CHAPTER 3

CHAPTER OUTLINE

Biological Psychology

Module 3.1: Neurons and Behavior
1) A good explanation should relate one observation to other measurable conditions. Often, explanations in psychology attempt to relate observations to unobservable mental events. The most satisfying explanations in psychology usually relate observed behaviors to physiology, evolution, or development. A physiological explanation describes the mechanism that produces a behavior. An evolutionary explanation relates behavior to the evolutionary history of the species. A developmental explanation focuses on changes during the life of an organism. This chapter will focus primarily on physiological explanations.

2) Nervous System Cells: Reductionism is the scientific strategy of explaining complex phenomena in terms of simpler components. As physicists try to break down matter and physical processes into the tiniest and most indivisible particles and forces, biological psychologists examine the cells and chemicals that make up the structure and functioning of the nervous system.

a) Neurons, or nerve cells, are the basic cells that make up the nervous system. Neurons receive information and transmit it to other cells by conducting electrochemical impulses. Glia are cells that support the neurons in many ways, such as by insulating them, protecting them, and removing waste products. Neurons consist of three basic parts: the cell body houses the nucleus of the cell; the dendrites are branching structures that receive transmissions from other dendrites; and the axon is a single long, thin, straight fiber with branches near its tip. Its function is to send the neural transmission on to neighboring neurons. Some axons are covered with an insulating sheath of myelin that speeds up transmission of impulses along the axon. Neurons vary widely in shape and array of dendrites and axons, depending on the cell’s location and function. They are also constantly growing new dendrites and axons, and losing old branches, especially in association with new experiences and learning.

3) The Action Potential: Axons convey information through a combination of electrical and chemical processes known as an action potential. According to the all-or-none law, action potentials do not vary in strength—either they occur or they do not. An action potential is superior to simple electrical conduction in that no matter where it originates, it arrives at the brain at full strength, though it is a little slower than electrical conduction. The resting potential is an electrical polarization across the membrane of an axon, with a negative charge on the inside of the axon. Certain types of stimulation can upset this resting potential, generating an action potential, an event in which the membrane briefly opens little gates along its surface to allow sodium ions to enter the axon and potassium atoms to exit, eliminating the negative potential inside the cell.

4) Synapses: The synapses are junctions or gaps between neurons. The sending neuron releases chemical into the synapse that either excites or inhibits the next neuron. The
Typical axon has several branches ending in little bulges, variously called presynaptic endings, terminal boutons, or terminal buttons. The terminal buttons contain neurotransmitters, chemicals that are stored in the neuron that activate the receptors of other neurons. The neurotransmitter molecules diffuse across the synapse to the postsynaptic neuron, the receiving neuron, where they attach to receptors on the dendrite or cell body. Whether the next cell fires depends on the proportion of the total amount of excitatory messages versus inhibitory messages. After the neurotransmitter has finished its job at the receptors of the receiving neuron, it is reabsorbed by the sending neuron, or metabolized, or diffuses away.

5) Neurotransmitters and Behavior: Sometimes the connection between a neurotransmitter and a behavioral or functional problem is quite clear. The connection between Parkinson’s disease and the gradual decay of pathways of axons that use the neurotransmitter dopamine, which promotes activity levels and facilitates movement, is well established. On the other hand, the connection between the condition attention-deficit disorder or ADD and dopamine is not so clear-cut. Drugs that prevent presynaptic neurons from reabsorbing dopamine help children who have ADD whether or not those children have an underlying abnormality in the release of dopamine. Neurotransmitters should not be regarded as directly causal in any behavior, mood, or problem of mental functioning; rather, they are a part of a multi-causal chain in a complex system.

Module 3.2: Drugs and Their Effects

1) Most psychoactive drugs enhance or weaken experiences and garble cognition and speech by acting on receptors at the synapses in the brain. The addictive actions of dopamine are particularly in evidence at the nucleus accumbens, an area of the brain that is involved in attention and habit formation. However, behaviors such as gambling can also affect dopamine production. Addiction is in the person, not the drug.

a) Stimulants: These drugs boost energy, alertness, and activity, and are associated with a feeling of well-being. Caffeine is a common stimulant. Amphetamine and cocaine are much more powerful stimulants, and have wide-ranging effects. Cocaine inhibits the activity of inhibitory neurons, thus stimulating behavior. Crack cocaine is cocaine that has been converted into free-base rocks, ready to be smoked. It is fast-acting and produces a powerful high. Methylphenidate is the generic name for Ritalin. It works at the same synapses as cocaine but not as quickly, reducing its addictive potential. Nicotine is another common and highly addictive stimulant.

b) Depressants: These are drugs that decrease arousal. Alcohol is a category of chemical compound that includes methanol, ethanol, propyl alcohol (rubbing alcohol), and others. Humans drink ethanol. It acts primarily as a relaxant. Alcohol abuse occurs around the world, varying somewhat by ethnic group. All alcohol is toxic, and excessive use of ethanol can damage many organ systems, including the brain and nervous system. Tranquilizers were developed to help people to relax and fall asleep. They also decrease muscle tension and suppress epileptic seizures. The most commonly used class of tranquilizers is the benzodiazepines, which facilitate transmission at synapses that use GABA.
“date rape drug,” flunitrazepam, is classified as a benzodiazepine.

c) Narcotics: *Opiates* are drugs that are derived from the opium poppy or synthetic drugs with a chemical structure similar to that of the natural opiates. These include morphine, heroin, methadone, and codeine. They are associated with inhibition of pain and feelings of elation, followed by anxiety, pain, and over-responsiveness to stimulation. The brain produces chemicals known as *endorphins* that bind to opiate receptors, helping to inhibit pain.

d) Marijuana: *Marijuana* (*cannabis*) produces a variety of effects including drowsiness and intensification of sensory experiences. Its active ingredient is *THC* (*tetrahydrocannabinol*). It has some (controversial) medical uses. It is difficult to discern the truth about the harmfulness of marijuana’s effects. Most evidence is correlational in nature. Marijuana has been shown to have some damaging effects on memory that usually end when use ceases. Marijuana has some legitimate medical uses, but also may increase the risk of Parkinson’s disease and lung cancer.

e) Hallucinogens: *Hallucinogens* are drugs that induce distorted sensory experiences. LSD, MDMA (“ecstasy”), and PCP (“angel dust”) are classified as hallucinogens. LSD attaches mainly to brain receptors sensitive to serotonin. MDMA stimulates dopamine and serotonin receptors. PCP works by inhibiting the action of glutamate.

**Module 3.3: Brain and Behavior**

1) The Major Divisions of the Nervous System: The *central nervous system* is comprised of the brain and spinal cord. The *peripheral nervous system* is composed of bundles of axons between the spinal cord and the rest of the body. The *somatic nervous system* consists of the peripheral nerves that communicate with the muscles and skin and carry information about these structures to the brain. The nerves that control the heart, stomach, and other organs are called the *autonomic nervous system*.

   a) The central nervous system in vertebrates (animals with backbones) develops out of a simple tube during the embryonic stages into a *forebrain*, *midbrain*, and *hindbrain*. What remains of the tube becomes the spinal cord.

   b) The Forebrain: Cerebral Cortex: The “master area” of the brain is the *cerebral cortex*, the outer surface of the forebrain. The cortex consists of two *hemispheres*, the left and right halves. Parts of the cortex have specialized functions, and interact with other areas for some functions.

      i) The *occipital lobe*, at the rear of the head, is specialized for vision.

      ii) The *temporal lobe* is the main processing center for hearing, as well as some complex aspects of vision and language processing, such as recognizing faces and the movement of visual objects and sounds and remembering the names of objects. The *amygdala* is a structure in this area that is related to the experience and processing of emotion.

      iii) The *parietal lobe*, just in front of the occipital lobe, is specialized for body senses. The *primary somatosensory cortex*, a strip in the parietal lobe, has neurons that are touch-sensitive for various areas of the body.

      iv) The *frontal lobe* contains the *primary motor cortex*, an important area for controlling fine movements. The *prefrontal cortex* contributes to the planning
and organization of movements, and to certain aspects of memory. The frontal cortex also contains areas important for language function and some networks of mirror neurons which facilitate learning from watching and copying others.

c) The Forebrain: Subcortical Areas: Several structures below the cortex mediate information entering and exiting the forebrain. The thalamus processes sensory information before the cerebral cortex does and is surrounded by the limbic system. The hypothalamus, part of this area, is important in regulating drives like hunger, thirst, temperature regulation, and sexual motivation.

d) Motor Control: Hindbrain structures such as the pons and medulla, which help to control various life-preserving functions, also control the muscles of the head. The medulla, pons, and midbrain contain the reticular formation and other systems that help regulate brain arousal. The cerebellum (also in the hindbrain) is important for behaviors that require timing, coordination, balance, and rapid shifts or attention between multiple stimuli.

i) The spinal cord communicates with the body below the level of the head by means of sensory neurons and motor neurons. It also sends and receives information from the brain traveling to other parts of the body. Sensory neurons carry information about touch, pain, and other senses from the periphery of the body to the spinal cord. Motor neurons transmit impulses from the central nervous system to the muscles and glands. They are involved in both reflexive and voluntary behavior. A reflex is an automatic response to a stimulus, typically requiring no higher cognitive process of any kind.

2) Measuring Brain Activity: One electronic method for recording the activity of the brain uses the electroencephalograph (EEG), which uses electrodes on the scalp to record electrical activity of the neurons in the brain. A version of EEG that records magnetic changes in the brain is called a magnetoencephalograph (MEG). Research techniques for investigating the brain include positron emission tomography (PET) which records radioactivity emitted from injected chemicals. Functional magnetic resonance imaging (fMRI) uses magnetic detectors located outside the head to measure the amounts of oxygenated hemoglobin in different parts of the brain. These are powerful tools for research, but require careful comparisons and interpretation.

3) The Autonomic Nervous System and Endocrine System:

a) The autonomic nervous system controls internal organs, and consists of two parts. The sympathetic nervous system readies the body for “fight or flight.” The parasympathetic nervous system promotes bodily activities that take place during rest, the so-called “vegetative functions.”

b) The endocrine system is comprised of glands that produce hormones and release them into the blood. Hormones are long-acting chemicals released by glands and conveyed by the blood to other parts of the body, where they alter activity, structure and growth. The production and dispersal of hormones are regulated by the hypothalamus and pituitary gland.

4) Areas of the cerebral cortex vary in size across individuals due to the effects of genetics and experience. A few areas of the brain contain undifferentiated cells called stem cells that can develop into additional neurons. These neurons develop slowly and sporadically, though, and it is not a process analogous to growing new skin or blood cells. Brain plasticity occurs due to the growth and modification of synapses.
5) The Two Hemispheres and Their Connections: Although gross anatomy of the brain does not vary from individual to individual, detailed anatomy does differ, and depends on experience. Brain anatomy is not fixed at birth—it can be affected by unusual or prolonged experiences. Learning and experience do seem to affect our brains to some extent—certain areas of the brain grow larger when we gain significant skill or knowledge through practice, as in the examples given in the text of musicians and London cab drivers.

a) Language information is not exclusively processed in the left hemisphere. The right hemisphere understands language in a more limited manner than does the left and is especially important for comprehending emotional aspects of speech. It is also important for spatial reasoning, recognizing faces, and facial expressions.

b) The corpus callosum is a set of axons connecting the two hemispheres. Damage to this structure affects communication between the two hemispheres, and in some unusual cases, provides evidence of separate spheres of consciousness. Severing the corpus callosum was a treatment used for epilepsy, a condition in which some neurons in the brain begin to emit abnormal rhythmic, spontaneous impulses. The treatment was fairly successful, but created some interesting side effects.

c) For almost all right-handed people and about 60% of left-handed people, the brain areas controlling speech are located in the left hemisphere. When the corpus callosum is severed, behavioral oddities emerge. For example, a woman grasps something with her right hand that she cannot see. She can name it, but not if it is placed in her left hand, because the information goes to the less linguistic right hemisphere. The right hemisphere is not entirely “illiterate” but is more sensitive to the emotional content of speech.

6) The Binding Problem: As our knowledge of the different brain parts has increased, our curiosity about how the different specialized structures combine forces to produce a unified set of perceptions and consciousness. Studies of people who become face blind, motion blind or lose their ability to experience color constancy have provided us with interesting information about how the different parts work together, but still leave many interesting questions unanswered.

Module 3.4: Genetics and Evolutionary Psychology

1) Genes influence development, personality and behavior. Genes work independently or in combination and are subject to varying degrees of interaction with environmental conditions. They may also mutate which may change their functions, sometimes with deleterious consequences for the organism. People are accustomed to discussing “nature versus nurture” as if the two forces were in a struggle. The interaction is much more complicated than this.

2) Genetic Principles: Most body cells contain chromosomes which are strands of hereditary material called DNA. There are 46 chromosomes in body cells and 23 unpaired chromosomes in each gamete (egg or sperm cell.) Genes are sections of the chromosome and they control chemical reactions that in each turn direct characteristics and development (height, eye color, etc.) DNA controls the production of RNA, and RNA controls the production of proteins that are absorbed into the body or influence chemical reactions in it. Some genes are
dominant and can exert influence even if lacking a matching gene donated by the other parent. Others are recessive and can only direct development if present paired with a second matching copy of the gene.

3) Sex-Linked and Sex-Limited Genes: Females have two X chromosomes and males have an XY; these are the combinations that determine biological sex. Genes that are located on the X or Y chromosome are sex-linked genes. Recessive genes on the X chromosome in a male with no match on the Y result in conditions that are much more commonly found in males than females (such as color blindness.) Sex-limited genes are those that occur in both sexes but mainly affect one sex or the other. Usually they are activated by hormones. (The hormones that cause the growth of facial hair or breast development are two examples of these.)

4) Epigenetics: A More Complex View of Genes: Research in genetics suggests that the expression of genetic traits is more complicated than we previously suspected. Environmental influences interact with genes, encouraging or discouraging the appearance of their associated traits. This differs from mutations as it does not involve any changes in the DNA sequence. A simple example of this would be freckles which arise from a dominant gene, but do not appear, or appear in only a limited manner, in environments of limited sunlight.
   a. Identifying and Localizing Genes: Modern technology has allowed us to identify and localize the genes responsible for various conditions, which has led to an array of practical and ethical questions.
   b. Estimating Heritability in Humans: Heritability is an estimate of the variance within a population that is due to heredity.
      i. To assess heritability, researchers rely on evidence comparing monozygotic (identical) and dizygotic (fraternal) twins, and the degree to which these types of twins show similar abilities. It is necessary to keep in mind that the prenatal environment that is shared will play a role.
      ii. Comparisons between adopted children and their adoptive and biological parents are also utilized to estimate heritability. This research, though useful, is also thought to underestimate the role that environment plays.
      iii. Studies have revealed a wide variety of conditions with moderate heritability, including schizophrenia and depression, as well as some attitudes and personality traits.

5) How Genes Influence Behavior: Genes can influence a behavior by influencing other characteristics that are either associated with it or antagonistic to it—the link between genes and complex behavioral patterns (e.g., alcoholism) is rarely a direct one.
   a. Direct Influences: If a gene alters neuroanatomy at any level (gross anatomy or microscopic) it will change the organism’s experience and behavior. The number of taste buds is regulated by genes and will affect the experience of eating and food preferences.
   b. Indirect Influences: If a gene alters processes outside the nervous system, such as how certain substances are digested, thus also affecting behavior (food selection or preference.)
c. The Multiplier Effect: This occurs when a small initial advantage in performance, possibly genetically based, alters the environment and magnifies the advantage.
d. Environmental Modification of Genetic Effects: Although genetic influences play a major role, environmental intervention might change results. For example, phenylketonuria is an inherited condition that can lead to mental retardation if left untreated. Although genetic influences play a major role, environmental intervention might change results. For example, phenylketonuria is an inherited condition that can lead to mental retardation if left untreated.

6) Evolutionary Psychology: In simplest terms this is the branch of psychological science that explains human (and other organismal) behavior and experience in terms of utility for promoting the survival and flourishing of the species.
a. Descent with Modification: As part of his explanation of the process of natural selection Darwin proposed that a gradual change in the frequency of some genes occurred over the generations. Genes that facilitated survival increased and those that had no effect, or detracted from changes of living long enough to reproduce, did not.
b. One objection that is raised frequently with regard to evolutionary psychology is that the explanations for behavioral tendencies are used to excuse potentially objectionable behavior – for example, sexual infidelity among human males. Evolutionary psychologists counter that we should not confuse what is with what should be. Also, since humans learn and change so much over the course of development, it is very hard to separate innate from learned behaviors – much more difficult than it is for other species.
c. Explanations based on evolutionary psychology range from fairly convincing and testable to more speculative and hard to test.