Chapter 3: The Biological Bases of Behavior

I. The Neural System

a. The nervous system is a complex communication network in which signals are constantly being transmitted, received and integrated.

b. Anatomy of the nervous system:

i. **Neurons**: individual cells in the nervous system that receive, integrate, and transmit info.

1. Most neurons communicate with other neurons, however some neurons communicate with sensory organs and some with muscles.

ii. **Soma**: cell body, contains cell nucleus and much of the chemical machinery common to most cells.

iii. **Dendrites**: parts of a neuron that are specialized to receive info.

iv. **Axon**: a long thin fiber that transmits signals away from the soma to other neurons or to muscles or to glands.

v. **Myelin Sheath**: insulating material that encases most axons, derived from the glial cells. Speeds up the transmission of signals that move along the axon.

vi. **Terminal Buttons**: small knobs that secrete chemicals called neurotransmitters.

vii. **Neurotransmitters** are chemical messengers that activate neurons, by sending messages (info) from one neuron to another.

viii. **Synapse**: a small gap separating neurons, where the chemical message flows to another neuron.

1. **Synaptic Cleft**: a microscopic gap between the terminal buttons of one neuron and the cell body of another neuron. Chemical messages must jump the gap.
2. presynaptic neuron: the neuron that sends the signal across the gap.
3. postsynaptic neuron: the neuron that receives the signal.

c. **Neural Impulses**: a neural impulse is an electrochemical reaction.

i. The electric impulse travels through the axon and is then released as a chemical at the synaptic terminals.

ii. The fluid outside and inside a neuron contains electrically charged ions. Positively charged sodium and potassium ions and negatively charged chloride ions.

iii. The ions flow back and forth across the cell membrane at different rates, resulting in a slightly higher negative ion concentration within the cell.

iv. **Resting Potential** when the cell is stable and inactive, negative charge.

v. **Action Potential**: a brief shift in the neuron's electrical charge that travels along an axon; the charge is less negative or is positive creates an action potential.

vi. **Absolute Refractory Period**: a minimum period of time when the cell membrane that allowed positive ions in closes after an action potential and another action potential cannot begin.

vii. **Relative Refractory period**: the neuron can fire, but requires more intense stimulation is required to initiate an action potential.

viii. **All-or-None Principle (Law)**: a neuron either fires or it does not, there is no partial firing. And all action potentials are the same strength; however speed can change based on the strength of the stimulus.

d. Sending and Receiving Signals

i. After the release of neurotransmitters, they diffuse across the synaptic cleft to the membrane of the receiving cell, and bind with receptor sites in the postsynaptic cell membrane.

1. **Receptor sites** are specifically programmed to recognize and respond to some neurotransmitters and not to others.
2. **Postsynaptic Potential (PSP)**: a voltage change at a receptor site on a postsynaptic cell membrane due to the reaction of the neurotransmitter with a receptor molecule.
    a. postsynaptic potentials are graded; they vary in size and increase and decrease the probability of a neural impulse in the receiving cell in proportion to the voltage change.
3. **Excitatory PSP**: increases the likelihood that a postsynaptic neuron will fire action potentials, due to a positive voltage shift.
4. **Inhibitory PSP**: decreases the likelihood that a postsynaptic neuron will fire an action potential, due to a negative voltage shift.
    a. Excitatory and inhibitory effects last only a fraction of a second.

5. **Reuptake**: neurotransmitters are reabsorbed from the synaptic cleft by the presynaptic membrane.
6. A neuron may receive thousands of signals from thousands of neurons, it must therefore integrate the signals arriving at the synapse and "decide" whether to fire a neural impulse.
    a. If a neuron receives enough excitatory PSPs, an action potential will be fired.
    b. Our thoughts, perceptions and actions depend on a patterns of neural activity in elaborate interlinked chains, circuits and networks of neural activity.
    c. Old synaptic connections are eliminated while new synapses are created to reflect learning and use.
    d. The number of synapses in the human visual cortex peaks around age 1 and then declines
    e. **Synaptic Pruning** is a key process in the formation of neural networks and the communication of the nervous system.

e. Neurotransmitters and Behavior:

i. Neurotransmitter are essential to behavior, there are 9 well-established transmitters and about 40 additional neuropeptide chemicals that function as neurotransmitters (some of the time)

ii. Specific Neurotransmitters only work at specific synapses, a transmitter has to fit at the receptor site in order for binding to occur.

iii. **Acetylcholine (Ach)** is the only neurotransmitter between motor neurons and voluntary muscles. Every move you make depends on Ach and it also contributes to attention, arousal and possibly memory.
    1. **Agonist**: a chemical that mimics the action of a neurotransmitter (nicotine is an Ach agonist)
    2. **Antagonist**: a chemical that opposes the action of a neurotransmitter (curare is an Ach antagonist, it blocks action)

iv. Monoamines: 3 neurotransmitters: dopamine, norepinephrine and serotonin.
    1. **Dopamine**: used by neurons that control voluntary movements (degeneration of dopamine seems to cause Parkinson's Disease); influences movement, learning, attention and emotion.
        a. Abnormalities in dopamine levels have been implicated in Schizophrenia
    2. **Serotonin**: plays a role in sleep and wakefulness and eating behavior. There is evidence that serotonin levels control aggressive behavior in animals and new evidence suggesting that it also relates to aggression and impulsive behavior in humans)
    3. **Norephinephrine:** helps control alertness and arousal
    4. People who suffer from depression appear to have lowered levels of activation at norepinephrine and serotonin synapses.
    5. Amphetamines and cocaine seem to exert most of their effects by creating a storm on increased activity at dopamine and norepinephrine synapses.

v. Amino Acids
    1. GABA, gamma-aminobutyric acid and glycine produce only postsynaptic potentials and appear to have inhibitory effects at virtually all synapses where either is present.
        a. GABA contributes to the regulation of anxiety in humans and plays arole in seizures.

vi. **Endorphins**: natural opiates released in response to pain and vigorous exercise, results in good feelings and painkilling. Endorphins and their receptor sites are widely distributed throughout the body.
    1. Morphine exerts its effects by binding with the specialized receptor sites for endorphins in the brain.

II. **Organization of the Nervous System**: roughly 100 billion neurons are in the human brain, all of which work together to keep info flowing effectively.

a. The **Peripheral Nervous System** (PNS): consists of all the nerves that are outside the brain and spinal cord.

i. Nerves are bundles of neuron fibers (axons) that are routed together in the peripheral nervous system.

b. The PNS is subdivided into the somatic nervous system and the autonomic nervous system.

c. **Somatic Nervous System**: controls the movements of skeletal muscles, it consists of nerves that connect to voluntary muscles and sensory receptors.
   i. These nerves carry info from receptors in the skin, muscles, and joints to the CNS and also carry messages from the CNS to the muscles.
   ii. Requires two types of nerve fibers; **Afferent**: a nerve carrying a message toward the CNS; and **Efferent**: a nerve carrying a message away from the CNS

d. **Autonomic Nervous system**: Controls the glands and the muscles of our internal organs. Consists of nerves that connect to the heart, blood vessels, smooth muscles and glands.
   i. Controls automatic, involuntary functions; heart rate, digestion, perspiration.
   ii. **Fight or Flight Response**: organisms respond to a threat by preparing physiologically attacking (fight) or fleeing (flight) from the enemy/danger.
      1. prolonged autonomic arousal can contribute to physiological diseases.
   iii. The autonomic nervous system can be subdivided into the sympathetic and parasympathetic divisions.
   iv. **Sympathetic Division**: the branch of the ANS that gets the body ready for emergencies.
      1. slows digestion, drains blood from periphery, increases respiration and heart rate and signals to thye adrenal gland to release hormones that ready the body for exertion.
   v. **Parasympathetic division**: the branch of the ANS that conserves bodily resources and allows the body to store energy.
      1. slows heart rate, reduces blood pressure, calms respiration and promotes digestion

e. **Central Nervous System**: the brain and the spinal cord. It is protected by sheaths called meninges
   i. **Cerebrospinal fluid** (CSF) surrounds and nourishes the brain and provides a protective cushion. The hollow cavaties in the brain are full of CSF and are called ventricles.
   ii. **Spinal Cord**: connects the brain to the rest of the body through the peripheral nervous system. It is enclosed by the meniges and surrounded by CSF.
      1. The Spinal Cord houses bundles of axons that carry the brains commands to the peripheral nerves and that relay sensations from the peripheral of the body back to the brain.
   iii. The **Brain**: contains billions of interacting cells that integrate info from inside and outside the body, coordinates action, and enables speech, thought and memory.

III. Studying the Brain: Neuroscientists use many specialized techniques to investigate connections between the brain and behavior.

a. **Electrical Recordings**: the electrical activity of the brain can be recorded by a machine, the **electroencephalograph** (EEG).It records the electrical activity of the brain over time by means of electrodes connected to the scalp.
   i. The resulting reading of thousands of electric potentials in thousands of brain cells are translated into line tracings called brain waves
   ii. different brain wave patterns are associated with different states of mental activity → patterns of brain activity can be identified when subjects engage in a specific behavior or experience a specific emotion.

b. **Lesioning**: destroying a piece of the brain. Researchers intentionally damage specific parts of the brain in animals to see exactly what effect that part of the brain has on behavior.
   i. Research is done on humans following brain tumors, strokes, head injuries and other brain damaging experiences to gain insights about the brain and behavior.
      1. Problems: few subjects, no control over location or extent of damage and patient history prior creates many extraneous variables.

c. **Electrical Stimulation** of the Brain (ESB): weak electrical impulses are sent into the brain structure to stimulate it. The stimulation attempts to duplicate normal signals to the brain.
   i. Most ESB research is done with animals, however it is used on humans during brain surgery for medical purposes (assure the surgeon is in the right part of the brain).

d. **Brain-Imaging Procedures**: taking pictures of the brain
   i. **CT scan**(computerized tomography): computer enhanced x-ray of the structure of the brain. Multiple x-rays combine to create a horizontal slice of the brain.
   ii. **PET scan**(position emission tomography): maps activity in the brain over time, brain function; radioactive chemicals are introduced into the brain, they serve as markers for blood flow or metabolic activity in the brain (different colors).
   iii. **MRI scan** (Magnetic Resonance Imaging): magnetic fields, radio waves and computerized enhancements are used to map out the brain. Produces 3D high resolution images of the brain structure.
   iv. ***f* MRI**: several new variations on MRI processing, monitors blood and oxygen flow in the brain, identifying areas of activity →info on structure and function

IV. The Brain and Behavior: the brain can be divided into 3 major areas: hindbrain, midbrain and forebrain.
   a. **Brainstem**: the oldest and most central part of the brain, it begins where the spinal cord swells up into the brain. It is responsible for the autonomic survival functions.
   b. **Hindbrain**: includes the cerebellum and the structures found in the lower part of the brain stem, the medulla and the pons.
      i. **Medulla**: base of the brain stem; controls heartbeat and breathing
      ii. **Pons**: a bridge of fibers that connects the brainstem with the cerebellum and contains cell bodies that involve sleep and arousal
      iii. **reticular formation**: a nerve network in the brain stem that plays an important role in arousal; runs through the hindbrain and midbrain. Contributes to muscle reflexes, breathing, and pain perception
      iv. **Cerebellum**: the "little brain" attached to the rear of the brain stem, helps coordinate voluntary movement and balance (first thing affected by alcohol)
   c. **Midbrain**: the segment of the brain stem that is between the hindbrain and the forebrain. Contains an area concerned with integrating sensory processes, like vision and hearing.
   d. **The Forebrain**: largest and most complex region of the brain.
      i. **Thalamus**: the brain's sensory switchboard, located on top of the brainstem; it directs messages to the sensory receiving areas in the cortex and transmits replies to the cerebellum and medulla.
      ii. **Hypothalamus**: a structure in forebrain through which all sensory info, except smell, must pass to the cerebral cortex. It directs maintenance activities (eating, drinking, body temp.) and helps govern the endocrine system and is linked to emotions. It controls the autonomic nervous system and regulates biological drives such as fighting, fleeing, feeding and mating.
      iii. **Limbic System**: a doughnut-shaped system of neural structures at the border of the brainstem and the cerebral hemispheres; it is associated with emotions such as fear and aggression and drives for food and sex. Includes the hippocampus, amygdala and hypothalamus.
         1. **Amygdala**: two almond-shaped neural clusters that are linked to emotion and play a central role in the learning of fear responses.
         2. the **limbic system** is rich with pleasure centers, the heaviest are where the medial forebrain bundle (a bunch of axons) passes through the hypothalamus.
      iv. **Cerebrum**: the largest and most complex part of the human brain; responsible for complex mental activities, including learning, remembering, thinking, and consciousness itself.
      v. **Cerebral Cortex**: the intricate fabric of interconnected neural cells that covers the cerebral hemispheres (outer layer of cerebrum)
      vi. **Cerebral Hemispheres**: right and left halves of the cerebellum; they are separated by a deep longitudinal fissure that runs front to back of the brain
         1. Corpus Collosum: the band of fibers that connects the two cerebral hemispheres.
      vii. Each hemisphere is divided into four lobes.
         1. **occipital lobe**: at the back of the head, includes cortical area where most visual signals are sent and visual processing is started (primary visual cortex)
         2. **Parietal lobe**: forward of the occipital lobe, registers the sense of touch (primary somatosensory cortex). Also involved in integrating visual input and in monitoring the body's position in space.

3. **temporal lobe**: lies below the parietal lobe (near the temples), devoted to auditory processing (primary auditory cortex)
4. **Frontal lobe**: the largest lobe in the human brain, principle areas that control movement of muscles (primary motor cortex)
    a. Prefrontal cortex is somewhat a mystery, it does contribute to high-order functions such as memory; some theorists believe it is like an executive control center and that it is thought to monitor, organize and direct thought processes.

e. **The Plasticity of the Brain**: the brain is more malleable or "plastic" than we once thought.
    i. Brain structure can be sculpted by experience
    ii. Damage to incoming sensory pathways or destruction of brain tissue can lead to neural reorganization
    iii. Recent studies indicate that the adult brain can generate new neurons
    iv. The neural pathways of the brain are flexible and constantly evolving however, there is a limit to the flexibility. Rehabilitation efforts are evidence of this.
    v. Younger brains are more malleable than older brains.

V. Right brain/ Left Brain: Cerebral Laterality
    a. **Broca's Area**: left side of the frontal lobe that plays an important role in the production of speech.
    b. **Wernicke's Area**: temporal lobe in the left hemisphere that deals with comprehension of language.
    c. **Split-Brain Research:** split-brain surgery: the corpus callosum (bundle of fibers that connect the cerebral hemispheres) is cut to reduce the severity of epileptic seizures.
        i. Each hemispheres primary connections are to the opposite side of the body; right hemisphere controls left side, left hemisphere controls right side.
        ii. Eyes: both eyes deliver info to both hemispheres, but there is a separation of input.
        iii. Information received by one hemisphere is readily shared with the other via the corpus collosum. However, when the hemispheres are surgically disconnected, the functional specialization of the brain becomes apparent.
        iv. The right hemisphere (left hand) is superior to the left hemisphere (right hand) in assembling little puzzles and copying drawings, even when the subjects are right handed.
        v. Right Hemisphere is better than the left at visual-spatial tasks, including discerning colors, arranging blocks, and recognizing faces
        vi. Left Hemisphere is better than the right at language, writing and algebraic math.
    d. **The Intact Brain**:
        i. **Perceptual asymmetries**: left-right imbalances between the cerebral hemispheres in the speed of visual or auditory processing.
            1. Based on the specialization of the hemispheres, abilities specialized to the right hemisphere will process quicker if first presented to the right hemisphere rather than to the left; and abilities specialized to the left hemisphere will process quicker when first presented to the left hemisphere rather than the right.
            2. Example: verbal stimuli is more quickly recognized in the left hemisphere than if presented to the right and then sent to the left for interpretation. Visual-spatial tasks (locate a dot on a paper) are more quickly processed if presented to the right hemisphere than if presented to the left and then sent to the right for processing.