"***You have an organ in your head. Part of that organ is called the cerebral Cortex. This nifty gadget transforms matter into consciousness. With it we can do what no other organism on this Planet has ever been able to do. We can change ourselves. Think of the Possibilities."***

Michael P. Black, Cambridge University

"If the human brain were so simple that we could understand it, we would be so simple that we couldn't."

Emerson M. Pugh, Professor of Physics, Carnegie Mellon University,

---

Notes on the Brain and Behavior – Chapter 2

Essential Questions:

- *How do biological processes relate to behavior?*
- *How do the biological processes work to create and sustain behavior?*
- *How does damage to a biological process or part affect behavior?*

Unit Objectives:

- Explain the process of neural communication.
- Explain how neurotransmitters work.
- Delineate the different steps of the neural chain.
- Analyze the difference between the neural and hormonal systems.
- Identify the parts of the brain and the functions of each.
- Analyze how the brain is specialized in terms of function.
- Describe the different types of brain scans.
- Determine the role of genetics in influencing human behavior.

I. Nature vs. Nurture

A. Nature
   1. A person's inherited characteristics
   2. Genetics:
      a. chromosomes contain genes which are made up of DNA.
      b. there are 23 chromosomes in the human egg and sperm; they are combined (fertilized) to make a 46 chromosome cell
      c. twin studies: psychologists study identical twins (raised together and raised apart to look at genetic influences
      d. genes are self-regulating – instead of acting a just a blueprint, genes can react
      e. chromosomal abnormalities:
         1. Turner's syndrome – babies born with only a single X chromosome that causes the physical abnormalities of shortness, webbed necks, and sexual development.
         2. Klinefelter's Syndrome – babies born with an extra X chromosome which can cause minimal sexual development and personality traits such as introversion
         3. Down's Syndrome - babies born with an extra chromosome on the 21st pair which causes the physical characteristics of a rounded face, shorter fingers and toes, slanted eyes, and different extents of mental retardation.

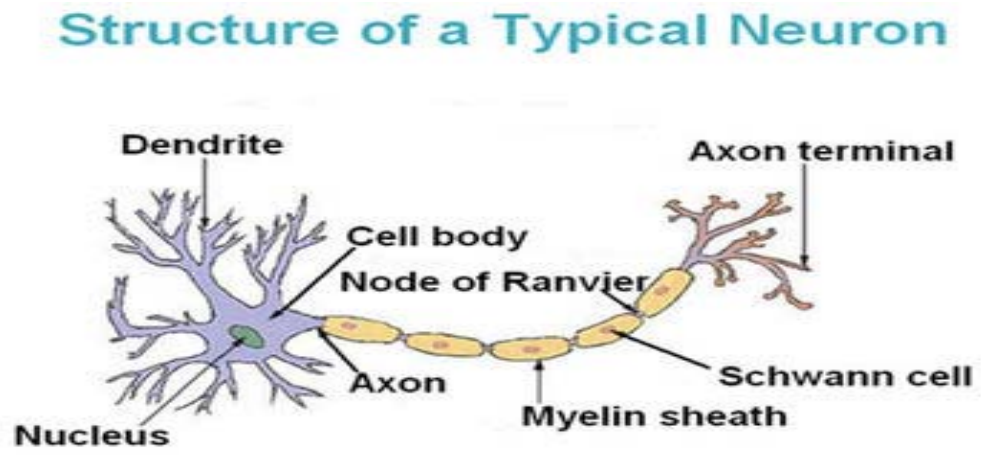
B. Nurture
   1. A person's learned characteristics, from their environment
   2. adoptive studies: psychologists study children with both their biological parents and adoptive parents to compare behavior and traits

C. Combined View
   1. Development and behavior are explained by both nature and nurture

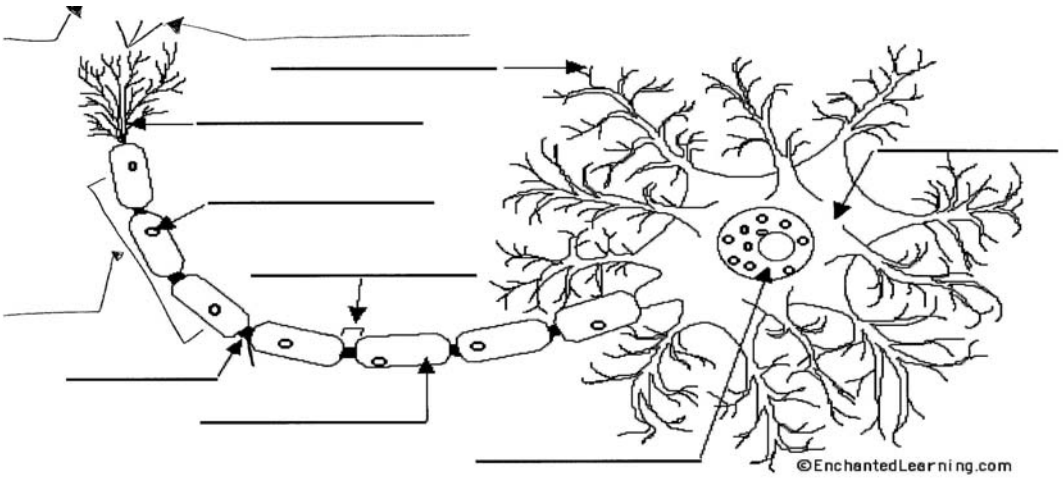
D. Studying Nature v. Nurture
   1. Twin studies
      a. Identical twins are perfect subjects to look at the impact of nature v. nurture because of their identical genetic make up [nature's own human clones]
      b. Fraternal twins are genetically no different than an ordinary brother or sister except they are the same age
      c. A person whose twin has Alzheimer's disease has a 60% chance of getting the disease, where as a fraternal twin has a 30% chance.
      d. Separated twins (identical twins who are raised a part) gives insight into how much can be attributed to nature and nurture [Jim-Jim]
   2. Adoption studies create two groups of relatives – genetic and environmental. This gives insight into amount of environmental influence [seen especially in personality types and temperament]
   3. Temperament studies look at the emotional excitability of infants. Some believe by studying the temperament of infants one can predict later adult personality traits [difficult, irritable, intense, unpredictable – Baby Connor and the dog & teen Connor]
   4. *Heritability*
      a. Using twin and adoption studies, behavior geneticists can mathematically estimate the extent to which variation among individuals can be attributed to their differing genes.
      b. Heritability of intelligence is 50% and height is 90% - that does not mean that your intelligence is 50% genetic – rather it means that we can attribute genetic influences of the observed variation among people

II. Nervous System

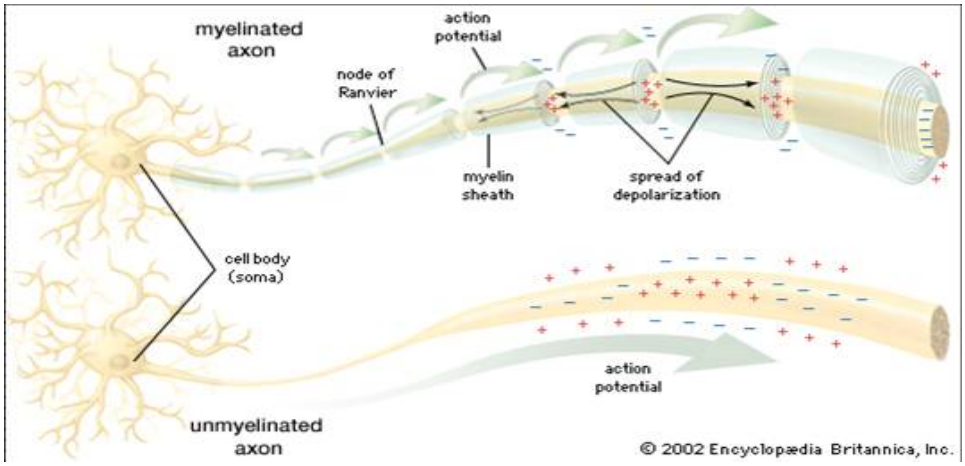
A. The Neuron
   1. The neuron, the basic building block of the nervous system, are body cells that are specialized for transmitting information or messages in the form of electrical impulses. [a neuron carrying orders from a leg muscle to the brain is roughly the size of a rope 4 miles long and can travel at speeds from between 2 and 200 mpr – depending on the type of nerve fiber]
   2. Types of neurons -
      a. *Afferent neurons*: neurons that send messages to the spinal cord and brain
      b. *Efferent neurons*: neurons that send messages from the brain and spinal cord to other structures in the body
   3. Structure of the neuron:

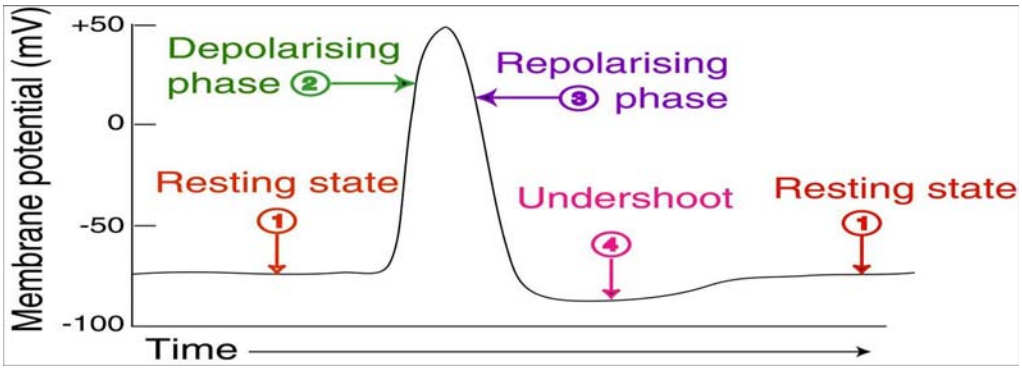


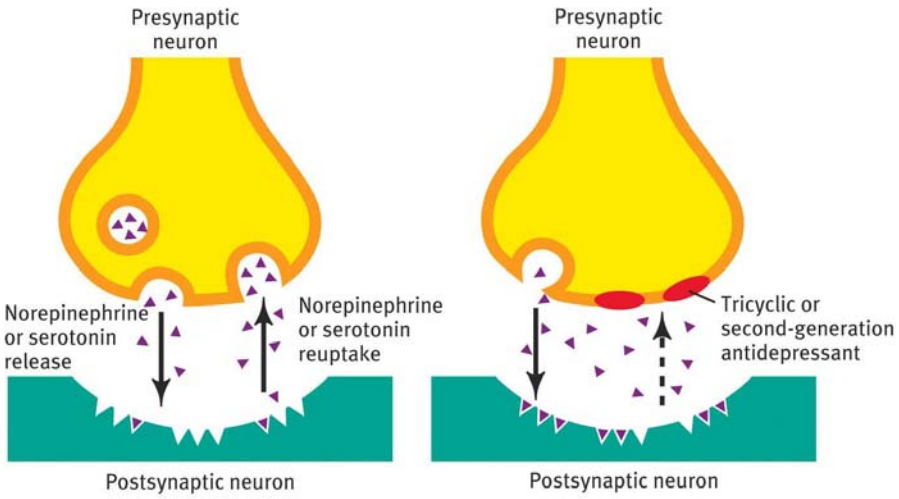
a. *Cell body* – contains the cell nucleus and genetic information, also carries out metabolic function of the cell. It also attaches the dendrites to the axon.
b. *Dendrites* – Root-like structures at then end of the cell body. It receives messages, or neural impulses, from other neurons.
c. *Axon* – The tube-like part of the neuron which carries messages from the cell body to the synapse.
d. *Myelin sheath* – a layer of fatty tissue which insulates the axon and helps speed messages across the axon (nodes of Ranvier – gaps in the myelin sheath which create gates)
e. *Schwann's Terminal* – cells that produce myelin - they are located within the myelin sheath.
f. *Axon terminal branches or buttons* – of the axon where neurotransmitters are stored
g. *Synapse* – The fluid-filled gap between the neurons through which neurotransmitters neural impulses
h. *Synaptic vesicle* - "bubbles" in the axon terminal which hold neurotransmitters until they are released into the synapse



4. <u>Action Potential</u> – process of moving a message across the neuron
   a. neuron is at rest (refractory period)
   b. when neuron is stimulated to its threshold (a level of stimulation below which nothing happens, all-or-nothing), the neuron becomes depolarized
      1. <u>excitatory</u> – push the neuron to threshold or action
      2. <u>inhibitory</u> – putting on the brakes to neural signals
   c. *depolarized* – the gates on the cell membrane on the axon open and positively charged ions (sodium and potassium) enter (spike charge) to convert the chemical (neurotransmitter) into an electric impulse and pushes it down the axon
   d. as the electronic charge travels down the axon, it pushes against the axon terminal sending the synaptic vesicles into the back wall of the axon terminal and out into the synapse
   e. the synaptic vesicle releases a chemical (neurotransmitter) into the synapse
      1. the dendrites on the next neuron take in the neurotransmitter (and the process begins again!) or
      2. reuptake – when the excess neurotransmitters from the synapse are reabsorbed by the sending neuron which bonds to the receptor site on the neuron (dendrite or axon terminal)







B. <u>Neurotransmitters</u>

1. Neural transmission (information being sent from neuron to neuron) works at both the electrical and chemical levels. These chemicals are neurotransmitters, which can be defined as chemicals released by neurons which carry information from one neuron to another. These chemicals are then read or received by a neuron's synapses.

<u>Neurotransmitter</u>	<u>Functions</u>	<u>Examples of Malfunction</u>
Acetylcholine	Enables muscle action, learning, and memory	Undersupply as neurons deteriorate marks Alzheimer's disease.
Dopamine	Influences movement, learning, attention, and emotion	Excess dopamine receptor activity linked to schizophrenia, starved of dopamine, the brain produces the tremors and decreased mobility

		of Parkinson's disease.
Serotonin	Affects mood, hunger, sleep, and arousal	Undersupply linked to sleep and eating disorders as well as depression; Prozac and some other antidepressant drugs raise serotonin levels. Excess levels have been linked to autism.
Norepinephrine	Helps control alertness and arousal	Under supplies can depress mood and have been linked to ADD and ADHD
GABA	Involved in virtually all behaviors and a major inhibitory (of dopamine) neurotransmitter (inhibit firing of neurons)	Undersupply linked to anxiety, seizures, tremors, insomnia, and possibly alcoholism. Excess levels have been linked to aggressive and violent behavior. Huntington's disease has been linked to an undersupply.
Glutamate	A major excitatory neurotransmitter; involved in memory ("coincidence detector")	Oversupply can over-stimulate the brain, producing migraines or seizures (MSG)
Endorphins	A natural, opiate-like neurotransmitter linked to pain control and to pleasure [synthetic – morphine]	Excess levels (externally - due to drug addiction) causes a decreased production and withdrawal systems.

C. Organization of the Nervous System:
   1. *Central Nervous System (CNS)* – the brain and the spinal cord
   2. *Peripheral Nervous System (PNS)* – the sensory and motor neurons that connects or links the central nervous system to the rest of the body
      a. *Autonomic Nervous System* – part of the PNS which controls vital or automatic activities of the body such as heart rate or breathing as well as glands and muscles. The two parts of this system work together daily to keep us in a steady internal state
         - *Sympathetic nervous system* – part of the Autonomic Nervous System that responds in an emergency or stressful situation by activating bodily resources needed for making you alert and ready for action.
         - *Parasympathetic nervous system* - part of the Autonomic Nervous System that controls the normal operations of the body (digestion) and calms the body by conserving energy.
      b. *Somatic Nervous System* – part of the PNS which carries information from sense organs to the brain and from the brain to the skeletal muscles, thereby affects bodily movement; it controls voluntary, conscious, sensory, and motor functions

III. Brain Structure

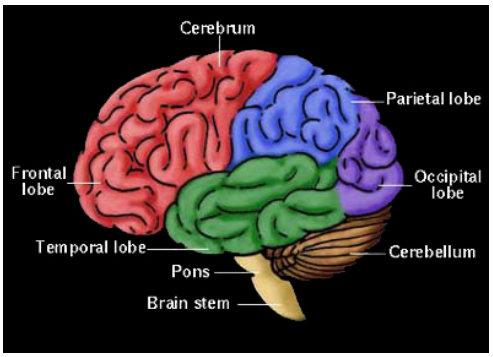
A. Hindbrain – most primitive part of the brain where information is processed outside of our awareness without any conscious effort
   1. *Medulla* – controls automatic functions such as heartbeat, blood pressure, breathing, and some reflexes such as eye blinking
   2. *Reticular Formation (RAS)* – controls basic bodily functions including the state of arousal, waking, and sleeping [Magoun – severed cats RAS from higher brain regions without damaging neural pathways which put the cat into a coma from which it never woke]
   3. *Cerebellum* – regulation of balance, voluntary movement, coordination, judgment of time, nonverbal learning and memory, adjust emotions, discriminate sounds and textures
   4. *Pons* – affects sleep, dreaming, and movement (lack)

B. Midbrain – relay or switching station; sends message onto the correct parts of the brain

C. Forebrain –
   1. *Thalamus* – routing station for all senses (except smell) and directs sensory messages to the cortex

2. *Hypothalamus* – directs several maintenance activities (eating, drinking, body temperature), helps govern the endocrine gland system to release hormones, and is linked to emotion and instinctual functions such as hunger, thirst, anger, sexual behavior, and fright. "Pleasure or reward center of the brain" – ["fs" – fighting, fleeing, feeding and mating"]
   a. *lateral hypothalamus* causes laboratory animals to start eating even if it has consumed a full meal. When this area is surgically destroyed, the animal will stop eating and eventually starve to death.
   b. *ventromedial hypothalamus* acts as an off-switch that signals when it is time to stop eating. When this area is destroyed, animals will overeat and eventually become severely obese.
3. *Limbic System* – located within the temporal lobe, it influences emotions, memory, and social behavior
   a. *amygdala* – control emotional behavior, and aspects of learning and memory, fear, rage, and aggression [place a mouse in a cage with a cat and electrically stimulate one area of the amygdala and the cat prepares to attack, stimulate another area and the cat cowers in terror]
   b. *hippocampus* – controls memory (short term memory), aspects of learning and emotion
4. *Basil ganglia* – regulation of movement, coordination, and posture
5. *Corpus callosum* – bundle of nerve fibers that connect the left and the right hemispheres of the brain
6. *Cerebrum* – controls higher level thinking such as critical thinking and problem solving
   a. Cerebral *cortex* – thin surface of interconnected neural cells [glial cells] that is the ultimate control and information-processing center
   b. Structure of the cortex*:*

Lobes/Cortex	**Location**	**Function**
Frontal Lobe	In front of central fissure; contains motor cortex and Broca's area	▪ Broca's area – speech production ▪ Motor cortex – voluntary movement ▪ Prefrontal cortex – planning, structuring, evaluating, impulse control, decision making, accessing and acting on stored memories (higher mental functions)
Parietal Lobe	Behind frontal lobe	▪ Somatosensory (sensory) cortex – registers and processes body sensations (sense of touch such as pressure, temperature, pain as well as body position)
Temporal Lobe	Below lateral fissure and parietal lobe	▪ Wernicke's area - understanding language ▪ Auditory cortex – process auditory information (sensation of sound) ▪ Olfactory cortex - smell ▪ some visual information processing
Occipital Lobe	Back of the brain, next to and behind parietal and temporal lobes	▪ Visual cortex - visual sense (sensation of vision)
Association Cortex	Areas between parietal, temporal, and occipital lobes	▪ Integrate information and complex behaviors that involve thinking and sensory processing (associate sensory inputs with stored memories)



IV. Studying the Brain

A. *Phineas Gage*
   1. A level-headed, calm foreman of a railway crew (1848) until an explosion hurled a tamping iron through his head.
   2. After the injury severed several connection between his limbic system and frontal cortex, Gage became volatile
   3. His lesions (destruction of tissue) where the limbic system is connected to the frontal lobes related frontal lobes with mediation and control of emotional behavior

B. *Paul Broca*
   1. He performed an autopsy on the brain of a patient named Leborgne (a.k.a. Tan) who had lost capacity for speech with no paralysis of the articulatory tract and no loss of verbal comprehension or intelligence
   2. Tan's brain showed deterioration of part of the frontal lobe of the left cerebral hemisphere as did the brains of several similar cases relating destruction of "Broca's area" to expressive aphasia (1861)
   3. *Carl Wernicke* (1848-1905) similarly found a second brain area involved in processing language in the temporal lobe of the left central hemisphere
   4. *aphasia* – impairment of language, usually caused by left hemisphere damage either to Broca's area (impairment of speaking) or Wernicke's area (impairment of understanding)

C. Gunshot wounds, tumors, stokes (obstructing blood clot which blocks the supply of oxygen and nutrients to the brain), Alzheimer's disease, and Korsakoff's syndrome (memory disorder caused by a lack of vitamin B) enabled further mapping of the brain

D. *Plasticity* – the brain's capacity for modification, as evidenced in brain reorganization [neural networks] following damage (especially in children) and in experiments on the effects of experience on brain development

E. Brain imaging techniques:

Technique	**Description**	**Used for**
EEG (electroencephalograph)	A device that uses electrodes attached to the skull to record brain wave activity	Sleep and dream research, to measure if the brain is functioning
CT or CAT Scan (computed "axial" tomography)	A computer-enhanced x-ray technique that can provide images of internal brain structure	Doctors to look at the size or location of a part of the brain, also to identify brain tumors
PET (positron emission tomography)	A method that can provide computer-generated image of the brain, formed by tracing the amounts of a certain chemical (glucose) used in different parts of the brain during different activities	Researches can identify if a patient is lacking in certain neurotransmitters
MRI (magnetic resonance imaging)	A method of producing computer images of the brain and other body parts by measuring the signals they emit when placed in a strong magnetic field	Similar to the CAT scan in giving a good view of brain structure it does not expose a patient to radiation from x-rays
fMRI (functional magnetic resonance imaging)	A relatively new imaging technique that combines the elements of a PET and MRI to give a picture of not only structure but also function (blood flow).	Used primarily to tie brain structure to activity during tasks such as cognitive tasks

V. Left and Right Hemispheres of the Brain

A. The cerebral hemispheres are divided right down the middle into a right hemisphere and a left hemisphere. The hemispheres communicate with each other the corpus callosum.

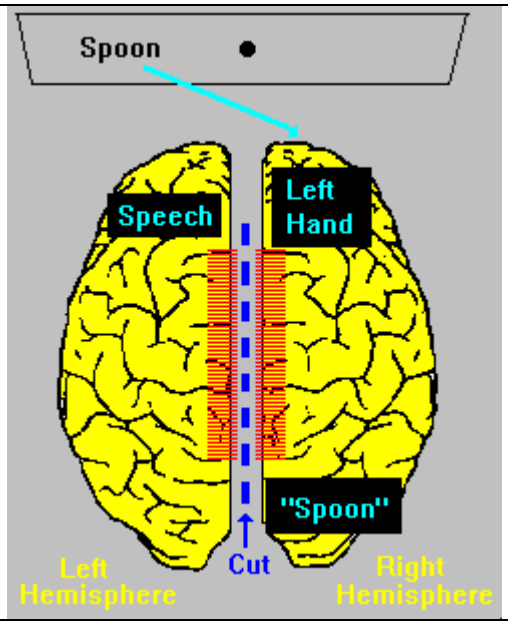
B. Each hemisphere appears to be specialized for some behaviors.
   1. The right side of the brain controls muscles on the left side of the body and the left side of the brain controls muscles on the right side of the body. [Localization of function]
   2. Sensory information from the left side of the body crosses over to the right side of the brain and information from the right side of the body crosses over to the left side of the brain. Therefore, damage to one side of the brain will affect the opposite side of the body

C. Each hemisphere of the brain is dominant for other behaviors. [Hemispheric specialization]
   1. It appears that the right brain is dominant for spatial abilities, face recognition, visual imagery and music.
   2. The left-brain may be more dominant for calculations, math and logical abilities.

Left Hemisphere	Right Hemisphere
Linear	Intuitive
Logical	Imaginative
Analytical	Spatial
Factual	Simulations
Organized	Emotional
Sequential	Musical
Verbal	Holistic
Rational	Creative
Recognizes objects	Recognizes faces
Perceptive of order	Perceptive of patterns
Active	Receptive
Mechanics, methodical	Art, symbols

D. Much of what we know about the right and left hemispheres comes from studies in people who have had the corpus callosum split - this surgical operation isolates most of the right hemisphere from the left hemisphere. This type of surgery is performed in patients suffering from epilepsy. The corpus callosum is cut to prevent the spread of the "epileptic seizure" from one hemisphere to the other.

E. *Roger Sperry* (who won the Nobel prize in 1981) and Michael Gazzaniga are two neuroscientists who studied patients who had surgery to cut the corpus callosum.
   1. These studies are called "Split-Brain Experiments". After surgery, these people appeared quite "normal" - they could walk, read, talk, play sports and do all the everyday things they did before surgery.
   2. Only after careful experiments that isolated information from reaching one hemisphere, could the real effects of the surgery be determined.
   3. Dr. Sperry used a tachistoscope to present visual information to one hemisphere or the other. The tachistoscope requires people to focus on a point in the center of their visual field.
   4. Because each half of the visual field projects to the opposite site of the brain (crossing in the optic chiasm), it is possible to project a picture to either the right hemisphere OR the left hemisphere.



http://faculty.washington.edu/chudler/split.html

VI. Hormones and Glands

A. hormones – chemicals that are produced by glands and regulate the specific organs or cells

Gland	Function	Produces
Pineal	Regulates sleep and waking functions, located in the medulla	Melatonin – regulates sleeping-waking cycles (an increased amount makes individuals sleep); circadian rhythm
Endocrine Glands:		
Pituitary	Controls growth and other endocrine glands, closely liked to the hypothalamus	Somatotrophins - growth hormones Prolactin – growth hormones Antidirretic hormone (ADH) – acts on the kidneys Oxytocin – stimulates urine, contractions
Adrenal	Alters energy levels and affects a person's reactions to stress and fear	Epinephrine (adrenaline) – stimulates the sympathetic nervous system
Thyroid	Controls the rate of metabolism	Thyroxin – influences growth (i.e. fat or thin) and metabolism
Testes	Male reproductive glands	Testosterone – responsible for triggering the development of sperm and many secondary sexual characteristics
Ovaries	Female reproductive glands	Progesterone – associated with changes during the menstrual cycle Estrogen – responsible for the fertilization period of the menstrual cycle, helps produce an environment for fertilization and development of an embryo, and many secondary sexual characteristics
Pancreas	Regulates the body's blood sugar (energy level)	Insulin – moderates the level of blood sugar Glycogen – releases sugar into the body

Notes based on information from the following sources:

- Chudler, Eric. "Neuroscience for Kids." http://faculty.washington.edu/chudler/neurok.html. 2005
- Lefton, Lester. *Psychology* - seventh edition. Allyn and Bacon. Boston. 2000
- Myers, David. Psychology – seventh edition. Worth Publishing. Michigan. 2004
- Nevid, Jeffery. Psychology: Concepts and Applications. Houghton Mifflin Company. Boston. 2003
- Pettijohn, Terry. Psychology: A ConnecText. McGraw-Hill. Ohio. 1998.
- Passer, Michael *and* Smith, Ronald. Psychology: The Science of Mind and Behavior. McGraw-Hill. Boston. 2004