Eat the Rainbow

Lucinda Barca Supernavage

Objectives

Do you want to live longer? To be healthier? To look younger? Well, what color is your diet? "Never mind proteins, carbs and those other old-hat nutritional obsessions; what's really important in food, says a new group of docs, is hue, the more vibrant the better."[1] Fruits and vegetables come closer than any other category of food to behaving like a fountain of youth. Each fruit or vegetable is packed with plant-based chemicals, or phytonutrients, that can help to prevent or even reverse one or more chronic, debilitating and often deadly diseases.[2]

Americans do not eat enough colorful foods and lean more towards a diet high in fat and processed beige or tan foods and snacks. These foods tend to be the weakest nutritional link. In fact, Egyptian mummies, who enjoyed diets consisting mostly of grains while living, exhibited many signs of diseases such as cancer and heart disease when excavated. This idea is also evidenced while comparing the heights of early farmers, hunters and gatherers. The farmers, who tended to be shorter than hunters and gatherers ate mostly grains which lacked the adequate nutrients that are found in plant and animal foods.[3] On average, nowadays, we eat only three servings of fruits and vegetables per day instead of the recommended seven to eleven servings. "If those three servings consist of iceberg lettuce, French Fries, and a little ketchup for color, you are in big trouble."[4] As we age, our genes become damaged and change which put us at a higher risk for diseases such as cancer, Alzheimer's and heart disease. Colorful plant foods contain beneficial compounds that help to shelter and protect our DNA. This can counteract certain negative responses that occur in our bodies and defend us against the common diseases that affect many of us as we age.[5]

The main goal of this unit is to explore an essential question that must be answered within my seventh grade science curriculum. How do nutrients affect the health of the human organism? This unit ties nicely into the Human Biology component of seventh grade science and can be used in any life science class that requires discussion about human anatomy and physiology. I also teach high school Biology and plan to use all that I have learned through my research in that class as well. I will use a whole quarter to entwine my research and my lessons into this unit, which will culminate in a final project completed by each student. I teach at an arts school so I will also include historical fun

facts about painting, how color was important to music and theatre lighting, among other topics that I know will fascinate my students.

The topic of the human body always seems to be a big hit with my seventh graders because they are very interested in learning about their bodies. I spend a lot of time and energy helping them to better understand why the human body functions the way it does and what it needs to function properly. Good nutrition is the first step. I think it is difficult for students to comprehend why they need to eat well, what could happen if they did not eat well, and what happens to food and the nutrients in food once they enter the body.

Nutrients come in a variety of forms…and colors. It has always been difficult for me to effectively communicate to students the importance of nutrition to their young bodies and minds without sounding similar to a nagging, lecturing parent. This talk never seems to be taken seriously. Most students would rather eat what tastes good instead of what actually is good for them. This unit will focus on the different colors of food, specifically fruits and vegetables, and their nutritional values and content. We will discuss why natural foods are best and why foods are made with synthetic food dyes. Upon the conclusion of my unit, students will hopefully be more aware of what is in what they are eating and the extreme significance of eating the right foods and colorizing their diets. Understanding these important concepts will help students make better decisions regarding their health so that, perhaps, their lunch trays will consist of more than just french fries, which for some children are their only intake daily of a vegetable.

Background

Light and Color

An important concept for students to master in this unit is how color benefits the human body. In order to understand this, I believe students need to first comprehend how and why things appeared colored. This takes us to the origin of light and color.

"One thing we do know about light is that, without it, there is no colour."[6] We can attribute light and, therefore, colors mostly to the radiating sun which supplies us with a massive amount of energy. Energy comes in different wavelengths spanning from very small, fast waves of energy (gamma rays and X-rays) to larger, slower waves of energy (radio waves). Right in the middle of this electromagnetic spectrum (400 to 700 nanometers) lies a range of energies that we can perceive with our own eyes: visible light. Light is composed of photons or tiny particles traveling in waves and appears to be white because it is heterogeneous and contains a mixture of all wavelengths in that visible range noted above.

When light hits matter, it can be transmitted (allowed to pass through), reflected (bouncing back from surface), scattered (bouncing back in many directions) or absorbed (being soaked up by the matter) depending on the different molecules found in that matter. This is why objects (like fruits and vegetables) can appear to be colored. When different wavelengths of visible light are absorbed and others are reflected by the matter, this is when a color can be perceived. For instance, the carrots we are accustomed to seeing are orange because they contain carotenoids (hence, the name carrot evolved), beta-carotene to be specific, which is a chemical that absorbs specific wavelengths of light (violet and blue) and reflects others (red and green).[7] The colors we see are the reflected colors, or mixtures of them. Hmmm…could this color be extracted from plants and used as a natural food dye? You bet!

Natural plant chemicals (phytochemicals), which will be discussed in more detail later in this unit, are the reasons why our fruits and vegetables have different colors…and different health benefits. For instance, green vegetables such as lettuce or spinach, contain chlorophylls which absorb wavelengths of light except green. In more chemical terms, green plants can carry a lot of energy to undergo photosynthesis to create food and oxygen. "So to chlorophyll we owe not only our food but also the means by which we use it."[8] When the chlorophyll in plants breaks down, yellow pigments will then appear because it is losing its energy-carrying capacity and color.

Another example would be the flavonoids we find in foods. Flavonoids are plant chemicals that are classified into two categories (anthocyanins and anthoxanthins) that cause a beautiful range of colors to be perceived based on pH (how acidic or basic something is). For example, red cabbage juice appears red only if it is acidic. If you slowly add a basic substance (such as ammonia) to the juice, it will begin to turn blue to turquoise to green. Anthocyanins appear red in acidic environments and blue in alkaline environments. Anthoxanthins are colorless in acidic environments and yellow in basic environments.[9] The different pH surroundings slightly alter the molecular structure of the plant chemicals which changes the wavelengths of visible light, or photons of energies, the plant can absorb. This, in turn, causes the color change.

Cells

In order for students to understand why nutrition is important to how the human body functions, they must first break it down into the smallest, functioning unit. This basic unit of life is the cell. All living things are made up of at least one cell. The human body is made up of trillions of cells. Each cell contains the individual organism's DNA and requires energy to do its special job. How do we get this energy? By converting the foods we eat and the oxygen we breathe into a form of energy our cells can use, via

mitochondria, which are organelles found in every cell of every organism. This process is called cellular respiration and can be described further as *sugar + oxygen = energy + wastes*.

The more active something is, the more mitochondria its cells will contain. For example, the cells of a hummingbird will contain more mitochondria than the cells of a slug. How do we use this energy? All cells in the human body have a specific job; they are specialized. We have brain cells, blood cells, stomach cells, skin cells, our bones are made of cells, etc. When a group of cells works together with the same ambition (to mash up solid food into a soupy mixture), they are then considered to be a tissue (stomach tissue). When a group of tissues work together to achieve that same task, they are said to be an organ (stomach). Finally, a bunch of organs (esophagus, stomach, intestines, etc.) that "collaborate" and accomplish the ultimate goal (digestion) will make up the organ system. Understanding this hierarchy is crucial to the development of this unit. It all comes down to the cell. Without this very complex and specialized system of cells, we would not exist.

Organ Systems

The human body is broken down into many organ systems that all work together to achieve one huge goal: maintaining homeostasis. Homeostasis is defined as the ability of our body to sustain normal internal conditions such as body temperature or blood sugar levels. The human body can only normalize itself for so long without our help. We need to do our part to help our bodies stay healthy.

In order for students to understand the big picture and the extreme complexity of the human body, they must learn about each organ system separately (musculoskeletal, circulatory, endocrine, nervous, digestive, excretory, respiratory, immune). Each of these systems relies on us to provide for the needs of the cells so that it can function properly. We will spend two to three class periods on each organ system to be learned through discussion and activities. All the while, I will add bits and pieces of color information throughout their studies. An ongoing question will be present throughout this curriculum unit: what color vegetables and fruits are best for this system?

Digestion

Digestion is a process that takes place in most organisms. It is required for our bodies to break down the food we eat into two categories: what we need and what we do not need. The system most responsible for this is the digestive system, but again, all human body systems work together to fulfill the needs of the organism. Without the circulatory system replenishing all our cells, including those responsible for digestion, with oxygen,

the digestive system would not work. Without the blood also transporting the nutrients it removes from the food to other cells, digestion would be unnecessary. Additionally, the digestive system would be useless without the help of the muscular system. Peristalsis is the muscular action that moves food through the digestive tract.

The pathway of digestion starts in the mouth with the mechanically-digesting teeth and the chemically-digesting saliva. Once we soften and break down the food enough, it enters the esophagus which brings it to the stomach. The motion and the acids of the stomach churn up the food you eat, mechanically and chemically respectively, and turn it into a soupy mixture. This "stomach bisque" then enters the small intestine, which contains the nutrient-absorbing villi along its walls. What is left over will make its way to the large intestine, or colon. Excess water is squeezed out and recycled to be used again in the body, and the rest, considered waste, is sent down to the rectum to be exited from the body.

This complex process of digestion is only truly effective because of the villi. These fingerlike structures located along the walls of the small intestine transfer nutrients from the digestive system to the circulatory system. It is here that the greatest amounts of nutrients are mopped up by the bloodstream and broken down into a more usable form. It is then up to the circulatory system to transport these important fragments of our food to the areas that need them.

Nutrition

There are four main nutrients that the human body needs: carbohydrates, fats, protein and water. Dr. David Heber states that there are both desirable and undesirable forms of these nutrients such as fruits versus pasta in the carbohydrate category or olive oil versus butter in the fats department.[10] We should be mindful of which forms of these nutrients we eat. In addition to these four basics, many nutraceuticals exist and should be included in our daily meals. Nutraceuticals refer to foods that supply us with health benefits such as calcium (found in dairy products) preventing osteoporosis. Phytochemicals and antioxidants are two types of nutraceuticals.[11] There are over one thousand phytochemicals that exist and, though not necessarily essential to sustaining life, should be an important part of our diets due to the numerous ways they benefit our bodies and minds. The word phytochemicals comes from the Greek root "phyto" which means plant and is defined as being "non-nutritive plant chemicals that have protective or disease-preventative properties."[12] Plants (and the high-blood-pressure-lowering dark chocolate, which ultimately comes from the cacao plant) also contain antioxidants which are compounds that help our bodies avoid chronic diseases. "They act as a defense system against oxidative damage in our bodies and may be helpful in avoiding chronic diseases and the effects of aging. Some examples of antioxidants are Vitamins A, C, and E and

beta-carotene."[13] Antioxidants have been said to "gobble up free radicals" which are the culprits in many ailments such as heart disease.[14] Students will not be required to know the thousands of these chemicals that are found in foods, but they will get the gist of how they *fight-o* to protect their bodies.

Natural chemicals such as those found in onions, garlic, carrots, fruits, etc. are called antioxidants and can reduce the risk of developing certain cancers. Garlic also contains phytochemicals which act as an anti-bacterial agent. Saponins are phytochemicals found in beans that decrease the multiplication of cancerous cells once they do develop. Other benefits include protection of the heart, defense against pathogens, protease inhibition, lowering cholesterol, defeating free radicals, decreasing inflammation, aiding in vision, etc. Dr. Heber codes plant food into different categories based on their color and health benefits.[15] I call this the edible rainbow.

Edible Rainbow

White

Foods in this color group prevent cancer and heart disease and should not be confused with the beige foods discussed earlier. Onions, mushrooms, garlic, white wine, chives and cauliflower contain anti-tumor allicin and selenium and are rich in flavonoids. We will review this category also during the cell and cancer talk and while discussing the circulatory system.

Red and *Red/Purple*

"This color group delivers lycopene, a powerful carotenoid, as well as anthocyanins. They may help maintain a healthy heart, vision, immunity and may reduce cancer risks."[16] Lycopene is also better in cooked form (tomato sauce) rather than raw form (tomato).[17] Red foods are also known to prevent ultraviolet damage from the sun. Those from this group that will be discussed are tomatoes, cherries, watermelon, pomegranates, pink grapefruit and red bell peppers. Discussion of this category will take place at the beginning of the Human Biology unit while reviewing information about cells and cancer.

The reddish-purple grapes and grape juice, red wine (although this will not be discussed in the classroom), apples and berries (cranberries, strawberries, blueberries, blackberries) all contain anthocyanins. These antioxidants minimize blood clots, which help to prevent heart disease.[18]

Blue and Purple

Similarly, blue foods, such as blueberries, can prevent heart disease and improve cardiovascular health. Blue (and purple) foods are also said to improve memory, prevent cancer, contribute to urinary tract health and have anti-aging effects. Options of foods that contain anthocyanins and phenolics are eggplant, purple cabbage, prunes, plums, beets and blackberries. Discussion of blue and purple foods will take place within the circulatory, urinary and nervous systems.

Orange and *Orange/Yellow*

"Carotenoids, bioflavonoids and the antioxidant vitamin C in orange foods promote a healthy heart, vision, immunity and reduced risk for some cancers. The deeper the orange or deep yellow color, the more carotenoids they have."[19] Vitamin A is also plentiful in many of these foods. Pumpkins, carrots, oranges, mango, sweet potatoes, apricots and papaya are edible ingredients of this spectrum of the rainbow and will be discussed during the cells and cancer section as well as the circulatory, immune and nervous systems.

Yellow/Green

Yellow/green foods prevent vision loss due to the types of carotenoids (lutein and zeaxanthin) they provide. "Lower intakes have been associated with cataracts and age-related macular degeneration, the primary preventable cause of blindness in America."[20] They also contain a profusion of other carotenoids which can also prevent cancer, decrease joint inflammation and arthritis. This category will be linked to the nervous and the musculoskeletal systems as well as the introduction part of this unit. Squash, spinach, yellow bell peppers, green peas, yellow corn, pineapple and avocado are all considered yellow/green foods. In addition, the absorbable form of vitamin A, retinol, is a yellow vitamin that aids in vision, reproduction and bone health. It also helps to regulate the immune system and can be found in most animal products.

Green

Like blue and red foods, green foods offer a wealth of vitamins and antioxidants. The lutein we already learned about helps with vision and to prevent cancer. The phytochemicals in these foods tell the body to create enzymes (proteins that speed up chemical reactions) that will break down and get rid of cancer-causing agents in the body.[21] Examples of green foods are bok choi cabbage, artichokes, green apples, kiwi, broccoli, asparagus, zucchini, romaine lettuce, green beans and green grapes. Some of these greens are also high in calcium which is important to the skeletal system.

While not a fruit or vegetable, green tea has been used in China for more than 5,000 years for ceremonial, meditative and medical reasons, among others. Green tea comes from the *Camellia sinensis* plant along with black tea and oolong tea. Nowadays, it has been tested on humans and has shown significant activity with respect to getting rid of genital warts, lowering anxiety, cholesterol levels and the risk for cancer or heart disease, reducing arthritis and asthma bouts, preventing the common cold, dental cavities and diabetes, increasing fertility and mental alertness, etc.[22] The relationship between green tea and some of these issues does remain inconclusive for now and further research is indeed needed. However, would it hurt to drink this yummy tea if you are at risk for what it is thought to help? Note: green tea is not recommended for children and infants.

Food Dyes

Highly processed and colorless foods have been dyed for hundreds of years to give them a more appealing look to consumers. Humans expect lemon-flavored candies to be yellow or strawberry-flavored ice cream to be pink. "Thanks to non-toxic food dyes, commercially produced meats have become redder, smoked sausages are an appetizing russet, and shrimps and prawns are a brighter pink than nature made them."[23] But food dyes have not always been carcinogen-free nor are there very many synthetic food dyes that are actually approved by the Food and Drug Administration.

Synthetic food dyes have been used since 1856 and rightfully questioned since the early 1900s. In fact, in the 1970s, Dr. Ben Feingold, pediatrician and allergist, linked these unnatural foods and dyes to hyperactivity (overactive, inattentive, impulsive, etc.) and abnormal behavior in people, mostly children. He affirmed that the effects of synthetic chemicals in foods are comparable to those of caffeine, nicotine and other drugs. He helped 70% of children diagnosed with hyperactivity just by eliminating preservatives such as BHT and BHA and certain synthetic colorants from their diets. His new diet plan was said to also help people suffering from migraines and asthma. Three synthetic food dyes were delisted shortly after Feingold's studies and were no longer permitted for use in the United States (Violet 1 in 1973 and Red 2 and Red 4 both in 1976). In another similar study that took place in Britain in 2007, hyperactivity was shown to increase in children just an hour after eating six different food dyes.[24]

The Food and Drug Act of 1906 banned the number of synthetic colorants that were allowed to be added to foods from 80 to seven and two more were later added in 1938 for certain foods such as oranges (see below). The 1906 law was enacted because certain metals were used in foods and were causing people to fall ill. Why were they used in the first place? Synthetic food dyes were thought to be superior over natural food dyes. They were able to provide a more intense color, were easier to add to foods and had a low cost associated with them.

Currently Approved Food Dyes in the United States

Blue 1 – Brilliant Blue
Blue 2 – Indigotine
Green 3 – Fast Green
Red 3 – Erythrosine
Red 40 – Allura Red
Yellow 5 – Tartrazine
Yellow 6 – Sunset Yellow

What is quite alarming still is that two of the food dyes that are "generally" considered safe in the United States are actually banned in the UK (Yellow 6 and Red 40). In fact, "some global companies now sell two versions of their products: a version without food dyes for the UK, and a version with food dyes found to cause hyperactivity for the U.S."[25] Besides hyperactivity, synthetic food dyes have been linked to other ailments such as asthma, irritability, sleep disturbances, violent behavior, tumors and genetic damage among others.[26] A complete list outlining the chronological history of synthetic food colorants in the United States, banned or currently in use, can be found in a wonderful chemistry book of food dyes.[27] A list of health concerns associated with currently approved food dyes is illustrated by the Institute for Agriculture and Trade Policy.[28]

There are many naturally occurring food dyes such as carotenoids, chlorophylls, anthocyanins, among others. Carotenoids are found to cause the natural red, orange and yellow colors in foods. For example, lycopene causes tomatoes to appear that bright red. Chlorophylls provide vegetables, fruits and leaves with that green look. Two types include a and b and provide bluish-green and yellow-green coloring respectively. Anthocyanins are found in the sap of plant cells and supply fruits and vegetables with their pink, violet, red and blue colors. Sources of this colorant would be black grapes, cranberry skins and pulp.[29] Another alternative to synthetic colorants, algae, is being tested in Japan. Cochineal and sea archil are also used in foods.[30] It is true there are problems associated with these natural food dyes: they are not as stable and do not hold up as well to light or heat as synthetic colorants. The instability of natural food dyes could cause the coloring to fade during processing or cooking of food. So the choice is faded food with no side effects or vibrant food with associated health risks. Hmmm…

Strategies

There are many strategies one could use while teaching about nutrition…and the color varieties involved. I will incorporate color within the discussions and notes about each organ system. This will give the students a brief, but powerful look at how color and

their diet are linked and why both are important in their everyday lives. They will be required to keep their color and nutrition information organized (see Figure 1 in the **Appendix**) and will be constantly reminded how this benefits the human body. My unit will also promote reading, research and the use of technology. Students will use graphic organizers to chart and organize relevant information. Math skills will be exercised while collecting, comparing, analyzing and graphing data. Students will sharpen their laboratory etiquette and develop their writing skills through professional laboratory reports. Creativity is of utmost importance throughout this unit. A culminating project and presentation will also be required. Towards the end of the unit, students will be assessed on the information learned including the following summary of which color groups positively affect which human body system:

Cells and Cancer – all color groups (and dark chocolate) benefit
Musculoskeletal System – yellow color group (and green tea) benefit this system
Digestive System – any fruit or vegetable with fiber will benefit this system
Respiratory System – green tea and iron-rich foods will benefit this system
Urinary System – blue/purple color group benefits this system
Nervous System – red, red/purple, blue/purple, green, yellow, orange color groups
Endocrine System – blue/purple color group (and green tea) benefits this system
Circulatory System – red, red/purple, white, orange (and dark chocolate)
Immune System – red, red/purple, yellow, orange color groups (and green tea)
Reproductive System – yellow color group (and green tea) benefit this system
Integumentary (skin, hair, nails) – red, red/purple, blue color groups benefit this system

Classroom Activities

Activity 1

During the lessons on the nervous system, there is a fantastic station activity I use each year on our senses. The students learn about tastes, smells, reflexes and vision as they rotate through twelve different stations. I will incorporate a more comprehensive tutorial on the eye (specifically the rods and cones) and how and why we see color according to what I have learned in my seminar. Students will label a diagram of the eye and examine different websites to see afterimages and try catching a ping pong ball with only one eye open. They will also investigate why colorblindness occurs. The students should realize that they would never be able to see the colors of their fruits and vegetables without this amazing organ and all its components.

Activity 2

Prior to starting this unit, students will participate in a laboratory activity investigating if the color of foods and drinks affects the perception of taste. Students will be asked to work in groups and create a set of procedures to test the idea that people expect a specific color to be a specific flavor (i.e. foods that are canary yellow should be lemon-flavored or strawberry flavors yield from pinkish-red foods).[31] After discussing the student-generated experiments, the groups will proceed with the planned activity. For the first part, students will test variously flavored, yet colorless, carbonated beverages and record their data (see Figure 2 in the **Appendix**). A double bar graph can ultimately be created to illustrate the data findings in the class. The second part of this activity will require students to distinguish the flavors of gelatin and analyze and graph their data (see Figure 3). The gelatin will be prepared in cubes with mismatched flavors and colors as follows:[32]

1. Mix 2 packets of unflavored gelatin in 50 milliliters of cold water.
2. Add 300 milliliters of hot water.
3. Immediately, stir in one-third a cup of sugar until both solutes are dissolved.
4. Divide the gelatin solution into five different containers marked as Sample A, B, C, D and E.
5. Stir in three drops of color and six drops of flavor extracts according to Figure 3 in the **Appendix**.
6. Allow the gelatin to coagulate in the containers. Then cut into enough cubes for each student to have one serving of each colored flavor.

Not only will this lesson get them to start thinking about the role of color in our diets (both negative and positive), but it will allow them to review the steps of the scientific method and practice laboratory reports that will be required in higher levels of science. Inquiry-based lessons are an excellent way to get students involved, keep them engaged, increase their responsibility and enhance their learning.

Activity 3

As a warm-up activity, I will draw and briefly review the spectrum of energy that the students should have learned in sixth grade. We already talk about ultraviolet and infrared radiations, as well as other parts of the electromagnetic spectrum, at the beginning of the year in the Earth's Atmosphere unit, so I will plot these on the spectrum as well as visible light. Instead of describing wavelengths in terms of nanometers, I will use the colors and ask the students to draw foods that fall into those categories. My goal with this task is to get them to review prior knowledge and comprehend the meaning of some powerful words by which one should live. When planning your meals, envision the color wheel.

Activity 4

When we end the dialogue on the organ systems, the students will complete a "show what you know" activity where they will match up each color group to several scrambled facts about it using information learned from a clever book on the history and origins of color.[33] It is a very detailed project that involves cutting out, pasting and organizing their information into a color wheel (see Figure 4 in the **Appendix**). It will take one class period and a night at home and will count as a test to assess what the students have learned throughout this unit. Of course, the goal with this activity is intended to direct the students to answer one very important question: Why is this color so important in nutrition? Figure 5 in the **Appendix** gives an example of part of a worksheet used for this activity. Boxes should be enlarged to make for easier cutting and pasting along the color wheel. All color groups should be included in this activity (only information for the red group is shown in Figure 5). Students will also need to find pictures of two fruits or vegetables per color group to paste and organize with their information.

Activity 5

Each student will choose from an array of fruits and vegetables by picking out of a hat. No two students in a class will have the same topic. This will be their topic for the rest of the nutrition unit. We will start this research with a fun activity using a subtractive dye mixing technique learned in seminar. I will model how to mix the appropriate proportions of red, yellow and blue dyes in small, plastic cups to make different colors, which will create a ten-color color wheel. Students will then be given the opportunity to create the color of their fruit or vegetable using this same technique. This will get them interested in their final unit project and allow them to practice hands-on laboratory skills with equipment such as a graduated cylinder. Students will then be able to find the exact color match (hue being actual color, value being how light or dark the color and chroma being how strong or weak the color) of their fruit or vegetable using a professional art book of color notation published by the late, great Albert Munsell (1858 – 1918).[34] Both measurements will be recorded in Figure 6 in the **Appendix**.

Activity 6

Students will get the opportunity to create frescoes from scratch on which they could paint their topic fruit or vegetable. Fresco means "fresh" so I thought it would be suitable to our lessons since we have been discussing the benefits of fresh fruits and vegetables. To prep for this activity, I will soak small tiles in water overnight. One can purchase 4-inch tiles from a home improvement store. Students will each get their own tile. Once removed from the water, students should delicately dry it prior to creating their fresco.

While it is still drying on its own, students should thoroughly (and with some muscle) mix equal amounts of pit lime (can be purchased from Kremer Pigments) and fine sand (also purchased from a home improvement store), about thirty milliliters of each. Once the mixture is of consistent texture, it can be applied to the unglazed side of the tile. The whole side of the tile should be covered with the lime putty. Spreading it to the edges, students should try to get it as flat and smooth as possible. Paper towels can be used to level the surface by gently pressing it on the lime putty and rubbing lightly.

Students can outline their design into the lime-puttied tile using a toothpick if they so wish. After the surface is allowed a few minutes to partially dry out, the painting can begin. Pigment paints lacking binder work best for this activity. I recommend the students use the whole tile for their painting instead of just one small area. Students should allow the surface to dry for an hour or so and then put their creations in a plastic zipper bag (propped open) which will allow the fresco to dry slowly to eliminate the possibility of cracking to occur.[35]

Activity 7

Students will be required to complete extensive research on their topic using the Internet and any literature our Media Center contains. Figure 6 in the **Appendix** will be used to help the students organize and simplify their research. The culminating project will be to create a bound book about their designated fruit or vegetable as outlined below. Adequate time will be allotted for the students to work in the Media Center, classroom, and at home on this project. They will be required to present their typed, bound books as well as their frescoes to the class.

Bound Book Requirements

Cover: title, picture, author
Page 1: phytochemicals and/or antioxidants found in this fruit or vegetable
Page 2: health benefits
Page 3: human body systems it benefits
Page 4: other fruits/vegetables included in this color group with colorful pictures
Page 5: healthy recipe containing topic fruit or vegetable[36]
Page 6: Munsell color notation, dye mixing measurements, complementary color
Page 7: fun facts about this color and/or fruit/vegetable[37]
Page 8: resources used

Activity 8

In an effort to expose the controversy of synthetic food colorings such as Red 40 or Yellow 6, we will briefly discuss why synthetic food dyes are used, the nine that are actually approved for use by the Food and Drug Administration in the United States, the health hazards linked to food dyes and the alternatives to using them. For example, a hybrid of purple corn, non-genetically modified, can produce natural red and yellow dyes. Students will complete a webquest in the Media Center using a pamphlet published by the Institute for Agriculture and Trade Policy in February of 2009[38] and other resources. Students will practice reading nutrition labels and identifying the food dyes used in different foods. I will also ask them to think of or investigate alternatives to that food or to that dye. Lastly, students will complete a chromatography activity using M&M®s (which are made with synthetic food colorants for the United States and with natural colorants for the UK).[39] The candy chromatography activity is outlined below in great detail. Students will ultimately conclude why natural is indeed better and realize there are many alternatives that do exist and perhaps will eat more whole foods.

I will introduce the lab activity to the students. Chromatography comes from the Greek work *chromos* meaning color and *graph*, meaning to write. It is a process used to separate parts of a mixture. Students will use paper chromatography to separate and identify the food colorants used in making M&M®'s. Did you know that synthetic food dyes are used in M&Ms made for the United States, but not for the UK?

Chromatography consists of two phases: the stationary phase (the chromatography paper) and the mobile phase (the solvent used). The stationary phase slows down the movement of some molecules in the mixture while the mobile phase helps other molecules of that same mixture progress up the paper. Different molecules are attracted to the different phases and this is how the substances are able to be separated. An aqueous solution of sodium chloride will be used as the solvent which will help the substances break free from each other during the mobile phase. After the substances separate, students will calculate the retention factor (RF) of the solute which is a comparison of how far the substance moves relative to how far the solvent moves. RF values are expressed in number form and are dependent on a number of factors including the thickness and how porous the paper is and what solvent is used, alcohol versus water for example. To calculate the RF value, students would take the distance the solute moved and divide it by the distance the solvent moved.

Materials Needed

- Lab sheet (see Figure 7 in the **Appendix**)
- Different color M&M®s for each lab group (and perhaps some extras for them to snack on while waiting for their substances to separate)
- 600-mL beaker
- 0.1% sodium chloride solution (NaCl)

- Kool-Aid® powders containing individual food dyes (red 3, red 40, yellow 5, yellow 6, blue 1, blue 2, green 3) mixed with water
- Plastic wrap
- 1 or 2 sheets of chromatography paper depending on the size of your paper (see Figure 8 in the **Appendix** for an example)
- Pencil
- Ruler
- Stapler

Procedures[40]

1. In order to remove (and use) the color from the candy shell, the color must be dissolved in water.
2. Place a red M&M® in 6 drops of water in a small plastic cup. While stirring the candy, it will start to turn white as the colorants dissolve.
3. Repeat the previous step for four more pieces of red candy, one at a time, in the same water.
4. Extract the color from other candy colors using a separate plastic cup for each repeating steps 2 and 3.
5. Holding the chromatography paper lengthwise, use a ruler and pencil to draw a line the whole width of the paper one centimeter from the bottom edge of the paper. NOTE: Pen should NOT be used because it might dissolve in the solvent and mess up the results of the experiment.
6. Beginning three centimeters from the left side of the paper, place a dot from the red M&M on the line. Label this spot in pencil using the key in Figures 7 and 8 in the **Appendix**.
7. Continue placing dots from the other candy colors in the same order as the other students (orange, yellow, green, brown, red 3, red 40, yellow 5, yellow 6, blue 1, blue 2, green 3) at least a quarter-inch apart on the line.
8. Without causing a crease, form a cylinder of the chromatography paper from the first colorant to the last colorant. The ends should meet, but not overlap. Staple the ends together at the top and bottom.
9. Pour the sodium chloride solution (twenty milliliters) into the beaker and place the paper cylinder in the beaker. The paper should be placed in the beaker carefully and with the colored dots on the bottom. **NOTE: The colored dots need to be above the liquid level to be sure the colors will travel up the paper properly.
10. Cover the beaker tightly with plastic wrap.
11. Remove the chromatography paper after about fifteen minutes or when the solvent (the NaCl) is about one centimeter from the top of the chromatography paper.
12. Carefully take out the staples and lay the paper on a flat, clean surface.
13. Immediately, mark the location of where the solvent stopped (known as the solvent front) by drawing a straight line across the paper with a pencil.
14. Also mark the top and bottom of each color band with a pencil.

15. To figure out how far the solvent moved, measure the distance from its starting line to its solvent front. Record this measurement in the data table (see Figure 7 in the **Appendix**).
16. Now, measure the distances from the starting line to about the middle of each band of color for each sample. This will give a fairly accurate value of how far each color traveled up the chromatography paper. Record this data in the table (see Figure 7 in the **Appendix**).
17. Calculate and record the RF values for each color (see Figure 7 in the **Appendix**).

Analysis and Conclusion

Students will complete an analysis upon the completion of the chromatography process. The following questions will need be contemplated and answered.

1. List the seven synthetic food dyes that are currently approved for use in the United States by their common names.
2. Why are synthetic colorants preferred over natural colorants in the food and cosmetic industry?
3. What are the health hazards associated with synthetic food dyes such as Red-40 for example?
4. List some alternatives to each synthetic food colorant.
5. What does RF measure?
6. How did the RF values compare in each candy color?
7. Which candies appeared to be made up of a single food dye? How do you know?
8. Which candies appeared to be made up of several colored dyes? How do you know?
9. Which candy color contains Yellow 5? Yellow 6?
10. Which candy color contains Red 3? Red 40?
11. Which candy color contains Blue 1? Blue 2?
12. Which candy color contains Green 3?

Activity 9

Lastly, we will celebrate the conclusion of the unit and all that we have learned with a rainbow picnic finale. I will ask that each student bring in his or her topic fruit or vegetable so that they can be organized into a color wheel and photographed. While presenting their bound books and frescoes to the class, the students can snack on the different fruits and vegetables.

Appendix

Figure 1 - The phytochemicals and antioxidants found in different colored fruits and vegetables and their health benefits on the human body.

Phytochemical or Antioxidant	Vegetable or Fruit Color Group	Health Benefits	Organ System(s) That Benefit	Food Examples
Allicin				
Selenium				
Flavonoids				
Lycopene				
Carotenoids				
Anthocyanins				
Phenolics				
Vitamin C				
Bioflavonoids				
Lutein				
Vitamin A				
Zeaxanthin				
Retinol				
Saponins				

Figure 2 - How does color help identify flavors?

Sample	Perceived Taste	Real Flavor (given later)	Class Data: # Wrong	Class Data: # Right
A		Raspberry		
B		Lemon		
C		Orange		
D		Cherry		
E		Cola		

Figure 3 - Color Cues and Flavors

Sample	Gelatin Color	Real Flavor (given later)	Perceived Taste	Class Data: # Wrong	Class Data: # Right
A	Red	Lemon			
B	Orange	Mint			
C	Yellow	Cherry			
D	Green	Chocolate			
E	Blue	Vanilla			

Figure 4 - Color Wheel Template

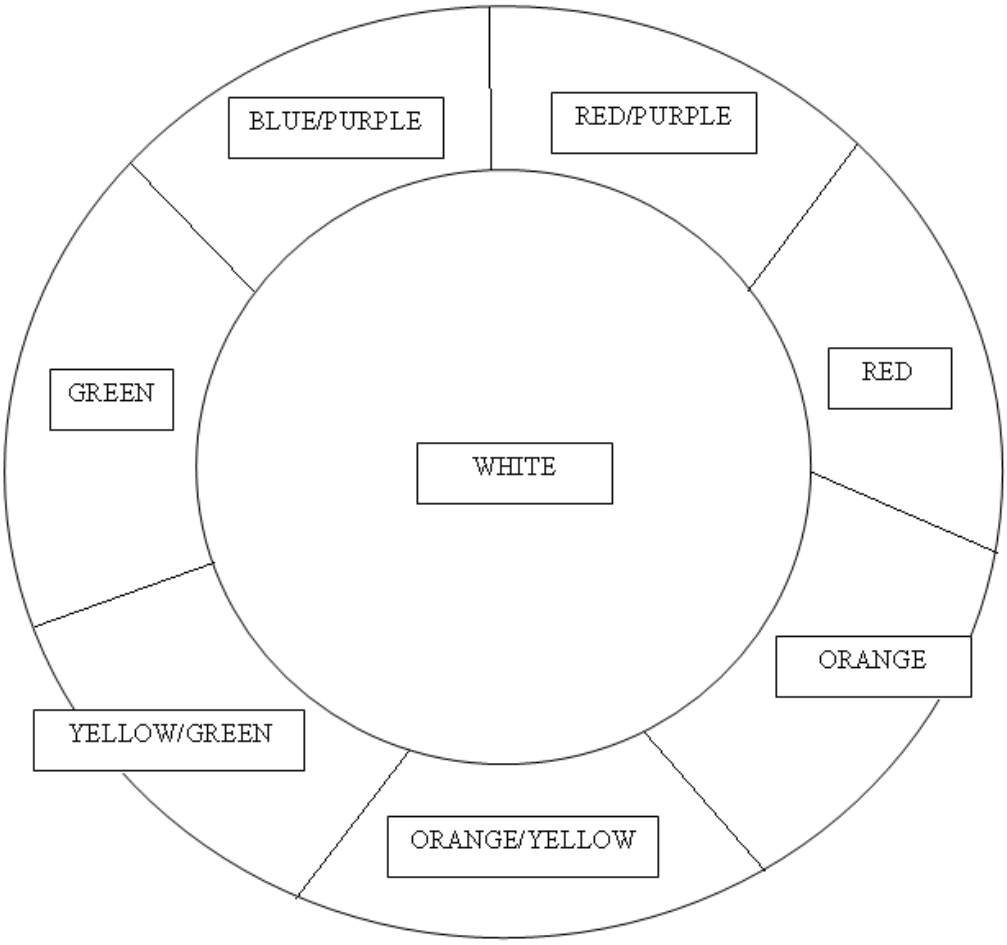


Figure 5 – Matching Activity (only one color group shown below)

RED

healthy heart, helps vision, reduce cancer risks, increase immunity

Lycopene
Anthocyanins

strawberries
tomatoes
cherries
pomegranates

Female cochineal beetles harvested since 1500s to make red dye

Figure 6 - A research and data log to help the students keep their information organized for their final project.

Topic: _____

Subtractive Dye Mixing Measurements

_____ ml of blue dye _____ ml of yellow dye _____ ml of red dye

Albert Munsell Color Notation

Hue _____ Value _____ Chroma _____

Energy/light facts:

Complementary color _____

Complementary fruits:

Phytochemicals/Antioxidants Present Health Benefits (include Body System)

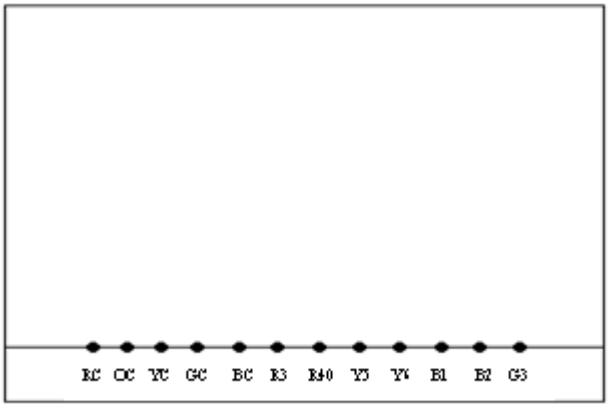
Other fruits and vegetables included in this color group:

Healthy recipe for _____
must include your fruit or vegetable

Figure 7 - Candy Chromatography Data Table

Colorant	Label Key	Solute Distance	Solvent Distance	RF
Red candy	RC			
Orange Candy	OC			
Yellow Candy	YC			
Green Candy	GC			
Brown Candy	BC			
Red 3	R3			
Red 40	R40			
Yellow 5	Y5			
Yellow 6	Y6			
Blue 1	B1			
Blue 2	B2			
Green 3	G3			

Figure 8 – Sample Chromatography Paper



North Carolina Standard Course of Study

Below is a list of the Seventh Grade Science objectives that will be met throughout this unit.

Competency Goal 1: The learner will design and conduct investigations to demonstrate an understanding of scientific inquiry

1. Identify and create questions and hypotheses that can be answered through scientific investigations.

1.02 Develop appropriate experimental procedures for given questions and student generated questions.

1.03 Apply safety procedures in the laboratory and in field studies to recognize potential hazards, manipulate materials and equipment and conduct appropriate procedures.

1.04 Analyze variables in scientific investigations, how they are manipulated and the relationships between them (dependent, independent, control).

1.05 Analyze evidence to explain observations, make inferences and predictions and develop the relationship between evidence and explanation.\

1.06 Use mathematics to gather, organize, and present quantitative data resulting from scientific investigations (measurement, analysis of data, graphing, etc.).

1.09 Use technologies and information systems to research, gather and analyze data, visualize data and disseminate findings to others.

1.10 Analyze and evaluate information from a scientifically literate viewpoint by reading, hearing, and/or viewing scientific text, articles and events in the popular press.

Competency Goal 4: The learner will conduct investigations, use models, simulations, and appropriate technologies and information systems to build an understanding of the complementary nature of the human body system.

4.01 Analyze how human body systems interact to provide for the needs of the human organism (musculoskeletal, cardiovascular, endocrine and nervous, digestive and circulatory, excretory, reproductive, respiratory, immune, integumentary)

4.02 Describe how systems within the human body are defined by the functions it performs.

4.04 Evaluate how systems in the human body help regulate the internal environment.

4.05 Analyze how an imbalance in homeostasis may result from a disruption in any human system.

4.07 Explain the effects of environmental influences on human embryo development and human health including smoking, alcohol, drugs and diet.

4.08 Explain how understanding human body systems can help make informed decisions regarding health.

Bibliography

Brody, Jane E. "The Color of Nutrition: Fruits and Vegetables." The New York Times. http://www.nytimes.com/2002/05/14/health/personal-health-the-color-of-nutrition-fruits-and-vegetables.html (accessed September 19, 2009). An online news article describing the colors of nutrition.

Brennan, Georgeanne and Dana Jacobi and Annabel Langbein. *Williams-Sonoma Eating by Color for Maximum Health*. Oxmoor House, 2007. A cookbook featuring healthy and colorful recipes.

Cleland, T. M. "Munsell Color Chart Explained." The Munsell Color System. http://www.applepainter.com/Forward/ (accessed October 14, 2009). An online pamphlet describing the Munsell Color System.

DeNoon, Daniel J. "Dark Chocolate Is Healthy Chocolate." WebMD. http://www.webmd.com/diet/news/20030827/dark-chocolate-is-healthy-chocolate (accessed October 13, 2009). An online health article detailing the health benefits of dark chocolate.

Delamare, Francois, and Bernard Guinea. *Colors: The Story of Dyes and Pigments*. New York: Harry N. Abrams, 2000. A fascinating look at the history of colorful dyes and pigments.

Duyff, Roberta Larson. *The American Dietetic Association's Complete Food and Nutrition Guide*. Hoboken: John Wiley & Sons, 2007. The latest healthy eating guidelines and strategies to maintain good health.

Epp, Diane N.. *The Chemistry of Food Dyes: Palette of Monograph Series*. Middletown: Terrific Science Press, 2000. A resourceful activity and information book for both teachers and students that presents the history and chemistry of natural and synthetic food dyes.

Finlay, Victoria. *Color: A Natural History of the Palette*. New York: Random House Trade Paperbacks, 2002. A clever look at the history and origin of color.

"Green tea (Camellia sinensis)." Mayo Clinic. http://www.mayoclinic.com/health/green-tea/NS_patient-green_tea (accessed October 15, 2009). An online monograph detailing the background and history of green tea.

Heber, David. *What Color Is Your Diet?*. New York: Collins, 2001. Heber's book aims to teach us how eating healthier foods, specifically colorful plant foods, will protect our genes and help us to live a longer life.

Oliver, Cindy S. *Nutraceuticals, Phytochemicals, and Antioxidants - What Are They All About?*. Ohioline. http://ohioline.osu.edu/ss-fact/0210.html (accessed August 22, 2009). An online article outlining important definitions and facts for this unit.

"Phytochemicals." Phytochemicals. http://www.phytochemicals.info (accessed May 2, 2009). An online article defining phytochemicals, describing where they come from, how they work and what the future holds with regards to phytochemicals.

Rossotti, Hazel. *Colour: Why the World Isn't Grey*. Princeton: Princeton University Press, 1985. A highly scientific look at most aspects of color.

Sachs, Andrea. "Color-Coded Nutrition - TIME." Breaking News, Analysis, Politics, Blogs, News Photos, Video, Tech Reviews - TIME.com. http://www.time.com/time/magazine/article/0,9171,1000331,00.html (accessed August 1, 2009). An online news article detailing the importance of choosing foods based on color.

"Smart Guide to Food Dyes: Buying Foods That Can Help Learning." Institute for Agriculture and Trade Policy. http://www.healthyschools.org/documents/food_dyes-CEH_2-09.pdf (accessed October 19, 2009). An educational pamphlet about buying foods that can help with learning.

---

[1]**Notes**

Andrea Sachs, "Color-Coded Nutrition - TIME." Breaking News, Analysis, Politics, Blogs, News Photos, Video, Tech Reviews - TIME.com. http://www.time.com/time/magazine/article/0,9171,1000331,00.html (accessed August 1, 2009).

[2]Jane E. Brody, "The Color of Nutrition: Fruits and Vegetables." The New York Times. http://www.nytimes.com/2002/05/14/health/personal-health-the-color-of-nutrition-fruits-and-vegetables.html (accessed September 19, 2009).

[3]David Heber, *What Color Is Your Diet?*. (New York: Collins, 2001), 3.

[4]Ibid., xiii.

[5]Ibid., 9.

[6]Hazel Rossotti, *Colour: Why the World Isn't Grey*. (Princeton: Princeton University Press, 1985), 19.

[7]Heber, *What Color Is Your Diet?*, 16.

[8]Rossotti, *Colour: Why the World Isn't Grey*, 85.

[9]Ibid., 88, 89.

[10]Heber, *What Color Is Your Diet?*, 19.

[11]"Nutraceuticals, Phytochemicals, and Antioxidants - What Are They All About?." Ohioline. http://ohioline.osu.edu/ss-fact/0210.html (accessed August 22, 2009).

[12]"Phytochemicals." Phytochemicals. http://www.phytochemicals.info (accessed May 2, 2009).

[13]"Nutraceuticals, Phytochemicals, and Antioxidants - What Are They All About?."

[14]Daniel J. DeNoon, "Dark Chocolate is Healthy Chocolate." *WebMD Health News*. (WebMD, Inc., August 27, 2003), http://www.webmd.com/diet/news/20030827/dark-chocolate-is-healthy-chocolate.

[15]Heber, *What Color Is Your Diet?*, 16.

[16]Roberta Larson Duyff, *The American Dietetic Association's Complete Food and Nutrition Guide*. (Hoboken: John Wiley & Sons, 2007), 309.

[17]

Heber, *What Color Is Your Diet?*, 16.

[18]Ibid., 17.

[19]Duyff, *The American Dietetic Association's Complete Food and Nutrition Guide*, 309.

[20]

Heber, *What Color Is Your Diet?*, 18.

[21]Ibid., 18.

[22]"Green tea (Camellia sinensis)." *MayoClinic.com*. (Natural Standard® Patient Monograph, 2009), http://www.mayoclinic.com/health/green-tea/NS_patient-green_tea.

[23]

Francois Delamare and Bernard Guinea, *Colors: The Story of Dyes and Pigments* (New York, Abrams, 2000), 124.

[24]

"Smart Guide to Food Dyes: Buying Foods That Can Help Learning." (Minnesota, Institute for Agriculture and Trade Policy, February 2009). http://www.healthyschools.org/documents/food_dyes-CEH_2-09.pdf., 1.

[25]

Ibid., 1.

[26]Ibid., 4.

[27]Diane N. Epp, *The Chemistry of Food Dyes: Palette of Monograph Series*. (Middletown: Terrific Science Press, 2000), 32.

[28]*Smart Guide to Food Dyes: Buying Foods That Can Help Learning*, 4.

[29]Epp, *Palette of Color Monograph Series: The Chemistry of Food Dyes*, 7.

[30]Delamare and Guinea, *Colors: The Story of Dyes and Pigments*, 124.

[31]Epp, *Palette of Color Monograph Series: The Chemistry of Food Dyes*, 29.

[32]Ibid., 30.

[33]Victoria Finlay, *Color: A Natural History of the Palette*. (New York: Random House Trade Paperbacks, 2002).

[34]"Munsell Color Chart Explained" Applepainter.com 1996 – 2000 Chapters http://www.applepainter.com, forward.

[35]This procedure was learned in the Charlotte Teacher's Institute seminar on Color as taught by Ruth Beeston.

[36]Georgeanne Brennan and Dana Jacobi and Annabel Langbein, *Williams-Sonoma Eating by Color for Maximum Health*. (Oxmoor House, 2007).

[37]Finlay, *Color: A Natural History of the Palette*, all.

[38]*Smart Guide to Food Dyes: Buying Foods That Can Help Learning*, 1-4.

[39]Epp, *Palette of Color Monograph Series: The Chemistry of Food Dyes*, 50.

[40]Ibid., 46.