Chapter 2

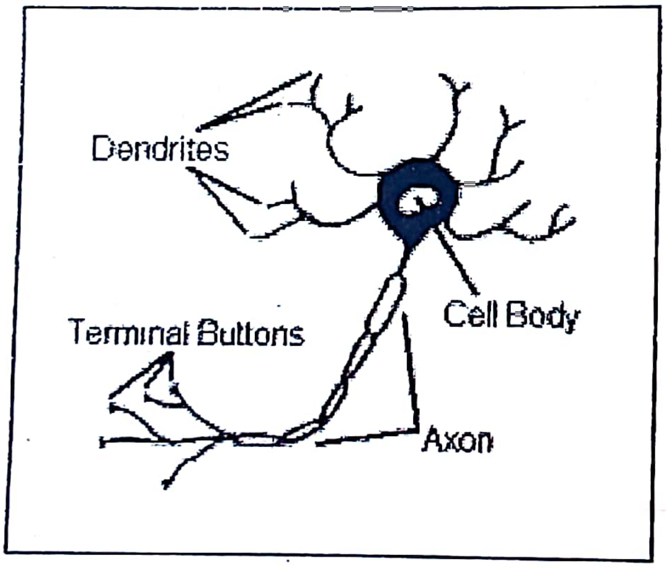
BIOPSYCHOLOGY

The physical structure of the body plays an important role in the behavior of an individual. The most important physical structure for psychologists is the nervous system. The nervous system carries orders from the brain and spinal cord to various glands and muscles, it also carries signals from stimuli receptors to the spinal cord and brain. If you wanted to blink your eye a signal would be created in the brain, then it would be transported by neurons to the muscle controlling the eyelid.

NEURON

A Neuron is a specialized nerve cell that receives, processes, and transmits information to other cells in the body. We have a fixed number of neurons, which means they do not regenerate. About 10,000 neurons die everyday, but since we start out with between ten and 100 billion (Hooper & Teresi, 1987), we only lose about 2% over our lifetime.

Information comes into the neuron through the Dendrites from other neurons. It then continues to the Cell Body – (soma) which is the main part of the neuron, which contains the nucleus and maintains the life sustaining functions of the neuron. The soma processes information and then passes it along the Axon. At the end of the axon are bulb-like structures called Terminal Buttons that pass the information on to glands, muscles, or other neurons.



Anatomy of a Neuron

Information is carried by biochemical substances called neurotransmitters, which we will talk about in more detail shortly. The terminal buttons and the dendrites of other neurons do not touch, but instead pass the information containing neurotransmitters through a Synapse. Once the neurotransmitter leaves the axon, and passes through the synapse, it is caught on the dendrite by what are termed Receptor Sites.

The Transmission of the Signal

The transmission of the signal is basically the same in all cells, the signal is sent across the synapse by the axon and the dendrite of the next cell picks up the signal.

Synapse

The synapse is a gap between two cells. Synapse are one way junctions between neurons and other cells. The neurotransmitter is emitted from the axon of one cell and usually goes to the dendrite of the next cell. Sometimes the signal goes to the soma or the axon of the next cell instead of the dendrite (Arnold Wittig 2001).

Neurotransmitter

The terminal button at the end of the axon holds the synaptic vesicles. When the signal reaches the end of the axon the vesicles discharge a chemical called a neuro transmitter. Neurotransmitters are chemicals that are used to relay, amplify and modulate electrical signals between a neuron and another cell. There are approximately 40 to 50 different chemicals that are used as neurotransmitters. The neurotransmitters from the axon fit into receptors of the dendrite on the next neuron. They will then either *excite* the cell and make it fire or *inhibit* it and stop it from doing so. The sum of the excitation and inhibition of the neuron is called the graded potential. If the graded potential is greater than that cells threshold then the cell fires, sending the message to the next cell

Resting Potential

When the cell hasn't fired for a certain amount of time it is considered at its resting potential. The resting potential of a neuron is approx. 70 mV because the membrane surrounding the cell lets in positive potassium ions (K+) and negative chloride ions (C1-) and keeps out positive sodium ions (Na+). It is easier to fire a cell that is at its resting potential than one that is in the refractory phase.

Action potential

When the graded potential passes the neurons threshold, an action potential takes place. The action potential sends the signal the entire length of the cell and never dies within the cell, which can be referred to as the *all-or-none-principle*. During firing the inside of the cell becomes positive, which is sometimes incorrectly called Depolarization and should be called the raising phase of the action potential. After the action potential hits its peak the cell starts the refractory phase.

Refractory Phase

After the action potential changes the neuron from negative to positive there is a refractory phase where it changes back to negative. At the beginning of this period it is impossible for another signal to be transmitted, this is called *absolute refractory phase*.

After the absolute refractory phase is the relative refractory phase where it is possible to send another signal but more excitation than normal is needed.

- Signal Strength

For the signal to be passed from one neuron to the next it must have enough energy to break a point called the threshold. Once the threshold is broken the signal is transmitted. The neuron fires at the same strength every time. The strength of a signal is decided by how many different neurons are being fired and at what frequency they are being fired.

Glial cells

The amount of glial cells to every neuron in the nervous system is disputed. Glial cells function as support for the neurons; they produce the myelin sheath which surrounds some neurons and also form part of the *blood-brain* barrier. The blood-brain barrier is a structure that prevents certain substances in the bloodstream from reaching the brain. Many axons are sheathed with tubes of *myelin*, which is a fatty material. Myelin is produced by the *glial* cells. The myelin sheaths on axons have gaps, which are called the

Neurotransmitters have been studied quite a bit in relation to psychology and human behavior. What we have found is that several neurotransmitters play a role in the way we behave, learn, the way we feel, and sleep. And, some play a role in mental illnesses. The following are those neurotransmitters which play a significant role in our mental health.

Acetylcholine – involved in *voluntary* movement, learning, memory, and sleep

Too much acetylcholine is associated with depression, and too little in the hippocampus has been associated with dementia.

Dopamine – correlated with movement, attention, and learning

Too much dopamine has been associated with schizophrenia, and too little is associated with some forms of depression as well as the muscular rigidity and tremors found in Parkinson's disease.

Norepinephrine – associated with eating, alertness

Too little norepinephrine has been associated with depression, while an excess has been associated with schizophrenia.

Epinephrine – involved in energy, and glucose metabolism

Too little epinephrine has been associated with depression.

Serotonin – plays a role in mood, sleep, appetite, and impulsive and aggressive behavior

Too little serotonin is associated with depression and some anxiety disorders, especially obsessive-compulsive disorder. Some antidepressant medications increase the availability of serotonin at the receptor sites.

GABA (Gamma-Amino Butyric Acid) – inhibits excitation and anxiety

Too little GABA is associated with anxiety and anxiety disorders. Some antianxiety medication increases GABA at the receptor sites.

Endorphins – involved in pain relief and feelings of pleasure and contentedness

Please note that these associations are merely correlations, and do not necessarily demonstrate any cause and effect relationship. We don't know what other variables may be affecting both the neurotransmitter and the mental illness, and we don't know if the change in the neurotransmitter causes the illness, or the illness causes the change in the neurotransmitter.

The Brain and Nervous System

The nervous system is broken down into two major systems: Central Nervous System and Peripheral Nervous System. We'll discuss the Central Nervous System first.

The Central Nervous System consists of the brain and the spinal cord. The Cerebral Cortex, which is involved in a variety of higher cognitive, emotional, sensory, and motor functions is more developed in humans than any other animal. It is what we see when we picture a human brain, the gray matter with a multitude of folds covering the cerebrum. The brain is divided into two symmetrical hemispheres: left (language, the 'rational' half of the brain, associated with analytical thinking and logical abilities) and right (more involved with musical and artistic abilities). The brain is also divided into four lobes:

Frontal – (motor cortex) motor behavior, expressive language, higher level cognitive processes, and orientation to person, place, time, and situation

Parietal – (somatosensory Cortex) involved in the processing of touch, pressure, temperature, and pain

Occipital – (visual cortex) interpretation of visual information

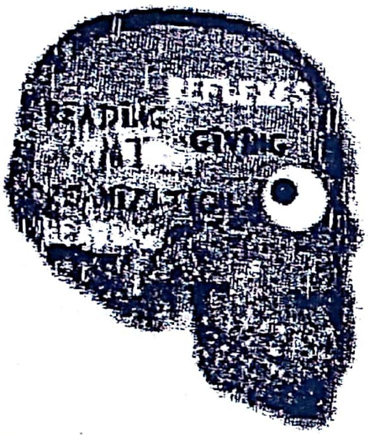
Temporal – (auditory cortex) receptive language (understanding language), as well as memory and emotion

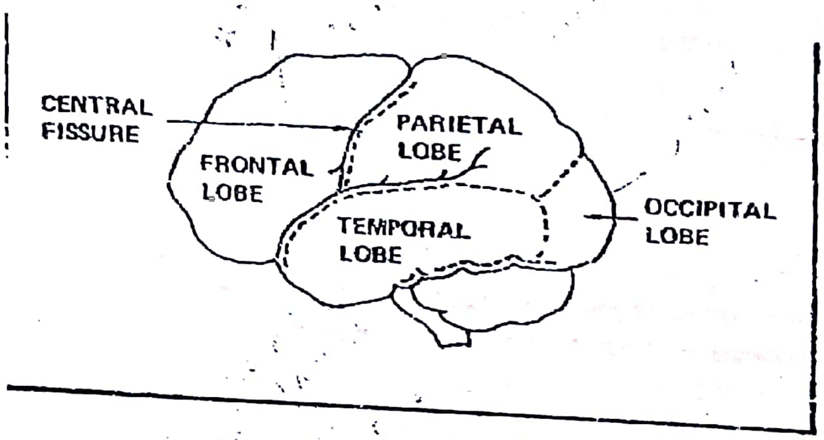
Typically the brain and spinal cord act together, but there are some actions, such as those associated with pain, where the spinal cord acts even before the information enters the brain for processing. The spinal cord consists of the Brainstem which is involved in life sustaining functions. Damage to the brainstem is very often fatal. Other parts of the brainstem include the Medulla Oblongata, which controls heartbeat, breathing, blood pressure, digestion; Reticular Activating System (Reticular Formation), involved in arousal and attention, sleep and wakefulness, and control of reflexes; Pons – regulates states of arousal, including sleep and dreaming.

Cerebellum – balance, smooth movement, and posture

Thalamus – "central switching station" – relays incoming sensory information (except olfactory) to the brain

Hypothalamus – controls the autonomic nervous system, and therefore maintains the body's homeostasis, which we will discuss later (controls body temperature, metabolism, and appetite. Translates extreme emotions into physical responses.





Limbic System – emotional expression, particularly the emotional component of behavior, memory, and motivation

Amygdala – attaches emotional significance to information and mediates both defensive and aggressive behavior

Hippocampus – involved more in memory, and the transfer of information from short-term to long-term memory

The Peripheral Nervous System is divided into two sub-systems. The Somatic Nervous System – primary function is to regulate the actions of the skeletal muscles. Often thought of as mediating voluntary activity. The other sub-system, called the Autonomic Nervous System, regulates primarily involuntary activity such as heart rate, breathing, blood pressure, and digestion. Although these activities are considered involuntary, they can be altered either through specific events or through changing our perceptions about a specific experience. This system is further broken down into two complimentary systems: Sympathetic and Parasympathetic Nervous Systems.

The Sympathetic Nervous System controls what has been called the "Fight or Flight" phenomenon because of its control over the necessary bodily changes needed when we are faced with a situation where we may need to defend ourselves or escape. Imagine walking down a dark street at night by yourself. Suddenly you hear what you suspect are footsteps approaching you rapidly. What happens?

Your Sympathetic Nervous System kicks in to prepare your body: your heart rate quickens to get more blood to the muscles, your breathing becomes faster and deeper to increase your oxygen, blood flow is diverted from the organs so digestion is reduced and the skin gets cold and clammy and rerouted so to speak to the muscles, and your pupils dilate for better vision. In an instant, your body is prepared to either defend or escape.

Now imagine that the footsteps belong to a good friend who catches up to you and offers to walk you home. You feel relief instantly, but your body takes longer to adjust. In order to return everything to normal, the Parasympathetic Nervous System kicks in. This system is slow acting, unlike its counterpart, and may take several minutes or even longer to get your body back to where it was before the scare.

These two subsystems are at work constantly shifting your body to more prepared states and more relaxed states. Every time a potentially threatening experience occurs (e.g., someone slams on their breaks in front of you, you hear a noise in your house at night, you hear a loud bang, a stranger taps you on the shoulder unexpectedly), your body reacts. The constant shifting of control between these two systems keeps your body ready for your current situation.

The glandular systems

The body has two types of glandular systems, the endocrine, which generally secrete hormones through the bloodstream, and the exocrene which secrete fluids to the outer surfaces of the body, such as sweating.

Methods for observing or evaluating brain activity

In the past only two methods of observation were available. The first was observing individuals who have received brain damage and assume that the part of the brain that was damaged controlled the behavior or sense that had changed. The second was connecting electrodes to the outside of someones head and recording the readings.

Newer methods include computed tomography (CT scan), positron emission tomography (PET scan), magnetic resonance imaging (MRI), and superconduction quantum interference devices (SQUID).