CHAPTER 2
BIOLOGY AND BEHAVIOUR

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LECTURE GUIDE

Module 2A The Neurons and the Neurotransmitters (text p. 30)

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LO 2.1 Define the function of the three types of neurons. [2A] (text p.30)

Afferent (sensory) neurons relay messages from the sense organs and receptors - eyes, ears, nose, mouth, and skin- to the brain or spinal cord.

Efferent (motor) neurons convey signals from the brain and spinal cord to the glands and muscles, enabling us to move.

Interneurons, thousands of times more numerous than sensory or motor neurons, carry information between neurons in the brain and between neurons in the spinal cord.

LO 2.2 Identify the three key structures of a neuron. [2A] (text p.30)

The three key structures of a neuron are the cell body (soma), dendrites, and axon.

The cell body (soma) contains the nucleus and carries out the metabolic, or life-sustaining, functions of the neuron.

The dendrites branch out from the cell body and are the primary receivers of signals from other neurons. They can relay messages backwards from the cell body to their own branches (called *back propagating*).

The axon is a slender, tail-like extension of the neuron that sprouts into many branches, each ending in a rounded axon terminal. The axon terminals transmit signals to the dendrites or cell bodies of other neurons, and to muscles, gland, and other parts of the body.

LO 2.3 Explain how neural impulses work. [2A] (text p. 31)

The action potential is the firing of a neuron that results when the charge within the neuron becomes more positive than the charge outside the cell's membrane.

When a neuron is at rest (not firing), the inside of the neuron has a slight negative electrical charge compared to the outside; this is referred to as the neuron's resting potential. When a neuron is stimulated, more positively charged particles flow into the cell, making the insides suddenly positive compared to the outside of the cell. This sudden reversal is the action potential. Immediately after the neuron fires, some positive particles are actively pumped out of the cell. The neuron returns to its resting potential and is ready to fire again if stimulated.

LO 2.4 Contrast excitatory and inhibitory effects of neurotransmitters and how they affect behaviour. [2A] (text p. 32)

When neurotransmitters enter receptor sites on the dendrites or cell bodies of receiving neurons, their action is either excitatory (influencing the neurons to fire) or inhibitory (influencing them not to fire). 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. This is an inhibitory effect. A substance in the venom of black widow spiders stimulates release of acetylcholine at the synapses. Botulism, a 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 behavior. Psychoactive drugs affect consciousness because of their effects on synaptic transmission. For example, cocaine and the amphetamines prolong the action of certain neurotransmitters and opiates imitate the action of natural neuromodulators called the endorphins. This is an excititory effect. 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 behavior. Could intelligence be primarily a matter of having plenty of the right neurotransmitter at the right synapses?

LO 2.5 Understand the role of the following neurotransmitters: acetylcholine, dopamine, norepinephrine, epinephrine, serotonin, amino acids, and endorphins. [2A] (text p. 33)

Acetylcholine was the first to be discovered; it is an excitatory neurotransmitter that causes your muscles to contract. It has an inhibitory effect on the muscle fibres of the heart, which keeps the heart from beating too fast. It also plays a role in stimulating neurons involved in learning new information. (ACh) Affects movement, learning, memory, REM sleep.

An important class of neurotransmitters known as monoamines includes four neurotransmitters — dopamine, norepinephrine (noradrenalin), epinephrine (adrenalin), and serotonin.

Like acetylcholine, dopamine (DA) produces both excitatory and inhibitory effects and is involved in several functions, including learning, attention, movement, and reinforcement. It is also important to our ability to feel pleasure. 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. Dopamine affects learning, attention, movement, reinforcement.

Norepinephrine (NE) affects eating habits (it stimulates the intake of carbohydrates) and plays a major role in alertness and wakefulness.

Serotonin produces inhibitory effects at most of the receptors with which it forms synapses. It plays an important role in regulating mood, sleep, impulsivity, aggression, and appetite (Greden, 1994). It has also been linked to depression and anxiety disorders. Some antidepressant drugs relieve the symptoms of depression by blocking the uptake of serotonin or norepinephrine, thus increasing the neurotransmitter’s availability in the synapses.

There are two amino acids of particular importance that are found more often than any others in the central nervous system—glutamate (glutamic acid) and GABA (gamma-aminobutyric acid).

Glutamate is the primary excitatory neurotransmitter in the brain (Riedel, 1996). It may be released by 40 percent of neurons and is active in the higher brain centres that are involved in learning, thought, and emotions.

Gamma-aminobutyric acid (GABA) is the main inhibitory neurotransmitter in the brain (R. Miles, 1999) and is widely distributed throughout the central nervous system (brain and spinal cord). It is thought to facilitate the control of anxiety in humans. Tranquilizers, barbiturates, and alcohol appear to have a calming and relaxing effect because they bind with and stimulate one type of GABA receptor and thus increase GABA’s anxiety-controlling effect.

Endorphins are opiate-like substances produced naturally by the brain that provide relief from pain or the stress of vigorous exercise and produce feelings of pleasure and well being.

Module 2B The Central Nervous System (text p. 35)

Lecture Launchers and Discussion Topics: [2B]

- The Perception of Phantom Pain [2B]
- The Brain [2B]
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- The Limbic System [2B]

MyPsychLab Video Series: [2B]

- Episode 3 – Biological Psychology [2B]

LO 2.6 Identify the major structures of the central nervous system: brainstem, cerebellum, thalamus, hypothalamus, and limbic system. [2B] (text p. 35)

The nervous system is divided into two parts: (1) the central nervous system (CNS), which is composed of the brain and the spinal cord, and (2) the peripheral nervous system, which connects the central nervous system to all other parts of the body. The central nervous system is composed of the spinal cord and the brain. The spinal cord descends from the brain and transmits messages between the brain and the peripheral nervous system, the brainstem, the cerebellum, the thalamus, the hypothalamus, the limbic system, and the cerebral hemispheres (including the frontal, parietal, occipital, and temporal lobes).

LO 2.7 Explain the function of each of the major structures of the central nervous system. [2B] (text p. 36)

The brainstem contains (1) the medulla, which controls heartbeat, breathing, blood pressure, coughing and swallowing, and (2) the reticular formation (also called reticular activating system or RAS), which plays a crucial role in arousal and attention.

Cerebellum means "little cerebrum." The main functions of the cerebellum are to execute smooth, skilled movements and to regulate muscle tone and posture.

The thalamus acts as a relay station for for virtually all the information that flows into and out of the higher brain centres.

The hypothalamus regulates hunger, thirst, sexual behaviour, body temperature, our biological clock, and a variety of emotional behaviours. As small as it is, the hypothalamus maintains nearly all our bodily functions except blood pressure, heart rhythm, and breathing.

The limbic system is a group of structures deep within the brain, including the amygdala and the hippocampus, that are collectively involved in emotional expression, memory, and motivation. The amygdala helps us form associations between external events (including social ones) and the emotions related to those events. The hippocampus is absolutely essential in the formation of conscious memory. It also plays a role in the brain's internal representation of space in the form of neural "maps" that help us learn our way around new environments and remember where we have been.

The cerebral hemispheres are the right and left halves of the cerebrum, connected by the corpus callosum and covered by the cerebral cortex, which is responsible for higher mental processes such as language, memory, and thinking.

The frontal lobes contain (1) the motor cortex, which controls voluntary motor activity; (2) Broca's area, which functions in speech production; and (3) the frontal association areas, which are involved in thinking, motivation, planning for the future, impulse control, and emotional responses.

The parietal lobes contain the somatosensory cortex (where touch, pressure, temperature, and pain register) and other areas that are responsible for body awareness and spatial orientation.

The occipital lobes contain the primary visual cortex, where vision registers, and association areas involved in the interpretation of visual information.

Module 2C The Cerebral Hemispheres (text p. 39)

Lecture Launchers/Discussions Topics: [2C]

- Freak Accidents and Brain Injuries [2C]
- Neural Effects of a Concussion [2C]
- The Phineas Gage Story [2C]

Classroom Activities, Demonstrations, and Exercises: [2C]

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- Connie: Head Injury [2C]
- Roger Sperry [2C]
- Split-Brain Experiments [2C]
- The Visual Cortex [2C]

MyPsychLab Video Series: [2C]

- Episode 3 – Biological Psychology [2C]

LO 2.8 Identify and explain the function of each of the lobes of the cerebral hemisphere. [2C] (text p. 40)

The frontal lobes contain (1) the motor cortex, which controls voluntary motor activity; (2) Broca's area, which functions in speech production; and (3) the frontal association areas, which are involved in thinking, motivation, planning for the future, impulse control, and emotional responses.

The parietal lobes contain the somatosensory cortex (where touch, pressure, temperature, and pain register) and other areas that are responsible for body awareness and spatial orientation.

The occipital lobes contain the primary visual cortex, where vision registers, and association areas involved in the interpretation of visual information.

LO 2.9 Explain how damage within a lobe might affect performance and functioning in everyday life. [2C] (text p. 40)

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.

Module 2D Specialization of the Cerebral Hemispheres [2D] (text p. 44)

Lecture Launchers/Discussions Topics: [2D]

- Workplace Problems [2D]
- Understanding Hemispheric Function [2D]
- Brain's Bilingual Broca [2D]

Classroom Activities, Demonstrations, and Exercises: [2D]

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- Roger Sperry [2D]
- Split Brain Experiments [2D]
- The Visual Cortex [2D]

MyPsychLab Video Series: [2D]

- Episode 3 – Biological Psychology [2D]

LO 2.10 Contrast the functions of the left and right hemispheres. [2D] (text p. 44)

The left hemisphere controls the right side of the body, coordinates complex movements, and (in 95 percent of people) controls the production of speech and written language.

The right hemisphere controls the left side of the body and, in most people, is specialized for visual-spatial perception and for understanding of non-verbal behaviour.

Research with split-brain patients has expanded our knowledge of the unique capabilities of the individual hemispheres. A split-brain operation, performed in severe cases of epilepsy, is an operation in which the corpus callosum is cut, separating the cerebral hemispheres and usually lessening the severity and frequency of grand mal seizures.

Module 2E The Brain across the Lifespan [2E] (text p. 47)

Web Resources: [2E]

- General Resources [2E]

Multimedia Library: [2E]

- Connie: Head Injury [2E]
- Exercise Your Brain [2E]

MyPsychLab Video Series: [2E]

- Episode 3 – Biological Psychology [2E]

LO 2.11 Map out the major developmental changes of the brain across the lifespan. [2E] (text p. 47)

The brain grows in spurts from conception until well into adulthood. These spurts are correlated with major advances in physical and intellectual skills. Each spurt also seems to involve a different brain area. The spurt from 17 to 20 primarily affects the frontal lobes. Brain weight begins to decline around age 30.

LO 2.12 Understand the impact of synaptic losses across the lifespan. [2E] (text p. 47)

Age related deficits due to the loss of grey matter are common. For example, elderly people tend to experience problems with balance. However, as is true in childhood, intellectual and motor training can positively influence the brains of older adults.

LO 2.13 Understand the implications that plasticity has for recovery from brain damage. [2E] (text p. 47)

The brain's ability to reorganize and to compensate for brain damage is termed plasticity. The ability of the brain and spinal cord to change both in structure and function is referred to as neuroplasticity. One type of cell that facilitates these changes are stem cells. Some abilities lost through brain damage can be regained if areas near the damaged site take over the lost function.

Plasticity is greatest in young children, whose hemispheres haven't yet been completely lateralized (Bach-y-Rita & Bach-y-Rita, 1990). Some individuals who have had entire hemispheres removed early in life because of uncontrollable epilepsy have been able to lead near-normal intellectual lives (Bower, 1988).

Module 2F Discovering the Brain's Mysteries [2F] (text p. 48)

Lecture Launchers/Discussions Topics: [2F]

- Berger's Wave [2F]
- Measurement of Brain Activity [2F]

Classroom Activities, Demonstrations, and Exercises: [2F]

- Review of Brain-Imaging Techniques [2F]
- Trip to the Hospital [2F]

Web Resources: [2F]

- General Resources [2F]

Multimedia Library: [2F]

- ALS: Lost Nerve Power [2F]
- MKM and Brain Scans [2F]
- The Visual Cortex [2F]

MyPsychLab Video Series: [2F]

- Episode 3 – Biological Psychology [2F]

LO 2.14 Identify tools used to study the brain, including the electroencephalograph, computerized axial tomography, magnetic resonance imaging, and position emission tomography. [2F] (text p. 48)

We can study the brain by using deep lesioning to destroy certain areas of the brain in laboratory animals, or by electrically stimulating those areas (ESB).

We can use case studies of human brain damage to learn about the brain's functions, but cannot easily generalize from one case to another.

The EEG (electroencephalogram) 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.

CT (computerized axial tomography) scans are computer-aided X-rays of the brain and show a great deal of brain structure.

MRI (magnetic resonance imaging) scans use a magnetic field and a computer to give researchers an even more detailed look at the structure of the brain. A related technique, fMRI, allows researchers to look at the activity of the brain during various mental tasks.

PET (position emission tomography) 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.

LO 2.15 Understand the kind of information that can be gained from each tool used to study the brain. [2F] (text p. 49)

EEG (electroencephalogram) measures electrical activity occurring in the brain. It can show an epileptic seizure process and can be used to study neural activity in people with learning disabilities, schizophrenia, Alzheimer's disease, sleep disorders, and other neurological problems. While the EEG (electroencephalogram) is able to detect electrical activity in different areas of the brain, it cannot reveal what is happening in individual neurons, while microelectrodes can.

Microelectrodes have been used to discover the exact functions of single cells within the primary visual cortex and the primary auditory cortex.

CT (computerized axial tomography) reveals the structures within the brain (or other parts of the body) as well as abnormalities and injuries, including tumours and old or recent strokes.

MRI (magnetic resonance imaging) is a powerful diagnostic tool that can be used to find abnormalities in the central nervous system and in other systems of the body.

fMRI (functional magnetic resonance imaging) can image both brain structure and brain activity by examining changes in oxygen flow within the brain. It has the ability to image precise locations of activity detecting changes that take place in less than a second.

PET scan (position emission tomography) is a powerful instrument for identifying malfunctions that cause physical and psychological disorders and also for studying normal brain activity (Volkow &Tancredi, 1991). The PET can also map the patterns of blood flow, oxygen use, and consumption of glucose. It will show the action of drugs and other biochemical substances in the brain and other organs.

Module 2G The Peripheral Nervous System [2G] (text p. 51)

Web Resources: [2G]

- General Resources [2G]

Multimedia Library: [2G]

- The Nerve Impulse and Afferent and Efferent Neurons [2G]

MyPsychLab Video Series: [2G]

- Episode 3 – Biological Psychology [2G]

LO 2.16 Identify and explain the function of the two components of the peripheral nervous system. [2G] (text p. 51)

The peripheral nervous system connects the central nervous system to the rest of the body. It has two subdivisions: (1) the somatic nervous system, which consists of the nerves that make it possible for us to sense and move; and (2) the autonomic nervous system.

The autonomic nervous system has two parts: (1) the sympathetic nervous system, which mobilizes the body's resources during emergencies or during stress; and (2) the parasympathetic nervous system, which is associated with relaxation and brings the heightened bodily responses back to normal after an emergency.

LO 2.17 Explain the function of the sympathetic and parasympathetic nervous systems. [2G] (text p. 51)

Any time you are faced with stress, or in an emergency, the sympathetic nervous system automatically mobilizes the body's resources, preparing you for action. This results in the 'fight or flight' response. Specifically, this increases heart and respiration rate, enhances blood flow to skeletal muscles, and almost shuts down the digestive system.

The parasympathetic nervous system is responsible for bringing your bodily functions back to normal after the stress or emergency is over. As a result of its action your pulse and breathing return to normal, as does your digestive system.

Module 2H The Endocrine System (text p. 52)

Lecture Launchers/Discussions Topics: [2H]

- Too Much or Too Little: Hormone Imbalances [2H]
- Would You Like Fries with That Peptide? [2H]

Web Resources: [2H]

- General Resources [2H]

Multimedia Library: [2H]

- The Endocrine System [2H]

LO 2.18 Identify the components of the endocrine system. [2H] (text p. 52)

The endocrine system is a series of ductless glands, found in various parts of the body, that manufacture and secrete chemicals known as hormones (from the Greek word for "excite"). The pituitary gland, the thyroid gland, the adrenal glands, the pancreas, and the sex glands all have important roles in the function of the body that in turn influence behaviour.

LO 2.19 Understand the role of glands and hormones within the endocrine system. [2H] (text p. 53)

Hormones are secreted directly into the bloodstream, influencing the activity of the muscles and organs.

The pituitary gland is considered to be the “master gland” of the body because it releases the hormones that “turn on,” or activate, the other glands in the endocrine system. The pituitary gland is found in the brain just below the hypothalamus. The pituitary also produces the hormone that is responsible for body growth.

The thyroid gland is located inside the neck. It controls metabolism (the burning of energy) by secreting thyroxine.

The adrenal glands are a pair of endocrine glands that release hormones that prepare the body for emergencies and stressful situations and also release small amounts of the sex hormones.

The pancreas regulates the level of sugar in the blood by secreting insulin and glucagon. Too much insulin produces hypoglycemia, while too little causes diabetes.

The sex glands (gonads) are the ovaries in women and testes in men. They secrete hormones to regulate sexual growth, activity, and reproduction.

Summary and Review (text p. 56)

Classroom Activities, Demonstrations, and Exercises: [Summary & Review]

- The Brain Diagram [Summary & Review]
- Twenty Questions [Summary & Review]
- Crossword Puzzle [Summary & Review]
- Fill-in-the-Blanks [Summary & Review]

Web Resources: [Summary & Review]

- General Resources [Summary & Review]

Multimedia Library: [Summary & Review]

- Glossary Flashcards for Chapter 2 [Summary & Review]

MyPsychLab Video Series: [Summary & Review]

- Episode 3 – Biological Psychology [Summary & Review]

LECTURE LAUNCHERS AND DISCUSSIONS TOPICS

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Berger's Wave [2F]
Measurement of Brain Activity [2F]
Too much or too little: Hormone Imbalances [2H]
Would You Like Fries With That Peptide? [2H]

Introducing the Chapter: [2A]

This chapter is often students' first encounter with in-depth information about these biological topics. The current chapter introduces this topic with an interesting discussion of how we interpret others' facial expressions. This introduction demonstrates how intriguing it is to understand the biological underpinnings of behavior and how little we know about the brain.

Another interesting way to engage students in this area is to ask them to consider both how resilient and how fragile the brain is. The story of Phineas Gage provides a good starter for this discussion. The full story is provided below, although Phineas' case is highlighted in the body of the text as well.

> On September 13, 1848, 25-year-old Phineas Gage, a foreman on a railway construction crew, was using dynamite to blast away rock and dirt. Suddenly, an unplanned explosion almost took Gage's head off, sending a 105-centimetre, 6-kilogram metal rod under his left cheekbone and out through the top of his skull.
>
> Much of the brain tissue in Gage's frontal lobe was torn away, along with flesh, pieces of skull, and other bone fragments. This should have been the end of Phineas Gage but it wasn't. He regained consciousness within a few minutes and was loaded onto a cart and wheeled to his hotel nearly two kilometres away. He got out with a little help, walked upstairs, entered his room, and walked to his bed. He was still conscious when the doctor arrived nearly two hours later.

Gage recovered and returned home in about five weeks, but he was not the same man. Before the accident, he was described as a hard worker who was polite, dependable and well-liked. But the new Phineas Gage, without part of his frontal lobe, was found to be loud-mouthed and profane, rude and impulsive, and contemptuous toward others. He no longer planned realistically for the future and was no longer motivated and industrious, as he once had been. Gage lost his job as foreman and joined P.T. Barnum's circus as a sideshow exhibit at carnivals and county fairs. (Story adapted from J.M. Harlow (1848). Passage of an iron rod through the head. *Boston Medical and Surgical Journal, 39,* 389-393.)

Lecture/Discussion: Neurotransmitters: Chemical Communicators of the Nervous System [2A]

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 than 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 behavior. Psychoactive drugs affect consciousness because of their effects on synaptic transmission. For example, cocaine and the amphetamines prolong the action of certain neurotransmitters, and opiates imitate the action of natural neuromodulators called the endorphins. It appears that the neurotransmitters dopamine, norepinephrine, and serotonin are associated with some of the most severe forms of mental illness.

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Lecture/Discussion: Synaptic Transmission and Neurotransmitters [2A]

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 electrical. 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: Acetylcholine and Serotonin [2A]

Acetylcholine (ACh) is a neurotransmitter that plays an important role in transmitting the electrical impulse from motor neurons to the skeletal muscles, enabling our muscles to contract. ACh is involved in a variety of functions (Panksepp, 1986). Its crucial role in the formation of memories can be seen in Alzheimer’s patients, who have a deficiency in acetylcholine and suffer from severe memory loss (Mishkin & Appenzeller, 1987; Silberner, 1985).

Serotonin is a neurotransmitter that inhibits behaviours ranging from feeding, play, and aggression to sexual and maternal behaviours, and its presence promotes sleep (Panksepp, 1986). Adequate levels of both serotonin and norepinephrine are related to positive feelings (Carlson, 1990), and a deficiency in the two has been linked to depression. A class of antidepressant drugs called tricyclics relieves the symptoms of depression in many of its victims by blocking the reuptake of these neurotransmitters, thus increasing their availability in the synapses.

Carlson, N.R. (1990). *Physiology of behaviour* (4th ed.). Boston: Allyn and Bacon.

Mishkin, M., & Appenzeller, T. (1987). The anatomy of memory. *Scientific American, 25*, 680-689.

Panksepp, J. (1986). The neurochemistry of behaviour. *Annual Review of Psychology, 37*, 77-107.

Lecture/Discussion: The Perception of Phantom Pain [2B]

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 though 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 anesthesia 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 centers 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 [2B]

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 [2B]

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.

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.

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: The Hippocampus [2B]

Studies with animals have confirmed the role of the hippocampus in learning, and autopsies performed on patients suffering from Alzheimer's disease have revealed extensive damage to neurons in the hippocampus (Wolozin, 1986). But a tragic experimental surgical procedure performed on a man known as H. M. provides the most dramatic evidence of the critical role the hippocampus plays in human memory. Brenda Milner (1972), who made an extensive study of H. M.'s case, reported that his general intelligence suffered not at all, and the information stored in his memory before the surgery was not affected either. But H. M. could no longer learn new information and store it in memory for later recall. He could not remember what he had said, done, read, or experienced from one day to the next. He would read the same magazines over and over, and each time the material was completely unfamiliar to him. H. M.'s memory was forever imprisoned in his past.

Milner, B. (1972). Disorders of learning and memory after temporal lobe lesions in man. *Clinical Neurosurgery, 19*, 421-446.

Wolozin, B.L., Pruchnicki, A., Dickson, D.W., & Davies, P. (1986). A neuronal antigen in the brains of Alzheimer patients. *Science, 232*, 648-650.

Silberner, J. (1985). Alzheimer's disease: Source searching. *Science News*, *12*, 824.

Lecture/Discussion: Freak Accidents and Brain Injuries [2C]

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 link below. 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.

http://www.thefreelibrary.com/SIX+NAILS+IN+THE+HEAD+BUT+HE+SURVIVES.(News)-a0116316354

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 [2C]

During the fall term, when college football is in season, it is especially appropriate to stress the discussion of the neuronal and behavioral 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 signaling is disrupted, either temporarily or permanently. Depending on the brain areas where the damaged axons are located, different physiological symptoms may occur.

Lecture/Discussion: The Phineas Gage Story [2C]

Recently, the journal History of Psychiatry reprinted the original presentation of the case study of Phineas P. Gage, noteworthy in psychology for surviving having an iron tamping rod driven through his skull and brain. The case notes, by physician John M. Harlow, reveal aspects of the event that provide greater detail about Gage and his unfortunate accident.

> Phineas Gage stood five feet six inches tall, weighed 150 pounds, and was 25 years old at the time of the incident. By all accounts this muscular foreman of the Rutland and Burlington Railroad excavating crew was well-liked and respected by his workers, due in part to "an iron will" that matched "his iron frame." He had scarcely known illness until his accident on September 13, 1848, in Cavendish, Vermont. Here is an account of the incident, in Harlow's own words:
>
> "He was engaged in charging a hold (sic) drilled in the rock, for the purpose of blasting, sitting at the time upon a shelf of rock above the hole. His men were engaged in the pit, a few feet behind him... The powder and fuse had been adjusted in the hole, and he was in the act of 'tamping it in,' as it is called...While

> doing this, his attention was attracted by his men in the pit behind him. Averting his head and looking over his right shoulder, at the same instant dropping the iron upon the charge, it struck fire upon the rock, and the explosion followed, which projected the iron obliquely upwards...passing completely through his head, and high into the air, falling to the ground several rods behind him, where it was afterwards picked up by his men, smeared with blood and brain."
>
> The tamping rod itself was three feet seven inches in length, with a diameter of 1¼ inches at its base and a weight of 13¼ pounds. The bar was round and smooth from continued use, and it tapered to a point 12 inches from the end; the point itself was approximately ¼ inch in diameter.

The accounts of Phineas' frontal lobe damage and personality change are well-known, and are corroborated by Harlow's presentation. Details of Phineas' subsequent life (he lived 12 years after the accident) are less known. Phineas apparently tried to regain his job as a railroad foreman, but his erratic behavior and altered personality made it impossible to do so. He took to traveling, visiting Boston and most major New England cities, and New York, where he did a brief stint at Barnum's sideshow. He eventually returned to work in a livery stable in New Hampshire, but in August, 1852, he turned his back on New England forever. Gage lived in Chile until June of 1860, then left to join his mother and sister in San Francisco. In February, 1861, he suffered a series of epileptic seizures, leading to a rather severe convulsion at 5 a.m. on February 20. The family physician unfortunately chose bloodletting as the course of treatment. At 10 p.m., May 21, 1861, Phineas eventually died, having suffered several more seizures. Although an autopsy was not performed, Phineas' relatives agreed to donate his skull and the iron rod (which Phineas carried with him almost daily after the accident) to the Museum of the Medical Department of Harvard University.

Miller (1993) also briefly notes that John Martyn Harlow himself had a rather pedestrian career, save for his association with the Gage case. Born in 1819, qualifying for medical practice in 1844, and dying in 1907, he practiced medicine in Vermont and later in Woburn, Massachusetts, where he engaged in civic affairs and apparently amassed a respectable fortune as an investor. Like Gage himself, Harlow was an unremarkable person brought into the annals of psychology by one remarkable event.

Harlow, J. M. (1848). Passage of an iron rod through the head. *Boston Medical and Surgical Journal*, *39*, 389–393.

Harlow, J. M. (1868). Recovery from the passage of an iron bar through the head. Paper read before the Massachusetts Medical Society.

Miller, E. (1993). Recovery from the passage of an iron bar through the head. *History of Psychiatry*, *4*, 271–281.

Lecture/Discussion: Workplace Problems: Left Handedness [2D]

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 [2D]

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 signaling 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 humor 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 Classroom Activities, Demonstrations and Exercises 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 [2D]

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: Berger's Wave [2E]

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 honor of Berger's discovery.

Lecture/Discussion: Measurement of Brain Activity [2E]

Sophisticated fMRI scans allow neuroscientists to explore the working brain and to determine what areas are being used during performance of a verbal task.

Lecture/Discussion: Too much or too little: Hormone Imbalances [2H]

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 (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* and *Cushing’s Syndrome.* 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? [2H]

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 being 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, whereas 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 estrogen 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 centers 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/research/faculty/leibowitz/research

CLASSROOM ACTIVITIES, DEMONSTRATIONS, AND EXERCISES

Using Reaction Time to Show the Speed of Neurons [2A]
The Dollar Bill Drop [2A]
Using Dominoes to Understand the Action Potential [2A]
Demonstrating Neural Conduction: The Class as a Neural Network [2A]
Human Neuronal Chain [2A]
Mapping the Brain [2B]
The Importance of a Wrinkled Cortex [2B]
Probing the Cerebral Cortex [2B]
Localization of Function Exercise [2C]
Looking Left, Looking Right [2C]
Lateralization Activities [2D]
Review of Brain-Imaging Techniques [2F]
Trip to the Hospital [2F]
The Brain Diagram [Summary and Review]

Twenty Questions [Summary and Review]
Crossword Puzzle [Summary and Review]
Fill-in-the-Blanks Chapter 2 [Summary and Review]

Activity: Using Reaction Time to Show the Speed of Neurons [2A]

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 [2A]

After engaging in the neural network exercise, try following it up with a modified activity based on the original "dollar bill drop" activity (Fisher, 1979), which not only delights students but also clearly illustrates the speed of neural transmission. Ask students to get into pairs and have them use an item such as a ruler, a piece of paper, or even a $5 bill. First, each member of the pair should take turns trying to catch the item with their non-dominant (for most people, the left) hand as they drop it from their dominant (typically right) hand. To do this, they should hold the item vertically so that the top, center of the item is held by the thumb and middle finger of their dominant hand. Next, they should place the thumb and middle finger of their non-dominant hand around the dead center of the item, as close as they can get without touching it. When students drop the item 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 item (i.e., with the thumb and middle finger of the non-dominant hand) while the other person drops it (i.e., from the top center of the item). Student "droppers" are instructed to release the item without warning, and "catchers" are warned not to grab before the item is dropped. (Students should take turns playing dropper and catcher.) There will be stunned looks all around as the items 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 item, but when trying to catch it from someone else, the signal to catch the item 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 [2A]

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 [2A]

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

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

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

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

Activity: Human Neuronal Chain [2A]

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:

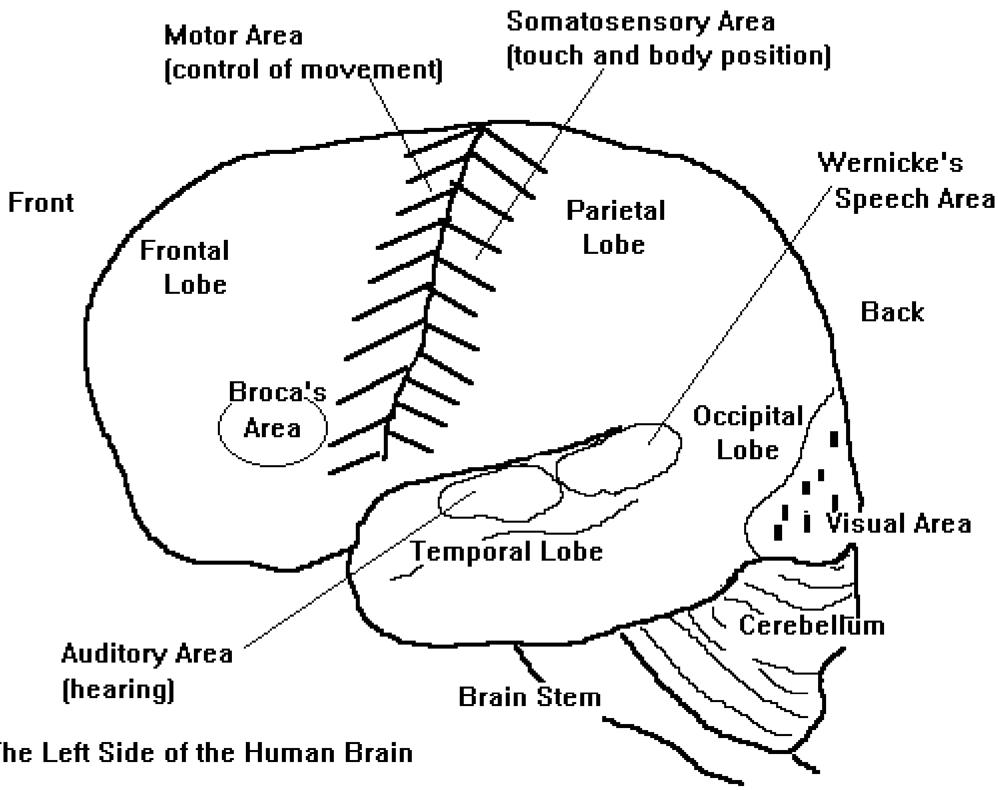
Ask the last student to tap either shoulder of the next person and each subsequent person to continue the process through the entire line, always using the same shoulder and never crossing the body (i.e., left hand to right shoulder). Use the stopwatch to time how long it takes for the last person to 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 [2B]

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 below.



The Left Side of the Human Brain

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 labelled 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, decision making, and planning.

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 labelled on the diagram above.

5. The motor cortex is labelled on the diagram above. The motor cortex in each hemisphere controls movements on the opposite side of the body.

6. The visual cortex is labelled 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 labelled on the diagram above. The auditory cortex is responsible for processing sounds.

8. The somatosensory cortex is labelled 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 labelled 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 labelled 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: The Importance of a Wrinkled Cortex [2B]

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.

Activity: Probing the Cerebral Cortex [2B]

Wilder Penfield was a pioneer in mapping the areas of the cerebral cortex via electrode-stimulation of the cortex. Stimulation of various areas of the cortex can produce memories of past events and even, for example, the perception of music playing.

Form a Hypothesis

Q What would happen if 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 behavior 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 behavioral neuroscience?
A.
1. Microelectrode techniques are used to study the functions of individual neurons.
2. Macroelectrode techniques, such as an EEG, record activities of brain areas.
3. Structural imaging, such as computerized axial tomography or CAT scans, is useful for mapping brain structures.

4. 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: Localization of Function Exercise [2C]

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 behavior; 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 [2C]

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 non-language, 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.

Activity: Lateralization Activities [2D]

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 is 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 behavior is no problem. Generally, students who have been trained in martial arts, dance and/or gymnastics have less difficulty completing these activities due to 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: Review of Brain-Imaging Techniques [2F]

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 [2F]

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 first hand far exceeds what students can gain from the text. Such a trip can be undertaken only if you have a small class 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.

Assignment: The Brain Diagram [Summary and Review]

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: Twenty Questions [Summary and Review]

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 [Summary and Review]

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.

Crossword Puzzle

Answers to the crossword puzzle:

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 center of the brain, it acts as a relay from the lower part of the brain to the proper areas of the cortex. **thalamus**
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-Blanks [Summary and Review]

Copy and distribute **<u>Handout Master 2.4</u>** to students as a homework or in-class review assignment.

<u>Answer Key: Chapter 2 Biology and Behaviour – Fill-in-the-Blanks</u>

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 for Chapter 2: Biology and Behaviour

Handout Master 2.1 Mapping the Brain
Handout Master 2.2 Localization of Function Exercise
Handout Master 2.3 Crossword Puzzle
Handout Master 2.4 Fill-in-the-Blanks Exercise for Chapter 2

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.

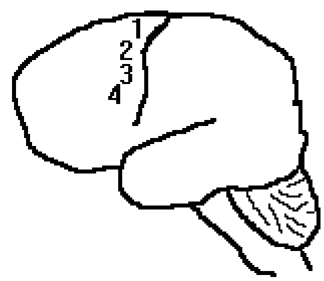
9. Label Broca's and Wernicke's areas and describe their functions.

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.

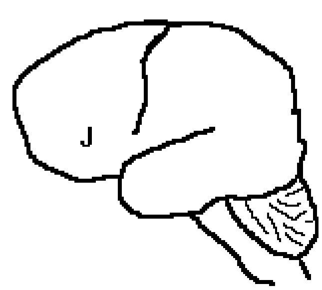


Case 1:a. What method is being used to study brain function?

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.

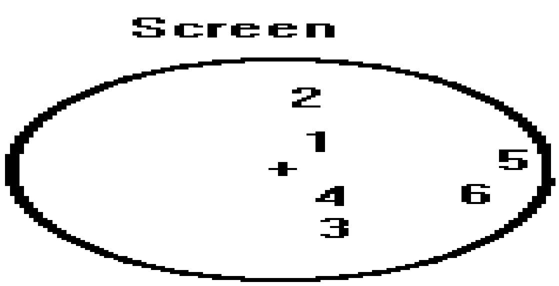


Case 2: a. What method is being used to study brain function?

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.

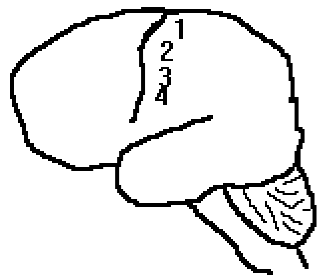


Case 3: a. What method is being used to study brain function?

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 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?

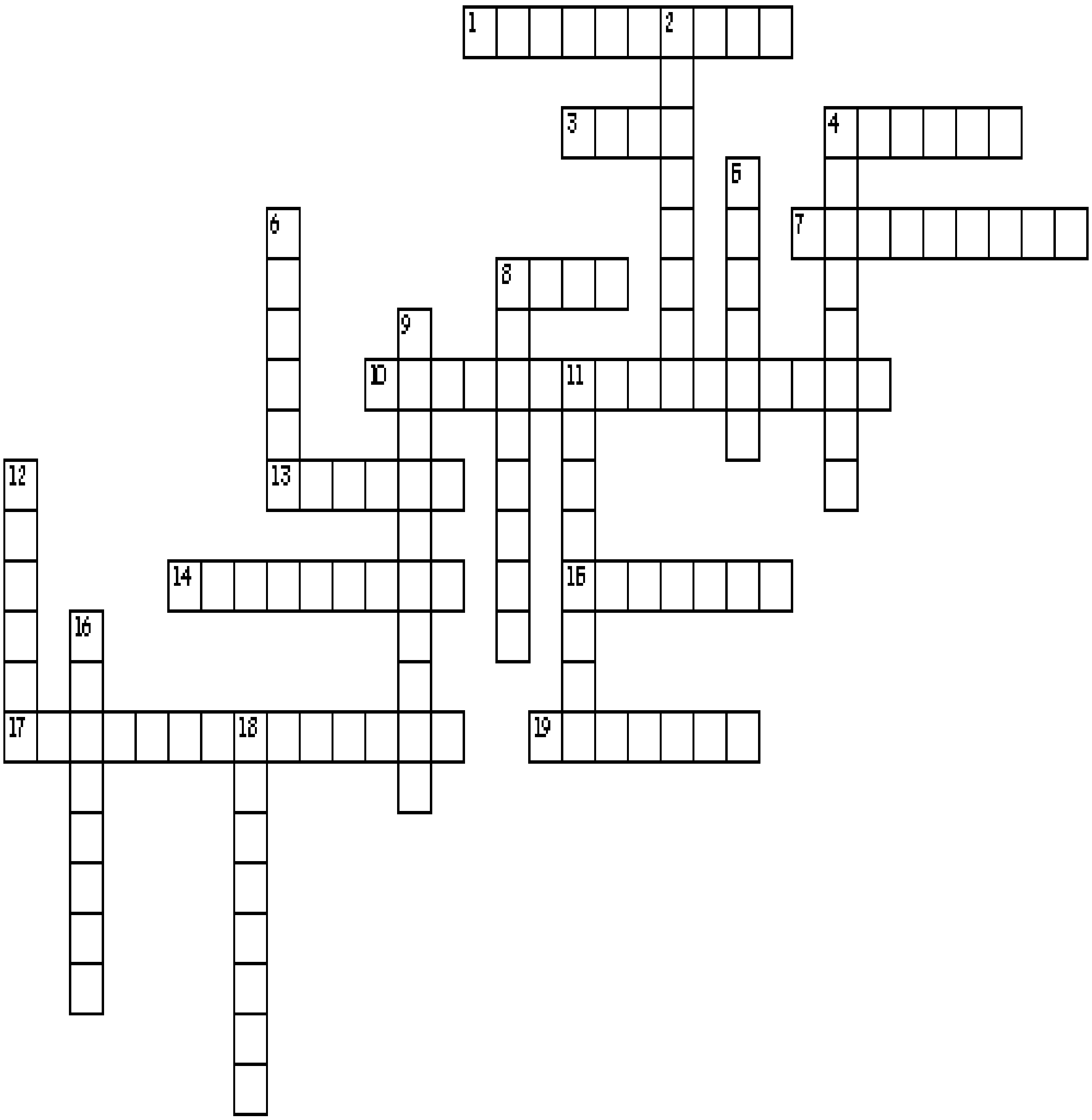
Case 7. Dr. Sperry cuts the corpus callosum of a young woman to stop the spread of intractable epilepsy from one side of the brain to the other. After the woman has had time to recover from the surgery, Dr. Sperry tests her on various tasks. Dr. Sperry finds no impairment on most tasks. There are two 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



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 center 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
FILL-IN-THE-BLANKS CHAPTER 2

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 is the _________________________________.
5. The cell body of the neuron, responsible for maintaining the life of the cell and contains 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, has 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 ________________________________ 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 ______________________________________.
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 consisting of nerves that control all of the *involuntary* muscles, organs, and glands sensory pathway nerves coming from the sensory organs to the CNS consisting of sensory neurons.
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 an ____.
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 center 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. The ______________________________________ 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 centers 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 centers for touch, taste, and temperature sensations is called the ____.
32. The ___________________________________ is the area of the cortex located just behind the temples containing the neurons responsible for the sense of hearing and meaningful speech.
33. The ____ are 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 nervous
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.

Neuroguide.com – Neurosciences on the Internet: http://www.neuroguide.com/
A resource for all things related to neuroscience: databases, diseases, research centers, 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.

The Neurons and Neurotransmitters

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.

Neural Processes Tutorial: http://psych.hanover.edu/Krantz/neurotut.html
An excellent interactive animated tutorial.

The Central 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 Behavior" or "Neuropsychology."

Brain and Behavior: http://serendip.brynmawr.edu/bb/
This mega-site contains lots of links to information about the brain, behavior, 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://brainconnection.positscience.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.

Drugs, Brains, and Behavior: 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

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.

He Brains, She 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.

Phineas Gage Information Page: http://www.deakin.edu.au/health/psychology/gagepage
Everything you ever wanted to know about Phineas Gage is on this page prepared by Malcolm Macmillan at Deakin University, Victoria, Australia.

MULTIMEDIA LIBRARY

The titles of relevant multimedia links are listed below. The links are available in both the eText and MyPsychLab. Go to MyPsychLab to find web resources for your text that supplement the material in this chapter.

Module 2A The Neurons and the Neurotransmitters

ALS: Lost Nerve Power [2A]
Neuronal Transmission [2A]
The Action Potential [2A]
The Nerve Impulse and Afferent and Efferent Neurons [2A]
The Synapse [2A]

Module 2B The Human Nervous System

ALS: Lost Nerve Power [2B]
An Overview of the Nervous System [2B]
The Autonomic Nervous System [2B]
The Endocrine System [2B]
The Limbic System [2B]

Module 2C The Cerebral Hemispheres

ALS: Lost Nerve Power [2C]
Connie: Head Injury [2C]
Roger Sperry [2C]
Split-Brain Experiments [2C]
The Visual Cortex [2C]

Module 2D Specialization of the Cerebral Hemispheres

Roger Sperry [2D]
Split Brain Experiments [2D]
The Visual Cortex [2D]

Module 2E The Brain Across the Lifespan

Connie: Head Injury [2E]
Exercise Your Brain [2E]

Module 2F Discovering the Brain's Mysteries

ALS: Lost Nerve Power [2F]
MKM and Brain Scans [2F]
The Visual Cortex [2F]

Module 2G The Peripheral Nervous System

The Nerve Impulse and Afferent and Efferent Neurons [2G]

Module 2H The Endocrine System (text p. 52)

The Endocrine System [2H]

Summary & Review

Glossary Flashcards for Chapter 2 [Summary & Review]

MYPSYCHLAB VIDEO SERIES

Episode 3 – Biological Psychology

- **The Big Picture: My Brain Made Me Do It**
    - This episode explains the function of different parts of the nervous system and how it integrates multiple signals to create experience.

- **Basics: How the Brain Works, Part 1**
    - In this video, we are introduced to the neuron and what purpose neurons serve in the brain. We also learn about the different parts of the neuron and how neurons communicate with each other.

- **Basics: How the Brain Works, Part 2**
    - This video explains how the nervous system is divided and how it processes information, the significance of each of the different brain structures, and how neuronal transmission works.

- **Thinking Like a Psychologist: The Pre-Frontal Cortex: The Good, the Bad, and the Criminal**
    - In this video we learn how certain areas of the brain contribute to different behaviors, and how both biological and environmental factors can lead a person to become a violent criminal later in life.

- **In the Real World: Neurotransmitters**
    - In this video we learned more about the neurotransmitter dopamine and its role in various aspects of our lives, including what happens when there is an imbalance of dopamine either by natural causes or with the assistance of drugs.

- **What's In It For Me?: Your Brain on Drugs**
    - In this video we learn more about how various drugs work at the synaptic level to affect the balance of neurotransmitters and affect our perceptions and behaviors.

- **Special Topics:** The Plastic Brain
    - In this video, we learn specifics about how the human brain grows and develops throughout the lifespan and how the brain can remarkably repair itself or compensate after being damaged.