September 25:

- The critical part of the Central Nervous System is the brain. The brain is where a lot of the primary decision making happens. The rest of the nervous system connects the brain to the rest of the body.
- We have brain-like tissue in our spine and that brain-like tissue can make very simple decisions, like reflexive behaviour.
- The Peripheral Nervous System is the nerve fibres that connect the brain to the rest of the body.
- Your body has 2 modes, one for when it's under threat and one for when there's no threat. When our body is under threat, we go into **fight or flight mode**. When our body is not under threat, we go into **long-term survival mode**.
- Both parts of the autonomic nervous system, the sympathetic and parasympathetic nervous systems work involuntarily. Sympathetic is responsible for the response commonly referred to as "fight or flight," while parasympathetic is referred to as "rest and digest." Both originate in the spinal cord and branch out from there. You cannot have both systems simultaneously active. The action of one inhibits the action of the other.
- The **sympathetic nervous system** is the part of the autonomic nervous system that prepares the body to react to stresses such as threat or injury. It causes muscles to contract and heart rate to increase.
  In addition to the diagram above, when the sympathetic nervous system is on, blood drains from our frontal lobes.
- The **parasympathetic nervous system** is the part of the autonomic nervous system that controls functions of the body at rest. It helps maintain homeostasis in the body. It causes muscles to relax and heart rate to decrease.
- Since you can't have both the sympathetic nervous system and the parasympathetic nervous system on at the same time, if you're feeling stressed or anxious, instead of trying not to be nervous, try to turn on the parasympathetic system.
- While the sympathetic nervous system is usually worried about the present, it also wants to make sure that you're not in this situation in the future. We have a part of our brain, called the **amygdala**, which is responsible for emotions, survival instincts, and memory. It kicks in the sympathetic system and sends signals to the hippocampus when it senses danger. The hippocampus stores the memory. When the amygdala sends signals to the hippocampus, it is telling the hippocampus to remember anything associated with the threat/danger, so the next time you encounter those same things, the amygdala will kick in right away.
- The amygdala sending signals to the hippocampus is a reason why people get PTSD. To help overcome PTSD, doctors/psychiatrists will sometimes give patients **beta blockers**, pills that prevent your sympathetic systems from engaging, to help calm them down and then get them to talk about their experience. If you allow someone to relive traumatic experiences on beta blockers enough times, they'll start to form a memory of that experience that won't trigger their PTSD.

September 27:

- The **cerebral cortex** is the place where high level perception of the world occurs, and is also the place where controlled motor activities originate. This contrasts with a number of more basic brain regions (the **midbrain parts**) which are more devoted to monitoring and controlling internal behaviours and automatic responses to external stimuli. The midbrain parts are very old and primitive.
- Humans are the most complex animals. While most animals only have the midbrain parts, humans also have the cerebral cortex.
- The **primary cortex** deals with direct sensory or motor connections. It deals with raw input. The primary cortex is towards the center of the lobes.
- The **association cortex** deals with memory, analyzation of the input and understanding what the input is. Some of the things the association cortex does include recognition of shape, form, textures of objects, awareness of body image, and relationships of body parts to each other and their location. The association cortex is around the border of the lobes.
- The 4 lobes of the cortex are:
    1. **Frontal Lobe:** The parietal, occipital and temporal lobes are primarily responsible for getting information and that information goes to the frontal lobe. The frontal lobe combines that information with our memory and goals and guide our actions. As a result, the frontal lobe is mostly about output and behaving in the world.
    2. **Parietal Lobe:** The left parietal appears to keep track of the spatial location of our body parts, **proprioception**. The primary sensory function involves perception of the body. Damage is often associated with poor motor movements. The right parietal appears to keep track of the spatial location of things in our external world. Damage can lead to problems of neglect and spatial integration of parts. The association cortex is involved in complex spatial functions that differ across the hemispheres.
    3. **Occipital Lobe:** The occipital and lower part of the temporal lobes are responsible for vision. The primary visual cortex is directly related to sight, and damage to it produces a hole in a person's visual field, a **scotoma**. An interesting fact about people with scotomas is that even though they can't see that part, they can usually guess it correctly. The association visual cortex in this area performs the function of providing an interface between visual input and memory. Damage to this part can lead to **agnosia**, the inability to name common objects. This lobe is the furthest away from the eyes.
    4. **Temporal Lobe:** Most of the temporal lobe is responsible for audition. The primary auditory cortex is mostly hidden from view, lying on the inside to the upper temporal lobe. Damage to this leads to hearing problems.
    The association auditory cortex is located on the lateral surface of the upper temporal lobe. Damage to left leads to severe language deficits.
    Broca's area is responsible for production of speech.

Wernicke's area is responsible for the comprehension of speech. Damage to the right affects the patient's ability to properly perceive non-speech sounds, like the rhythm in music.

- **Contralateral organization** is the property that the left side of the brain relates to the right side of the body and vice versa for many functions.
- **Lateralization of function** refers to the notion that the brain is composed of separate hemispheres creating left and right sides of all cortical tissue, and sometimes the left and right have different priorities.
- In between the 2 hemispheres of the brain is the **corpus callosum**. It connects the two hemispheres of the brain using a bundle of neuronal fibers that allows the two hemispheres to talk to one another.
- A lot of what we know about the brain came from **neuropsychology**, the study and characterization of the behavioral modifications that follow a neurological trauma or condition.

September 30:

- A **frontal lobotomy** is a surgical procedure that severs, sometimes completely, the frontal lobe from the rest of the brain.
- Before modern medicine, when a person was violent and aggressive because of a disease or condition, doctors would perform a frontal lobotomy to calm the person down. However, after the surgery, the person would be a zombie. They also used to restrain patients by tying them down. Nowadays, drugs are used to calm the patients.
- Lobotomies started in 1935 by António Egas Moniz. He won a nobel prize in 1949. Lobotomies are now considered one of medicine's biggest mistakes. Many people now regret awarding Moniz with a nobel prize.
- The premotor cortex controls complex movements, like reaching or grasping with the hands. It also helps control posture. In the spinal cord, signals from the premotor cortex combine with signals from primary motor cortex to create unified and intentional motions. The premotor cortex also plays a role in decision making, similar to the prefrontal cortex. It is the primary cortex of the frontal lobe.
- The pre-frontal cortex is responsible for:
    - Planning complex cognitive behavior
    - Personality expression
    - Decision making
    - Moderating social behaviour
    - Pushing us to do new things
- Damage to the pre-frontal cortex causes:
    - The slowing of thoughts and loss of spontaneity
    - Perseveration errors
    - Loss of self-awareness and flat affect, especially empathy
    - Deficiencies in foresight and planning
    - Tendency to confabulate
- The **limbic system** is a large group of brain structure responsible for motivation, emotion, learning and memory. Structures in the limbic system include the **olfactory bulb** (smell), **hippocampus** (memory), **amygdala** (fear and reward),

hypothalamus (hormones and sleep), **basal ganglia** (motivation and voluntary movement), and **cingulate gyrus** (gateway to the limbic system from the cerebral cortex).

- The sensory strip is a part of the brain located in the parietal lobe, near the border of the frontal lobe. The sensory strip is involved in registering sensation that are connected to specific body parts or body functions. The sensory strip is the primary cortex of the parietal lobe.
- Motor strips, which are located in the frontal lobe is what controls all muscle movement including the ones that are necessary for speech.
- The amount of brain tissue tells you how sensitive that area is. The more brain tissue there is, the more sensitive the area is and vice versa.
- **Phantom limb pain** refers to ongoing painful sensations that seem to be coming from the part of the limb that is no longer there.

Textbook:

- **Section 3.1:**
- **The Genetic Code:**
- **Genes** are the basic units of heredity. Genes are responsible for guiding the process of creating the proteins that make up our physical structures and regulate development and physiological processes throughout the lifespan.
- Genes are composed of segments of **DNA (deoxyribonucleic acid)**, a molecule formed in a double-helix shape that contains four nucleotides: adenine, cytosine, guanine, and thymine. These nucleotides are typically abbreviated using the first letter of their names, A, C, G, and T. Each gene is a unique combination of these four nucleotides.
- These genes represent the instructions used to create the thousands of different proteins found in the human body. These proteins specify which types of molecules to produce and when to produce them. Genes also contain information about which environmental factors might influence whether the genes become active or not. Together, this information makes up an individual's **genotype**, the genetic makeup of an organism. The result is an organism's **phenotype**, the physical traits and behavioural characteristics that show genetic variation, such as eye colour, the shape and size of facial features, intelligence, and even personality. This phenotype develops because of differences in the nucleotide sequencing of A, C, G, and T as well as through interactions with the environment.
- Genes are organized in pairs along **chromosomes**, structures in the cellular nucleus that are lined with all of the genes an individual inherits. Humans have approximately 20 000–25 000 genes distributed across 23 pairs of chromosomes, half contributed by the mother and half by the father. Sometimes, an extra chromosome, a trisomy, is present, thus altering the genetic make-up as well as the phenotype of the individual. The most common chromosomal abnormality is Down Syndrome, a trisomy on the 21st chromosome.
- Human DNA is aligned along 23 paired chromosomes. Numbers 1–22 are common to both males and females. Chromosome 23 is sex linked, with males having the XY pattern and females the XX pattern.

- If two corresponding genes at a given location on a pair of chromosomes are the same, they are **homozygous**. If the two genes differ, they are **heterozygous**.
- Whether a trait is expressed depends on which combination of pairs is inherited. E.g. Researchers have shown that the ability to taste a very bitter substance called phenylthiocarbamide (PTC) is based on which combination of genes we inherit from either parent. The test for whether you can taste PTC is typically performed by placing a small tab of paper soaked in the substance on the tongue. Those who report tasting PTC are either homozygous dominant (TT) or heterozygous dominant (Tt). Non-tasters are homozygous recessive (tt).
- **Behavioural Genomics The Molecular Approach:**
- **Behavioural genomics** is the study of DNA and the ways in which specific genes are related to behaviour.
- The **Human Genome Project** resulted in the identification of approximately 20 000–25 000 genes. While the Human Genome Project did not directly provide a cure for a disease or an understanding of any particular behaviour, it has led to an abundance of new techniques and information about where genes are located, and it opened the door for an entirely new era of research.
- However, we must be cautious in our interpretation of such discoveries. Like any approach to answering scientific questions, behavioural genomic research does have its limitations. For example, although a single gene has been identified as a risk factor for Alzheimer's disease, not everyone who inherits it develops the disease.
- **Behavioural Genetics Twin and Adoption Studies:**
- **Behavioural genetics** is the study of how genes and the environment influence behaviour. Behavioural genetic methods applied to humans typically involve comparing people of different levels of relatedness and measuring resemblances for a specific trait of interest. The group that has provided the most insight into the genetic effects on behaviour is twins.
- **Monozygotic twins/Identical twins** come from a single egg, which makes them genetically identical (almost 100% genetic similarity).
- **Dizygotic twins/Fraternal twins** come from two separate eggs fertilized by two different sperm cells that share the same womb. These twins have approximately 50% of their genetics in common.
- Researchers have also examined these different groups in **longitudinal studies**, studies that follow the same individuals for many years, often decades.
- Behavioural geneticists use twin studies to calculate **heritability**, a statistic, expressed as a number between zero and one, that represents the degree to which genetic differences between individuals contribute to individual differences in a behaviour or trait found in a population. A heritability of 0 means that genes do not contribute to individual differences in a trait, whereas a heritability of 1 indicates that genes account for all individual differences in a trait.
- Heritability scores fall between 0 and 1, inclusively. However, heritability estimates are rarely ever 0 or 1. Instead, genetics and environmental factors both account for some of the differences in our behaviour.
- Heritability estimates for behaviours change as we age.

- In a **family study**, researchers would measure individuals from a large number of families on some particular behavioural trait of interest. The researchers would then correlate the scores on the trait between family members. Higher correlations between more genetically similar relatives (family members who are closely related and share many genes) versus less genetically similar relatives provide some evidence that the trait is influenced by genes.
- In an **adoption study**, researchers track the presence or absence of traits in adopted children as well as their biological and adoptive parents. If there's a higher correlation for a trait between the adopted children and their biological parents, it suggests a genetic contribution to that trait. If there's a higher correlation for a trait between adopted children and their adoptive parents, then environmental factors may play a more significant role for that trait than genetics.
- In a **twin study**, researchers compare the frequency of traits in identical twins with the frequency of the same traits in fraternal twins. If two twins share the same trait, they are described as **concordant** for that trait. A **concordance rate** is the percentage of twins in a study who share a particular trait.
- **Gene Expression and Behaviour:**
- The fact that heritability estimates change over time based on our different experiences shows us that nature and nurture interact to produce behaviour.
- Almost every cell in our bodies contains the same genes, but only some of these genes are active. Of the approximately 20 000–25 000 genes in the human genome, between 6000 and 7000 are active in the human brain. These genes influence the development of different brain structures, the production of chemicals that allow brain cells to communicate with each other, and the refinement of connections between cells that allow large-scale brain networks to form. The expression of these genes is influenced by genetics, environmental factors or a combination of the two.
- If some genes fail to be activated properly, people may be at a greater risk for developing brain-related disorders.
- Gene expression is a lifelong process. Factors such as diet, stress level, and sleep can influence whether genes are turned on or off. This study of changes in gene expression that occur as a result of experience and that do not alter the genetic code is known as **epigenetics**.
- **Evolutionary Insights into Human Behaviour:**
- **Natural selection** is the process by which favourable traits become increasingly common in a population of interbreeding individuals, while traits that are unfavourable become less common. This term was developed by Charles Darwin.
- When animals mate, each parent provides half of the offspring's genetic material. The genes of some animals would combine in such a way to produce traits favourable to that setting and the genes of other animals would combine in less useful ways. Because the adaptive animals were more likely to survive and reproduce, these traits and genes would be more likely to be passed onto future generations. This process is known as **evolution**, the change in the frequency of genes occurring in an interbreeding population over generations.

- **Evolutionary Psychology:**
- A modern branch of psychology known as **evolutionary psychology** attempts to explain human behaviours based on the beneficial functions they may have served in our species' development.
- The **hunter-gatherer theory** is a theory that links performance on specific tasks to the different roles performed by males and females over the course of our evolutionary history.
- **Sexual Selection and Evolution:**
- **Intrasexual selection** is when members of the same sex compete in order to win the opportunity to mate with members of the opposite sex. Intrasexual selection is evolutionarily advantageous because the animals most likely to become dominant are the strongest and/or smartest, and therefore the most fit for that time and place. If this trend continues across many generations, the species as a whole will become stronger and smarter.
- **Intersexual selection** is when members of one sex select a mating partner based on their desirable traits.
- **Section 3.2:**
- **The Neuron:**
- The primary purpose of neurons is to receive input from one group of neurons and then to transmit that information to other neurons. Neurons are designed in such a way that there are parts of the cell specialized for receiving incoming information from other neurons and parts of the cell specialized for transmitting information to other neurons.
- All neurons have a **cell body/soma**, the part of a neuron that contains the nucleus that houses the cell's genetic material. Genes in the cell body synthesize proteins that form the chemicals and structures that allow the neuron to function. The activity of these genes can be influenced by the input coming from other cells. This input is received by **dendrites**, small branches radiating from the cell body that receive messages from other cells and transmit those messages toward the rest of the cell. At any given point in time, a neuron will receive input from several other neurons. These impulses from other cells will travel across the neuron to the base of the cell body known as the **axon hillock**. If the axon hillock receives enough stimulation from other neurons, it will initiate a chemical reaction that will flow down the rest of the neuron. This chemical reaction is the initial step in a neuron communicating with other cells. The activity will travel from the axon hillock along the **axon**. The **axon** transports information in the form of electrochemical reactions from the cell body to the end of the neuron. When the activity reaches the end of the axon, it will arrive at axon terminals, bulb-like extensions filled with vesicles. These vesicles contain **neurotransmitters**, the chemicals that function as messengers allowing neurons to communicate with each other. The impulse travelling down the axon will stimulate the release of these neurotransmitters, thus allowing neural communication to take place.
- Although all neurons are designed to transmit information, not all neurons perform the same function. **Sensory neurons** receive information from the bodily senses and bring it toward the brain, often via the spinal cord. In contrast, **motor**

neurons carry messages away from the brain and spinal cord and toward muscles in order to control their flexion and extension.

- For decades, neuroscience taught us that nerves do not regenerate. However, in the past 15 years or so, advances in brain science have challenged this belief. Researchers have observed **neurogenesis**, the formation of new neurons, in a limited number of brain regions, particularly in a region critical for learning and memory. The growth of a new cell, including neurons, starts with **stem cells**, a unique type of cell that does not have a predestined function. When a stem cell divides, the resulting cells can become part of just about anything. The deciding factor seems to be the stem cell's chemical environment.
- **Glial Cells:**
- **Glial cells** are specialized cells of the nervous system that are involved in mounting immune responses in the brain, removing waste, and synchronizing the activity of the billions of neurons that constitute the nervous system.
- Glial cells outnumber neurons in the brain by a ratio of approximately 10 to 1.
- A critical function served by certain glial cells is to insulate the axon of a neuron. These glial cells form a white substance called **myelin**, a fatty sheath that insulates axons from one another, resulting in increased speed and efficiency of neural communication. In an unmyelinated axon, the neural impulse decays quickly and needs to be regenerated along the axon; the myelin protects the impulse from this decay, thus reducing how often the impulse needs to be regenerated.
- When the myelin sheath is damaged, the efficiency of the axon decreases substantially. For instance, multiple sclerosis is a disease in which the immune system does not recognize myelin and attacks it, a process that can devastate the structural and functional integrity of the nervous system.
- **The Neuron's Electrical System: Resting and Action Potentials:**
- Neural activity is based on changes in the concentrations of charged atoms called **ions**. When a neuron is not transmitting information, the outside of the neuron has a relatively high concentration of positively charged ions, particularly sodium and potassium, while the interior of the axon has fewer positively charged ions as well as a relatively high concentration of negatively charged chloride ions. This relatively stable state during which the cell is not transmitting messages is known as its **resting potential**.
- The resting state involves a great deal of tension. This is because of two forces, the **electrostatic gradient** and the **concentration gradient**. **Electrostatic gradient** means that the inside and outside of the cell have different charges. **Concentration gradient** means that different types of ions are more densely packed on one side of the membrane than on the other. However, most substances have a tendency to move from areas of high concentration to areas of low concentration whenever possible.
- When a neuron is stimulated, a surge of positive ions into the cell changes the potential of the neuron. These charges flow down the dendrites and cross the cell body to the axon hillock, where the cell body meets the axon. If enough positively charged ions reach the axon hillock to push its charge past that cell's firing

threshold, the neuron will then initiate an **action potential**, a wave of electrical activity that originates at the beginning of the axon near the cell body and rapidly travels down its length. When an action potential occurs, the charge of that part of the axon changes from approximately –70 mV to approximately +35 mV. This change does not occur along the entire axon at once, but rather as one part of the axon becomes depolarized, it forces open the ion channels ahead of it, thus causing the action potential to move down the length of the axon as positively charged ions rush through the membrane pores. This pattern continues until the action potential reaches the axon terminal.

- There are mechanisms in place to help our neurons return to their resting state (–70 mV) so that they can fire again. At each point of the axon, the ion channels slam shut as soon as the action potential occurs. The sodium ions that had rushed into the axon are then rapidly pumped back out of the cell, returning it to a resting state. This process of removing the sodium ions from the cell often causes the neuron to become **hyperpolarized**. This means that the cell is more negative than its normal resting potential. This additional negativity makes the cell less likely to fire. It normally takes 2–3 milliseconds for the membrane to adjust back to its normal resting potential. This brief period in which a neuron cannot fire is known as a **refractory period**.
- When the action potential reaches the axon terminal, it triggers the release of that cell's neurotransmitters into the **synapses**, the microscopically small spaces that separate individual nerve cells. The cell that releases these chemicals is known as the **presynaptic cell** whereas the cell that receives this input is known as the **postsynaptic cell**.
- When stimulated, a given neuron always fires at the same intensity and speed. This activity adheres to the **all-or-none principle**: Individual nerve cells fire at the same strength every time an action potential occurs. The strength of a sensation is determined by the rate at which nerve cells fire as well as by the number of nerve cells that are stimulated. A stimulus is experienced intensely because a greater number of cells are stimulated, and the firing of each cell occurs repeatedly.
- **The Chemical Messengers Neurotransmitters and Hormones:**
- The presynaptic neuron releases neurotransmitters into the synapse and then a fraction of these neurotransmitters will bind to receptors on the postsynaptic neuron. This binding can have one of two effects on the postsynaptic cell.
    1. If the actions of a neurotransmitter cause the neuron's membrane potential to become less negative, it is referred to as **excitatory** because it has increased the probability that an action potential will occur in a given period of time.
    2. If the actions of a neurotransmitter cause the membrane potential to become more negative, it is referred to as **inhibitory** because it has decreased the likelihood that an action potential will occur.
- An important factor in determining whether a postsynaptic neuron is excited or inhibited is the type of neurotransmitter binding with its receptors. Each neurotransmitter typically has its own unique molecular shape. When

neurotransmitters are released at the axon terminal, they cross the synapse and fit in a particular receptor of the dendrite.

- After neurotransmitter molecules have bound to postsynaptic receptors of a neighbouring cell, they are released back into the **synaptic cleft**, the minute space between the axon terminal and the dendrite. This process is almost as important as the action potential itself. Prolonged stimulation of the receptors makes it more difficult for the cell to return to its resting potential. Therefore, if a neurotransmitter remained latched onto a receptor for long periods of time, it would decrease the number of times that the neurons could fire.
- Once neurotransmitters have detached from the receptors and float back into the synapse, they are either broken down by enzymes or go through **reuptake**, a process whereby neurotransmitter molecules that have been released into the synapse are reabsorbed into the axon terminals of the presynaptic neuron. Reuptake serves as a sort of natural recycling system for neurotransmitters. It is also a process that is modified by many commonly used drugs.
- **Types of Neurotransmitters:**
- The most common neurotransmitters in the brain are glutamate and GABA.
- **Glutamate** is the most common excitatory neurotransmitter in the brains of vertebrates. It is involved in a number of processes, including our ability to form new memories. Abnormal functioning of glutamate-releasing neurons has also been implicated in a number of brain disorders including the triggering of seizures in epilepsy and damage caused by strokes.
- **GABA (gamma-amino butyric acid)** is the primary inhibitory neurotransmitter of the nervous system. It accomplishes this feat by reducing the negative charge of neighbouring neurons even further than their resting state of −70 mV. When GABA binds to receptors, it causes an influx of negatively charged chloride ions to enter the cell, which is the opposite net effect of what happens when a neuron is stimulated. As an inhibitor, GABA facilitates sleep and reduces arousal of the nervous system. Low levels of GABA have been linked to epilepsy.
- **Acetylcholine** is one of the most widespread neurotransmitters within the body. It is found at the junctions between nerve cells and skeletal muscles. It is very important for voluntary movement. Acetylcholine released from neurons connected to the spinal cord binds to receptors on muscles. The change in the electrical properties of the muscle fibres leads to a contraction of that muscle. This link between the nervous system and muscles is known as a **neuromuscular junction**. A number of animals release venom that influences the release of acetylcholine, including the black widow spider and a number of snakes. Neurotoxic snake venom disrupts the activity of acetylcholine transmission at the neuromuscular junctions. Some types of venom block acetylcholine release at the presynaptic terminals, preventing its release into the synapse, while another type of venom blocks the receptors on the postsynaptic cell, preventing acetylcholine from binding to them. In addition, acetylcholine activity in the brain is associated with attention and memory. Altered levels of this neurotransmitter have also been linked to cognitive deficits associated with aging and Alzheimer’s disease.

- **Monoamines** include the well-known neurotransmitters dopamine, norepinephrine, and serotonin. Their functions change depending on where the neurotransmitter is released.
- **Dopamine** is a monoamine neurotransmitter involved in such varied functions as mood, control of voluntary movement, and processing of rewarding experiences.
- **Norepinephrine/noradrenaline** is a monoamine synthesized from dopamine molecules that is involved in regulating stress responses, including increasing arousal, attention, and heart rate. Norepinephrine is formed in specialized nuclei in the brainstem and projects throughout the cortex, influencing the activity of a number of different systems ranging from wakefulness to attention. It also projects down the spinal cord and serves as part of the "fight-or-flight" response to threatening stimuli. Norepinephrine often works alongside **epinephrine/adrenaline**, a hormone and neurotransmitter created in the adrenal gland on the kidneys. Both norepinephrine and epinephrine energize individuals to help them become more engaged with a given activity.
- **Serotonin** is a monoamine involved in regulating mood, sleep, aggression, and appetite. It is formed in the brainstem and projects throughout the brain and spinal cord. Serotonin is the neurotransmitter that you are most likely to have heard of due to its critical role in depression.
- **Drug Effects on Neurotransmission:**
- **Agonists** are drugs that enhance or mimic the effects of a neurotransmitter's action.
- Nicotine is an acetylcholine agonist while Xanax is a GABA agonist.
- A drug that behaves as a **direct agonist** physically binds to that neurotransmitter's receptors at the postsynaptic cells. A drug that acts as an **indirect agonist** facilitates the effects of a neurotransmitter, but does not physically bind to the same part of the receptor as the neurotransmitter. A drug that attaches to another binding site on a receptor but does not interfere with the neurotransmitter's binding would also be an indirect agonist.
- Drugs classified as **antagonists** inhibit neurotransmitter activity by blocking receptors or preventing synthesis of a neurotransmitter. An example of this is botox. Botox, which is derived from the nerve-paralyzing bacterium that causes botulism, blocks the action of acetylcholine by binding to its postsynaptic receptor sites. Because Botox directly binds with acetylcholine receptors, it is considered a **direct antagonist**. If a chemical reduces the influence of a neurotransmitter without physically blocking the receptor, it would be classified as an **indirect antagonist**.
- **Hormones and the Endocrine System:**
- **Hormones** are chemicals secreted by the glands of the endocrine system.
- Generally, neurotransmitters work almost immediately within the microscopic space of the synapse, whereas hormones are secreted into the bloodstream and travel throughout the body. Thus, the effects of hormones are much slower than those of neurotransmitters. With help from the nervous system, the endocrine system contributes to **homeostasis**, the balance of energy, metabolism, body temperature, and other basic functions that keep the body working properly.

- The brain area that is critical for this brain-endocrine relationship is the **hypothalamus**, a brain structure that regulates basic biological needs and motivational systems. The hypothalamus releases specialized chemicals called **releasing factors** that stimulate the **pituitary gland**, the master gland of the endocrine system that produces hormones and sends commands about hormone production to the other glands of the endocrine system.
- How we respond to stress illustrates nicely how the nervous and endocrine systems influence each other. In psychological terms, **stress** is loosely defined as an imbalance between perceived demands and the perceived resources available to meet those demands. The hypothalamus will set chemical events in motion that physically prepare the body for stress. It signals the pituitary gland to release a hormone into the bloodstream that in turn stimulates the **adrenal glands**, a pair of endocrine glands located adjacent to the kidneys that release stress hormones, such as **cortisol** and **epinephrine**. Cortisol and epinephrine help mobilize the body during stress, thus providing enough energy for you to deal with the sudden increase in activity necessary to respond to the stress-inducing situation.
- The **endorphin** is a hormone produced by the pituitary gland and the hypothalamus that functions to reduce pain and induce feelings of pleasure. Endorphins are released into the bloodstream during events such as strenuous exercise, sexual activity, or injury. They act on portions of the brain that are attuned to reward, reinforcement, and pleasure, inhibiting the perception of pain and increasing feelings of euphoria. Morphine molecules bind onto the same receptor sites as endorphins and therefore, produce the same painkilling and euphoric effects.
- Testosterone serves multiple functions, including driving physical and sexual development over the long term. Testosterone levels also surge during sexual activity. Testosterone is one of the main sex hormones produced by the body. In men, it is produced by specialized cells in the testes. In women, it is produced in the ovaries. It can also be secreted by the adrenal cortex on the kidneys. Because it is related to male sexual development and functioning, this hormone was traditionally targeted as an explanation for why men tend to be more physically aggressive than women. In other words, there was an assumption that testosterone causes aggression. Experiments and studies were done that shows that humans and rats with higher levels of testosterone were more socially aggressive. Testosterone appears to be involved with social aggression and dominance rather than with non-social forms of aggression.

- **Section 3.3:**
- **The Central Nervous System:**
- The **central nervous system (CNS)** consists of the brain and the spinal cord.
- The spinal cord runs from your neck down to the base of your spine. The spinal cord receives information from the brain and stimulates nerves that extend out into the body. This stimulation produces movements. It also receives information

from sensory nerves in the body and transmits it back to the brain, or in the case of reflexes, organizes rapid movements without the help of the brain.

- **The Peripheral Nervous System**
- The **peripheral nervous system (PNS)** is a division of the nervous system that transmits signals between the brain and the rest of the body and is divided into two subcomponents, the somatic system and the autonomic system.
- The **somatic nervous system** consists of nerves that control skeletal muscles, which are responsible for voluntary and reflexive movement. It also consists of nerves that receive sensory input from the body. Any voluntary behaviour makes use of the somatic nervous system.
- The **autonomic nervous system** is the portion of the peripheral nervous system responsible for regulating the activity of organs and glands. This system includes two subcomponents, the **sympathetic nervous system** and the **parasympathetic nervous system**.
- The **sympathetic nervous system** is responsible for the fight-or-flight response. In this process, blood is directed toward your skeletal muscles, heart rate and perspiration increase, and digestive processes are slowed. Each of these responses helps to direct energy where it is most needed in case you need to respond. However, if you remained in this heightened state of emotional arousal, you would quickly run out of energy resources.
- The **parasympathetic nervous system** helps maintain homeostatic balance in the presence of change. Following sympathetic arousal, it works to return the body to a baseline, non-emergency state.
- **The Brain and Its Structures**
- The brain is divided into two symmetrical halves known as **cerebral hemispheres**. Each hemisphere contains the same structures, although there are some small differences in the size of these brain areas.
- The human brain can be subdivided into three main regions: The hindbrain, midbrain and forebrain.
- **The Hindbrain Sustaining the Body:**
- At the top of the spinal cord is a region called the **brainstem**, which consists of two structures: the medulla and the pons.
- Nerve cells in the medulla connect with the body to perform basic functions such as regulating breathing, heart rate, sneezing, salivating, and even vomiting, all actions your body does with little conscious control on your part.
- The pons contributes to general levels of wakefulness, and also appears to have a role in dreaming. Due to its connections to other structures in the brain and spinal cord, the pons is also part of a number of networks including those that control balance, eye movements, and swallowing.
- A hindbrain structure, the **reticular formation**, extends from the medulla upwards to the midbrain. The reticular formation influences attention and alertness.
- The **cerebellum** is the lobe-like structure at the base of the brain that is involved in the monitoring of movement, maintaining balance, attention, and emotional responses. Patients with damage to the cerebellum have difficulty controlling

their attention as well as problems with emotional control, including personality changes and impulsivity, a set of symptoms now known as the **cognitive affective behavioural syndrome**.

- **The Midbrain Sensation and Action:**
- The **midbrain**, which resides just above the hindbrain, primarily functions as a relay station between sensory and motor areas.
- The ability to capture your visual attention is influenced by the **superior colliculus**.
- The ability to move your auditory attention is influenced by the **inferior colliculus**.
- **The Forebrain Emotion, Memory, and Thought:**
- The **forebrain** consists of all of the neural structures that are located above the midbrain, including all of the folds and grooves on the outer surface of the brain. The multiple interconnected structures in the forebrain are critical to complex processes such as emotion, memory, thinking, and reasoning.
- The forebrain also contains spaces called **ventricles**. Although the ventricles appear hollow, they are filled with **cerebrospinal fluid**, a solution that helps to eliminate wastes and provides nutrition and hormones to the brain and spinal cord. Cerebrospinal fluid also cushions the brain from impact against the skull.
- Next to the ventricles are the **basal ganglia**, a group of three structures that are involved in facilitating planned movements, skill learning, and integrating sensory and movement information with the brain's reward system.
- People who are very practised at a specific motor skill have actually modified their basal ganglia through practice to better coordinate engaging in the activity.
- Improper functioning of the basal ganglia can lead to movement disorders like Parkinson's disease, Huntington's disease and Tourette's syndrome.
- Some parts of the basal ganglia are also involved in emotion, particularly experiences of pleasure and reward. These structures form a network with the **nucleus accumbens**, whose activity accompanies many kinds of pleasurable experiences.
- Another major set of forebrain structures comprises of the **limbic system**, an integrated network involved in emotion and memory.
- One key structure in the limbic system is the **amygdala**, which facilitates memory formation for emotional events, mediates fear responses, and appears to play a role in recognizing and interpreting emotional stimuli, including facial expressions. In addition, the amygdala connects with structures in the nervous system that are responsible for adaptive fear responses.
- The **hippocampus** is critical for learning and memory, particularly the formation of new memories.
- The **hypothalamus** maintains body temperature and regulates drives such as aggression and sex by interacting with the endocrine system. Regions of the hypothalamus trigger orgasm for both females and males.
- The **thalamus** is a set of nuclei involved in relaying sensory information to different regions of the brain.
- **The Cerebral Cortex:**

- The **cerebral cortex** is the convoluted, wrinkled outer layer of the brain that is involved in multiple higher functions, such as thought, language, and personality.
- The cerebral cortex has increased dramatically in size as the primate brain has evolved. The wrinkled surface of the brain seems to have solved a biological problem endured by our species: how to pack more cells into the same amount of space. Because the skull can only be so large, the brain has countered this constraint by forming a wrinkled surface, thereby increasing the surface area of the cortex. More surface area means more neurons and greater cognitive complexity.
- **The Four Lobes:**
- In each cerebral hemisphere, the cortex forms the outer surface of four major areas known as lobes: the occipital, parietal, temporal, and frontal lobes.
- The **occipital lobes** are located at the rear of the brain and are where visual information is processed.
- The **parietal lobes** are involved in our experiences of touch as well our bodily awareness. At the front edge of the parietal lobe is the **somatosensory cortex**, a band of densely packed nerve cells that register touch sensations. The amount of neural tissue dedicated to a given body part in this region is roughly based on the number of sensory receptors present at each respective body region. Regions within the parietal lobes also function in performing mathematical, visuospatial, and attention tasks. Damage to different regions of the parietal lobe can lead to specific impairments. For instance, right parietal lobe damage can lead to **neglect**, a situation in which the patient does not attend to anything that appears in the left half of his or her visual field.
- The **temporal lobes** are located at the sides of the brain near the ears and are involved in hearing, language, and some higher-level aspects of vision such as object and face recognition. Different sections of the temporal cortex perform different roles. The top part of the temporal cortex is known as the **auditory cortex**, the part of the temporal lobe that processes auditory information in humans. Damage to this region leads to problems with hearing despite the fact that the patient's ears work perfectly, a condition called **cortical deafness**. Slightly behind this region is **Wernicke's area**, which is related to understanding language.
- The **frontal lobes** are important in numerous higher cognitive functions, such as planning, regulating impulses and emotions, language production, and voluntary movement. The frontal lobes also allow you to deliberately guide and reflect on your own thought processes. Toward the rear of the frontal lobes is a thick band of neurons that form the **primary motor cortex**, which is involved in the control of voluntary movement. Importantly, motor areas in the frontal lobes are also active when planning a movement. The front two-thirds of the frontal lobes are known as the **prefrontal cortex**. This region performs many of our higher-order cognitive functions such as decision making and controlling our attention. These control processes are known as **executive functions**.

- The **corpus callosum** is a collection of neural fibres connecting the two brain hemispheres. This thick band of fibres allows the right and left hemispheres to communicate with each other.
- **Left Brain, Right Brain Hemispheric Specialization:**
- Although they appear to be mirror images of each other, the two sides of the cortex often perform very different functions, a phenomenon called **hemispheric specialization**.
- Speaking in very general terms, the right hemisphere is specialized for cognitive tasks that involve visual and spatial skills, recognition of visual stimuli, and musical processing. In contrast, the left hemisphere is more specialized for language and math.
- **Section 3.4:**
- **Lesioning and Brain Stimulation:**
- Scientists will sometimes intentionally damage an area in the brain, a process called **lesioning**, to gain more experimental control.
- In addition, researchers can study brain functions using **transcranial magnetic stimulation (TMS)**, a procedure in which an electromagnetic pulse is delivered to a targeted region of the brain. This pulse interacts with the flow of ions around the neurons of the affected area. The result is a temporary disruption of brain activity, similar to the permanent disruption caused by a brain lesion. This procedure has the advantage that healthy human volunteers can be studied.
- **Structural Neuroimaging:**
- **Structural neuroimaging** is a type of brain scanning that produces images of the different structures of the brain. This type of neuroimaging is used to measure the size of different brain areas and to determine whether any brain injury has occurred.
- There are three commonly used types of structural neuroimaging:
    1. **Computerized tomography (CT scan)** is a structural neuroimaging technique in which x-rays are sent through the brain by a tube that rotates around the head. The x-rays will pass through dense tissue at a different speed than they will pass through less dense tissue. A computer then calculates these differences for each image that is taken as the tube moves around the head and combines that information into a three-dimensional image. CT scans are both cheap and safe.
    2. **Magnetic resonance imaging (MRI)** is a structural imaging technique in which clear images of the brain are created based on how different neural regions absorb and release energy while in a magnetic field. First, a brain or other body part is placed inside a strong magnetic field and this causes the protons of the brain's hydrogen atoms to spin in the same direction. Second, a pulse of radio waves is sent through the brain; the energy of this pulse is absorbed by the atoms in the brain and knocks them out of their previous position (aligned with the magnetic field). Finally, the pulse of radio waves is turned off. At this point, the atoms again become aligned with the magnetic field. But, as they do so, they release the energy they absorbed during the pulse. Different types of tissue, grey matter, white

matter, and fluid, release different amounts of energy and return to their magnetic alignment at different speeds. Computers are used to calculate these differences and provide a very detailed three-dimensional image of the brain. MRIs produce much clearer images than CT scans and are more accurate at detecting many forms of damage, but CT scans are still used because they are cheaper. Also, if the person has metal in their body, the metal would not react well to the magnet used in the MRI scan.

3. **Diffusion tensor imaging (DTI)** is a form of structural neuroimaging allowing researchers or medical personnel to measure white-matter pathways in the brain. Although it is natural to assume that grey matter, the cell bodies, is the most sensitive part of the brain, white-matter damage has been found in an increasing number of brain disorders.

- **Functional Neuroimaging:**
- **Functional neuroimaging** is a type of brain scanning that provides information about which areas of the brain are active when a person performs a particular behaviour.
- A common trade-off is between **temporal resolution** and **spatial resolution**.
- A neuroimaging method with fantastic temporal resolution is an **electroencephalogram (EEG)**, which measures patterns of brain activity with the use of multiple electrodes attached to the scalp. The neural firing of the billions of cells in the brain can be detected with these electrodes, amplified, and depicted in an electroencephalogram. EEGs measure this activity every millisecond. They can tell us a lot about general brain activity during sleep, during wakefulness, and while patients or research participants are engaged in a particular cognitive activity. The convenience and relatively inexpensive nature of EEGs, compared to other modern methods, make them very appealing to researchers.
- To link the EEG output with your stimuli, researchers have developed a technique known as **event-related potentials (ERPs)**. ERPs use the same sensors as EEGs, however, a computer takes note of exactly when a given stimulus was presented to the participant. The experimenter can then examine the EEG readout for a brief period of time following the appearance of that stimulus.
- Although ERPs are very useful for measuring when brain activity is occurring, they are much less effective at identifying exactly where that activity is taking place. Part of this problem is due to the fact that the skull disrupts the electrical signals from the neurons' firing. In order to get around this, some researchers measure the magnetic activity associated with cells firing by using **magnetoencephalography (MEG)**, a neuroimaging technique that measures the tiny magnetic fields created by the electrical activity of nerve cells in the brain. Like EEG, MEG records the electrical activity of nerve cells just a few milliseconds after it occurs, which allows researchers to record brain activity at nearly the instant a stimulus is presented. However, like ERPs, MEGs do not provide a detailed picture of the activity of specific brain areas. So, although its

ability to isolate the location of brain activity is slightly better than that of ERPs, it is still difficult to isolate exactly where in the brain the activity occurred.

- A **positron emission tomography (PET)** is a type of scan in which a low level of a radioactive isotope is injected into the blood, and its movement to regions of the brain engaged in a particular task is measured. This method works under the assumption that active nerve cells use up energy at a faster rate than do cells that are less active. As a result, more blood will need to flow into those active areas in order to bring more oxygen and glucose to the cells. If the blood contains a radioactive isotope, more radioactivity will be detected in areas of the brain that were active during that period of time. The greatest strength of PET scans is that they show metabolic activity of the brain. PET also allows researchers to measure the involvement of specific types of receptors in different brain regions while people perform an experimental task. A drawback is that PET scans take a long time to acquire, at least two minutes, which is a problem when you want to see moment-by-moment activity of the brain. The radioactivity of PET also generally limits the participants to men because it is possible that female participants could be in the early stages of pregnancy.
- **Functional magnetic resonance imaging** measures brain activity by detecting the influx of oxygen-rich blood into neural areas that were just active. The way fMRI works is the following. When a brain area is involved with a particular function, it will use up oxygen. The result is that blood in these areas will be deoxygenated. The body responds by sending in more oxygen-rich blood to replace the deoxygenated blood. Critically, these two types of blood have different magnetic properties. So, by measuring the changing magnetic properties of the blood in different brain areas, it is possible to see which areas were active when the person performed a particular task. fMRI provides very detailed images of where brain activity is occurring, but it can only measure activity at the level of seconds rather than milliseconds. Therefore, it lacks the temporal resolution of ERP and MEG.

Definitions:

- **Acetylcholine:** One of the most widespread neurotransmitters within the body, found at the junctions between nerve cells and skeletal muscles; it is very important for voluntary movement.
- **Action potential:** A wave of electrical activity that originates at the beginning of the axon near the cell body and rapidly travels down its length.
- **Adrenal glands:** A pair of endocrine glands located adjacent to the kidneys that release stress hormones, such as cortisol and epinephrine.
- **Agonists:** Drugs that enhance or mimic the effects of a neurotransmitter's action.
- **All-or-none principle:** Individual nerve cells fire at the same strength every time an action potential occurs.
- **Amygdala:** A group of nuclei in the medial portion (near the middle) of the temporal lobes in each hemisphere of the brain that facilitates memory formation for emotional events, mediates fear responses, and appears to play a role in recognizing and interpreting emotional stimuli, including facial expressions.

- **Antagonists:** Inhibit neurotransmitter activity by blocking receptors or preventing synthesis of a neurotransmitter.
- **Autonomic nervous system:** The portion of the peripheral nervous system responsible for regulating the activity of organs and glands.
- **Axon:** Transports information in the form of electrochemical reactions from the cell body to the end of the neuron.
- **Basal ganglia:** A group of three structures that are involved in facilitating planned movements, skill learning, and integrating sensory and movement information with the brain's reward system.
- **Behavioural genomics:** The study of DNA and the ways in which specific genes are related to behaviour
- **Behavioural genetics:** The study of how genes and the environment influence behaviour.
- **Brainstem:** The bottom of the brain and consists of two structures: the medulla and the pons.
- **Cell body:** The part of a neuron that contains the nucleus that houses the cell's genetic material.
- **Central nervous system (CNS):** Consists of the brain and the spinal cord.
- **Cerebellum:** The lobe-like structure at the base of the brain that is involved in the monitoring of movement, maintaining balance, attention, and emotional responses.
- **Cerebral cortex:** The convoluted, wrinkled outer layer of the brain that is involved in multiple higher functions, such as thought, language, and personality.
- **Chromosomes:** Structures in the cellular nucleus that are lined with all of the genes an individual inherits.
- **Computerized tomography (CT scans):** A structural neuroimaging technique in which x-rays are sent through the brain by a tube that rotates around the head.
- **Corpus callosum:** A collection of neural fibres connecting the two brain hemispheres.
- **Dendrites:** Small branches radiating from the cell body that receive messages from other cells and transmit those messages toward the rest of the cell.
- **Dizygotic twins:** Fraternal twins who come from two separate eggs fertilized by two different sperm cells that share the same womb; these twins have approximately 50% of their genetics in common.
- **DNA (deoxyribonucleic acid):** A molecule formed in a double-helix shape that contains four amino acids: adenine, cytosine, guanine, and thymine.
- **Dopamine:** A monoamine neurotransmitter involved in such varied functions as mood, control of voluntary movement, and processing of rewarding experiences.
- **Diffusion tensor imaging (DTI):** A form of structural neuroimaging allowing researchers or medical personnel to measure white-matter pathways in the brain.
- **Electroencephalogram (EEG):** A measure of brain activity that uses electrodes attached to the scalp to measure patterns of brain activity.
- **Endorphin:** A hormone produced by the pituitary gland and the hypothalamus that functions to reduce pain and induce feelings of pleasure.

- **Epigenetics:** Changes in gene expression that occur as a result of experience and that do not alter the genetic code.
- **Evolution:** The change in the frequency of genes occurring in an interbreeding population over generations.
- **Evolutionary psychology:** A field of psychology that attempts to explain human behaviours based on the beneficial function they may have served in our species' development.
- **Forebrain:** The most visibly obvious region of the brain, consists of all of the neural structures that are located above the midbrain, including all of the folds and grooves on the outer surface of the brain; the multiple interconnected structures in the forebrain are critical to such complex processes as emotion, memory, thinking, and reasoning.
- **Frontal lobes:** Important in numerous higher cognitive functions, such as planning, regulating impulses and emotion, language production, and voluntary movement.
- **Functional MRI (fMRI):** Brain imaging technology designed to measure changes in blood flow, which is correlated with neural activity, throughout the brain. It measures brain activity by detecting the influx of oxygen-rich blood into neural areas that were just active.
- **Functional neuroimaging:** A type of brain scanning that provides information about which areas of the brain are active when a person performs a particular behaviour.
- **GABA (gamma-amino butyric acid):** The primary inhibitory neurotransmitter of the nervous system, meaning that it prevents neurons from generating action potentials.
- **Genes:** The basic units of heredity; genes are responsible for guiding the process of creating the proteins that make up our physical structures and regulate development and physiological processes throughout the lifespan.
- **Genotype:** The genetic makeup of an organism. The unique set of genes that comprise that individual's genetic code.
- **Glial cells:** Specialized cells of the nervous system that are involved in mounting immune responses in the brain, removing waste, and synchronizing the activity of the billions of neurons that constitute the nervous system.
- **Glutamate:** Most common excitatory neurotransmitter in the brains of vertebrates.
- **Heritability:** A statistic, expressed as a number between zero and one, that represents the degree to which genetic differences between individuals contribute to individual differences in a behaviour or trait found in a population.
- **Hindbrain:** A brain region consisting of structures that are critical to controlling basic, life-sustaining processes.
- **Hippocampus:** Critical for learning and memory, particularly the formation of new memories.
- **Hormones**: Chemicals secreted by the glands of the endocrine system.

- **Hunter-gatherer theory:** Links performance on specific tasks to the different roles performed by males and females over the course of our evolutionary history.
- **Hypothalamus:** A brain structure that regulates basic biological needs and motivational systems.
- **Intersexual selection:** A situation in which members of one sex select a mating partner based on their desirable traits.
- **Intrasexual selection:** A situation in which members of the same sex compete in order to win the opportunity to mate with members of the opposite sex.
- **Lesioning:** A technique that inflicts controlled damage to brain tissue so as to study its function.
- **Limbic system:** An integrated network involved in emotion and memory.
- **Longitudinal studies:** Studies that follow the same set of individuals for many years, often decades.
- **Magnetic resonance imaging (MRI):** A structural imaging technique in which clear images of the brain are created based on how different neural regions absorb and release energy while in a magnetic field.
- **Magnetoencephalography (MEG):** A neuroimaging technique that measures the tiny magnetic fields created by the electrical activity of nerve cells in the brain.
- **Midbrain:** Resides just above the hindbrain, primarily functions as a relay station between sensory and motor areas.
- **Monozygotic twins:** Twins who come from a single ovum (egg), which makes them genetically identical (almost 100% genetic similarity).
- **Myelin:** A fatty sheath that insulates axons from one another, resulting in increased speed and efficiency of neural communication.
- **Natural selection:** The process by which favourable traits become increasingly common in a population of interbreeding individuals, while traits that are unfavourable become less common.
- **Neurogenesis:** The formation of new neurons.
- **Neurons:** One of the major types of cells found in the nervous system, which are responsible for sending and receiving messages throughout the body.
- **Neuroplasticity:** The capacity of the brain to change and rewire itself based on individual experience.
- **Neurotransmitters:** The chemicals that function as messengers allowing neurons to communicate with each other.
- **Norepinephrine/noradrenaline:** A monoamine synthesized from dopamine molecules that is involved in regulating stress responses, including increasing arousal, attention, and heart rate.
- **Occipital lobes:** Located at the rear of the brain and are where visual information is processed.
- **Parasympathetic nervous system:** Helps maintain homeostatic balance in the presence of change; following sympathetic arousal, it works to return the body to a baseline, non-emergency state.

- **Parietal lobes:** Involved in our experiences of touch as well our bodily awareness.
- **Phenotype:** The physical traits and behavioural characteristics that show genetic variation, such as eye colour, the shape and size of facial features, intelligence, and even personality.
- **Pituitary gland:** The master gland of the endocrine system that produces hormones and sends commands about hormone production to the other glands of the endocrine system.
- **Peripheral nervous system (PNS):** A division of the nervous system that transmits signals between the brain and the rest of the body and is divided into two subcomponents, the somatic system and the autonomic system.
- **Positron emission tomography (PET):** A type of brain scanning technology in which a low level of radioactive glucose is injected into the blood, and its movement to regions of the brain engaged in a particular task is measured.
- **Refractory period:** A brief period in which a neuron cannot fire and a time period during which erection and orgasm are not physically possible.
- **Resting potential:** Relatively stable state during which the cell is not transmitting messages.
- **Reuptake:** A process whereby neurotransmitter molecules that have been released into the synapse are reabsorbed into the axon terminals of the presynaptic neuron.
- **Serotonin:** A monoamine involved in regulating mood, sleep, aggression, and appetite.
- **Somatic nervous system:** Consists of nerves that control skeletal muscles, which are responsible for voluntary and reflexive movement; it also consists of nerves that receive sensory input from the body.
- **Stem cells:** A unique type of cell that does not have a predestined function.
- **Structural neuroimaging:** A type of brain scanning that produces images of the different structures of the brain.
- **Sympathetic nervous system:** Responsible for the fight-or-flight response of an increased heart rate, dilated pupils, and decreased salivary flow—responses that prepare the body for action.
- **Synapses:** The microscopically small spaces that separate individual nerve cells.
- **Synaptic cleft:** The minute space between the axon terminal and the dendrite.
- **Temporal lobes:** Located at the sides of the brain near the ears and are involved in hearing, language, and some higher-level aspects of vision such as object and face recognition.
- **Thalamus:** A set of nuclei involved in relaying sensory information to different regions of the brain.
- **Transcranial magnetic stimulation (TMS):** A procedure in which researchers send an electromagnetic pulse to a targeted region of the brain, which can either stimulate or temporarily disable it.