3. The Biological Bases of Behavior
compiled by Yaniv

I. Communication in the Nervous System
A. Nervous Tissue: The Basic Hardware
- nervous system tissue is composed of two types: gila and neurons
1. Glia: The Supporting System
- glia cells exist throughout the nervous system and provide structural support and insulation for neurons
- glia cells may supply nutrients, remove wastes, repair damage, or perform other non neural tasks for neurons
2. Neurons: The Communication Links
- defined as "individual cells in the nervous system that recieve, integrate, and transmit information."
- most are interneurons (neuron to neuron), a small minority are sensory neurons (receive signals from stimuli), or motor neurons (neurons to muscles).
- although neurons are diverse in form, the typical neuron posseses (1) a soma - or cell body which contains the nucleus and other standard organelles, (2) dendrites - branch-like structures connected to the soma which receive signals, (3) an axon - "a long, thin fiber that transmits signals away from the soma to other neurons, or to muscles, or glands." (4) a myelin sheath - insulating material derived from glia cells that strengthen the signal by insulating it within the axon, (5) terminal buttons - small "knobs" that secrete neurotransmitters, and (6) synapses - a junction between a terminal button and dendrite of two different neurons. (see image p.75)
B. The Neural Impulse: Using Energy to Send Information
- research by Hodgkin and Huxley into the functioning of neurons was performed on squid neurons due to the thickness of their axons
1. The Neuron at Rest: A Tiny Battery
- the research showed that Na and K cations and Cl anions flowed at different rates accross the cell's membrane causing an electrical potential of -70 millivolts
2. The Action Potential
- the stable voltage is disrupted upon the stimulation by neurotransmitters at dendrites
- channels along the axon membrane open to allow cations into the cell easily resulting in an electric current along the axon
- after the action potential, another cannot occur until the -70 mV potential is restored; this is called the refractory period (minimum length of time between action potentials)
- (certain drugs can prolong this period usually for the purpose of inducing numbness for medical procedures)
3. The All-or-None Law
- one must note that a neuron can only send one type of action potential, so information regarding the intensity of a sensation must be conveyed by the rate at which they fire action potentials
- action potentials vary between neurons - myelin sheaths and thicker axons increase the intensity and speed of the signal
C. The Synapse: Where Neurons Meet
- in some cases, neurons signal other cells by directly passing the electrical current of the action potential across the synapse; in the case of humans, neurotransmitters appear to signal across synapses
1. Sending Signals: Chemicals as Couriers
- terms: (1) synaptic cleft: microscopic gap between the terminal button of one cell and the membrane of another, (2) presynaptic neuron - transmits the signal, (3) postsynaptic neuron - receives the signal, (4) neurotransmitters - "chemicals that transmit information from one neuron to another."
- as an action potential arrives at the terminal button, it secretes neurotransmitters which were initially stored in synaptic vesicles; the chemicals diffuse across the synaptic cleft and attach to receptor sites on the postsynaptic cell's membrane
2. Receiving Signals: Postsynaptic Potentials
- upon receiving the signal from the neurotransmitter, reactions in the cell membrane cause a post synaptic potential
- PSP's do not follow the all or none law as they vary in size and some increases the probability of an action potential in the cell (excitatory PSP) while others decrease the likelihood of this (inhibitory PSP)
- the inhibitory ability is necessary as a negative feedback and some seizures are caused by a lack of inhibitory signals
- also unlike action potentials, PSP's diminish in voltage as they travel along dendrites and the soma
- neurotransmitters do not remain at synapses, some drift away while others are actively reabsorbed by the

presynaptic membrane

3. Integrating Signals: A Balancing Act

- neurons not only relay received information, in deciding whether or not to fire an action potential, a neuron may depend on temporal summation (several PSPs in rapid succession) or spacial summation (several PSPs simultaneously at different receptor sites)

D. Neurotransmitters and Behavior#

II. Organization of the Nervous System

A. The Peripheral Nervous System

- defined as all nerves "that lie outside the brain and spinal cord"; nerves are defined as "bundles of neuron fibers (axons) that are routed together in the peripheral nervous system."
- this is further divided into the somatic and autonomic nervous system

1. The Somatic Nervous System

- consists of nerves that connect to voluntary skeletal muscles and sensory receptors
- these nerves send information to the brain (afferent nerve fibers) and send back skeletal responses (efferent nerve fibers)

2. The Autonomic Nervous System (ANS)

- made up of nerves that connect to the heart, blood vessels, smooth muscles, and glands; the ANS controls involuntary responses such as the fight or flight response
- this can also be divided into the sympathetic (mobilizes the body's resources for emergencies and parasympathetic (conserves bodily resources for emergencies) divisions

B. The Central Nervous System

- consists of the brain and spinal cord; protected by sheaths called the meninges; bathed in the cerebrospinal fluid which nourishes and cushion the brain (derived from blood but filtered of some harmful chemicals by the blood-brain barrier

1. The Spinal Cord

- the spinal cord is not a cable from which somatic nerves branch, instead it is a branch of the brain and is protected by the meninges and bathed in cerebrospinal fluid
- houses bundles of axons that carry the brain's commands to peripheral nerves and relays sensory signals to the brain

2. The Brain

III. Looking Inside the Brain: Research Methods

A. Electrical Recordings

- the electroencephalograph (EEG) "monitors the electrical activity of the brain over time by means of recording electrodes attached to the surface of the scalp"
- the EEG sums and amplifies the electric potentials of the thousands of brain cells

B. Lesioning

- individuals with head injuries or other damage to the brain are often studied to determine which mental functions have been lost and can then be attributed to the lost area - problematic due to uncontrollable size and area of the damage, and countless possible extraneous variables makes this type of analysis problematic
- lesioning involves destroying a portion of the brain in animals, and is done systematically to isolate the lesioning as the sole variable

C. Electrical Stimulation of the Brain (ESB)

- defined as "sending a weak electric current into a brain structure to stimulate it"
- mostly performed on animals but occasionally in humans

D. Brain-Imaging Procedures

1. Computerized Tomography (CT) Scan

- defined as "a computer-enhanced X ray of brain structure."
- provides images of horizontal slices of the brain
- cheapest and most widely used method in research

2. Positron Emission Tomography (PET) Scan

- not only show structure but also activity by introducing radioactively marked chemicals to the brain, and tracking concentrations of the chemical as active portions of the brain receive more blood for their functioning

3. Magnetic Resonance Imaging (MRI) Scan

- uses magnetic fields, radio waves, and computer enhancement to produce 3D pictures of the brain with especially high resolution
- too new and expensive to have been used much in studies

IV. The Brain and Behavior

A. The Hindbrain
- the medulla handles breathing, maintaining muscle tone, and regulating breathing
- the pons connects the brain to the cerebellum and possesses a group of cells involved with sleep and arousal
- the cerebellum plays a key role in the execution of commands for muscular movement; allows for fine muscle movement

B. The Mid brain
- concerned with certain sensory processes
- a system of DA neurons which extends to high areas of the brain is involved in the performance of voluntary movements
- the reticular formation contributes to the modulation of muscle reflexes, breathing, and pain perception; best known for its role in the regulation of sleep and arousal

C. The Forebrain

1. The Thalamus: A Way Station
- structure through which all sensory information must pass to reach the cerebral cortex
- also involved in integrating information from various senses

2. The Hypothalamus: Regulator of Biological Needs
- involved in the regulation of basic biological needs; is a critical structure in the ANS; vital link between the brain and the endocrine system
- also plays a major role in basic needs: hunger, fight/flight, and mating

3. The Limbic System: The Seat of Emotion
- unclear definition of boundaries - includes parts of the thalamus, hypothalamus, hippocampus, the amygdala, the septum, and other structures
- the limbic system is "involved in the regulation of emotion, memory, and motivation"
- hippocampus is involved in the formation of memories
- amygdala may play a major role in the learning of fear responses
- limbic system is also rich in "pleasure centers"

4. The Cerebellum: The Seat of Complex Thought
- responsible for most complex mental activities including learning, remembering, thinking, and consciousness itself
- divided into two halves joined by the corpus callosum
- each hemisphere is then divided into four lobes
- occipital lobe is located at the back of the head and is where most visual signals are sent and processing begins
- parietal lobe is forward of the occipital lobe and "includes the area that registers the sense of touch."
- temporal lobe lies below the parietal lobe; contains an area devoted to auditory processing
- frontal lobe contains the "principal areas that control the movement of muscles." the lobe devotes more space in the brain to parts requiring fine control such as the hands and face

V. Right Brain / Left Brain: Cerebral Laterality

A. Bisecting the Brain: Split-Brain Research#
- split brain research studies the effect of removing the corpus callosum from a human brain (done in severe cases to reduce the intensity of epileptic seizures)
- (recommended read: p. 102)

B. Hemispheric Specialization in the Intact Brain
- since split brain patients initially possessed atypical brains, research into the hemispheres required some testing with undivided brains
- tests measured the accuracy and speed of processing sounds and images from different sides and noted certain differences which account for the brain's need to at times consult the opposite hemisphere to interpret stimuli

C. Handedness and Laterality
- preference for one hand over another has been exceptionally difficult to understand with either genetic or environmental explanations
- some correlation has been found between left handed individuals and the existence of language centers in the right brain or both hemispheres; left handedness is also overrepresented among schizophrenics, alcoholics, and those suffering from retardation or immune disorders, however these associations are weak

VI. The Endocrine System: Another Way to Communicate

- defined as "system consisting of glands that secrete chemicals into the bloodstream that help control bodily functioning."
- a significant link between the brain and endocrine system is the hypothalamus which functions often with the adjacent pituitary gland ("gland which releases a great variety of hormones that fan out around the body,

stimulating actions in other endocrine glands.")
- hormones play a key role in the fight/flight responds and physiological development

VII. Heredity and behavior: Is it All in the Genes?

A. Basic Principles of Genetics

- (recommended read for students without a background in biology)

B. Investigating Hereditary Influence: Research Methods

1. Family Studies

- "researchers assess hereditary influence by examining blood relatives to see how much they resemble one another on a specific trait"
- traits with genetic roots should also show greater correlation between family members with greater gene correlations (ex. brothers:50%, parents: 50%, grandparents: 25%, etc)
- cannot prove genetic bases definitively since families also share environment and this too tends to correlate with greater shared genes

2. Twin Studies

- "researchers assess hereditary influence by comparing the resemblance of identical twins and fraternal twins with respect to a trait"
- identical twins are expected to correlate better than fraternal twins who only share 50% of their genes
- this is much more solid evidence than family studies, but is somewhat problematic as in both cases, the children are raised together, but identical twins are treated more similarly and therefore the environment may cause the correlation

3. Adoption Studies

- researchers "assess hereditary influence by examining the resemblance between adoptive children and both their biological and adoptive parents."
- most reliable of the three methods to determine genetic causes

4. The Cutting Edge: Genetic Mapping

- defined as "the process of determining the location and chemical sequence of specific genes on specific chromosomes."
- researchers have located the genes responsible for various diseases and even some behavioral tendencies
- potential for some qualities are limited as they appear to be polygenetic traits that are shaped by numerous genes

C. The Interplay of Heredity and Environment

- in many cases, a trait or quality cannot be solely attributed to genetics or environment; rather, genetics may make the individual more likely to posses the trait and the environment ultimately determines whether or not the trait emerges

VIII. Putting it in Perspective#