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Our Brain's Fat and Carbohydrate Connection

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Introduction

How often have we heard the saying "you are what you eat?" The truth of the matter is what we eat really does determine to a vast extent who we are, especially from our brain's standpoint. The brain, like the rest of our body, needs a specific diet in order for it to function at an optimal level. We eat food to satisfy hunger and to provide nourishment for our bodies. Hunger is the body's method of saying: provide me nutrients so I can operate properly. The brain also notifies us that it needs certain nutrients by causing us to feel tired, or have unexplained mood changes, or even lapses in our memory. However, most of us never think of this as the brain's method of notifying us of its specific nutritional needs.

Every day, I observe students at my school consuming simple carbohydrates with little nutritional value, and high trans fat foods in the form of hot fries, hot cheetos, french fries, potato chips, candy and Big Texas honey buns, which are then topped off with several sugar laced Fruitopia drinks. This food consumption begins early in the morning and continues throughout the day, up to the time the students get onto their buses to go home. Most students' first stop on the way to lunch is the snack machine, and their last stop before the bus, is once again the snack machine. I also witness the same students having difficulty focusing in class, staying on task, struggling to maintain physical stamina and alertness, and failing to make it through class without some type of disruption. Thus, I am convinced that their poor choices are not providing the best foods for optimal brain functions. These poor dietary choices may be partly to blame for many of the academic, emotional, and physical struggles students encounter in their daily routines.

I feel it is imperative that my students be educated about how their brain works and what chemicals it needs to work properly. My students need to understand the connection between their diet and the chemicals necessary for the brain to operate. Children need to understand that what they put into their mouths has an impact on the output of their brains. "The sad nutritional realities of the modern diet are not supportive of optimal functioning and survival of the brain." [1] Students need to understand that what they eat is the source of chemicals for brain responses and reactions both immediate and long term. When students do not provide the brain with adequate nutrients, it does not function at its best. It has been stated that "a brain that cannot function normally because of a lack of essential nutrients is like trying to run a 220 volt electrical appliance on a 120 volt system." [2] The appliance works; however, it will not operate at its maximum capacity. The same holds true for our brains: feeding the brain excess sugar and trans fats may not halt its functioning; but it will

result in functioning at less than an optimum level.

Overview

If we prepare to drive a Mercedes Benz and are told that it operates on premium gas, we will use premium gas or risk eventually destroying the car's engine and other operating components. When we try and drive our brains on regular gas instead of the premium gas it needs, we are doing the same thing to our body's engine. We are creating wear by not providing it the foods it needs to prevent damage.

Our brains need wholesome foods that incorporate a mixture of key ingredients. Two key players that have emerged as important nutrients are fats and carbohydrates. Fats in the form of fatty acids have been identified as the nutrient responsible for development of the protective covering that surrounds neurons (nerve cells). Fatty acids are considered to be the "backbone" of the brain's structural development because they greatly influence the brains ability to communicate with other systems in the body. [3] The insulating fat layer around the neuron is necessary for rapid transmission of signals from one nerve cell to another nerve cell. [4] When damage occurs to this protective layer of fat, transmission of signals from neuron to neuron can be affected. Carbohydrates are needed to supply the brain energy. The neurons need this energy to transmit various signals throughout the body and to produce enzymes and other proteins that are needed for cell function.

In today's society everyone wants something that is quick and can be eaten fast. However all of this quick, fast food is affecting our children's brains. Today's school districts and teachers are being held responsible for the academic success of their students. Annual yearly progress reports have become the marker for whether a school is considered to be a good school or a mediocre school. The "No Child Left Behind" laws require every district in the nation to make annual progress by ensuring that a certain percentage of students pass state mandated test. Just as we hold school districts responsible for educating our students, we must help to hold our students accountable for making good nutritional choices. Patrick Holford stated "Many of our children are struggling to keep up. They're living with constant tiredness, inattention, erratic behavior, anxiety, stress, depression, and sleeping problems." He goes on to say, "But when he's concentrating poorly, behaving badly or is struggling to read, does poor nourishment cross our minds? [5] The fact of the matter is that all of these behaviors he has described are "governed by a network of interconnecting brain cells, each of which depends profoundly on what children put into their mouths." [6] Without a firm foundation in the form of a brain that is structurally sound and highly functional, students will continue to struggle. Helping students understand the brain-diet connection is another method of helping them reach their maximum academic potential, emotional stability, and physical capabilities. Helping them understand that their control center, the brain, requires premium fuel not regular fuel to develop and operate at its maximum level, may just raise the bar for thousands of our children.

Rationale

Many of the low performing schools in districts across the nation have students who are also from low socioeconomic backgrounds. Ninety percent of the students at my school receive free or reduced breakfast and lunch; they fall into the low socioeconomic group. However, when it comes to eating breakfast and lunch, they would rather buy junk food from the vending machines. Observations of my students have revealed that many of the students select the french fries or nachos for lunch, instead of salads, meats, vegetables and fruits. The majority choose the items that have the least nutritional value or skip lunch altogether. Thus, it leads me to believe that my students may not understand the brain needs certain foods that include specific fats and complex carbohydrates to function properly. I want my students to make correlations between what they eat and how their choices could be impacting their performance in school. I want them to understand that their diet is needed for more than giving them the sensation of satisfaction, but that it has a direct impact on their academic success, their mood and emotions, and their physical well-being. Students need to learn that the body has some nutrients that can only be obtained from the foods they eat, and deficiencies in these nutrients can spell trouble for the brain both structurally and functionally. I also want students to understand that all fats are not unhealthy and that certain carbohydrates are necessary for the brain.

When we talk about the human body, there are many facts we accept and hold to be true without a challenge. We do not disagree with the idea that strong bones and teeth need calcium. We eat meat because it has been stated that our muscles need protein which we know meat can provide. When reports stated we needed to reduce our fat intake to help protect our heart, Americans accepted it, and manufacturers capitalized on it with a non-fat, low-fat multi-million dollar consumer business. However, when was the last time we saw an ad that recommended eating fatty acids and complex carbohydrates to ensure a healthy brain? Reports have begun to emerge because of extensive research performed by scientists who work in the area known as neuroscience (branch of science that studies the structure and function of the brain and the nervous system); however, they have not yet received the attention that campaigns for a healthy heart have gotten. Extensive studies have been conducted that support the idea that deficiencies in the essential fatty acids, and consumption of simple carbohydrate foods instead of complex carbohydrates cause the brain to work at a less than an optimal level and set the stage for a lower IQ and disruptive behavior. [7] Studies have demonstrated that children who have deficiencies in the essential fatty acids (those fats that must come from the diet because the body cannot manufacture them) have difficulty learning, exhibit reading problems, and have a higher rate of school failure. [8] The brain also needs a continuous supply of energy. Complex carbohydrates are the food source that will provide this energy. The complex carbohydrates are critical for the proper functioning of the brain. Many of today's low-fat, low-carbohydrate diets are creating less than optimal conditions for our brains. In order for the brain to develop structurally and function properly, it needs specific fats and complex carbohydrates.

Diets that consist of the foods many of my students eat provide a quick uptake of sugar, which provides a quick but short-term boost of energy. These quick energy fixes do come at a price, for along with quick energy comes increased blood sugar levels that cause the body's insulin levels to increase to accommodate the sudden sugar rush these foods provide. Continuous increases in blood sugar and insulin can lead to problems such as diabetes, heart disease and some types of neurological degenerative diseases, aggression, poor memory, poor attention and depression. [9] Simple sugars do not provide long term energy to the brain, thus the neurons do not get the energy they need to function properly.

My unit will focus on fatty acids and complex carbohydrates that impact the biochemical function of the brain and aid in the structural development of the brain. The unit will show the chemical reactions used to convert carbohydrates to glucose, which is then used as energy for the brain so that nerve cells can do their respective jobs. The unit will also strive to demonstrate how deficiencies and overloads of these two nutrients can impact learning, mood, and physical alertness. Students will have opportunities to learn about the brain through a variety of technical support devices as well as through hands-on inquiry based activities. We will study the structure of the brain and how the brain uses specific chemicals to create interactions within the body, with emphasis placed on those structures that utilize fatty acids and carbohydrates for our day-to-day functions. We will also investigate how and why the body needs fats and complex carbohydrates for its structural development and function. These two key nutrients will be the focus of the chemical aspect of the brain, with the acknowledgement that other nutrients are also needed. However, I selected these key nutrients, because fatty acids and carbohydrates have been linked to memory and learning. I have also selected these two nutrients because the students I teach eat them in large quantities. Thus, I want my students to learn the difference between healthy required fats and unhealthy non-essential fats as they relate to the brain. I want them to discover healthier carbohydrates and steer away from the high sugar carbohydrates to enhance their brain's energy levels for optimal brain function.

A comparative observation study involving a sheep brain and a human brain will be conducted. The emphasis of the comparative study will be to compare the brain development and size of a sheep brain to a human brain. Emphasis will be placed on the different diets each mammal utilizes and how the diet may have impacted the brain. Some connections to the evolution of the human brain will be made as they relate to early man's diet and consumption of fatty acids. The essential idea for students to think about here is how fatty acids could be a factor in the development of the two brains. A diet plan for the sheep will be provided for the students. This will also provide the students an opportunity to see firsthand how the formation of the brain relates to fats, by giving them an opportunity to touch and get up close observations of brains.

The demographics of my school are that 97 percent of the students are African American. Approximately half of these students come from single parent homes where they either reside with their mother or father. Approximately two percent of the student body is Hispanic, and about one percent is White. Seventy percent of the parents at our school have educational backgrounds that are beyond high school, with less than 10 percent of the parents falling into the category of not completing high school.

The primary target group of this unit will be eighth grade students in physical science. However, seventh grade students could also use components from the unit when studying body systems to help them understand the nervous system. Because I teach students on three different levels, differentiated activities will be incorporated to meet the needs of my gifted, high achiever, and general population students.

Background Information

Fatty Acids and Evolution of the Modern Human

Scientific discoveries have confirmed that life originated in the seas where omega-3 fatty acids were abundant. As the modern human brain evolved, it too was influenced by the fatty acids. Evidence supports the fact that species were able to develop larger brains once omega-3 fats from food supplied by the sea and

omega-6 fats from plants and seeds were available as a food source. One very noticeable difference in the species was the size of the brain. The change in the brain size was attributed to the fact that seventy percent of their food's nutrients were for brain development. [10] A major change occurred in the human brain about 200,000 years ago, which resulted in some human brains becoming larger than those of other mammals. Scientists found that populations who lived near oceans and consumed seafood that was rich in DHA (docosahexaenoic acid, a major contributor to brain growth) had larger brains. [11] People who lived in the interior areas and consumed meat from animals common to the area had smaller brains, about the size of a chimpanzee, for approximately 3 million years longer. [12] Stephen Cunnane, a professor of nutrition at the University of Toronto called the study "an important finding" that supports a theory that DHA from seafood boosted the brain power of early humans, and gave them the excess energy and nutrients they needed for brain growth. [13]

Fats Impact on Brain Development and Function

The brain begins a process of protection during prenatal development known as myelination. This process continues until the cerebral cortex is fully formed. Myelination involves fatty acids that are incorporated into the brain's structure. This process involves thin layers of fat wrapping around axons (axons are cellular processes that extends from a neuron and link to other neurons). [14] Myelin formation is critical to the development of children's brains. Damage or unprotected nerve fibers can impact future intelligence of a child. [15] The myelin covering has a double job to protect the brain cells and to help these cells communicate with one another. The myelin covering provides cells with more rapid passage of signals that are transmitted by the brain cells. Communication between nerve cells occur at the synapse (a gap or space between neurons where one nerve cell can communicate with another): this space could be compared to a gap in a spark plug. Chemicals called neurotransmitters (chemicals that allow communication between nerve cells) are released at these gaps, these chemicals travel through the synaptic cleft (the space between neurons) until they meet the surface of their targeted neuron. The targeted neuron contains receptor sites for a specific signal. Evidence has shown that fatty acids have a great influence on the "docking" of neurotransmitters with their receptors, the receptors are held in place by phospholipids and fatty acids. [16] If the myelin covering becomes damaged the sending neuron cannot properly dock at the desired receptor site, thus exposing the brain cells to signals from other brain cells that they are not normally exposed to. When this happens the brain can experience an "electrical short circuit." [17] This loss of an electrical signal can result in disruptions with our motor control, bodily functions and cognitive skills. The process of myelination begins with the motor and sensory brain cells that give children the ability to complete specific tasks such as coordination, speech, control of arms and legs, crawling, walking and eventually higher order thinking. If the brain does not have the needed fat for this process to occur, our cognitive abilities are affected. These fatty membranes covering the axon are made up of 75 percent fat derived from essential fatty acids. [18] Sixty percent of our brain's structure is composed of fatty materials that must be supplied by our diet.

When we use our brains to come up with ideas, biochemical processes are occurring. Every time our bodies respond to some stimulus, a neurotransmitter has been activated by our brain. Neurotransmitters are supplied by the foods we eat. [19] The foods we consume have a direct affect on how well our brain performs. Eating a well balanced diet that contains essential fats and specific carbohydrates can provide mental sharpness, emotional stability, enhance memory, and aid coordination and balance.

Fats help regulate messengers in the brain that impact our immune systems, circulatory system, inflammation, memory and mood. [20] If your diet consists of foods that can be broken down into fatty acids,

then brain cell membranes can form properly. The formation of these cell membranes is what allows nutrients needed by the brain to enter the cell body for the cells proper functioning. Properly formed cell membranes also allow metabolism to occur within the cell. The metabolic process is what allows waste to be removed from the cell ridding it of harmful toxins that could impair the function of the neurons. The membranes that make up the brain cells must be soft and flexible so the chemical messengers can move into the cell. Thus, the essential fatty acids omega-3 and omega-6 are needed to ensure the cell membranes or the myelin stay flexible and soft. Diets that are deficient in omega-3 and omega-6 fatty acids, but high in saturated fats and trans fats can cause problems for nerve cells. If we want to determine whether our diet is deficient in essential fatty acids we need to look at the membrane covering our nerve cells. [21] Brain cells formed under optimal dietary conditions have a composition that is 30% protein and 70% fat. Oleic acid is a fatty acid found in myelin, which is used by oligodendrocytes (a type of glial cell that produces myelin and maintains a healthy nurturing microenvironment for neurons). [22] This fat is found in breast milk and foods that contain mono-unsaturated fats, such as olive oil, peanuts, almonds and avocadoes.

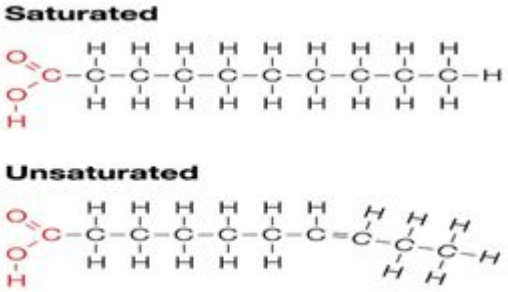
Many western diets do not contain high levels of omega-3 fatty acids, polyunsaturated fats, or mono-unsaturated fats. Instead they tend to be high in omega-6 fatty acids, saturated fats, and trans fats. Polyunsaturated and mono-unsaturated fats are fats that remain in a liquid state when allowed to sit at room temperature, saturated and trans fat tend to become solids. Omega-6 fats are fatty acids that are derived from plants and seeds that include safflower and corn oil. Although omega-6 oils are desired fats, we tend to consume them in overabundance, which places the brain at a disadvantage because the ratios of omega-3 and omega-6 fats are out of balance. For the brain to get the maximum benefit from these two fats, they need to exist in a 1:1 or 2:1 ratio. Most of our diets actually have a 20:1 ratio with the omega 6 fats being twenty times higher than our omega- 3. Combinations of trans fats, saturated fats, and an overabundance of omega-6 fatty acids can produce chemicals that are inflammatory for the brain. [23]

Brain fats help to keep the brain in a fluid state much like engine oil keeps your car's engine running smoothly. If the oil level in the engine drops too low it can be damaged. If the brain's fat level drops too low our mental, emotional, and physical well-being are adversely impacted. When our dietary fats consist primarily of trans fats, saturated fats, and too much omega-6 we began to experience problems with our mood, cognition, and the health of the brain from a long-term standpoint. A proper balance between omega-3 and omega-6 fatty acids has been given credit for our creative and highly technical society. However, if our current dietary trends persist as it relates to fats, we may be setting ourselves up for serious changes in the structure and physiology of our brains. These imbalances have been attributed to the alarming increases of brain disorders and depression among many of our children. Studies are also providing evidence that omega-3 fatty acids are also beginning to impact the brain on a genetic level. [24] The food we eat impacts the brain's "fatty architecture" from our childhood to old age. [25]

What are Fatty Acids?

Fatty acids are compounds made from long chains of hydrocarbons that have a carboxyl group (COOH) on the end of their hydrocarbon chain. The carboxyl group is what makes the fat an acid. Fatty acids are the simplest type of fat. Fats can be classified as saturated or unsaturated. Saturated fats have a carbon chain that has an equal number of hydrogen atoms. They are considered to be saturated with hydrogen. These fats are solids at room temperature because they exist in straight chains that can be packed very close together.

Unsaturated fats have two carbon atoms that are connected by a double bond; they have



two hydrogen atoms missing. Unsaturated fats are liquid at room temperature because they bend and cannot be packed close together; they are referred to as oils. The shape of unsaturated fats is determined by the number of missing hydrogen atoms. As the number of missing hydrogen atoms increase the unsaturated fat bends more creating more fluid oil. If an unsaturated fatty acid contains one double bond it called a monounsaturated fat. Unsaturated fats with multiple bonds are called polyunsaturated fats.

Polyunsaturated fats can be changed by adding hydrogen, in a process called "hydrogenation." In hydrogenation, unsaturated fatty acids are converted into saturated fatty acids, but also (as a side product) unhealthy fats called trans fats are formed. During the hydrogenation reaction, the unsaturated fat is saturated by addition of hydrogen across the double bond. This process is accomplished by heating the oil to high temperatures and adding "pressurized hydrogen gas and a nickel catalyst." [26] Once the process is completed a fat known as a partially hydrogenated vegetable oil is created (PHVO). Hydrogenation changes the shape of a polyunsaturated fat from bent to straight. The chemical structure of trans fats mimic polyunsaturated fats, but the straight shape allows it to be packed close like a saturated fat. The body perceives these fats as a polyunsaturated because of their chemical structure, but has trouble using them. These unnatural fatty acids are found in margarine and vegetable shortening. They are known as trans fats and are not good for our brains. Trans fats can replace flexible insulating fat on myelin in animals, with hard coverings on nerve cells. These hard inflexible coverings were found to prevent proper communication between neurons. Scientists have been able to establish that increased uptake of trans fats in humans result in cognitive decline. [27] Trans fats also deplete omega-3 essential fatty acids, which are important for brain development and function.

There are three main omega -3 fatty acids of importance for optimal development of our brains. First is alpha-linolenic acid (ALA). This fatty acid is the parent for the formation of omega-3 fatty acids and cannot be made by our body (therefore, it is an essential fatty acid). DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid) are known as the fish oils and derive their names from Greek because of the number of carbons they have in their chemical structure. The brain can make its most abundant fat DHA from ALA; however the production of this fat is not sufficient so most of it must come from the food we eat. Studies have confirmed that low levels of DHA result in a decline of the brain's structural and functional integrity. Increased levels of DHA have been associated with significant increases in mental intelligence among children. Breast milk that contained high levels of DHA was shown to increase IQ 3.2 points and enhance cognitive development in infants. Overall intelligence tests of breast fed babies from this group revealed that language abilities, problem-solving, and memory were higher. Infants who were deficient in DHA had lower overall intelligence test. Decreases in DHA have been associated with increased depression in individuals. [28] Countries eating large amounts of fish have lower rates of depression. DHA is also important to synapses, which have high concentrations of this fat in their membranes. Deceases in DHA in synaptic membranes can cause poor neuron function and death of neurons. [29] Foods rich in ALA are walnuts, sea vegetables and green leafy

vegetables. The main fatty acid for omega-6 fatty acids is linoleic acid (LA). Food sources that provide these fats are seeds, corn oil, sesame oil, safflower oil, and sunflower oil.

Carbohydrates and the Brain

Inflammation of the brain causes a reaction known as oxidation. Oxidation creates substances called free radicals. Free radicals take electrons from other molecules, which can cause damage to the brain. If the level of antioxidants is less than the free radicals brain cells can be damaged. The fat and protein components of brain cells can be damaged if our diet does not provide fuel for the brain from whole grains, fruits, and vegetables. These foods contain large quantities of complex carbohydrates. When the diet is full of simple carbohydrates, adequate fuel for our brains defense system is not provided. Damage from free radicals can result in damage to our DNA, which alters our genetic expression at some level. Thus, ensuring that we have dietary substances that promote antioxidant defense ensures optimal function of our brain and prevents damage to our genetic material.

Where Do Carbohydrates Come From-Photosynthesis

Plants undergo photosynthesis which allows them to take in carbon dioxide and give off oxygen. When this exchange occurs in plants carbohydrates are produced. The sun's energy changes the products and by-products of photosynthesis into useful chemical energy for humans. Plants transform carbon dioxide (CO_2) from the air, water (H_2O) from the ground, and energy from the sun into oxygen (O_2) and carbohydrates, ($C_6H_{12}O_6$) ($6CO_2$) + $6H_2O$ +energy = $C_6H_{12}O_6$+ $6O_2$). [30] Carbohydrates have a tendency to form a ratio of 1:2:1 of carbon, hydrogen, and oxygen.

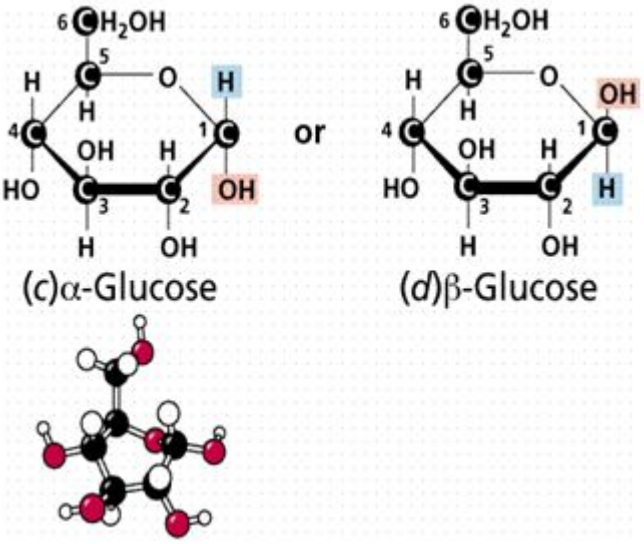
Metabolism of Carbohydrates

The main function of carbohydrates is to supply energy for the body, with emphasis for energy placed on the brain and nervous system. In order for our brain to utilize carbohydrates they must be broken down into glucose. The carbohydrates we consume must be "metabolized" to produce energy. Metabolized carbohydrates produce oxygen, carbon dioxide, and water, and energy. The body uses the energy and water but gets rid of the carbon dioxide. For metabolism to occur carbohydrates must be digested, absorbed, and undergo glycolysis (process that metabolizes carbohydrates to produce the high energy molecule adenosine tri-phosphate - ATP). Amylase helps breakdown carbohydrates for digestion.

Categories of Carbohydrates-Simple and Complex

Carbohydrates are classified as complex or simple. The chemical structure of the carbohydrate and the rate at which digestion and absorption occur determines the classification. Both simple and complex carbohydrates are made from atoms of carbon, hydrogen, and oxygen. Simple carbohydrates have either a single or double sugar unit. Single sugar units are called monosaccharides and double sugar units disaccharides. Glucose is the most common monosaccharide, and the main type of carbohydrate used and stored as energy by the body. Fructose, another common simple carbohydrate, is found in fruit, honey, and high-fructose corn syrup (which is manufactured). Galactose, another common monosaccharide, is not found naturally. Galactose tends to combine with glucose and form lactose known as "milk sugar". Because glucose is the main source of energy for the body some simple carbohydrates are needed in the diet. Fruits and dairy products are good sources. Refined carbohydrates such as white sugar, powdered sugar, candy, and brown sugar have little nutrient value and are digested and absorbed very rapidly compared to natural dietary simple carbohydrates. Refined

sugars form alpha bonds (a bond where the OH group is located on carbon #1below the carbon atom) which can be broken easily by the human body and accounts for the rapid production of energy. Lactose or dairy products form beta bonds (a bond where the OH group is located on carbon #1above the carbon atom) and are not digested as easy by the body, thus they take longer to be digested and release their energy slower than refined sugars.



Fruits also have a slower release because they contain fiber which cannot be digested by the body.

Complex carbohydrates are also known as polysaccharides. They are long chains of simple sugar units. (Long chain molecules made from repeated units, such as polysaccharides, are called polymers.) The three complex carbohydrates that are important nutritional sources are fiber, starch, and glycogen. Starch and glycogen contain alpha bonds and can be digested to release energy. Starch is the main digestible form of complex carbohydrates. When enzymes, such as amylase, act on starches, they break their alpha bonds and released smaller carbohydrates such as glucose. In the body, when glucose is released from carbohydrates, some of this glucose is used immediately to produce energy. Any unused glucose is stored, by chemical conversion into another polymer called glycogen, or converted into fat. Glycogen also has alpha bonds, but it contains many branches, which allow it to be digested quickly when digestive enzymes act on it. Fiber is the third type of complex carbohydrate. Dietary fiber is not easily broken down as it enters the large intestines, because digestive enzymes cannot break its bonds. Some fibers are indigestible and others are digestible. Indigestible fiber will not dissolve in water. The fibers considered to be indigestible are cellulose, hemicelluloses, and lignins. Cellulose has a straight chain of glucose molecules held together by beta bonds. Food sources include whole-wheat bread, bran, and vegetables. Hemicellulose is composed of galactose, xylose, and glucose, and other monosaccharides and form polymers. They are found in whole grains and bran. Lignins are non-soluble fibers that contain alcohols, acids, and a woody type fiber. They are common in fruits, seeds, vegetables, and wheat bran.

Soluble fibers will dissolve in water and swell up. Although they cannot be digested they can be metabolized and fermented by bacteria found in the large intestines. Pectins, mucilages, and gums are soluble fibers. Pectin is used in jams and jellies because it forms a gel when water is absorbed. Pectin contains galacturonic acid and other monosaccharides. Citrus fruits, apples, strawberries, and carrots are common food sources. Mucilages and gums are similar in structure; both contain galactose and other monosaccharides. However, mucilages also contain manose and gums contain glucuronic acid. Gums are found in legumes, oats, and

barley.

Consumption of fiber causes a slow release of glucose during digestion and absorption. Glucose is used by the brain and body to provide energy to cells. On the other hand, simple carbohydrates that have been refined are broken down quickly by the body, which can result in spikes in blood sugar. Rapid elevations in blood sugar can lead to overproduction of insulin. When too much sugar forms it can lead to obesity and health problems because of the continuous rises and dips in glucose and insulin concentrations. The brain needs a slow steady release of energy in order for it to function at an optimal level. Aggressive behavior and poor attention have been credited to children who had diets that were high in sugar. The correlation between serotonin and carbohydrate-insulin responses has been suggested as a possible reason for the aggressive behavior. If the serotonin levels were low the individual tended to have a propensity for aggression. [31]

Glucose must be supplied for the brain to function; however, the type of carbohydrate consumed to provide the glucose is important. Nerve cells do not have the ability to store glucose like the muscles of our body, so glucose must be constantly supplied. When the brain receives too much sugar, it causes a decrease in the glucose available for energy instead of a surge; because the sugar is absorbed at a faster rate resulting in lower glucose levels. Simple sugars result in depletion of the energy supply because they are used up quickly. Ideally, glucose for the brain should come from high fiber, slow releasing foods. Simple carbohydrates are like getting a onetime shot to stop pain. Complex carbohydrates, on the other hand, are like a slow release drug being released through an intravenous drip. Glucose is an important factor in learning and memory. Studies have indicated that when we have periods that involve mental concentration, we drain the hippocampus (which is a seahorse-shaped structure in the brain involved in learning and the formation of long term memories) [32] of glucose. Thus to maintain functioning of memory and learning, glucose must be supplied in this region of the brain. [33] The presence of glucose at normal levels is believed to improve one's memory and ability to learn. Glucose spikes are said to cause something similar to an "energy crisis"; these crises can cause an individual to become nervous and confused or feel weak and tired. Excess amounts of sugar can lead to glycation (reactions that causes glucose to react with proteins in the brain and nervous system, causing a slowdown in communication). Continuous drops can lead to a condition called hypoglycemia. When the brain is deprived of its main energy source, individuals process visual and auditory information at a much slower pace. The ability to concentrate is also affected when the brain's energy level are low or depleted.

The brain's cells consume about fifty percent more energy than any other cell in the body. They have such a high demand for energy because they are constantly undergoing biochemical processes. When we are asleep, our brain cells are still hard at work trying to maintain and fix structures that may be wearing out or may need restructuring. The brain cells are also responsible for making enzymes and neurotransmitters and getting these chemicals to their respective sites. The neurotransmitters alone can travel a few inches to several feet: energy is needed to keep this transport system working. The greatest user of energy by the brain cells comes from the processing of electrical signals that cause communication to occur in our nervous system. Half of the energy the cells receive goes to creating these "bioelectric "signals.

Breakfast and the Brain

Breakfast has been described as the most important meal for the brain. For maximum benefits, the meal should consist of high fiber low sugar meals with omega three foods such as eggs. Starting the day with foods that come from complex carbohydrates and essential fatty acids is believed to improve both cognitive and academic performance of students. Many studies have noted that attendance, as well as behavior, of students improves when a good wholesome breakfast is eaten. [34] Students who skip breakfast have difficulty with

problem solving, short-term memory, and staying focused. Students who eat a breakfast high in fiber demonstrated improvements in the same skills. Eating a high fiber, low sugar breakfast affords the brain a long-term release of energy needed for the brain to function. Feeding the brain a good breakfast will make a positive difference in a student's day.

Fats and Our Mental, Emotional, and Physical IQ

Most people think about IQ from the standpoint of one's mental ability. However, there is also emotional IQ and physical IQ. Mental IQ might be defined as how well someone can reason and learn facts or new information. Emotional IQ is how appropriately we respond to the world around us and the types of relationships we develop with others. Physical IQ refers to our ability to coordinate and balance our bodies and use our senses in response to stimuli in our world. Diet is not normally associated with our mental, emotional and physical IQs. The brain influences mental abilities, and sets the stage for memory, attention, and learning all of which reference mental IQ. Research has identified that diets deficient in essential fats and high simple sugars can cause changes in mood and behavior which pertains to emotional IQ. Diets that restrict coordination and movement, or impact the senses are affecting physical IQ. A review of the nutrients the brain needs to function, indicate the impact they have on ones total well being. The three intelligences are what make people individuals.

Deficiencies in the fatty acids particularly DHA during gestation and after birth can cause children to have difficulty learning. Dietary deficiencies in polyunsaturated fatty acids are cited as a key reason for "mental impairments." Children with decreased levels of omega-3 fatty acids were found to experience more problems with their academic studies. These deficiencies in the fatty acids were also found to impact adult's cognitive skills and ability to learn also. Many studies that have demonstrated that fats and carbohydrates impact our lives on every level of intelligence. Therefore, for a healthy mind and body foods rich in the essential fatty acids and complex carbohydrates must be incorporated into our diets. Foods such as, cold water fish, variety of seafood, lean meats, a variety of fresh vegetables and fruits, whole grains, nuts and seeds. Elimination of trans fats and reduction of saturated fats and high sugar, low nutrient foods ensure that you are feeding your brain a good diet.

Objectives

The unit will focus upon four key objectives. The first objective is for students to learn about the brain and the chemicals and nutrients it needs for optimal development and function. The students' knowledge of the brain will extend beyond what they may have learned in seventh grade life science about the nervous system, and focus on the molecular and chemical components responsible for our brain's structure and functions. Students will explore the relationship between two key nutrients, complex carbohydrates and fatty acids, selected as the focus of the unit because of their importance in brain development and function. Second, the unit will help students incorporate a better understanding of how and why atoms, elements, molecules and compounds are important in their daily lives by connecting their knowledge of these substances to functions and use of chemicals by the brain. Third, the unit will also engage students by helping them recognize how their diets have a direct connection to the function and development of their brains. The students will be able to demonstrate what they have learned about their diets and the connection it has to the function of their brain as it relates to their mental, emotional, and physical IQ's through inquiry based activities. Students will learn

that the brain is not just a structure that determines their academic ability, but that it also controls their emotions and ability to operate from a physical standpoint. A final objective will be for students to make direct observations of an animal's brain and compare how development and function of the animal brain differs from their brain, and how diet might account for these differences.

Strategies

The framework for instructional delivery in my district is a standards base classroom, modeled after a three-part lesson. The lessons must be delivered using an opening, work period, and closing. The opening is designed to review information, introduce new information by way of a sponge activity or prepare the students for the work period. The work period is designated as the instructional time for students where students must be actively engaged in the lesson. The final component is the closing. The closing is where reviews and assessments are conducted to assess student learning of a stated objective for the lesson. Our classes are also taught using an odd/ even block schedule. Therefore, because of the framework and timeline for classes, several strategies would be utilized during a single lesson delivery.

Scaffolding

Graphic organizers such as KWL's (identifies what the student know, would like to learn, and learn) will be utilized to help link to students' prior knowledge about the nervous system. This will allow me to assess what the students already know and what needs to be taught prior to introducing the unit's main focus. Scaffolding also gives me a chance to determine what students may be interested in learning about the unit topic so that ideas that fit within the unit's frame work can also be addressed. The use of an organizer can also function as an embedded assessment to determine what the students actually learned and may still be unsure about before moving to the next lesson in the unit.

Mind Mapping-Brainstorming

Vocabulary maps will be used to help students understand the terminology and vocabulary needed for the unit. Vocabulary maps provide students with a key term that is define based on a textbook or glossary definition. The student must then use symbols, pictures or words for the definitions to make sense to them so that the terminology learned can be applied. Brainstorming that utilizes concept maps will also be used to help students organize information they need to know. Concept maps will be used for the closing activity to help students assimilate and organize what they have learned, and formulate ways to deliver their knowledge to students in the building. The information will help students with our Brain-Diet Connection Educational Pep Rally. Thus, allowing students to take ownership in designing a program for the entire school.

Connect-Two

Connect -Two requires the student to make connections between two terms, concepts, or ideas and state how the two items are connected to each other. An example might be an axon is connected to a neuron because it is the wire like fiber that allows signals to be transmitted to other neurons. This type of organizer is good for helping students understand the relationship between ideas and concepts. It also helps the teacher see if the student really understands the concepts, terminology and has learned what was intended by the lesson. Thus it is a can be utilized as an embedded or informal assessment.

Journals

Journals will be an important component for the unit. Students will be required to maintain food journals from the beginning of the unit until the end. The journal will be used for students to reflect upon the types of foods they eat at the beginning of the unit. It will also allow students to reflect upon how they feel, respond to academic challenges, and function from a physical standpoint based on their diet. As the unit progresses and students are challenged to enhance their dietary selections they will use their journals to document the changes and choices they make regarding their individual diets. The journal will again allow them to reflect upon how these changes are affecting them from a mental, emotional, and physical standpoint. A set format for entries will be provided to the students to ensure that all students make certain self-observations. Items that will be included will be the date and time of day the student eats breakfast, lunch, and dinner; the type of food they eat from each of the food groups, how the food was prepared; and what influenced their decision to eat the foods they selected. The format will also require them to note if they skipped a meal. Thus, when students reflect upon their diet they will be able to share responses to similar experiences during discussions of their entries.

Cooperative Groups

Cooperative groups will involve grouping students together who are on different academic levels. Science, reading, and math scores from the districts standardized test will be assessed to determine the dynamics of each group. Once groups are formed if a student does not fit the profile suggested by the test information the student's role in the group will be adjusted. Cooperative groups will be a method for students to discuss and share information to come up with collective ideas about a topic. This will allow students who might not otherwise participate in a discussion a chance to get involved and take ownership for helping to develop a product or overall opinion about the topic. This also forces a student who would prefer to work alone to become a part of a group and work towards a common goal. It also helps the student who likes to take over to share ideas and allow others to have input. The teacher functions as a facilitator during group time to ensure that all participants are actively engaged. Group members will have specific tasks to complete to keep one person from taking over the group. Students may select their task within the group but each part must come together for the group to submit an end product or collective idea.

Technology Integration

Interactive video clips that relate to the brain will be shown using a promethium board. The system will allow students to interact with the video as they learn about the structure and components of the brain. Power Point presentations will also be presented using the promethium board to review key points and allow students to complete portions of the presentation as an imbedded assessment. Students will also use technology to complete various interactive memory reviews to connect memory to dietary changes as the unit progresses. The use of technology affords all students an opportunity to become an active learner in the classroom.

Differentiated Instruction

Lessons will be differentiated to accommodate the various learning styles and academic levels of my students. Many of the activities provided to the students in their group setting will be leveled to ensure that every student in the group experiences some type of success. Extension activities will also be available for the gifted and advanced students to help them extend beyond where the lesson may stop in class. Remediation activities will also be developed for students who demonstrate difficulty with the lesson to ensure that they have an understanding of the concepts taught.

Inquiry Based Exploration

Students will conduct hands on studies to determine and learn about fats and sugars and their relationship to the brain. These activities are designed so that students have an opportunity to apply the scientific method to learn information. The explorations provide the students with opportunities to write about what they learn by organizing their discoveries into lab reports. The lab reports require the students to utilize the scientific method to write about what they learned and explain its impact on their lives. These reports also incorporate the use of analysis and math skills because the students must analyze the collective data in the form of graphs, tables and or charts.

Participating in inquiry based explorations provide students with visual, tactile, and kinesthetic experiences as well as makes them communicate both verbally and in a written form.

Questioning

Questioning will allow students an opportunity to ask questions about information they are unsure about. It will also give me a chance to question them to see where any uncertainties still exist about the topic. This also allows for discussion of the answers so that both the students and the teacher learn and perceive ideas from different perspectives.

Comparative Studies

Comparative studies give students an opportunity to observe objects and make direct comparisons about the similarities and differences that may exist between the objects observed. These studies help to enhance observation skills and cause the students to apply critical thinking skills to make connection between their observations and the topic. Students have an opportunity to express their opinion about their observations and link their opinions to the topic without having to really worry about if their response is correct or not. These studies are designed to get the kids to make connections between things based on what they think and what they observe.

Class Activities

Prior to the start of the activities a graphic organizer will be utilized to assess student's prior knowledge of the brain. Students will also construct vocabulary word maps to use during the activity to help them with the terminology needed for the unit. Key terms will be provided to the students to begin the maps. Students will also be informed that the unit will focus on how fats and carbohydrates impact the brain from a structural, functional, and chemical level.

Activity One: How the Brain Works

Students will begin the unit by learning about how the brain works, what it looks like, and the function of its specific parts. Vocabulary maps will be utilized during each presentation to help students understand terminology that relates to the unit. Students must note three key points they learn about each term and then create visuals on their vocabulary maps that help them remember the term. Once the initial opening activities are completed, students will view a short video entitled "Brainworks" using the class promethean board (interactive white board). The video can be assessed by visiting the Neuroscience for Kids website: http://www.uwtv.org/program/displayevent.aspx?rID=4909. The video will introduce the students the brain from a structural, functional, and anatomical aspect. Students will be required to take notes on their KWL and

vocabulary maps during the video. Following the video a short discussion about what was learned will take place. Students will also have a chance to share what they wanted to learn about the brain from their opening KWL and note if their question was answered. Students will also complete the "what I learned" portion of their KWL to identify what they learned from the video. Vocabulary maps will be assigned to be completed for homework so students can reflect upon the terms and create visuals too help them understand the terms.

The second part of this lesson will involve a teacher generated power point presentation that will provide more insight into the components of the brain and their specific functions. The power point will also make connections to how fats and carbohydrates can enhance or harm the development and function of the brain's components. Information used in the power point can be found on the website "How Stuff Works": http://health.howstuffworks.com/brain.htm.

The closing activity will involve students completing two tasks. The first task will involve students working in cooperative groups to create connect two cards for assigned vocabulary terms. The activity will be timed so that each group has the same amount of time to complete the task. Connect two cards will be shared with the class to confirm that appropriate connections were made. This activity will also serve as an embedded assessment to see if students understood the connections and to determine if additional reviews are needed.

The final closing task will be a brain quiz via the promethium board. Cooperative groups will work to find the answers to question in a set amount of time. Each Group will note their responses and will be given an opportunity to reveal them during the quiz reveal. The team with the highest points will get to create a stump the teacher question about the brain to see if they are smarter than the teacher. The quiz can be obtained from the "How Stuff Works" website noted above. Activity Two: Comparative Study

Students will be introduced to comparative studies of the human brain and animal brains using the Neuroscience for Kids game "Brains, Brains, Brains." The class session will be divided into two sessions with the first session taking place in the computer lab so each student can access and play the game. The game can be found at the following website: http://faculty.washington.edu/chudler/compare2.html. The game will require students to answer independent questions at its conclusion. Students will complete their responses in their journals. As an extension to the game questions, students will be asked to note what type diet each animal observed was fed. A question and answer session will conclude the computer activity and introduce to the idea of diets impact on brain development. The following questions will be presented for students to respond to in their journals: Which animal's diet is closest to that of humans? How does this animal's brain compare to a human? Which animal's brain shows the least development? What do you think the animal with the least developed brain eats? Once the journal activities are completed students will transition back to the classroom for part two if the study.

Part II of the activity will involve students making actual observations of a human brain or brain model (If you have a local medical school they will sometimes come out and share an actual human brain with the class) and a sheep's brain. Students will be required to compare and contrast the two brains noting similarities and differences between the brains. Diagrams of each brain will also be provided to help students identify various parts the brains. Students will be challenged to note activities the sheep's brain controls as compared to the human brain controls. They will also be challenged to think about how the different diets of these two mammals may have impacted the brain's development. As a concluding activity students will be required to write a formal lab report that follows the framework of the scientific method. The lab report must include a stated problem, an independent and dependent variable, a hypothesis, observations, analysis of data, and conclusions. Students will be encouraged to make detailed drawings of the two brains as a component of the

observations. The written report will be completed as a homework assignment to be turned in the next time class meets.

Activity Three: Educating Our School about the Brain-Diet Connection

Students will be asked to take a closer look at their individual diets to determine if they are eating "brain smart" fats and carbohydrates. Prior to the start of the activity, parent letters will be sent home describing the goals of the activity, and responsibilities of the students in regards to their diet. The letter will ask for parental support in helping the students make smart choices when selecting their food. Smart Choice food cards will be created by the students for them to share with their families and use in selecting food. Students and parents will be asked to sign an agreement in support of the food choice activity. Students will be asked to keep detailed journals that log what they eat, when they eat, and how they feel after eating certain foods. Students will have the right to eat foods not on the choice cards provided they document the foods and their response to the foods in their journals. Students will be given a specific format to note responses in their journal to ensure each student is maintaining the same information. During the food observations and choice program information will be shared with the students about the chemical influence of fats and carbohydrates on the body. Students will be challenged to make connections between how the chemical processes of fats and carbohydrates affect them. At the conclusion of our food program we will create class charts and graphs to analyze our data. We will note how foods affected the students mentally, emotionally, and physically. Discussions will review chemical processes the foods undergo and why they may have reacted to the foods a certain way. Once the class has analyzed all data, cooperative groups will work together to create written materials that convey what the students learned. Writing activities from the Neuroscience for Kids will be utilized to allow various forms of creative expression. The students will be asked to organize and conduct an educational prep rally on the Brain-Diet Connection for the school. Students will be allowed to create items such as posters, flyers and bumper stickers to distribute during the pep rally. The pep rally will be the culminating event for the unit. The following web site may be helpful for the writing activity: http://faculty.washington.edu/chudler/writing.html.

Notes

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Holford, Patrick, and Deborah Colson. Optimum Nutrition for Your Child's Mind: Maximize Your Child's Potential. Berkeley: Ten Speed Press, 2008.

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Appendix A:Implementing District Standards

Georgia Science - S8P1- Students will examine the scientific view of the nature of matter.

This unit will allow students to examine how compounds can impact their daily lives.

Georgia Science - S8CS9 - Scientific Inquiry

Students use inquiry based activities to discover the importance of compounds.