Disease, 122,* 315–320.
Dorpat, T. L. (1971). Phantom sensations of internal organs. *Comprehensive Psychiatry, 12,* 27–35.
Katz, J. (1993). The reality of phantom limbs. *Motivation and Emotion, 17,* 147–179.
Ramachandran, V. S., & Blakeslee, S. (1998). *Phantoms in the Brain*. William Morrow, N.Y.
Ramachandran, V. S. and W. Hirstein (1998). The perception of phantom limbs: The D. O. Hebb lecture. *Brain, 121,* 1603–1630.
Shreeve, J. (1993, June). Touching the phantom. *Discover,* pp. 35–42.

Lecture/Discussion: The Brain

To set the mood for your discussion of the brain, try the following: (1) talk about the relatively small size of the brain; (2) discuss its role in humankind's most amazing accomplishments; (3) discuss its role in humankind's most destructive actions; and (4) note that, to our knowledge, the brain is probably the only thing in the universe that can ponder its own existence (by asking your students to think about it, the statement is supported).

Lecture/Discussion: 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 twelve 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 twelve cranial nerves are:

1. *Olfactory*. A sensory nerve that transmits odour 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.

Carlson, N. R. (1994). *Physiology of behavior* (5th ed.). Boston: Allyn and Bacon.
Thompson, R. F. (1993). *The brain: A neuroscience primer* (2nd ed.). New York: W. H. Freeman.

Reprinted from Hill, W. G. (1995). *Instructor's resource manual for Psychology* by S. F. Davis and J. J. Palladino. Englewood Cliffs, NJ: Prentice Hall.

Lecture/Discussion: 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 because researchers could only measure the electrical activity of the living human brain in individuals who had genetic defects of their skull bones that cause the skin of their scalps to be in direct contact with the surfaces of their brains.

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 its having been 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.

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.

The alpha wave is also sometimes called *Berger's wave* in honour of Berger's discovery.

Lecture/Discussion: 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 imbedded nails can be found at the USA Today link on the next page. Incredibly, none of the nails caused serious damage to Mejia's brain. One nail lodged near his spinal cord, while 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.

Nail Gun /Victim Lives. *Current Science*, A Weekly Reader publication, Sept. 10, 2004, v90 (1), Page 14.
http://www.summitdaily.com/article/20050119/NEWS/50119002/0/FRONTPAGE

Lecture/Discussion: Neural Effects of a Concussion

During the fall term, when college football is in season, it is especially appropriate to stress the discussion of the neuronal and behavioural effects of concussion. Chances are good that in any given class, you will have several students who will report having had a concussion in the past, usually as a result of participation in football or other sports activities, or as a result of an automobile accident. You can ask the students to discuss their experiences with the class, asking what kind of physiological and cognitive effects occurred. The most common effects include loss of vision ("black out"), blurred vision, ringing in the ears, nausea/vomiting, and not being able to think clearly. However, the physiological and cognitive effects vary between individuals; some may not have experienced nausea at all, whereas others only experienced blurred vision. It is important to point out the variability between individuals, because it can be inferred that concussions vary greatly in terms of the severity of brain damage and the brain areas affected.

The brain sits in the cranium surrounded by cerebral fluid. When a severe blow to the head occurs, the brain may collide with the cranium, then "bounce back" and collide with the opposite side of the cranium. For example, if a football player falls and hits the back of his or her head, the brain may hit the back of the cranium, then the front. At this point, you might ask students what brain areas would be affected in this example ("occipital and frontal lobes" are a pretty decent answer). Therefore, both vision and some cognitive functioning may be affected. At the neuronal level, a concussive blow to the head results in a twisting or stretching of the axons, which in turn creates swelling. Eventually, the swelling may subside and the neuron may return to its normal functioning. However, if the swelling of the axon is severe enough, the axon may disintegrate. A more severe blow to the head may even sever axons, rendering those neurons permanently damaged. Either way, neuronal signalling is disrupted, either temporarily or permanently. Depending on the brain areas where the damaged axons are located, different physiological symptoms may occur.

Lecture/Discussion: 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 behaviour. 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 behaviour for the rest of his life. This, however, is not necessarily supported by the few original sources researchers have to go on. For example, while 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 preformed 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 recover and 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 http://www.brightbytes.com/phineasgage/ or by searching the Internet for "Phineas Gage daguerreotype."

Macmillan, M. (2008). Phineas Gage—Unravelling the myth. *The Psychologist, 21(9),* 828–831.

Lecture/Discussion: Workplace Problems: Left Handedness

Between Canada and the United States, there are approximately 33 million people who are left-handed. This presents a severe detriment to the work place. It has been shown that left handed individuals are more likely to have accidents at work than are right handed individuals, in fact 25% more likely and if they are working with tools and machinery, 51% more likely. Accommodations such as being able to rearrange the work area and having tools available that are either left or right hand adapted would make the workplace a safer place to be. Have students suggest ways that the work place could be made safer or even what could be done in the classroom that would make it easier for students who are left handed to take notes or tests. What about the mouse on computers? The mouse is actually made for people who are right handed. How adaptable must a left handed person become in order not to be frustrated by using a right handed mouse?

Gunsch, D. For Your Information: Left-handed workers struggle in a right-handed work world. *Personnel Journal, 93,* 23–24.

Lecture/Discussion: Understanding Hemispheric Function

A variation on the rather dubious statement that "we only use one-tenth of our brain" is that "we only use one-half (hemisphere) of our brain." Research suggests that each cerebral hemisphere is specialized to perform certain tasks (e.g., left hemisphere/language; right hemisphere/visuospatial relationships), with the abilities of one hemisphere complementary to the other. From this came numerous distortions, oversimplifications, and unwarranted extensions, many of which are discussed in two interesting reviews of this trend toward "dichotomania" (Corballis, 1980; Levy, 1985). For example, the left hemisphere has been described variously as logical, intellectual, deductive, convergent, and "Western," while the right hemisphere has been described as intuitive or creative, sensuous, imaginative, divergent, and "Eastern." Even complex tasks are described as right- or left-hemispheric because of their language component. In every individual one hemisphere supposedly dominates, affecting that person's mode of thought, skills, and approach to life. One commonly cited, but questionable test for dominance is to note the direction of gaze when a person is asked a question (left gaze signalling right hemisphere activity; right gaze showing left hemisphere activity). Advertisements have claimed that artistic abilities can be improved if the right hemisphere is freed, and the public schools have been blamed for stifling creativity by emphasizing left-hemisphere skills and by neglecting to teach the children's right hemisphere.

Corballis and Levy explode these myths and trace their development. In reality, the two hemispheres are quite similar and can function remarkably well even if separated by split-brain surgery. Each hemisphere does have specialized abilities, but the two hemispheres work together in all complex tasks. For example, writing a story involves left-hemispheric input concerning syntax, but right-hemispheric input for developing an integrated structure and for using humour or metaphor. The left hemisphere is not the sole determinant of logic, nor is the right hemisphere essential for creativity. Disturbances of logic are more prevalent with right-hemisphere damage, and creativity is not necessarily affected. Although one hemisphere can be somewhat more active than the other, no individual is purely "right brained" or "left brained." Also, eye movement and hemispheric activity patterns poorly correlate with cognitive style or occupation. Finally, because of the coordinated, interactive manner of functioning of both hemispheres, educating or using only the right or left hemisphere is impossible (without split-brain surgery). (Note: Suggestions for a student activity on this topic are given in the following Demonstrations and Activities section of this manual).

Corballis, M.C. (1980). Laterality and myth. *American Psychologist, 35,* 284–295.
Levy, J. (1985). Right brain, left brain: Fact or fiction? *Psychology Today, 19,* 38–45.

Lecture/Discussion: 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 of Memorial Sloan-Kettering Cancer Center in New York and her colleagues 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. A functional magnetic resonance image (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.

Bower, B. (1997, July 12). Brains show signs of two bilingual roads. *Science News,* 152, 23.

Lecture/Discussion: The Results of a Hemispherectomy

Matthew is eight years old now. Two years ago surgeons removed half of his brain.

His first three years were completely normal. Just before he turned four, however, Matthew began to experience seizures, which did not respond to drug treatment. The seizures were severe (life threatening) and frequent (as often as every three 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 U.S., 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. It is interesting to note that Matt's personality never changed through the seizures and surgery

Boyle, M. (1997, August 1). Surgery to remove half of brain reduces seizures. *Austin American-Statesman,* A18.
Swerdlow, J. L. (1995, June). Quiet miracles of the brain. *National Geographic, 87,* 2-41.
Adapted from Davis, S. F., & Palladino, J. J. (1996) Interactions: A newsletter to accompany Psychology, 1(Spr), 4.

Lecture/Discussion: Too much or too little: Hormone Imbalances

Students may find it interesting to hear more about the various problems caused by problems within the endocrine system. The following disorders/medical problems are associated with abnormal levels within the pituitary, thyroid and adrenal glands.

Pituitary malfunctions

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.

Thyroid malfunctions

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 tends 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 (and I hate them for that—oh, if only we came equipped with thyroid control knobs!).

Adrenal Gland Malfunctions

Among the disorders that can result from malfunctioning of the adrenal glands are **Addison's Disease** levels of cortisol). In the former, fatigue, low blood pressure, weight loss, nausea, diarrhea, and muscle weakness are some of the symptoms, while for the latter, obesity, high blood pressure, a "moon" face, and poor healing of skin wounds is common.

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. There is a documented case of a 5-year old Peruvian girl who actually gave birth to a son (Strange, 1965). 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.

Lecture/Discussion: Would You Like Fries With That Peptide?

Toast and juice for breakfast. Pasta salad for lunch. An orange, rather than a bagel, for an afternoon snack. These sound like reasonable dietary choices, involving some amount of deliberation and free will. However, our craving for certain foods at certain times of the day may be more a product of the brain than of the mind.

Sarah F. Leibowitz, Rockefeller University, has been studying food preferences for over a decade. What she has learned is that a stew of neurochemicals in the paraventricular nucleus, housed in the hypothalamus, plays a crucial role in helping to determine what we eat and when. Two in particular – Neuropeptide Y and galanin – help guide the brain's craving for carbohydrates and for fat.

Here's how they work. Neuropeptide Y (NPY) is responsible for turning on and off our desire for carbohydrate. Animal studies have shown a striking correlation between NPY and carbohydrate intake; the more NPY produced, the more carbohydrates eaten, both in terms of meal size and duration. Earlier in the sequence, the stress hormone cortisol seems responsible, along with other factors, for upping the production of Neuropeptide Y. This stress ⇨ cortisol ⇨ Neuropeptide Y ⇨ carbohydrate craving sequence may help explain overweight due to high carbohydrate intake. But weight, and craving, rely on fat intake as well. Leibowitz has found that the neuropeptide galanin plays a critical role in this case. Galanin is the on/off switch for fat craving, correlating positively with fat intake; the more galanin produced, the heavier an animal will become. Galanin also triggers other hormones to process the fat consumed into stored fat. Galanin itself is triggered by metabolic cues resulting from burning fat as energy, but also from another source: estrogen.

Neuropeptide Y triggers a craving for carbohydrate, galanin triggers a craving for fat, but the two march to different drummers throughout a day's cycle. Neuropeptide Y has its greatest effects in the morning (at the start of the feeding cycle), after food deprivation (such as dieting), and during periods of stress. Galanin, by contrast, tends to increase after lunch and peaks toward the end of our daily feeding cycle.

The implications of this research are many. For example, the findings suggest that America's obsession with dieting is a losing proposition (but not around the waistline). Skipping meals, gulping appetite suppressers, or experiencing the stress of dieting will trigger Neuropeptide Y to encourage carbohydrate consumption, which in turn can foster overeating. Paradoxically, then, by trying to fight nature we may stimulate it even more. As another example, the onset and maintenance of anorexia may be tied to the chemical cravings in the hypothalamus. Anorexia tends to develop during puberty, a time when oestrogen is helping to trigger galanin's craving for fat consumption. Some women (due to societal demands, obsessive-compulsive tendencies, or other pressures) react to this fat trigger by trying to accomplish just the opposite; subsisting on very small, frequent, carbohydrate-rich meals. The problem is that the stress and starvation produced by this diet cause Neuropeptide Y to be released, confining dietary interest to carbohydrates, but also affecting the sex centres nearby in the hypothalamus. Specifically, neuropeptide Y may act to shut down production of gonadal hormones.

Marano, H. E. (1993, January/February). Chemistry and craving. *Psychology Today,* pp. 30–36, 74.
http://www.rockefeller.edu/labheads/leibowitz/research.php

CLASSROOM ACTIVITIES, DEMONSTRATIONS, AND EXERCISES

Building a Neuron
Using Reaction Time to Show the Speed of Neurons
The Dollar Bill Drop
Using Dominoes to Understand the Action Potential
Demonstrating Neural Conduction: The Class as a Neural Network
Human Neuronal Chain
Mapping the Brain
Review of Brain-Imaging Techniques
Trip to the Hospital
The Importance of a Wrinkled Cortex
Just How Big is the Surface Area of the Cortex?
Probing the Cerebral Cortex
The Cerebral Cortex
Lateralization Activities
Localization of Function Exercise
Looking Left, Looking Right
The Brain Diagram
Split Brain
Psychology in Literature: *The Man Who Mistook His Wife For a Hat*
Twenty Questions
Crossword Puzzle
Fill-in-the-Blank

Activity: Building a Neuron

This activity facilitates teaching about the anatomy of a neuron and about how neurons communicate—synaptically—with other neurons. This activity requires you to give each student five pipe cleaners, each of a different colour. Each pipe cleaner will either serve as a strand of DNA or a stem cell.

Begin the activity by picking up one of the pipe cleaners (DNA strands) and announcing to your students the first part of a neuron is its soma or cell body. The soma of the neuron contains the nucleus and DNA and tells the neuron what it is going to be doing—for example, whether it is going to be part of the occipital or parietal lobes, or whether it is an afferent or efferent neuron. Roll this first DNA strand into a ball and have your students do the same.

Pick up another DNA strand and announce to your students the second part of a neuron is its axon. The axon of the neuron sends information (neurotransmitters) to other neurons. Fold this DNA strand in half and then poke it into the soma, so that you have what looks like a sucker.

Pick up another DNA strand and announce to your students the third part of the neuron is its axon bulb. The axon bulb increases the surface area of the end of the axon so that the neuron has a greater potential to communicate with more neurons. Wrap this DNA strand around the end of the axon opposite of the soma.

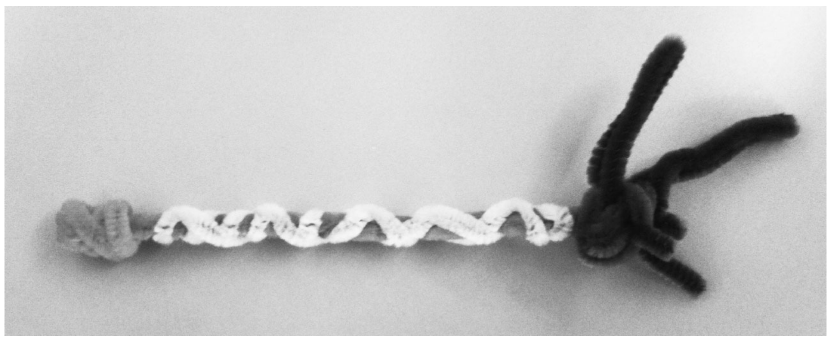
Pick up another DNA strand and announce to your students that the fourth part of the neuron is its branches or dendrites. The dendrites receive information (neurotransmitters) from other neurons. The dendrites are constantly growing relative to development and learning. Thus, the richer the dendritic trees are, the "smarter" the neuron is. Poke this DNA strand through the soma once, then twice, then thrice, then as many times as you can in an attempt to make as many "branches" as you can with this single DNA strand. Make this a competition within the class—seeing who can make the smartest, most-branched neuron.

With the last pipe cleaner (stem cell), announce to your students that this is either a glial cell (if we are building neurons within the central nervous system, oligodendrocyte) or a Schwann cell (if we are building neurons within the peripheral nervous system). Glial cells and Schwann cells wrap themselves around neurons in an effort to protect them and to speed up the communication between neurons. This wrapping is called Myelination. Demyelination is associated with Multiple Sclerosis. Wrap the glial or Schwann cell around the axon of the neuron. Have all your students now hold up their neurons to show off to the class (see Photograph 1).

Have your students make their neurons communicate with other neurons by forming synapses and building neural networks by placing the neurons' somas physically close to other neurons' dendrites; and neurons' axons physically close to other neurons' dendrites. Lastly, have a bit more fun with your students by counting the total number of neurons they have made and saying we are going to have to make a few more neurons and synapses to get to the 100 billion and 100 trillion that respectively compose the brain!

This activity initiates discussions about the anatomy and physiology of neurons, the neural impulse, and neurotransmitters.

This activity may take as long as 30 minutes or it may be done in as little as 10 minutes.



Photograph 1. Photograph of a completed Five-Part, Pipe Cleaner Neuron with Five Dendritic Branches.

Activity: Using Reaction Time to Show the Speed of Neurons

I always begin this demonstration by asking students if they believe that there is a difference in reaction time if the impulse has to travel farther. Most frequently students answer in the affirmative. Here is a simple demonstration of the time required to process information along sensory neurons in the arm and can be done by asking students to form a line by holding hands. Ask a student to start and stop a stopwatch. Then begin by asking for volunteers. The number of students who volunteer is irrelevant. Instruct the students to close their eyes and to squeeze the hand of the person next to them when they feel the person on the opposite side squeeze their hand. The last person in line should signal the timekeeper that his or her hand has been squeezed by raising a free hand. Have the student stop the watch and record the elapsed time. Repeat the process until the reaction times appear to be stable. Take the final reaction time and divide by the number of students in the line to obtain the average reaction time.

Next, ask the students to squeeze the next person's shoulder instead of hand. The average reaction time should now decrease since the sensory information has a shorter distance to travel. The difference in average reaction time obtained from the two procedures represents—roughly—the average conduction time for sensory information between the hand and shoulder.

Activity: The Dollar Bill Drop

After engaging in the neural network exercise, try following 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 bigger, 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, centre 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 centre 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 centre 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.

Activity: 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.

Activity: 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 favourite - 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.

Activity: Human Neuronal Chain

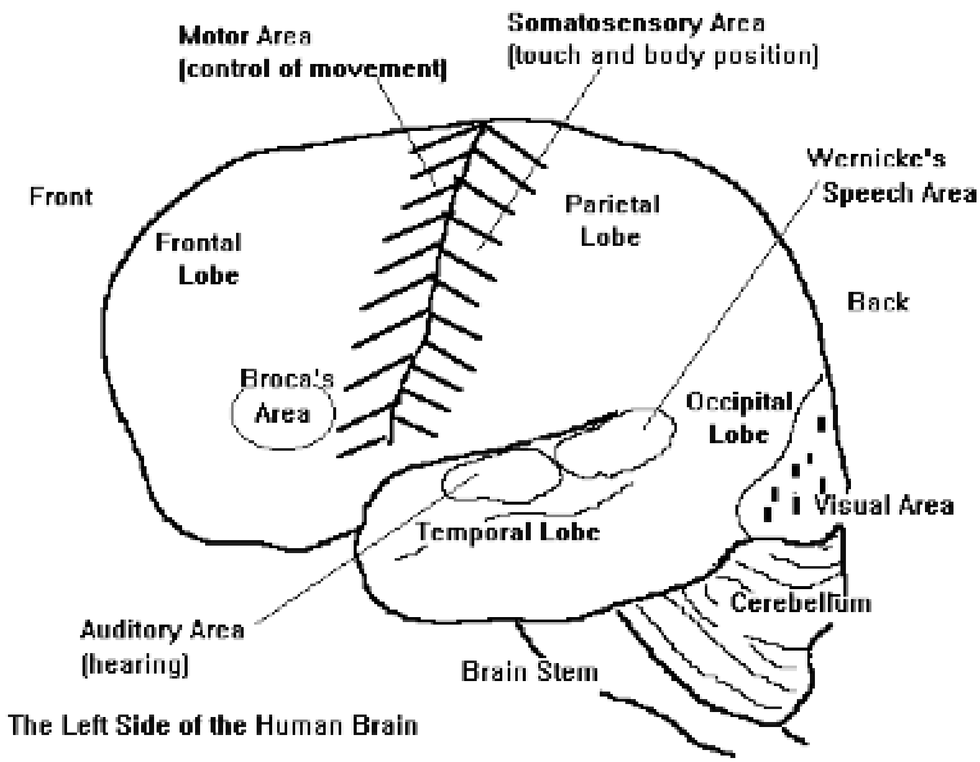
Objective: To illustrate that the transmission of messages in the nervous system is not instantaneous
Materials: 20 students standing, facing forward, in a line; a stopwatch
Procedure: Ask the last student to tap either shoulder of the next person and each subsequent person to continue the process through the entire line, always using the same shoulder and never crossing the body (i.e., left hand to right shoulder). Use the stopwatch to time how long it takes for the last person to receive the stimulus.

Harcum, E. R. (1988). Reaction time as a behavioral demonstration of neural mechanisms for a large introductory psychology class. *Teaching of Psychology, 15,* 208–209.

Activity: Mapping the Brain

Many students, especially those with little background in the sciences, will find it a challenge to keep track of the location of all the parts of the brain outlined in the text. One simple way to reinforce their learning of brain structure is to have students locate the various parts on a photocopied diagram of the brain. The brain diagram and the student instructions for this exercise are included as Handout Master 2.1. The day before you present this activity, ask students to bring coloured pencils or markers to class. On the day of the activity, divide students into small groups and distribute copies of the diagram of the brain and the accompanying questions in the student handouts. Within their groups they can help each other locate each part of the brain and then colour code them using their pencils or markers. They can also indicate the function of each part on the diagram. This exercise is very useful for helping students to memorize brain anatomy, and the colour-coded diagram serves as a helpful study guide.

For your convenience, a completed diagram and suggested answers to the questions are furnished on the next page.



1. This is a diagram of the left side of the brain.

   Left side functions: The left hemisphere controls touch and movement of the right side of the body, vision in the right half of the visual field, comprehension and production of speech, reading ability, mathematical reasoning, and a host of other abilities.

   Right side functions: The right hemisphere controls touch and movement of the left side of the body, vision in the left half of the visual field, visual-spatial ability, map-reading, art and music appreciation, analysis of nonverbal sounds, and a host of other abilities.
2. The front of the brain is on the left side of the diagram; the back of the brain is on the right.
3. The cerebrum is the sum of the frontal, parietal, temporal, and occipital lobes. The cerebellum is labeled on the diagram above.

   The cerebrum is responsible for higher forms of thinking, including a variety of specific abilities described under motor cortex, visual cortex, somatosensory cortex, and auditory cortex. The cerebral cortex also contains vast association areas, whose specific functions are poorly defined but may include reasoning and decision making, planning appropriate behaviour sequences, and knowing when to stop. The limbic system, which appears to be strongly involved in regulating emotions, is also part of the cerebrum.

   The cerebellum aids in the sense of balance and motor coordination.
4. The frontal, parietal, temporal, and occipital lobes are labeled on the diagram above.
5. The motor cortex is labeled on the diagram above. The motor cortex in each hemisphere controls movements on the opposite side of the body.
6. The visual cortex is labeled on the diagram above. The visual cortex in each hemisphere receives information from the visual field on the opposite side.
7. The auditory cortex is labeled on the diagram above. The auditory cortex is responsible for processing sounds.
8. The somatosensory cortex is labeled on the diagram above. The somatosensory cortex on each side receives information about touch, joint position, pressure, pain, and temperature from the opposite side of the body.
9. Broca's and Wernicke's areas are labeled on the diagram above.

   Broca's area is often referred to as the motor speech area. It is responsible for our ability to carry out the movements necessary to produce speech.

   Wernicke's area is often referred to a sensory speech area. It is mainly involved in comprehension and planning of speech.

10. Neurons would be found all over the drawing. (The brain is made up of billions of neurons.) Each neuron is very tiny compared to the size of the brain, so no single neuron would be visible to the naked eye in a drawing at this scale. The cell bodies of the largest neurons in the brain are about 1/20 of a millimeter in diameter!
11. The brain stem is labeled on the diagram above. Different parts of the brain stem are involved in regulation of sleep and wakefulness, dreaming, breathing, heart rate, and attentional processes.

Activity: Review of Brain-Imaging Techniques

Objectives: To review information on brain-imaging techniques
Materials: None
Procedures: Ask students to tell which brain-imaging technique could answer each of the following questions:

1. How do the brains of children and adults differ with regard to energy consumption? (PET)
2. In what ways do brain waves change as a person falls asleep? (EEG)
3. In which part of the brain has a stroke patient experienced a disruption of blood flow? (CT, MRI)
4. What is the precise location of a suspected brain tumour? (CT, MRI)
5. How can brain structures be examined without exposing a patient to radiation? (MRI)
6. How can scientists view structures and their functions at the same time? (fMRI)
7. What techniques allow scientists to view changes in the magnetic characteristics of neurons as they fire? (SQUID, MEG)

Activity: Trip to the Hospital

Objective: To demonstrate brain imaging techniques
Materials: Local or regional hospital
Procedure: Arrange a trip to the local or regional hospital to see their CAT, PET, MRI and fMRI facilities. Being able to see and hear about this equipment firsthand far exceeds what students can gain from the text. Such a trip can be undertaken only if you have a small class, recitation, or laboratory section. A voluntary sign-up list also can be used. You will have to make your plans well in advance and at the convenience of the hospital staff. If the size of your class precludes this field trip, you could invite a local physician or one of the technicians to discuss these procedures. It will be helpful if he or she can arrange to bring examples of the records or scans that are produced for evaluation of neurological disorders. You should plan to ask your guest speaker to compare modern procedures to earlier evaluations of neurological disorders.

Activity: 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 (Myers, 1995). Laughs usually erupt when the class imagines what our heads would look like if we had to accommodate an unwrinkled, newspaper-sized cerebral cortex!

Myers, D. G. (1995). *Psychology* (4th ed.). New York: Worth.

Demonstration: Just How Big is the Surface Area of the Cortex?

This is another simple demonstration about the brain's size and its fissures, but it really captures students' attention. Upon visual inspection of an adult human's cerebral cortex, it is obvious that the cortex is composed of dozens of convolutions and fissures (each with a name and a function). These convolutions and fissures beg the question: "Why do they exist?" The answer to this question comes from the knowledge about the size of the brain. The total cerebral cortex surface area of an adult human brain is about 2500 sq. cm (~2.5 ft^2).

To demonstrate this surface area to your students, get an old bed sheet or beach towel and cut a square from it with 2.5-foot (i.e., 30 inch) sides. When discussing the anatomical features of the cortex in class, hold up the square in front of your face and ask the class, "How am I going to fit all of this brain material inside my skull?" Students will eventually answer, "You are going to have to fold it up…" Now you start folding your square up—being careful to fold it in such a fashion to create the systematic convolutions and fissures (gyri and sulci) that compose the cortex.

This demonstration initiates discussions about the size and weight of the brain, the anatomical features of the brain, and the developmental changes that occur as the brain grows.

Activity: Probing the Cerebral Cortex

Use: Pearson Introductory Psychology Teaching Films

SYNOPSIS: This clip contains commentary by Wilder Penfield, a pioneer in mapping the areas of the cerebral cortex. Penfield discusses the work that led to electrode-stimulation of the cortex. He also interviews a brain surgery patient about her experiences during surgery: Stimulation of various areas of her cortex produced memories of past events and the perception of music playing.

Form a Hypothesis
Q What happens when Penfield stimulates a small area of the temporal lobe, called the auditory cortex?
A The patient "hears" sounds.

Test Your Understanding
Q What are the four lobes of the cerebral cortex?
A The four lobes of cerebral cortex are occipital, parietal, temporal, and frontal.
Q What are the functions of the somatosensory cortex, motor cortex, and association cortex areas?
A Somatosensory cortex interprets sensations and coordinates the motor behaviour of skeletal muscles. Association areas, located on all four cortical lobes, are involved in the integration of various brain functions, such as sensation, thought, memory, planning, etc.
Q What two areas of the association cortex specialize in language?
A Wernicke's area, located toward the back of the temporal lobe, is important in understanding the speech of others. Broca's area is essential to sequencing and producing language.

Thinking Critically
Q What four types of research methods are commonly used in the study of behavioural neuroscience?
A Microelectrode techniques are used to study the functions of individual neurons.

Macroelectrode techniques, such as an EEG, record activities of brain areas. Structural imaging, such as computerized axial tomography or CAT scans, is useful for mapping brain structures. Functional imaging, in which specific brain activity can be recorded in response to tasks or stimulation, offers the potential to identify specific brain areas and functions.

Activity: The Cerebral Cortex

In this charade-like exercise, students come to the front of the room and act out a behaviour (e.g., problem solving, balancing an object, smelling an object). The behaviours can be either student generated or instructor generated. The other students try to guess which lobe of the brain is responsible for that behaviour – Frontal, Occipital, Temporal or Parietal. There are many variations in how this activity can be scored. You can give points to teams with the most correct guesses, or you can give playing cards as a reward and use the poker-faced participation technique.

Marin, A.J. (2011). *Interactive Learning Companion*. Boston: Pearson Education, Inc.

Activity: Lateralization Activities

Procedure:
There are several demonstrations that illustrate the lateralization of the brain. Several have been described by Filipi, and Gravlin (1985). A variant by Morton 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's to ask students to pat their head and to rub their stomach 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 behaviour is no problem. Generally students who have been trained in martial arts, dance and/or gymnastics have less difficulty completing these activities due to rigorous physical training.

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.

Activity: Localization of Function Exercise

This exercise has several functions. It is designed to get students to review the methods which are used to study the brain and where particular functions are localized. It is also intended to make students think critically about how we know what we know about functional localization. The examples included are based on real life examples of situations which have provided information about localization of functions in the brain. Some of the situations described may be difficult for students to conceptualize. Be prepared to assist students in conceptualizing each situation. Students can do this exercise individually or in small groups. Group work is probably preferable because students can learn by bouncing ideas off of each other. The student handout for this activity is included as **Handout Master 2.2**. Suggested answers are included below.

1. The lesion method is being used to study brain function. Students may be puzzled by this, thinking that the lesion method always involves *intentionally* damaging part of the brain to study its function. This is not the case; much of the information we have about functional localization comes from fairly old studies of veterans who received gunshot wounds to their brains.

   This part of the brain controls movement on the opposite side of the body. It is the *motor* area of the cerebral cortex.

   By looking at the drawing we can see that damage high up on the brain results in paralysis, which is lower down on the body and vice versa. It is as if the body is "mapped" upside down and backwards on the motor cortex. (If you have a drawing of the "motor homunculus" it would be helpful to share this with the students after they have completed this exercise.)

2. The lesion method is being used to study brain function.
   Based on the information provided, the part of the brain labeled J is responsible for the ability to speak.
   The area marked J controls the ability to speak; it is on the left side of the brain. The equivalent area on the right side of the brain must be doing something else, since damage to this area does not produce any affect on speech.

3. The function of this part of the brain is being studied with the electrical stimulation method. Students may be surprised, and horrified, to find out that people are often awake during surgery on their brains. This is necessary because in real life the brain is not colour coded, nor does it come with nice little labels saying what its different parts do. During surgery, surgeons have a general idea where they are, but one part looks pretty much the same as the next. When the surgeon is planning to remove a part of the brain, for example, an area where a tumour is located or an area where a patient's epileptic seizures tend to start, he/she does not want to remove a part which would result in a marked decrement in the patient's quality of life (for example, a speech area). Therefore, it is fairly routine to stimulate an awake patient's brain during surgery, to verify the function of the areas the surgeon is working near. During surgery, the scalp, bone, and membranes covering the brain must be anesthetized, so that the patient does not feel pain. The brain itself does not have pain receptors, so that working on the brain is not physically painful.

   This part of the brain appears to process visual information; in fact, it is the *visual* cortex. When this part of the brain is stimulated electrically, neurons are activated in much the same way that they would be by natural visual stimulation. Therefore, the patient reports seeing a visual stimulus that is not actually there.

   The information provided suggests that there is an upside-down and backwards map of the visual world on the visual cortex (note the similarity to the upside-down and backwards map of the body on the motor cortex in the first example). Note that the left side of the brain is being stimulated. Yet, when the patient fixates on the cross in the middle of the screen, all of the points of light that he reports are to the right of the fixation point. Therefore, the information from the right side of the visual field is relayed to the left side of the brain. Note also, that when points which are higher up on the cortex are stimulated, the patient reports seeing flashing lights in the lower part of the visual field; conversely, when points lower down on the visual cortex are stimulated, the patient reports flashing lights in the upper part of the visual field. Hence, the notion of an upside-down and backwards map of the visual world in the visual cortex.

4. The function of this part of the brain is being studied through the electrical stimulation method.

   This part of the brain is responsible for the sense of touch (among other things) on the opposite side of the body. The area being stimulated is the *somatosensory* cortex.

   By looking at the drawing we can see that stimulation high up on the brain results in a tingling sensation, which is lower down on the body and vice versa. It is as if the body is "mapped" upside down and backwards on the somatosensory cortex. (If you have a drawing of the "sensory homunculus" it would be helpful to share this with the students after they have completed this exercise.) The notion of the world being mapped upside down and backwards on the brain should be starting to sound like a recurring theme by now!

5. The method being used is positron emission tomography (PET scanning).

   This area is responsible for processing information concerning sounds; it is the *auditory* cortex.

6. A needle electrode is being used to record the electrical activity of this part of the brain.

   The evidence suggests that this part of the brain may be responsible for triggering eating behaviour; alternately, it may be responsible for the sensation of hunger.

7. The lesion method is being used to study brain function, but this time, in contrast to examples 1 and 2, the damage to the brain was created intentionally.
   The corpus callosum relays information from one side of the brain to the other when it is intact. In this example, because the corpus callosum is cut, information cannot be relayed from one side of the brain to the other. This explains the two specific deficits noted in this example.

   The patient is unable to name an object placed in her left hand because the sensory information from that hand is relayed to the right side of her brain, which has little or no language or speech ability.

   The patient is unable to pick out an object with her right hand that she has already felt with her left hand because that would require comparison of sensory information relayed to the two sides of the brain, which is no longer possible with the corpus callosum cut.

   Students may wonder why it is important that the patient kept her eyes closed in these two examples. This was done because each eye, when open, sends information to both sides of the brain. If the patient had had her eyes open in these examples, information would have been sent to both sides of the brain, and the patient would not have had difficulty with these tasks.

Activity: Looking Left, Looking Right

Objective: To demonstrate that lateral eye movements are associated with thinking
Materials: Left and Right Hemisphere Questions (Handout 2.2)
Procedure: It has been theorized that when language-related tasks are being performed in the left hemisphere, the eyes look to the right; when nonlanguage, spatial abilities are being used in the right hemisphere, the eyes look to the left. This is a relatively easy class activity. After pairing up, one student asks the questions and records lateral eye movements, while the other attempts to answer the questions.

Assignment: The Brain Diagram

Students often have trouble encoding the location and function of the different parts of the brain, both because (a) they glance too quickly over the colourful textbook illustrations and (b) their eyes tend to glaze over during class discussion of the brain's structure and function. As an easy remedy to this problem, try asking students to draw their own colourful rendition of the human brain, an active learning strategy that ensures that they encode and think about the parts of the brain rather than passively glossing over them in the text. Prior to the class period in which you will be discussing the brain, ask students to read Chapter 2 and to hand-draw a diagram of the brain (in a cross-section) on a clean white sheet of unlined paper. For each of the following sections of the brain, students should colour and label the appropriate structure, and also list at least one or two of its major functions: (a) the cerebral cortex, including the four lobes, (b) the thalamus, (c) the hypothalamus, (d) the hippocampus, (e) the amygdala, (f) the cerebellum, (g) the pons, and (h) medulla. Added benefits of this assignment are that it is easy to grade, students enjoy doing it (and it is an easy and fun way for them to get points), and it can be used by students as a study aid for the exam.

Activity: Split Brain

This activity allows students to feel some of the difficulty and frustration following split-brain surgery where the person's hemispheres can no longer communicate directly. Students should sit next to their partner. Each student plays the role of one hemisphere. Their outside arms should go behind their backs or remain still during the exercise. Arms closest to their partner should cross each other so that each "hemisphere" is controlling the opposite hand. The instructor can provide a series of tasks such as the following:

- Tying a shoe
- Opening a can with an opener

- Sealing an envelope
- Tearing open a bag of chips

The exercises will be quite difficult because each student is only controlling one hand, and the hands must work together to complete the task. These activities are a good segue into further discussion of split-brain surgeries.

Marin, A.J. (2011). *Interactive Learning Companion*. Boston: Pearson Education, Inc.

Activity: Psychology in Literature

The Man Who Mistook His Wife For a Hat

Oliver Sacks' national bestseller chronicles over 20 case histories of patients with a variety of neurological disorders. His compassionate retelling of bizarre and fascinating tales includes patients plagued with memory loss, useless limbs, violent tics and jerky mannerisms, the inability to recognize people or objects, and unique artistic or mathematical talents despite severe mental deficits. A reading of this absorbing book will surely increase your students' understanding of the connection between the brain and the mind, and will also give them invaluable insights into the lives of disordered individuals. Ask your students to write a book report focusing on a few of the cases that most interest them, and to apply principles from the text and lecture to the stories. As a more elaborate project, you might consider assigning this book at the end of the semester, as many of the cases are ripe with psychological principles that may be encountered later in the course (e.g., perception, memory, mental retardation).

Sacks, O. (1985). *The man who mistook his wife for a hat*. New York: Harper Collins.
Staff (1995, May/June). PT interview: Oliver Sacks; the man who mistook his wife for a ... what? *Psychology Today,* 28–33.

Activity: Twenty Questions

Objective: To review information about hormones
Materials: None
Procedures: Play a round of the Twenty Questions game. Tell students that you are thinking of a certain hormone. The students are to determine which hormone by asking you questions to which you can respond only "yes" or "no."

Activity: Crossword Puzzle

Frequently instructors want an activity that is interactive for their students as well as a reinforcer of the material just covered in the lecture. An activity such as a crossword puzzle can fulfill both criteria. Copy and distribute **Handout Master 2.3** to students as a homework or in-class review assignment.

The answers for the crossword puzzle are:

Across

1. neurotransmitter that causes the receiving cell to stop firing. **Inhibitory**
3. the cell body of the neuron, responsible for maintaining the life of the cell. **soma**
4. endocrine gland located near the base of the cerebrum which secretes melatonin. **pineal**
7. glands that secrete chemicals called hormones directly into the bloodstream. **endocrine**
8. long tube-like structure that carries the neural message to other cells. **axon**
10. chemical found in the synaptic vesicles which, when released, has an effect on the next cell. **neurotransmitter**
13. bundles of axons coated in myelin that travels together through the body. **nerves**
14. branch-like structures that receive messages from other neurons. **dendrites**
15. endocrine gland found in the neck that regulates metabolism. **thyroid**
17. thick band of neurons that connects the right and left cerebral hemispheres. **Corpus Callosum**
19. part of the nervous system consisting of the brain and spinal cord. **Central**

Down

2. part of the limbic system located in the centre of the brain, it acts as a relay from the lower part of the brain to the proper areas of the cortex. t**halamus**
4. endocrine gland that controls the levels of sugar in the blood. **pancreas**
5. fatty substances produced by certain glial cells that coat the axons of neurons to insulate, protect, and speed up the neural impulse. **myelin**
6. the basic cell that makes up the nervous system and which receives and sends messages within that system. **Neuron**
8. chemical substances that mimic or enhance the effects of a neurotransmitter on the receptor sites of the next cell. **Agonists**
9. part of the lower brain that controls and coordinates involuntary, rapid, fine motor movement. **cerebellum**
11. process by which neurotransmitters are taken back into the synaptic vesicles. **reuptake**
12. a group of several brain structures located under the cortex and involved in learning, emotion, memory, and motivation. **Limbic**
16. chemicals released into the bloodstream by endocrine glands. **Hormones**
18. brain structure located near the hippocampus, responsible for fear responses and memory of fear. **Amygdala**

Activity: Fill in the Blank

Copy and distribute **Handout Master 2.6** to students as a homework or in-class review assignment.

Answer Key: Chapter 2 The Biological Perspective Fill-in-the-Blanks

1. nervous system
2. neuron
3. axon
4. dendrites
5. soma
6. myelin
7. nerves
8. ions
9. resting potential
10. All or none
11. synaptic vesicles
12. Neurotransmitters
13. excitatory
14. agonists
15. spinal cord
16. sensory
17. peripheral nervous
18. somatic nervous
19. autonomic nervous
20. sympathetic division
21. electroencephalograph
22. cerebellum
23. thalamus
24. pons
25. reticular formation
26. hippocampus
27. amygdala
28. cortex
29. corpus callosum
30. occipital cortex
31. parietal cortex
32. temporal lobes
33. frontal Lobes
34. endocrine
35. adrenal glands

HANDOUT MASTERS

2.1 Mapping the Brain
2.2 Localization of Function Exercise
2.3 Crossword Puzzle
2.4 The Automatic Nervous System
2.5 The Basic Structure of the Neuron
2.6 Fill-in-the-Blank Exercise

Handout Master 2.1

Mapping the Brain—Instructions

Label the diagram of the brain to show or answer the following questions.

1. Is this a drawing of the left side or the right side of the brain? What are the particular functions of that side of the brain as compared to the other hemisphere?

   Left side functions: Right side functions:

2. Where is the front of the brain? Where is the back?

3. Label the cerebrum and cerebellum and describe their functions.

   Cerebral functions: Cerebellar functions:

4. Label the four lobes of the cerebral cortex.

5. Label the motor cortex and describe its function.

6. Label the visual cortex and describe its function.

7. Label the auditory cortex and describe its function.

8. Label the somatosensory cortex and describe its function.

9. Label Broca's and Wernicke's areas and describe their functions.

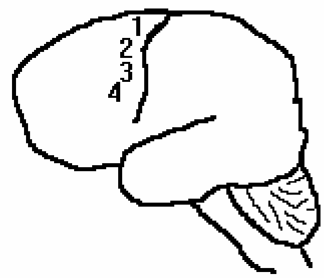
10. Where would you expect to find neurons in this drawing and how big would they be if they were drawn?

11. Label the brain stem. What is its function?

Handout Master 2.2

Localization of Function Exercise

Case 1. Dr. Holmes sees a series of patients with gunshot injuries to parts of their frontal lobes. The location of the damage to each person's brain is indicated in the drawing. Patient 1 has some paralysis of his right hip and thigh muscles. Patient 2 has paralyzed trunk muscles on his right side. Patient 3's right arm is paralyzed. Patient 4 shows paralysis of the muscles on the right side of her face.

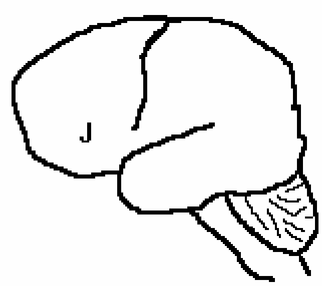


Case 1: a. What method is being used to study brain function?

b. What does this part of the brain do?

c. What can you say about the representation of this function in the brain based on this information (what are the rules of organization)?

Case 2. Dr. Broca's patient (J) has suddenly lost his ability to speak, apparently due to a stroke. After J dies, Dr. Broca studies the brain and discovers an area of damage in the location marked with J in the drawing below. Later another patient (K) dies and Dr. Broca is amazed to discover that this patient has damage to the comparable area of the brain on the right side, with NO effect on speech.

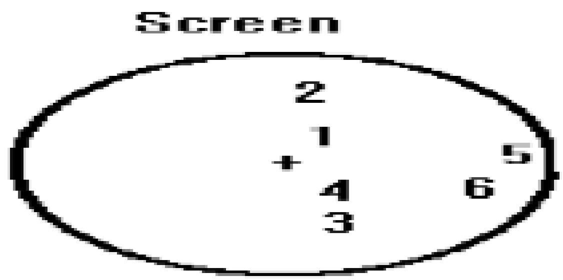


Case 2: a. What method is being used to study brain function?

b. What does the area of the brain marked J do?

c. What can we say about the lateralization of this function based on the information provided?

Case 3. Dr. Brightman is doing surgery on a patient to remove a rapidly growing tumour in the patient's brain. The patient is awake during the surgery. To check out where he is, Dr. Brightman applies a brief pulse of electricity to various areas of the brain and asks the patient to describe the sensation. The patient is looking up at a screen with a cross in the middle of it; he is fixating on the cross. After each point on the brain is touched, the patient reports seeing flashing lights and points to the area on the screen where he sees the lights.

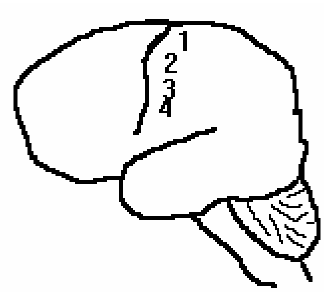


Case 3: a. What method is being used to study brain function?

b. What does this area of the brain do?

c. What can we say about how this function is mapped on the brain based on the information provided?

Case 4. Dr. Penfield is operating on the brain of a young woman with intractable epilepsy. He is going to remove the part of the brain where the seizure starts. He does not want to remove the wrong part, so the patient is awake during surgery, and Dr. Penfield identifies where he is in the brain by applying brief pulses of electricity to various parts of her brain. As Dr. Penfield touches each part of her brain, the patient reports feeling a tingling sensation on various parts of her body. At point 1 she feels tingling on her right thigh. At point 2 she feels tingling on the right part of her rib cage. At point 3 she reports a tingling on her right hand. At point 4 she feels a sensation on the right side of her face.

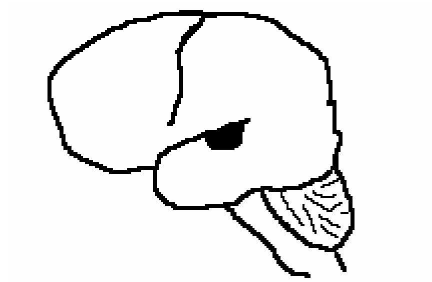


Case 4: a. What method is being used to study brain function?

b. What function is localized in this part of the brain?

c. How is this function mapped on the brain (how is it organized)?

Case 5. Dr. Lashley is doing experiments on brain function. He persuades a Doe College student to participate in his experiment. The student is injected with radioactive glucose and then asked to listen to recordings of various sounds for half an hour in a darkened room. Then the student's head is scanned to determine where in the brain the radioactivity has collected. The most intensely radioactive area is indicated on the drawing below.



Case 5: a. What method is being used to study brain function?

b. What does this area do?

Case 6. Dr. Gross places an electrode in part of the hypothalamus of a rat and measures the electrical activity in the hypothalamus during various activities. She finds that the part of the hypothalamus where the electrode is located is most active just before the rat eats.

Case 6: a. What method is being used to study brain function?

b. What does this part of the hypothalamus do?

Case 7. Dr. Sperry cuts the corpus callosum of a young woman to stop the spread of intractable epilepsy from one side of the brain to the other. After the woman has had time to recover from the surgery, Dr. Sperry tests her on various tasks. Dr. Sperry finds no impairment on most tasks. There are two exceptions. When the patient is asked to close her eyes and name an object placed in her hand, she can do so correctly for things placed in her right hand, but not for things placed in her left hand. (She has no problems with paralysis or lack of sensation, however.) When she is given a task where she is asked to close her eyes and feel something with her left hand, then pick it out of a group of objects using her right hand, she is also unable to do so.

Case 7: a. What method is being used to study function?

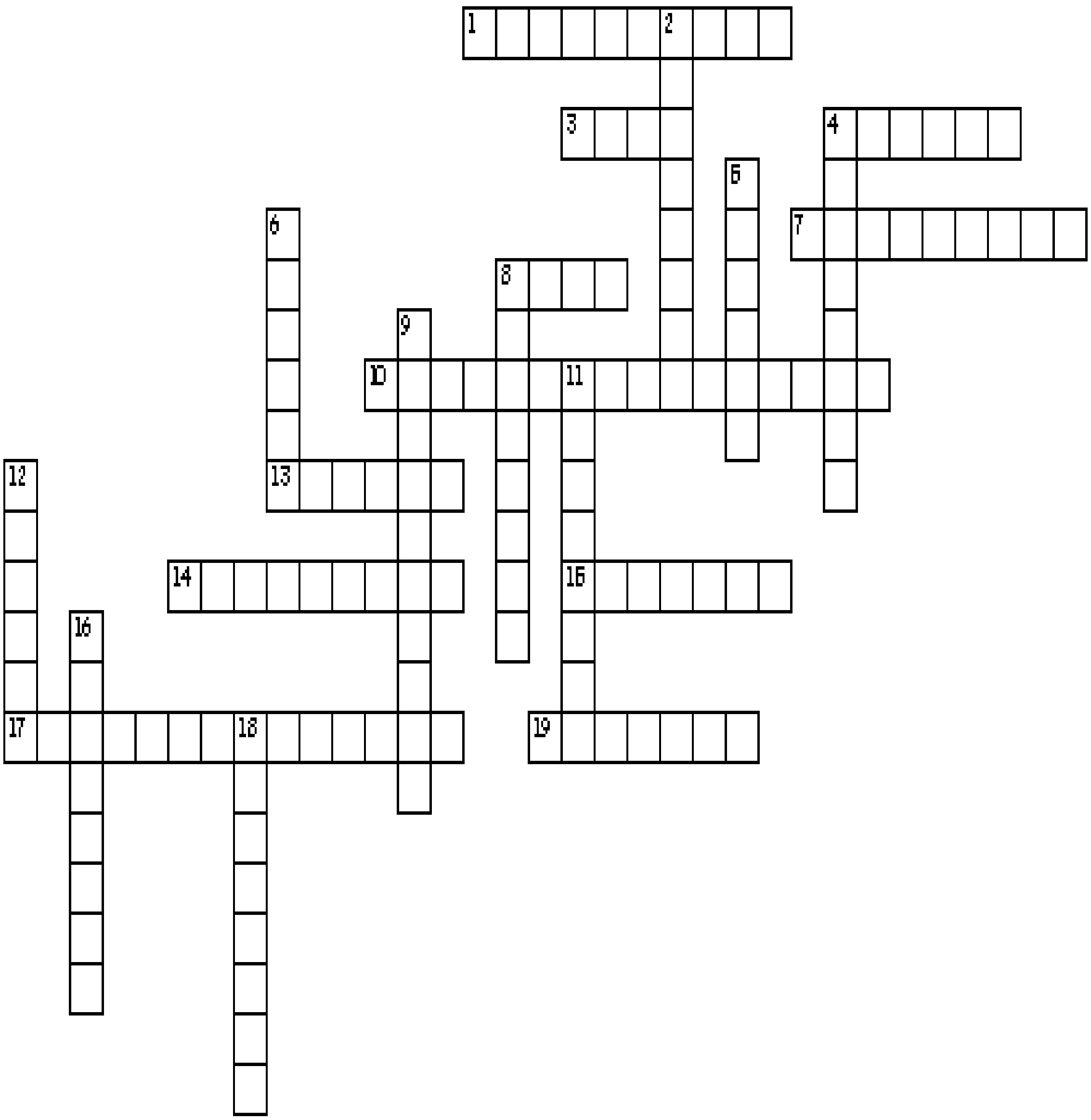
b. What does the corpus callosum do?

c. What accounts for the two specific impairments described here?

Handout Master 2.3

Crossword Puzzle Activity

Chapter 2: The Biological Perspective



Across

1. neurotransmitter that causes the receiving cell to stop firing.
3. the cell body of the neuron, responsible for maintaining the life of the cell.
4. endocrine gland located near the base of the cerebrum which secretes melatonin.
7. glands that secrete chemicals called hormones directly into the bloodstream.
8. long tube-like structure that carries the neural message to other cells.
10. chemical found in the synaptic vesicles which, when released, has an effect on the next cell.
13. bundles of axons coated in myelin that travel together through the body.
14. branch-like structures that receive messages from other neurons.
15. endocrine gland found in the neck that regulates metabolism.
17. thick band of neurons that connects the right and left cerebral hemispheres.
19. part of the nervous system consisting of the brain and spinal cord.

Down

2. part of the limbic system located in the centre of the brain, it acts as a relay from the lower part of the brain to the proper areas of the cortex.
4. endocrine gland that controls the levels of sugar in the blood.
5. fatty substances produced by certain glial cells that coat the axons of neurons to insulate, protect, and speed up the neural impulse.
6. the basic cell that makes up the nervous system and which receives and sends messages within that system.
8. chemical substances that mimic or enhance the effects of a neurotransmitter on the receptor sites of the next cell.
9. part of the lower brain that controls and coordinates involuntary, rapid, fine motor movement.
11. process by which neurotransmitters are taken back into the synaptic vesicles.
12. a group of several brain structures located under the cortex and involved in learning, emotion, memory, and motivation.
16. chemicals released into the bloodstream by endocrine glands.
18. brain structure located near the hippocampus, responsible for fear responses and memory of fear.

Handout Master 2.4

The Automatic Nervous System

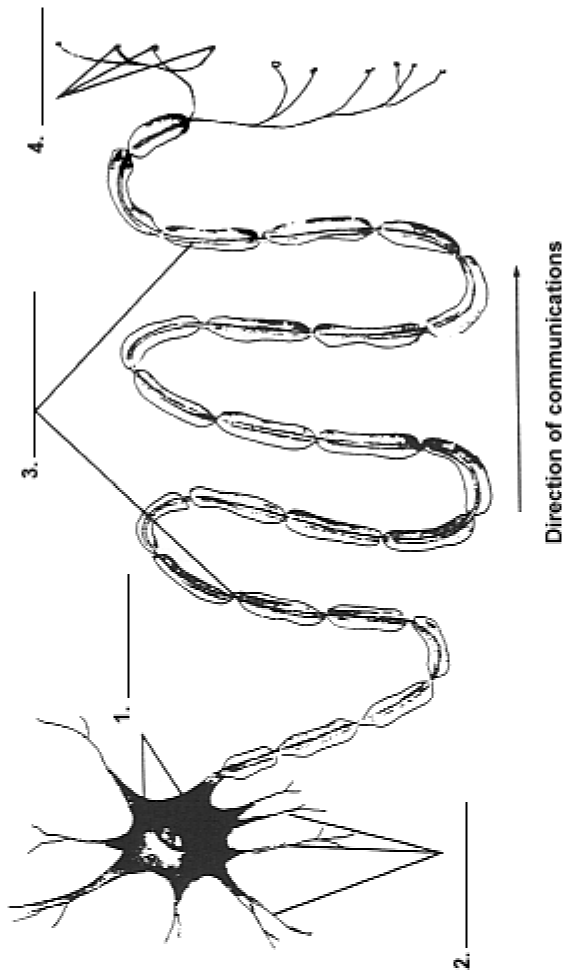
Describe how each organ is affected by the sympathetic and parasympathetic nervous system.

Organ	*Sympathetic*	*Parasympathetic*
Adrenal Medulla		
Bladder		
Blood Vessels Abdomen Muscles Skin		
Heart		
Intestines		
Liver		
Lungs		
Pupil of Eye		
Salivary Glands		
Sweat Glands		

Handout Master 2.5

The Basic Structure of the Neuron

Identify the parts of the neuron discussed in the text.



Handout Master 2.6

Fill-in-the-Blank Class Activity

1. An extensive network of specialized cells that carry information to and from all parts of the body is called the _______________ _______________.
2. The basic cell that makes up the nervous system and which receives and sends messages within that system is called a _______________.
3. The long tube-like structure that carries the neural message to other cells on the neuron is the _______________.
4. On a neuron, the branch-like structures that receive messages from other neurons are the _______________.
5. The cell body of the neuron, responsible for maintaining the life of the cell and containing the mitochondria is the _______________.
6. The fatty substances produced by certain glial cells that coat the axons of neurons to insulate, protect, and speed up the neural impulse is the _______________.
7. The bundles of axons in the body that travel together through the body are known as the _______________.
8. The charged particles located inside and outside of the neuron are called _______________.
9. The state of the neuron when not firing a neural impulse is known as the _______________ _______________.
10. _______________ _______________ _______________ refers to the fact that a neuron either fires completely or does not fire at all.
11. The _____________ _____________ are sack-like structures found inside the synaptic knob containing chemicals.
12. _______________ are chemicals found in the synaptic vesicles which, when released, have an effect on the next cell.
13. The _______________ neurotransmitter causes the receiving cell to fire.
14. The _______________ mimic or enhance the effects of a neurotransmitter on the receptor sites of the next cell, increasing or decreasing the activity of that cell.
15. The _______________ _______________ is a long bundle of neurons that carries messages to and from the body to the brain that is responsible for very fast, lifesaving reflexes.
16. A neuron that carries information from the senses to the central nervous system and is also known as the afferent is called a _______________ neuron.
17. All nerves and neurons that are not contained in the brain and spinal cord but that run through the body itself are in the _______________ _______________ system.
18. The division of the PNS consisting of nerves that carry information from the senses to the CNS and from the CNS to the voluntary muscles of the body is the _______________ _______________ system.
19. The _______________ _______________ system division of the PNS consists of nerves, which control all of the *involuntary* muscles, organs, glands, and sensory pathway nerves.
20. The part of the ANS that is responsible for reacting to stressful events and bodily arousal is called the _______________ _______________ of the nervous system.
21. A machine designed to record the brain wave patterns produced by electrical activity of the surface of the brain is called a(n) _______________.
22. The part of the lower brain located behind the pons that controls and coordinates involuntary, rapid, fine motor movement is called the _______________.
23. The part of the limbic system located in the centre of the brain, this structure relays sensory information from the lower part of the brain to the proper areas of the cortex and processes some sensory information before sending it to its proper area and is called the _______________.
24. The larger swelling above the medulla that connects the top of the brain to the bottom and that plays a part in sleep, dreaming, left–right body coordination, and arousal is called the _______________.
25. _______________ _______________ is an area of neurons running through the middle of the medulla and the pons, and slightly beyond, that is responsible for selective attention.
26. The _______________ is a curved structure located within each temporal lobe, responsible for the formation of long-term memories and the storage of memory for location of objects.

27. The _______________ is a brain structure located near the hippocampus, responsible for fear responses and memory of fear.
28. The _______________ is the outermost covering of the brain, consisting of densely packed neurons, responsible for higher thought processes and interpretation of sensory input.
29. The thick band of neurons that connects the right and left cerebral hemispheres is called the _________________ _______________.
30. The section of the brain located at the rear and bottom of each cerebral hemisphere containing the visual centres of the brain is the called the _______________ _______________.
31. The sections of the brain located at the top and back of each cerebral hemisphere, containing the centres for touch, taste, and temperature sensations is called the _______________ _______________.
32. The _______________ _______________ are the areas of the cortex located just behind the temples, containing the neurons responsible for the sense of hearing and meaningful speech.
33. The _______________ _______________are the areas of the cortex located in the front and top of the brain, responsible for higher mental processes and decision-making as well as the production of fluent speech.
34. The _______________ glands secrete chemicals called hormones directly into the bloodstream.
35. The endocrine glands located on top of each kidney that secrete over 30 different hormones to deal with stress, regulate salt intake, and provide a secondary source of sex hormones affecting the sexual changes that occur during adolescence are called the _______________ _______________.

Words to Use:

adrenal glands
agonists
all or none
amygdala
autonomic nervous
axon
cerebellum
corpus callosum
cortex
dendrites
electroencephalograph
endocrine
excitatory
frontal Lobes
hippocampus
ions
myelin
nerves
nervous system
neuron
neurotransmitters
occipital cortex
parietal cortex
peripheral pervous
pons
resting potential
reticular formation
sensory
soma
somatic nervous
spinal cord
sympathetic division
synaptic vesicles
temporal lobes
thalamus

WEB RESOURCES

General/Comprehensive

Biological and Physiological Resources: http://psych.athabascau.ca/html/aupr/biological.shtml
Links to several sites and interesting topical articles relevant to biological and physiological psychology. A good starting point for a number of assignments, such as writing short papers or assembling study guide terms. Maintained by the Centre for Psychology Resources at Athabasca University, Alberta, Canada.

CSBBCS – Canadian Society for Brain, Behaviour and Cognitive Science: https://www.csbbcs.org/

Neuroguide.com – Neurosciences on the Internet: http://www.neuroguide.com/
A resource for all things related to neuroscience: databases, diseases, research centres, software, biology, psychology, journals, tutorials, and so much more.

Neuropsychology Central: http://www.neuropsychologycentral.com/
Links to resources related to neuropsychology, including brain images, and extensive, well-organized, links to other sites.

Neuroscience for Kids: http://faculty.washington.edu/chudler/neurok.html
Don't be put off by the name! This site can be enjoyed by people of all ages who want to learn about the brain. Fun, superbly organized site providing information and links to other neuroscience sites. Includes informative pages regarding Brain Basics, Higher Functions, Spinal Cord, Peripheral Nervous System, The Neuron, Sensory Systems, Methods and Techniques, Drug Effects, and Neurological and Mental Disorders. Even includes a nice answer to the perennial question "Is it true that we only use 10% of our brain?" http://faculty.washington.edu/chudler/tenper.html

Whole Brain Atlas: http://www.med.harvard.edu:80/AANLIB/home.html
Prepared by Keith Johnson, M.D. and J. Alex Becker at Harvard University. Site includes brain images, information about imaging techniques, and information about specific brain disorders.

Neurons/Neural Processes

Basic Neural Processes Tutorials: http://psych.hanover.edu/Krantz/neurotut.html
A good site for your students to help them learn about basic brain functioning.

Making Connections – The Synapse: http://faculty.washington.edu/chudler/synapse.html
Clear, comprehensible, explanation of how synapses work, with nice illustrations, prepared by Eric Chudler.

Nervous System

Autonomic Nervous System: http://faculty.washington.edu/chudler/auto.html
Succinct summary of information about the structure and function of the autonomic nervous system, prepared by Eric Chudler.

Self-Quiz for Chapter on the Human Nervous System: http://www.psychwww.com/selfquiz/ch02mcq.htm
Self-quiz prepared by Russ Dewey at Georgia Southern University. Covers material typically found in an introductory psychology textbook chapter with a title like "Brain and Behaviour" or "Neuropsychology."

The Brain

Brain and Behaviour: http://serendip.brynmawr.edu/bb/
This mega-site contains lots of links to information about the brain, behaviour, and the bond between the two. Students can complete several interactive exercises to learn more about brain functions.

Brain Connection: The Brain and Learning: http://www.brainconnection.com/
A newspaper-style web page that contains interesting articles, news reports, activities, and commentary on brain-related issues.

Brain Function and Pathology: http://www.waiting.com/brainfunction.html
Concise table of diagrams of brain structures, descriptions of brain functions, and descriptions of signs and symptoms associated with brain structures and functions.

Brain Model Tutorial: http://pegasus.cc.ucf.edu/~Brainmd1/brain.html
This tutorial teaches students about the various parts of the human brain and allows them to test their knowledge of brain structures.

Brain: Right Down the Middle: http://faculty.washington.edu/chudler/sagittal.html
Useful drawing and succinct information about the location and functions of brain structures that can be seen on the midsagittal plane, presented by Eric Chudler.

***Conversations with Neil's Brain* (1994):** http://www.williamcalvin.com/index.html
An Online Book by William H. Calvin & George A. Ojemann of University of Washington. Teachers are allowed to print and photocopy chapters for educational use.

Drugs, Brains, and Behaviour: http://www.rci.rutgers.edu/~lwh/drugs/
An online textbook detailing the effects of various substances on the brain, authored by C. Robin Timmons & Leonard W. Hamilton.

Lobes of the Brain: http://faculty.washington.edu/chudler/lobe.html
Succinct information about the location and functions of the four lobes of the cerebrum, presented by Eric Chudler. Includes link to "Lobes of the Brain Review," a very brief quiz on functions associated with major lobes of the brain. Answers provided online: http://faculty.washington.edu/chudler/revlobe.html

U.S. National Library of Medicine from the NIH offers the Visible Human Project, where complete, anatomically detailed, three-dimensional representations of the normal male and female human bodies. Acquisition of transverse CT, MR and cryosection images of representative male and female cadavers has been completed. The male was sectioned at one-millimeter intervals, the female at one-third of millimeter intervals.
http://www.nlm.nih.gov/research/visible/visible_human.html

One Brain…or Two?: http://faculty.washington.edu/chudler/split.html
Information on lateralization of function and how the functions of the hemispheres may be studied, presented by Eric Chudler.

She Brains / He Brains
http://faculty.washington.edu/chudler/heshe.html: Nice summary of evidence for sex-related differences in brain structure, prepared by Eric Chudler.

What Does Handedness Have to Do with Brain Lateralization (and Who Cares?):
http://www.indiana.edu/~primate/brain.html
Very nice page on lateralization of function in the brain.