Brain Chemistry Essay, Research Paper

Brain Chemistry and Recent Advances

The mysteries surrounding the complexity of the brain and how it works has led scientists in diverse fields to search for answers. Chemicals in the brain and the reactions that take place are being understood now more than ever due to continuing research in genetics, pharmacology, and mental illness. Study and research in genetics has helped identify some of the genes involved in producing, receiving, or sending certain chemical reactions, the way they work, and how they affect certain behaviors. Pharmacological research has led to advances in medications available which can help regulate and change the way brain chemistry works. Research into mental illness has helped us to realize that these illnesses are due in part to biological chemical imbalances. As we understand our brain s chemistry better we also understand more about how we think and reason, why we react different to different situations, and even whether or not our children may be predisposed to certain mental illnesses.

The brain is saturated with the chemicals needed to manage moods, feelings, energy, memory, emotions and other processes. Brain chemicals are found inside brain cells known as neurons. Neurons serve as the basis of all brain activity. They have branches that connect and communicate with other cells. One neuron can receive information from thousands of other neurons. The movement of brain chemicals is the way information is communicated between neurons. Different neurons specialize in releasing different chemicals.

Neurons have projections called dendrites that receive information from other neurons into the cell body. When a neuron has accumulated enough information it sends an electrical pulse down one of its branches called an axon that takes information away from the cell body. Cell bodies contain a presynapse terminal, a synapse gap, and a postsynapse terminal. Information from one neuron flows to another neuron across the synapse gap. The synapse gap is a space between two neurons. The axon leads to a presynapse terminal where the electrical impulse pushes the information across the synapse gap. The postsynapse terminal contains receptors that carry the information to the receiving neuron. The action of the receiving neuron can be to either excite or inhibit other neuron action depending on the information received.

Neurotransmitters are brain chemicals that carry information across the synapse gap to the next neuron. Neurotransmitters can be neurotransmitter substances, amino acids, or peptides. Neuroscientists have set up guidelines to prove that a chemical is a neurotransmitter. The criteria that neurotransmitters must meet are that the chemical must be produced within a neuron, it must be found within a neuron, and when a neuron is stimulated, it must release the chemical. Also, when a chemical is released it must act on a postsynapse receptor and cause an effect, after a chemical is released it must be inactivated or swept away, and if the chemical is applied on the postsynapse it should have the same effect as when it is released by a neuron (Chudler).

There are many types of chemicals in the brain. To date there have been about fifty neurotransmitters identified. Some of them act only as neurotransmitters, some may have other roles as well. The chemical noradrenalin plays an important role in stress situations. It activates the brain to make you alert. A high noradrenalin level can lead to hypersensitivity. A low level relates to poor concentration and the inability to be able to tell what is important and what is not. Noradrenaline can act as a neurotransmitter and also as a hormone when it is released by the adrenal gland.

Dopamine has important roles over learning, memory, cognitive functions, abstract thinking, emotional behavior, and motor function ( The Neurotransmitters ). It is found in relatively few numbers of neurons, tens of thousands, compared with an estimated total of one hundred billion. Every enjoyable human experience, at a purely chemical level, is an explosion of dopamine.

Dopamine levels can be raised by a hug, a kiss, a word of praise, or a win of the lottery. Nicotine, heroin, and alcohol also trigger chemical reactions that elevate levels of dopamine. Dopamine disorders have been linked to addiction in recent years (Nash). Too much dopamine in the limbic system and not enough in the cortex may cause an individual to be paranoid or suspicious. Not enough dopamine in the frontal lobes of the brain may cause memory to be poor. Dopamine disorders in the brain may also cause severe mental illnesses.

Serotonin is a self regulating neurotransmitter. It is spontaneously rhythmic in generating action potentials. This spontaneous activity is quickened or slowed down by other neurotransmitters. Serotonin inhibits sensory action by neurons and excites motor action. Serotonin influences patterns of activity in different behavioral situations. Only during REM sleep, when the brain is very awake yet motor function is slowed, is serotonin activity at rest. Serotonin function has been linked to antisocial personality, violence, aggression, and impulsive behaviors ( The Neurotransmitters ).

Recent advances have been made that help us to understand the physiological role of serotonin receptor sites that inhibit or excite serotonin action. Of all the chemical neurotransmitters, serotonin is most implicated in various disorders, including anxiety, depression, obsessive-compulsive disorder, schizophrenia, pain and migraines. Serotonin is found in many cells in the body. About one to two percent of the body s supply of serotonin is found in neurons in the brain. It cannot cross the blood brain barrier; therefore, the brain must synthesize its own supply. The three main places serotonin is found are the central nervous system (including the brain), the intestinal wall, and the blood vessels (Borne).

Fifteen receptors have been identified specifically for serotonin so far. Serotonin gives emotional tones. While other chemicals may tell us to register the water level in a glass, serotonin helps us to decide if the glass is half full or half empty. Despite these impressive breakthroughs, researchers are only beginning to understand the roles of serotonin in the brain (Lemonick).

Endorphins have been identified as pain mediators at receptor sites. When we are injured signals are sent to the brain. The brain evaluates the pain and releases painkillers called endorphins. Endorphins bind at neuron receptors sites in the brain to inhibit the flow of dopamine. Large quantities of endorphins are released which shut off nerves leading to more dopamine flow. More dopamine straight to the frontal lobe replaces the pain with pleasure (Sundsten).

Glutamate and gamma-amino butyric acid (GABA) are amino acid neurotransmitters. Glutamate is identified as the most important stimulant in the brain. It activates heightened sensitivity to stimuli for other neurotransmitters. GABA is the most important inhibiting neurotransmitter.

It inhibits the activation of other neuron action which results in lowered sensitivity to stimuli ( The Neurotransmitters ).

Researchers in genetics are finding genes that contribute to particular behaviors. They are looking for specific bits of DNA, which may increase or decrease the risk of someone having or being predisposed to mental illnesses. To understand how this is being done, look at how genes affect what traits a person has.

In the nucleus of every living cell there are rod-like structures called chromosomes. There are 23 chromosomes in every body cell in a human being. Genes are located on chromosomes and are passed from parents to their children on chromosomes. Chromosomes are found in pairs. Generally, for any particular trait, the gene contributed by one parent is on one of the paired chromosomes. The other gene for that trait, contributed by the other parent, is on the second chromosome of the pair. Genes control the production of proteins. Proteins determine the traits of a person. The kind and number of proteins in a person determine its traits.

To further understand how genes work consider that DNA is said to carry the genetic code. The DNA molecule is the basic substance of heredity. Chromosomes are made up of long strands of DNA molecules. It is the DNA molecules in chromosomes that make up the genes (Maton 33-43). The DNA from a single cell is made up of about three billion components and would stretch six feet long if set out in a continuous strand. Most of this is nonfunctioning, or junk, DNA, but about 3 percent are working genes. The total number of working genes is believed to be between 60,000 and 100,000. The task of geneticist is to pinpoint the three percent that might contribute to a particular behavior (Colt 42).

Actually, DNA controls the production of the proteins that determine all of the traits that are passed down from parents to their children. The DNA molecule looks like a spiral staircase. Pairs of substances called nitrogen bases form the steps of the staircase. There are four different nitrogen bases in DNA. The order of the nitrogen bases in a DNA molecule determines the particular genes on a chromosome. Because a DNA molecule can have many hundreds of bases arranged in any order, the number of different genes is almost limitless. That is why there is such a

wide variety of human traits (Maton 44-51).

Geneticists now believe that many different genes shape any given trait. All of us carry probably four or five really fouled up genes and another couple of dozen that are not great and place us at some type of risk. There may be ten genes that influence anxiety level. Different people have different combinations of those ten genes. Therefore, one person with just a few of those anxiety genes might feel nervous when put on the spot but another person with six of those genes may completely fall to pieces when put on the spot. In 1997, a gene linked to anxiety was found. This gene was found to be involved in regulating levels of serotonin. Researchers have also located an unusually long version of a gene on chromosome 11 that is common among alcoholics and heroin addicts. This

same gene is common among risk takers who, not surprisingly, are also prone to addictive behaviors (Colt 42-48). The job of this gene is to produce a receptor for the brain chemical dopamine.

In 1996 researchers found that chromosome 17 has a gene that contributes to neuroticism. Neuroticism refers to being anxious, hostile, impulsive, and sometimes depressed. The gene makes a transporter that is suppose to sweep away the brain chemical serotonin from between neurons. The short form of the gene makes less of the transporter therefore sweeping away less serotonin causing more anxiety.

A gene on chromosome 22 has been linked to obsessive-compulsive disorder. Obsessive-compulsive disorder includes having intrusive, upsetting thoughts, and repetitive behaviors. This gene acts as a vacuum cleaner to get rid of brain chemicals after they have carried a signal between neurons. People with OCD keep getting the same message delivered over and over because the chemical triggering the signal isn t being swept away. Again, several genes are thought to cause OCD and more or less of these in a person will determine the degree of illness.

In December of 1997 researchers at John Hopkins University found yet another gene linked to manic-depression. This gene is on chromosome 18 and is the fifth to be found linked to this mental illness (Begley 54-55).

Though genes and their direct link to cause and effect on brain chemistry and personality traits can now be proven, it still cannot be proven that gene influence is destiny. Depending on what other genes you inherit, on your biology, and your environment, the genes you inherit will have more or less effect. For those with genetic disorders, it may someday be possible for DNA scans to check relevant genes and treat precise genetic needs.

Research in pharmacology has led to advances in medications that can affect specific brain chemicals. With the use of medications, brain chemistry can be regulated, adjusted, restrained, and changed. The drugs that will be discussed here are MAO inhibitors, tricyclic antidepressants, selective serotonin reuptake inhibitors, and antipsychotics.

Monoamine oxidase, or MAO, is an enzyme that regulates the amounts of monoamines in neuron activity. In other words, monoamine oxidase s job is to destroy leftover neurotransmitters that are floating around loose after they have done their work. MAO inhibitor drugs inhibit the effects of monoamines which break down serotonin, noradrenaline, and adrenaline. This leads to an increase in the effect of these neurotransmitters. MAO inhibitors can be used in the treatment of illnesses such as depression, anxiety, avoidance behavior, and social phobia. The drugs classified as MAO inhibitors include nardil, eldepryl, iproniazid, and pargyline. Potential toxicity and adverse interactions with dietary substances make this a group of last resort drugs. These drugs have unpleasant side effects including jitteriness, low blood pressure, weight gain, loss of sexual desire, and high blood pressure (Long).

Tricyclic antidepressants block the reuptake of noradrenaline, dopamine, histamine and to varying degrees serotonin. Since they block the reuptake of so many neurotransmitters means they also have many side affects including dry mouth, constipation, and blurred vision. The tricyclic drugs are mood elevators and are used primarily for depression. They also have a narrow range between therapeutic dosage and toxicity. The drugs classified as tricyclic antidepressants include amitriptyline and imipramine. Tricyclic antidepressants cross the placenta, thus, usage during pregnancy should be weighed against the severity of depression (Messer).

Selective serotonin reuptake inhibitors, or SSRIs, inhibit the reuptake of serotonin selectively. Selectively means that there is little effect on levels of other neurotransmitters. Depending on the choice of drug used, it would either inhibit the reuptake of serotonin into the synapse or increase circulating levels by other means. For example, the drug prozac does not interact directly with serotonin receptors and therefore does not interfere with serotonins self-regulating activity. SSRIs are used to treat obsessive-compulsive disorder, panic disorder, bulimia, chronic pain syndrome, anxiety, panic, and depression. The SSRI drugs include paxil, prozac, zoloft, and effexor (Fendley). Side effects are common but usually mild and improve as the body adjusts to the medication. Side effects include headache, nausea, sleepiness, and sometimes sexual disfunction (Lemonick).

Antipsychotic drugs primarily have a selective effect on dopamine cell firing, that is, they affect only those dopamine neurons which go to the limbic and frontal cortex but not the dopamine neurons that effect motor control. Some antipsychotic drugs also effect serotonin, noradrenaline, and histamine receptors. They are used in the treatment of schizophrenia, borderline personality, psychosis, delusions, hallucinations, and paranoid personality. The antipsychotic drugs include lithium, haldol, clozapine, and newer drugs such as risperidone, olanzapine, serditindole and, now in the trial phase of development is ziprazidone. The main side effect of these drugs is that they effect motor control but they also may have cardiac effect and induce seizures. The newer drugs offer fewer side effect than the traditional drugs (Tamminga).

Schizophrenia is a mental illness that affects one percent of the population. It is a degenerative disease. Symptoms usually begin in adolescence or early adulthood. The symptoms are psychotic episodes, hallucinations, delusions, and bizarre behavior characterized by lack of initiative, emotional unresponsiveness, social withdrawal, and strange speech patterns. Neurologists believe that schizophrenia might involve a defect in the connections between the temporal lobe of the cerebral cortex and dopamine producing neurons near the base of the brain. Studies have shown fewer neurons in these regions. They also believe that it may involve a defect in the neurotransmitter gamma-amino-butyric acid (GABA) which acts as an inhibitor. Schizophrenics show unusually low brain levels of GABA. Antipsychotic drugs have helped in the treatment of schizophrenia but they are still far from ideal. Twenty to thirty percent of patients with the disease do not respond to medications. Even some patients who initially respond well to drug treatment have only short term results and ultimately deteriorate in overall function (Benes).

Addiction comes in many forms. People can be addicted to alcohol, marijuana, cocaine, heroin, cigarettes and many other chemicals. There has been overwhelming evidence linking addiction and the brain chemical dopamine. Brain imaging technology has been used to track the rise of dopamine and link it to feelings of euphoria. Drugs can be thought of as sledgehammers in that they profoundly alter many pathways. Dopamine seems to be a common endpoint to all those pathways. Nicotine, heroin, alcohol, and cocaine raise dopamine levels. A genetic trait that produces too little dopamine may be a key factor in who gets addicted. This research is going a long way toward helping in the recognition that addiction is a biological disorder. The more science understands the biology of addiction, the better treatments will become. A number of MAO inhibitor drugs are being used to help people stop smoking. Cocaine withdrawal cravings have been helped by a drug that targets the dopamine receptor known as d1. Methodone, which activates d1, is used in treating heroin addiction. These drugs help tide people over the first few months of withdrawal and help curb cravings. Drugs alone will not solve the addiction problems. The most important message that seems to be coming from recent research is that the biological disorders associated with addiction can be reversed through learning and drug treatments (Nash).

Depression research suggests that it is related to deficiencies in dopamine, norepinephrine, and serotonin neurotransmitters. Symptoms of depression include an overwhelming sense of sadness, helplessness, inferiority, despair, worthlessness, crying, guilt, loss of energy, sleeping too much, loss of concentration, and thoughts of suicide. Depression is one of the more difficult disorders to treat because of the multitude of symptoms and episode frequency. Many treatments are available and usually include trial and error to see what works best. Treatments include antidepressant drugs used to increase concentrations of deficient neurotransmitters, sometimes in combination with antipsychotic drugs, and also electroconvulsive shock therapy (Messer).

There have been many advances in brain chemistry research during recent years. Understanding how the brain works has led to the identification of neurotransmitters and what their functions are. Understanding how genes affect brain chemistry and our behavior has helped us identify particular genes and their function leading us to treatments of specific disorders. Drugs are now available that target specific neurotransmitters and functions in the brain with fewer side effects. Treatment of mental illness is now more successful than at any other time in history due to advances in our understanding brain chemistry and how it works. The future looks promising as research in brain chemistry continues and the advancement of knowledge provides more insight as to what makes us who we are.

Works Cited

Begley,Sharon. Is Everybody Crazy? Newsweek Jan. 1998: 54,55.

Benes,Francine. Altered Neural Circuits in Schizophrenia. The Harvard

Mental Health Letter. Nov. 1996: 6 pp. 5 Feb. 1998.

Borne,Ronald. Serotonin: The Neurotransmitter for the 90 s.

Neurotransmitters. 9 pp. Online. U. of Miss. Internet. 1 Feb. 1998.

Chudler,Eric Neuroscience – Making Connections. Neuroscience.

(Dec.1997): 14 pp. Online. Internet. 1 Feb 1998.

Colt,George. Were you Born that way? Life Magazine Apr. 1998: 42. Fendley,P. Antidepressants. PharmInfoNet. 3 pp. Online. U. of Maryland.

Internet. 7 Feb. 1998.

Lemonick,Michael. The Mood Molecule. Time. (Sep 1997): 15 pp.

Online. Internet. 7 Feb. 1998.

Long,Phillip. Personality Disorders: The Anxious Cluster. The Harvard

Mental Health Letter. (Mar 1996): 7 pp. Online. Internet. 14 Mar.1998. Maton,Anthea. Heredity: The Code of Life. New Jersey: Prentice-Hall,

Inc., 1994.

Messer,William. Antidepressants. Lecture 13. (Feb. 1997): 4 pp. Online.

U. of Tenn. Internet. 7 Feb. 1998.

Nash,Madeline. Addicted. Time. (May 1997): 7 pp. Online. Internet.

14 Mar. 1998.

The Neurotransmitters. Pharmacology. 3 pp. Online. Internet. 7 Feb

1998.