The Student as Lab Specimen

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INTRODUCTION

I teach young people who are around sixteen years old. When I was that age I casually flirted with the notion of eating right and living a healthy lifestyle. I remember a period of raiding the refrigerator looking for raw eggs to whip into milk and some health powders, but that was the pre-smoothie era, so I lost interest for lack of encouragement from my environment. On and off I experimented with vegetarianism. It has occurred to me that maybe my students are similarly attracted to paying attention to their earth suits in a nurturing way, but until now I have done nothing definitive about it.

When I reached mid-life, my heart began to race out of control. It did this twice, and each time I went to the hospital no one said to me, "Aha. I know why this is happening!" No one seemed to know—disconcerting, to say the least. At the tender age of forty-something I began to take responsibility for paying attention to myself as a physical entity (since no one else was taking on the task). To my surprise I found that I was ingesting a toxic array of chemicals on a daily basis. I quit doing that. I read the literature I could find that related to my particular complaint, and I made adjustments to my lifestyle. Gradually my life changed for the better.

My personal experiences led to the following question for my teaching: why not teach children to monitor their own bodies? Why wait until a health crisis arises in their lives? Why rely on smelly, dead frogs and putrid fetal pigs to teach them the complexities of advanced life? Why indeed when every day they bring with them to class the most complex living structure on the planet (which nine times out of ten has been bathed within at least a day)?

When I began thinking about this curriculum unit, I tried to discern what I know about my body that the students might not know about their bodies. For one thing, students don't necessarily know much about the chemistry of life. They don't know, for example, that structurally speaking they are for the most part protein. Yet they usually do know that meat is a good source of protein. I always ask students to go home and do a little bathtub experiment in which they take a bath with a lollipop and a chicken leg. Since the lollipop melts, and we don't, we can safely assume that we are not made of sugar. Since the meat on the chicken does not dissolve we can assume it is not made of the same stuff as the lollipop. Students usually know that the meat is mostly protein, so I urge them to make the connection and to embrace the notion that they are made of mostly protein.

Logic would then demand that we eat protein, unless of course we are endowed with the capability of synthesizing proteins with carbohydrates and lipids as the raw materials. My students eat lipids and carbohydrates. They chug soda. They tote the ubiquitous chip bag, and they have candy on hand at all times. While there are some structural lipids, notably in the cell membrane, and there are structural carbohydrates, most notably in the form of cellulose in plants, for the most part carbohydrates and lipids are burned in the body as fuel. My students are eating plenty of fuel. I often feel battle fatigue as a result of being continually surrounded by young humans hyped on high-octane fuel. These same perpetrators are not overly concerned with supplying building materials for their developing, living machines. The fuels are made of various combinations of carbon, hydrogen, and oxygen, while proteins (building material) must have carbon, hydrogen, oxygen, and an additional component, nitrogen. And, is that the whole story?

How can we teach all this in a high school science class? Once we establish that ingesting the right chemicals is a must, we have to seriously address the question of what to eat? The answer is: proteins, lipids, carbohydrates, nucleic acids, vitamins, and minerals, yes, but which ones, when, and how much and in what form?

OBJECTIVES

TAKS Objective: The student will demonstrate an understanding of the nature of science.

1. The student for at least 40% of instructional time conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices.
2. The student will use the scientific methods during field and laboratory investigations:

    b. Collect data and make measurements with precision
    c. Organize, analyze, evaluate, and make inferences, and predict trends from data.

(Additional objectives can be stressed and applied as needed thoughout this unit.)

RATIONALE

This issue is not new. The Book of Daniel in the Old Testament gives evidence to the antiquity of the discussion about how to eat a healthy diet. Daniel found himself in a foreign country as a captive being groomed to be a royal advisor and being fed a royal diet. When he asked the caregiver if he and the other young Hebrew trainees could eat pulse instead of the king's rich meats, he was told *no* because those were the days when people feared for the removal of their heads if they disobeyed the king, and the king evidently had ordered that the students be well fed.

So Daniel resorted to the scientific method. He proposed an experiment in which the Hebrew children would eat pulse for a few weeks and then a comparison would be made to the native youngsters who had continued to dine sumptuously on the royal fare. The text tells us that Daniel's group looked healthier after the test period.

Pulse is a whole food mixture of nuts, seeds, and dried fruit, probably like trail mix. A trip to the Internet will find many opportunities to buy pulse at a price of about $3.69 a meal, which is less than a combo at McDonald's. Perhaps the Bible text can still influence readers today as people search for the best way to nourish themselves.

Carbohydrates are made of carbon, hydrogen, and oxygen, or more precisely, they are carbon and water bonded together (hydrated carbon). The energy they provide when used as fuel comes from the carbon to carbon bonds and, of course, the energy to form those bonds usually comes from the sun during a process called photosynthesis. The sugars are carbohydrates. The starches are carbohydrates. Wood is a carbohydrate called cellulose. Wood is a fuel for fireplaces and termites.

A more concentrated version of this same fuel would be the lipids. Cooking oil is a lipid and so is grease. The waxes are lipids. Lipids are concentrated carbohydrates. They are carbohydrates that have been stored using less space. (More carbon to carbon bonds and less oxygen.)

When you eat lipids you are really fueling yourself powerfully. That's why you should not eat too many of them unless you are an Eskimo and you have to maintain 98.6 degrees Fahrenheit in subzero weather. Such a situation might merit the ingestion of a bit of whale blubber now and then, but eating a six-pack of Snickers bars every day while pregnant was probably not the best thing I did for my children. In general people who are not digging ditches for a living should limit the lipids; in addition, if you eat too many carbohydrates, your body will store them as lipids, aka fats.

Proteins. Ah… proteins are the molecules that are often bathed in ignorance. Very few students finish a biology study appreciating the personal stake they have in keeping themselves properly nourished with proteins. Water is also a chemical that gets less than its share of weight in most curricula. Most students graduate from high school holding a relaxed and flippant attitude towards their role as caretakers of their earth suits (And I call them earth suits because they would not work very well anywhere else in the universe.)

For the purposes of this unit I have decided that if I can influence teenagers nutritionally in four ways, I will be passing on some knowledge and know-how that has cost me a lot to learn. I would feel good about making it possible for my students to avoid some of the mistakes I have made as a result of my inability to connect my own welfare to the knowledge scientists have been trying to pass along to the rest of us for years.

UNIT BACKGROUND

Proteins

Proteins are molecules to seriously consider. Remember the DNA (deoxyribonucleic acid) code? We teach students that DNA is a wonderful informational molecule that carries a code. Well, what does the DNA code for? It codes for proteins. Not lipids and carbohydrates. Proteins. So if you have not taken in the right raw materials, you can essentially hamstring the work of the all-important DNA. My son raises racehorses. Sometimes he'll get a horse that is stunted. What that means is that the parental DNA, inherited by the horse, coded for a great big horse but the DNA's orders could not be carried out because there was not enough proper nutrition in the diet.

Protein, like DNA, is a polymer. Polymers are string molecules made up of smaller units like beads on a necklace. The monomers (beads) in the case of DNA would be four different nucleotides. Each nucleotide contains a different nitrogenous base: adenine, guanine, cytosine or thymine. The sequence of nucleotides is a code, and in the cell, the DNA code is first transcribed into messenger RNA (ribonucleic acid), and then the coded message is taken out to the ribosomes in the cytoplasm where it is translated into proteins, or, said another way, into a sequence of amino acids. Proteins are made up of monomers called amino acids, and there are twenty different amino acids to build with.

The essential amino acids are the ones you have to get by eating them. The other amino acids can be synthesized in the body. Knowing what foods contain the necessary amino acids would seem to be something basic to teach the students, but that particular info-byte is not tested on the standardized test, so we don't teach it. We have to weigh the options. Which is worse...a stunted kid or a kid trying to face the job market without a diploma? Either way we lose because the stunted nutritionally ignorant kid won't know what to feed his progeny, even if he can afford food for them.

Eggs, which were recently stigmatized due to their cholesterol content, have now been given a celestial halo because they contain all the essential amino acids. They have been forgiven for their lipids (cholesterol is a lipid) because every cell in your body must have cholesterol as an essential component in the cell membrane, a selectively permeable sack of sorts that lets certain things into the cell and certain things out.

Meat is also a complete protein and so is milk. Of the nine essential amino acids only three are problematic. These are often called the limiting amino acids because they are not as readily available as the others. For vegetarians soybeans are the most complete protein source, but by combining foods a healthy vegetable diet can be maintained. The story is different depending on the species. Think about it. Horses eat grass exclusively and do very well. They develop incredible muscle and bone tissue out of nothing but greenery. My husband was raised on a farm in Mississippi. He thought it was unfortunate that they had to eat greens everyday. They ate greens whether they ate anything else or not. The fact that he grew to be a six-foot-four football player means that evidently enough protein was being ingested somehow. Maybe those greens weren't all bad.

We should note that proteins play a key role in building the organism, but recall that enzymes are proteins. Enzymes are the molecules that act as catalytic agents in the body, causing chemical reactions to occur at the right speed and the right temperature. Without enzymes homeostasis would not be within reach. (Homeostasis is the maintenance of stable conditions within a living system.) An example would be amylase, an enzyme produced in the salivary glands that breaks starch down into sugar. Starch is a complex carbohydrate, again a polymer and a rather huge molecule that cannot readily be absorbed through the cell membrane. The monomers, the beads in the necklace, are simple sugar molecules. Amylase facilitates the breakdown of starch into sugar that can then be absorbed and burned. Take a saltine cracker, for example. It is made of flour, which is mostly starch. Allow the cracker to melt in your mouth for a while and note that after a few moments it begins to taste sweet. Yeah. Amylase has been at work. This may seem like a small thing, but remember that the fuel for the body is sugar.

If there is not enough fuel, the body grinds to a halt. During the winter Olympics I remember hearing on the news that the favored female figure skater ate a plate of spaghetti before doing her routine because of all the starch in the noodles. Without amylase she would not have made it through the routine. None of the starch could have been absorbed into the blood stream and burned in the cells. We faithfully teach children about how enzymes do their jobs but rarely focus on the fact that these vital chemicals are proteins coded into the DNA and produced only if the proper materials are available.

We have not yet mentioned the immune system, the system that kicks in to help our students not miss so much school time. Do we ever teach them that antibodies are proteins? We mention it, but do they make the connection? Do they understand the importance of eating the proper foods when they are fighting a pathogen? Anecdotally, I began to notice this. I rarely stay home from school, even when my body is under attack. I have noticed that if I just go to bed and languish, the immune system takes longer to fight off a pathogenic agent than it does if I eat a balanced and rigorous diet accompanied by lots of fluids and moderate exercise.

After eating and drinking I can actually feel a strengthening that is pronounced beyond what would normally be felt if the body got better on its own. Antibodies cannot spring from thin air. Antibodies are proteins that recognize and bind to antigens. The antigen is the substance or organism that triggers an immune response. The antigen could be a virus, a bacteria, or a chemical arrangement of some sort. Proteins in the form of antibodies to the rescue! And what about interferons? I nterferons are proteins. They inhibit the ability of a virus to hijack the cell materials needed to synthesize viral protein. In so doing they help block the ability of the virus to replicate and replicate until the cell bursts. Go to bed and drink chicken soup? Could it be the protein in the soup? Or is it the combination of all three?

And what about the vital transport role of proteins? The cell membrane is a double layer of lipids, but imbedded in those lipids we find many proteins. These proteins help move specific materials across the membrane. Water can move easily (osmosis) through most membranes, but what about the other molecules that must get across, the bigger ones like the carbohydrate fuel molecules, for example? How much cellular respiration can occur without the glucose molecule? None. The glucose molecule is a protein that specifically channels this vital fuel into the cell.

Proteins wear many hats. They are the whole show as long as there is enough fuel to keep them upright on the stage. Hormones are proteins. Hormones are signal molecules. Histones are proteins. Histones are the spools that hold those long strings of DNA. Proteins have been shown to be activators of transcription. Hemoglobin is a protein that picks up oxygen in the lungs and carries it to the cells. Heart muscle is made of protein.

The point here is an alternative to drawing a blank stare from our students when it comes time to review, and we want them to know about proteins and the amino acids that make them up. If we have approached it from the very personal level of vital human health issues, might their memories serve them better? More importantly, should students know that getting enough protein in the diet is worth paying attention to even if you are really busy with other things, like going to college or raising children of your own?

Air

Stop reading this unit and breathe deep for a moment. How much would you pay to have a doctor tell you that? Probably not very much, and yet that is exactly what the doctor should have told me about my rapid heartbeat episodes. It is amazing how important air is to the human body. Air is 21% oxygen. Oxygen is the second key ingredient in cellular respiration. T he first ingredient is the before-mentioned fuel, sugar (usually glucose). The fuel does nothing for us unless it is burned, and every girl scout knows that to build a fire you must have air. As a child I remember my mom building fires in the fireplace. The structure of the fire had to provide for the ready access of oxygen to the wood that was being burned.

The overall equation for burning fuel is sugar + oxygen that yield carbon dioxide, water and energy. That energy is a big one. All living things require energy. They require lots of energy just to remain alive.

The Second Law of Thermodynamics, an exception to which has yet to be found, tells us that the universe is tending towards disorder. It is heading straight for randomness, not order. Considerable energy must be expended if this trend is to be reversed at any level of complexity. In a highly ordered system like the living cell, lots of energy is required to sustain order. Then add another huge energy bill when reproduction of the system is called for.

When sugar is burned to fuel cell activities it is called cellular respiration, a process that occurs in the mitochondria, which are tiny organelles in the cell. A muscle cell, because of its work load, has lots of mitochondria. Fat cells probably don't have so much. How much fuel can be burned in any cell if sufficient oxygen is not around?

When we breathe in oxygen we facilitate cellular respiration. If we do not breathe enough air, the cells will run out of energy and begin to die. This sounds very scientific, but it is a stark reality. When cell death begins to occur we get notices to that effect. We may feel dizzy or drowsy, or we may have sharp pains. In addition, the heart receives biofeedback in the form of a message that the oxygen level in the blood is low and it is time to speed up the heart, which is the pump that delivers the oxygen to the cells. The heart starts to pump faster, and faster, to try to ameliorate the situation by bringing oxygen levels up in the systemic blood.

Normally we breathe right along without having to think about it. We have a part of our nervous system (autonomic) that works whether we order it to or not.

As an act of my will I am typing this unit on a computer. It is not happening automatically. However, I am not sitting here willing my stomach to grind up my food. Nor am I deciding to have my small intestine squeeze the food along towards my large intestine. However, under stressful conditions these things can be affected. I might "forget" to breathe if I am scared or stressed in some way. Stress is not something that is endemic among the youth. I myself did not encounter significant stress until I tried to raise a child as a young adult.

I did not have rapid heartbeat until four years after my son was born. During these four years, I was sleep-deprived and often stressed. One evening I was particularly stressed because a lady had left her child with me to baby sit. I was okay with that since she had agreed to pay me handsomely. After a brief period of interaction with her child I realized that only a king's ransom could properly remunerate a person saddled with the care and feeding of such a pill. I was particularly overwhelmed when she did not return for the child at the agreed-upon time. Thoughts of infinity began to filter through my brain...would this nightmare go on indefinitely? Was there no end in sight?

Then I felt my heart sort of shift gears. It scrabbled around and began to pound rapidly. I could see it pounding away. After a trip to the emergency room I was kept in the hospital overnight. Many expensive tests were done, none of which gave even a slight clue to the attending physicians as to why this had happened to me. So, being possessed of a strong desire to raise my son to adulthood, I began to pray. I had been taught to pray as a child but had never really taken up the habit in a serious way. The occasion had never called for it.

But now, faced with an overly excitable heart, and a group of non-plussed doctors, I began to talk to God. Prayer is a very relaxing activity because as I understood it at the time, it involved my asking God questions about the things I could do something about, and my asking God for help with the things I could not in any way change. I was aided in this endeavor by the teachings of my parents. Prayer worked for me because I believed it would work. Every time I began to feel oppressed, I prayed. Prayer is increasingly seen, by physicans and philosophers alike, as a legitimate resource for healing.

Several additional things happened during this time. I found some literature about MSG. The literature said it was an excito-toxin (poison). According to the article, which I can no longer find, MSG (monosodium glutamate) is a substance that makes your taste buds taste more intensely than they otherwise would, but in some people it can negatively affect the nervous system elsewhere. In my situation I was looking for anything I could do to help myself, so I cut MSG out of my diet. It proved to be very difficult. For one thing I had to stop eating those wonderful little packages of Ramen noodles. That was a terrible loss because they were a cheap food item that I had been ingesting on a daily basis, and, yes, they tasted intensely wonderful. (No protein. Just taste.) The jury is still out on MSG. Nevertheless, I have noticed that within the last few years restaurants have begun to brag if they don't use it. Perhaps others suspect it as a health culprit even though I have read articles that classify it as a harmless and natural part of many foods.

I lost the ability to eat in 90% of the restaurants at that time. I would be hungry in a restaurant, but the thought of the emergency room would drive me to thoroughly question the cooking staff only to find that most restaurants loved MSG even more than I did. Very often I found myself chomping away assiduously on a plain salad while those around me scarfed to their hearts' content the house specialties. I also quit consuming caffeine, which cut out chocolate (one of life's true pleasures), and coffee, which I dearly love. When I first started teaching school, I would enter the building armed with a 64-ounce cup of coffee which I would swig intermittently throughout the day. No matter that it got cold and clammy...the heady scent and the enlivening effects were still there.

I even quit eating white sugar. My thinking was that since it would be absorbed very readily into the blood stream, it might empower my heart to go into overdrive. I instead went for the complex carbohydrates like whole wheat and oat flour. These I knew would not hit the town like a bomb, but would rather have to be released slowly through the action of the various enzymes.

I took these and other precautions as I tried to take my own health seriously. However, a key piece of the puzzle was not revealed until my next episode. Several years later my son and I took our pet donkey to participate in a live manger scene at Christmas. It was a lovely experience until a carload of teenagers went by and threw some firecrackers into the area where the animals were. The donkey came unglued and seemed to be bent on trampling me to death. My son, mercifully, got control of the donkey before he could affect my demise. Two hours later when we were at the house, I felt the tell-tale heart rumblings and realized my heart was once again trying to shift gears. I (erroneously) thought that if I stood really still and didn't breathe my heart would calm down. Wrong. It began to pound furiously just as it had previously.

When I returned to the hospital, I again had numerous tests administered by the same confused band of medical experts. I tried to sort through the events that had preceded the recurrence, and as I did I remembered the part where I tried not to move or breathe. Maybe I should have breathed. The crazed donkey had put me through some serious stress in the form of fear. I had not gone into prayer mode. I had instead perhaps built up an oxygen debt for lack of normal breathing, which I then exacerbated by holding my breath at the outset of the event. After all, what would my body be trying to accomplish with all the heart action, trying to get more oxygen to the cells so their mitochondria could burn fuel?

From then on, every time I felt that little scrabbling motion in my heart, I began to breathe deep and fast like my life depended on it. That was 14 years ago. I still don't eat caffeine or MSG or white sugar if I can avoid it. I still pray a lot, especially around donkeys. And whenever I feel that little irregularity in my heart I begin to inhale heartily. (No pun.)

So is my success due to the dietary changes, prayer, or breathing—or all three combined? Well, since it is working, I hesitate to experiment further. It is kind of like the old saying, “If it ain't broke, don't fix it.”

After experiencing all this I began thinking about the statistics. Most heart attacks occur around 9 a.m. Why at that time? Many people build up an oxygen debt through the night because of sleep apnea. That debt has to be paid so that the muscles, full of mitochondria, can work, especially the heart muscle. Could prescribing deep breathing as a morning exercise prevent some heart attacks? (I'll bet the drug companies would love that… yeah, right.)

The point is that even though the doctors had no explanations for me, I did not give up on myself. I did not bow myself in abject humility and say, "Woe is me. I have this complex thing called a body and I am just not smart enough to make a success of living in it. I wish I were a doctor or something." Have you noticed that the age of the family doctor is pretty much over, at least in the urban centers? The days of having someone beside you who feels responsible for your physical well-being are gone. Maybe, just maybe, we should begin to teach our students how to apply the scientific method to themselves. How to define a problem and then begin to collect information about that problem...and then in a safe way to begin to do experiments that are not life-threatening? It did not hurt me when I cut out MSG. It was something I could safely do without. It definitely did not hurt me to cut out white sugar. I lost weight in all the right places. Gulping air is also a safe thing to do for a short time. So far I have not hyperventilated. Cutting out caffeine involves a brief period of withdrawal, but, at least in my case, has provided long-term benefits in the form of less mindless nervous energy to expend. Putting a stimulant into the digestive tract is not a win-win situation at all. You want food to proceed slowly and steadily through the digestive tract so as to allow for maximum absorption.

Water

One school nurse told me that 90% of the students coming into her clinic were suffering from simple dehydration. The fact that the vast majority of the molecules in our bodies are water molecules should be something to which we attach personal significance. We teach students that water is the universal solvent and we teach them that it is a polar covalent compound in that its electrons are not equally shared, a fact that gives water many unique and vital properties. Water as a compound is definitely tested on the TAKS test. But do the students get it? I mean, do they understand that they need to drink water, water, and lots of it? From the point of view of the school nurse, the message is not being received. If it were it would be acted upon.

After I cut the caffeinated and sugary drinks, there was nothing left but water to drink. As it turns out, that is a good thing. Water is the solvent in which all the chemicals in the body are dissolved if indeed we want them to be dissolved. We don't want our structural molecules—some proteins, for example—to dissolve. That would be unfortunate, sort of like the fate of the bad witch in the *Wizard of Oz*. Almost all the vital chemical reactions in the body take place in solution—water solution, to be exact. Food moving through the digestive tract would be an obvious water-intensive march, but what about the replication of DNA and the synthesis of proteins and burning of sugar to release energy, *etc*? When children come in from lunch and say, "My stomach hurts," I say, "Go drink water. Your poor stomach cannot grind up solids comfortably. It was made to hold liquids."

Take away the water, dehydrate the body, and you have left a mere fraction of the body weight (maybe a fourth). Most of the mass of the human body is water. I have begun to drink water in a big way. I am finding that my medicine chest is clearing out as a result. What is a headache? Perhaps it involves a reduced blood flow to the brain?

And what is the solvent in which all the blood solids are dissolved other than water? Could it be that not enough water has been taken in to keep the volume of blood optimal in the body? Since I have been drinking lots of water, I have not had many headaches. And what about the contents of your stomach…too acidic? Well, by drinking a glass of water, the concentrated acid becomes a weaker acid that contains less hydrogen ions per unit of volume. I do not have to resort to a pink, gunky, gooey bottle of medicine. We teach water the chemical, but do we make the connection to water, the essential mineral to ingest? We should drink it many times per day.

Water is my number one weapon when fighting the flu or cold symptoms. I consume more water as well as soup and juice and anything else water-based. Pushing things along with water is like cleaning up the battlefield. After a war there is a lot of mess. When your body takes on an invasive pathogen there are battle scars to slough off—brave but dead white blood cells, for example—that need to be coughed up, spewed out, and removed, lest they become a rich breeding ground for secondary infection.

Whole Foods

We had a huge garden at home when I was a kid. We ate out of that garden all summer, and then we canned or froze the rest for consumption in the winter. I now live in the city and I find that eating the whole foods I ate as a child is a very expensive proposition. Most foods are processed and packaged and treated with non-nutritive chemicals. In order to read the labels on frozen dinners, it takes five minutes of heavy concentration and a thorough knowledge of chemistry. Should we teach our children to eat whole, unprocessed foods, even though it is cheaper and easier to heat something up in the microwave? In my opinion we should teach them two things. First, we need to teach them that those nice pieces of white bread and those delicious noodles made with white flower are pretty much just sugar waiting to happen. Second, we also need to let them see up close and personal how animals eat in the wild.

For biology class specifically, we need to take a field trip to a typical grocery store where the majority of people shop. We need to walk up and down those aisles with the kids and conduct a survey of just how much useless junk people buy and eat.

Horses eat grass. What is grass? It is a whole food. Bring the horse in from the pasture and feed him oats only. Get ready to spend some money at the vet because horses are not designed to eat just oats. If you cannot keep your horse in a grassy pasture you will have to buy dried grass or hay. Whole foods are complex. When we process grain and separate out the starch molecules, the white part of the grain, we are forgetting that the grain was attached to a plant which we never plan to eat. The horse in the wild eats not only the grain but the whole plant.

Scientists are finding that whole foods are intricate. Phytochemicals—phyto is a prefix meaning "plants"—are the many chemicals found naturally in plants. Aspirin was originally a phytochemical, and now we have learned how to produce it in the lab. When we process foods we lose many of these complex chemicals. We still do not understand the importance of all the ones we have identified, but some research indicates that we should take care to include them in a healthy diet.

But if we decide to eat whole foods, we generally pay more at the store. Grocery stores that specialize in whole foods are places that many people cannot afford to patronize. It is wonderful to visit there and find all the good food items, but it is not wonderful to face the cashier at the check-out. For a large family it might be more financially feasible to purchase the white-flour noodles instead of the whole grain noodles. Even at a regular grocery store, the price difference will be noticeable.

There are many other important things to know about hosting a successful body that we simply do not have the time for. The four I have chosen—proteins, air, water and whole foods—have been especially useful in my life. Regular exercise is extremely important, as is sleeping enough hours every night. Life habits have to be in place for the benefits of chemistry to be realized.

LESSON PLANS

Lesson Plan One (5 E's model -- http://www.pom-palm.k12.ia.us/office/Lesson_Description/5E%20Template.doc)

Purpose: To demystify the medical role and make self-monitoring possible for students

Engage: Give students a stethoscope and a sphygmomanometer. (Groups of two would be optimal, but if equipment is lacking, more could be in the group).

A good website to show the students is HOW STUFF WORKS, sponsored by The Discovery Channel. It shows a picture of a gentleman getting his blood pressure taken and lists the steps (http://healthguide.howstuffworks.com/blood-pressure-check-picture.htm).

It takes a little getting used to and a few tries, but the students should be able to secure the two numbers called for.

Explain: After collecting the numbers, the students may be willing to listen to an explanation of what the numbers mean. Most people do not know. We have been allowing this test to be conducted on ourselves for years, and we have no idea what the two numbers mean. At this point a laminated sheet should be provided on which the heart is pictured in a thoroughly labeled pictorial of how blood flows through the heart. Explain to the students that the heart is really two pumps. One pump supplies the lungs with oxygen-poor blood. The other pump supplies the rest of the body with oxygen-rich blood. This tool will need to be kept for use throughout the year. This activity will lead to the study of organs and systems later in the year.

<u>Korotkoff Sounds</u>: "Korotkoff sounds are the sounds that medical personnel listen for when they are taking blood pressure using a non-invasive procedure. They are named after Dr. Nikolai Korotkoff, a Russian physician who described them in 1905, when he was working at the Imperial Medical Academy in St. Petersburg" (Korotkoff Sounds" *Wikipedia).*

The best thing would be to let the students read the description of Korotkoff Sounds online (e.g., http://en.wikipedia.org/wiki/Korotkoff_sounds). Allow them to absorb the writing before explaining it to them. (Forcing children to read for scientific understanding is one of the kindest things we can do for them in preparation for the TAKS test, which is a reading test after all.)

Briefly, you cut off the blood flow in the upper arm and then allow it to start flowing again. When it starts flowing again it will be in spurts at first because of the pumping action of the heart. The spurts are audible. After awhile the flow in the artery is not turbulent because the artery is uniformly full of blood again as it was before you cut off the blood supply, ergo no additional sounds will be heard.

Explore: At this point it would be good, if you have computers available, to ask the students how this practice of measuring the pressure of the blood within the circulatory system got started. The Internet will tell them the history, and it is really fascinating. The most primitive record of blood pressure recording goes back to 1733 when Rev. Stephen Hales inserted a tube into a horse's artery. The blood shot up in the tubing to a height of 8 feet and 3 inches. This was representative of the force exerted by the heart as blood is transmitted throughout the body (http://www.answers.com/topic/blood-pressure). Times have changed, thankfully. Allow students to find out how the non-invasive method used today was invented. This could be a short written history or it could be adjusted. If computers are not available, a set of handouts could be used.

Elaborate: During this part of the lesson students could be alerted to the fact that blood pressure is just one aspect of health to be monitored. Give each child a Daily Log handout. Science is a way of answering questions using what we can see, touch, taste, hear, and smell. If we are going to study the human we need to begin to take account of the various things about this species that we are capable of measuring. Blood pressure is one dimension, but we can measure much more.

Daily Log***:*** Students should purchase a log book, or, they should allot space in their science binders for a long-term acquisition of data. Things to be measured and or recorded every class period would include: blood pressure, pulse, food consumed, temperature, any symptoms (headache, nausea, lots of energy, *etc*.), and anecdotes could include events of note that may (or may not) be affecting bodily function. Things to be recorded biweekly include weight and height.

Allow students time to make the first entry and establish procedures for measuring the various factors, paying close attention to safety. Explain that at the doctor's office each patient has a file. This log will be analogous to that file. Also explain that this data can be quickly and quietly gathered and recorded while students are waiting for class to start each day.

***Evaluate*:** The relevant fact for the students is that the entirety of the academic experience can be summed up for all of science in two words…yes and no. Either yes I passed the TAKS test or no I did not pass it. Therefore, anything we do with the students has to be traceable back to TAKS scores. The evaluation then would have to consist of a list of released TAKS questions that might pertain to this endeavor of which there is a rich supply since the process of science is the objective most tested.

There would be no reason to prevent the students from assessing this activity in terms of its attractiveness to them. When I was in high school, I thought science was the way to go. I loved it passionately because it was new every day. Then when I was 16 years old the government sent me for the summer to Penn State University to do research on maple cankers. I was thrilled to obtain this opportunity until I found out how boring and repetitive data collection can be. Science is only fun if you have lab techs doing all the boring stuff. Discussing what the data means, now, that is definitely a good time, but meticulously and faithfully getting the numbers down on paper, well, that is a definite no. Good for students to know that before setting off on a trek to scientific bliss. They might have years of details before any theoretical breakthroughs can manifest.

Lesson Plan Two

Purpose: To allow students a chance to be convinced of the key role played by proteins in the human body

Engage: Lesson One should be taught early on during the year so that significant data can be gathered over a long period of time. Data collection should go on daily and monthly. Lesson Two can be taught whenever the curriculum allows for it. This is the lesson in which you teach proteins. To get the students' attention, have a demonstration table with two large beakers of water. Drop a lollipop in one beaker and a chicken leg in the other. Ask the students to predict what will happen to the lollipop and the chicken leg during the class period. Try to steer the discussion in a direction that will allow the students to embrace the notion that structural proteins are fairly durable building materials. It might be a good idea to pre-test the brand of lollipop you plan to use to be sure it will dissolve rather handily.

Explain: The incredible versatility, flexibility and strength of the human body is directly attributable to the chemical properties of the carbon atom. The organic compounds have at least two carbon atoms. Carbon has four electrons in its outer shell. Students will already know about this from their studies in IPC (Integrated Physics and Chemistry). The electron shell needs four more electrons to become full, or chemically stable, i.e. less reactive. The chance that carbon would be able to just grab four more electrons from somewhere is nonexistent. Electrons are negatively charged and are attracted to the positively charged protons in the atomic nucleus. Since carbon has only six protons in its nucleus it can only attract six electrons. Two of those electrons fill the first energy shell, and the other four are in the second energy level waiting to bond in a way that will complete the outer shell (eight electrons). Since four electrons cannot be just grabbed due to a lack of pull power from the nucleus, a sharing bond (covalent) of some sort has to be worked out. Ionic bonds (electrons are actually grabbed or transferred, forming oppositely charged ions) are not as strong as covalent bonds. Covalent sharing bonds are strong, ergo carbon bonds are strong.

(Here it would be appropriate to insert a mini-demonstration in which you ask two couples to come to the front of the room. Have one couple demonstrate the weakness of ionic bonding. Have them stand next to each other, but do not have them hold hands or put their arms around each other: you boy, me girl, we opposite, we attract. Push them apart and show how easily they are separated. Then have another couple represent covalent bonding. Have this couple put their arms around each other to represent the sharing of electrons. Now try to push them apart and note how they move as a unit and they do not come apart. Encourage students to have covalent marriages instead of ionic marriages.)

While explaining this to the students, using beans or other cheap small objects to represent models of carbon to carbon bonds would be effective. Let one color of bean represent the protons in the nucleus and another the electrons in the first and second energy shells. The beans could be placed on a grid that has a two dimensional Bohr Model skeleton on it. Caution students that the two dimensionality of the Bohr model could lead to misconceptions and it is only useful as a temporary tool. This model can show the creative possibilities of carbon bonding in four different directions if necessary.

To make a long story short, the carbon bonds in proteins are strong. Carbohydrates, lipids, proteins, and nucleic acids, aka the life molecules, are all carbon-based compounds. Life on this planet is carbon-based. Breaking strong carbon bonds in lipids and carbohydrates releases energy. Proteinaceous bone and muscle tissue is strong because the extremely flexible bonding capabilities of carbon allow for strong arrangements (consider the potential of the carbon nanotubes as an example) that would not be possible with any other element. Properly motivated, the human body can accomplish incredible feats of strength, and it is all because of carbon, aided of course by its friends, hydrogen, oxygen, and nitrogen.

Explore: During the exploration it would be good to again use manipulatives. For example, I have used different colors of Christmas paper cut into tiny pieces so that kids could make models of the structural formulas for carbohydrates, lipids, and proteins. This is a crucial step, not just because those structural formulas have found their way onto the TAKS test before, but also because if the structural formulas are internalized, then the uniqueness of proteins will be abundantly clear. These works of art should be posted on the wall so that you can refer to them repeatedly throughout the year. It would be instructive perhaps to walk up to a student who is finishing a carbohydrate-rich snack while waiting for class to start.

Possible conversation:

"Ah I see you are fortifying yourself against the vicissitudes of life. What a clever plan! Let us look up here on the wall and see if you are being kind to yourself…hmmm. Here are some simple carbohydrates, the disaccharides, amply represented in your snack in the form of sucrose, the white stuff found in the bowl on the table at home, yes, you are taking on fuel in a big way. Energy and plenty of it. Ah…and I see lipids (oils, fats, grease), again another energy-rich set of compounds with their bountiful supply of stored carbohydrates…you should have been an Eskimo. Ah, but wait! Mercy me! Where are the proteins? One can only hope that not a single one of your cells died today and needs replacing because you have taken in no proteins. Let us peruse the wall charts here again and note painfully that you have not taken in ANY nitrogen (I see nitrogen in those amino acids on the wall chart) except the gas that came in through your nose when you breathed, and alack and alas, your body is not set up to capture that nitrogen, what with you not being an nitrogen-fixing bacterium and all. May I make a suggestion, and that would be that you carefully consider not taking a bath for awhile lest you slough off skin cells that you are in no position to replace, due to the nutrient-poor diet you have chosen to afflict yourself with?"

Could you find a student thoughtfully munching on peanuts (a whole food)? Not likely unless each peanut is submerged in a sweet and gooey candy bar. Can we possibly influence children to go against all the conditioning of the TV ads and actually eat food they need instead of food they want? Can we teach them to want what they need? Or are they going to be like me, and get interested at age forty-something because they have a heart that beats out of control, especially since they could easily argue that last night they ate a McDonald's burger and are, therefore, in possession of more protein in one sitting than most people in the world get in a week?

Speaking of McDonald's, there is a lab called the McMush lab in which a happy meal is blended into a liquid brown mush which is then tested for the presence of the organic macromolecules: the carbohydrates, the lipids, and the proteins. (Biuret Reagent is made of sodium hydroxide and copper sulfate. The blue reagent turns violet in the presence of proteins, and changes to pink when combined with short-chain polypeptides (simple proteins). The tests for each group can be obtained from multiple websites, one if which is http://www.sciencecompany.com/sci-exper/food_chemistry.htm#3. This is a nice traditional lab to do when exploring the macromolecules.

Elaborate: It is important to teach all the roles proteins play. It is not just the structural role (keratin in hair, for example) that the DNA codes for. When DNA dictates a specific amino acid sequence, the resultant shape of the molecule is what makes it suitable for different functions. Proteins play a role as signal molecules (hormones, for example), transport molecules (hemoglobin for example), and think about the histones that the long spindly DNA molecules use as spools, again proteins. Your body can burn protein as fuel. Proteins have been shown to regulate transcription (genomicsgtl.energy.gov/science/generegulatorynetwork.shtml). Proteins are the star performers, so to speak, in the processes of life.

Proteins wear many hats. It would be useful to construct a worksheet in which there are a number of hats, each with a role written on it, and each to be matched up with proteins, lipids, or carbohydrates. That would take some careful thought, and a handout could accompany it in which students must read text. (Preparation for the TAKS test should include reading and writing everyday.)

Evaluate: Released TAKS questions could be found in abundance since the macromolecules are tested.

Lesson Plan Three

Engage: Collect food labels and have the students bring in some as well. Give each group of students five labels. Be sure to include some labels that have a simple list of legitimate ingredients. A bag of unseasoned peanuts might have one thing on the list...peanuts. Also include some ingredient labels that go on and on endlessly listing one chemical after another. Ask students to generate an explanation for the differences in the lists.

Explain: After allowing students to account for the lists, explain that there are thousands of chemicals that are food additives that the Food and Drug Administration allows and tell them that they are about to find out some things about their own diets that might surprise them. Compile a master list of all the additives on the board. Let students copy them into their log books.

Explore: Reserve the computer lab for a day and give the students about half a class period to find out what the additives are and what the legitimate science sites have to say about the additives. Ask students to find out what the food industry says as opposed to what the government agencies say as opposed to what consumer groups say as opposed to what scientists say. Is there a consensus or is there controversy?

Ask students to decide whether or not the chemicals are safe for human consumption. What is the lethal dosage, if any, *etc*? Are the long-term consequences known, and if not, how long will it be before the evidence for and against ingestion are available?

Elaborate: This information has to be looked at in a personal way. Recently I bought a bag of seasoned peanuts. I did not take time to read the label before purchasing. I was hungry. I did not read the label until I was halfway through the bag. Then I read the label. Two percent of the contents of the bag was silicon dioxide. Well, I am not a chemist, but it stuck in my memory that silicon dioxide is glass. As soon as I got to a computer I went to *Wikipedia* and was told that yes, I was ingesting something used to make glass and concrete.

Then I went to the World Health Organization to find out what research has been done on this food additive. There I was told that if the dosage was fifteen parts per thousand instead of two parts per hundred, that the dosage could be lethal. I did not find this information encouraging. I laid the bag aside even though I found other sites that tried to calm my fears of this anti-caking compound by stressing how common this chemical is. It is everywhere. It is everywhere so eat it. Eat sand. Eat sand because in so doing you will increase the aesthetics that accompany the ingestion of peanuts.

Another dramatic rendition of silicon dioxide is in an article by Ivan Fraser in a magazine called *The Truth Campaign*. The title of this publication initially suggests a fanatic group of alarm sounders, but actually Fraser sounds kind of like me. He is a guy who has several medical conditions, including fibromyalgia and chronic fatigue syndrome. Fraser began to pay close attention to his body and was able to come up with a theory which he admits is not a proven fact, but as I read his theory, I saw another human being trying to make sense out of his health. If he is right, we should not be ingesting silicon dioxide unless we just happen to fall down and get a little sand in the mouth accidentally (http://www.ivanfraser.com/articles/health/sics.html).

Students need to know that while the Internet is rife with misinformation, the jury is still out on many health issues, and if you have an issue it may not be feasible to wait until the jury deliberates and then comes back in the room with a verdict.

Evaluate: Go to the test bank and you will find many TAKS questions in which the students have to read something and determine its scientific validity.

Lesson Plan Four

Engage: Take the students outside if you are teaching in Texas. You will probably not have to walk more than three steps to find huge ant mounds. These will house thousands and millions of red imported fire ants, *Solenopsis invicta*. Using nothing more scientific than an empty water bottle, scoop up ants in each of ten jars. Explain as you are scooping that you want to try to get an equal sample of ants into each jar BUT since these critters are bent on chewing on you, the size and character of each sample may be a variable that you are unable to control. The largest ant mounds I have ever found have been on school grounds. Are these organisms dangerous? Yes. That is why you the teacher must do ALL the handling in which there is a chance of being bitten. Children in Texas know if they are allergic to fire ants because fire ants rule Texas and all residents have been bitten at least once.

Explain: In setting up an experiment there must be a thorough attempt made to control variables. All jars need to be equally clean and they should all be the same size. The number of ants in the jars may not be exactly equal, but an attempt should be made anyway. Explain that as you go down through the mound collecting samples, the ants may vary, with ants on the outside of the mound being older foraging warrior ants and the inside ants being younger nurses. A jar must be set aside as the control jar, which in this case will be the jar that contains whole foods. One jar should contain pure carbohydrates and water, one jar pure lipids, another pure protein, and another a mixture of the pure macromolecules, while another jar contains water only and another contains no water, food, or air. You are using ants because you can get away with this kind of experiment, but believe me it may take months for the ants thus deprived to bow out, because ants are VERY well-adapted to adversity. Depending on the group of students you may want to try the food additives in some additional jars. You can do fifty jars if you like and you won't come even close to running out of research subjects.

Explore: On a daily basis these jars should be monitored. Observations and dates must be carefully logged into the log book of each student. When the contents of a jar goes flat line, that should be noted, the longevity duly recorded, and the jar should be started again to see if the first results can be repeated. Only results that can be repeated should be considered valid. The data being collected on the human subjects (log started in previous lesson) can then be compared to the data being collected for the ants. Admittedly there is a huge gap between arthropods and mammals, so direct students to compare the DNA to see the similarities. Ants have mitochondria in their cells and so do humans. Ants must burn fuel and so must humans. Ants need oxygen and so do humans. Ants must synthesize proteins, just as humans must.

Elaborate: Within the context of research, much discussion becomes possible concerning the nature of science, the process of science, the ethics of science, *etc*. Since this research would be ongoing, possibly all year, it offers a chance to teach and re-teach. It also facilitates critical thinking. The data collection begun in the previous lesson can concurrently be analyzed for interesting trends.

Evaluate: The TAKS questions available on the process of science are numerous, and because of the volume, pretests and posttests are possible.

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