



Effects of Carcinogens on Cells

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Content Objectives

Introduction

A sixth grade girl is walking home from school on a Friday afternoon. It is very hot and the sun is shining brightly. She is not wearing sunscreen. No one has ever explained to her the harmful affects of the sun. As she walks she comes upon a fruit stand and decides she would like an apple for a snack. She pays the vendor and munches on her apple. This apple has been grown with chemical pesticides and fertilizers. These chemicals pose a potential cancer risk. As she continues down the street towards her house she passes an apartment building. There is a group of three men and a woman sitting on the steps outside smoking cigarettes. The girl attempts to hold her breath as she walks by. She knows that cigarettes are not good for her and does not like the way the smoke smells. Eventually she arrives home and opens the door to find her uncle sitting in a chair sipping the first of his afternoon cocktails. She wonders why he drinks alcohol so much and if it does something more to his body than just affect how he behaves.

This scenario depicts the daily exposure of carcinogens into our lives. It is something we don't have a lot of control over. However, there are some things we can do to limit these exposures. Our school is located in the Tulsa Public School District and is a Title 1 school. Many of my students live in poverty and could possibly have an experience like the one described. Ultimately, in my curriculum unit, my hope is to show the effects of these types of carcinogens on the cells in our bodies and demonstrate the biology of cancer.

Rationale

Why do I want my students to know how our cells change because of carcinogens? This unit will teach my students about carcinogens and cancer and develop their minds to make informed decisions that will ultimately give them and their future families a happier and healthier life. I want this unit to be meaningful and impacting. In giving them the information and guiding discovery through discussion, research of their own, observation and analyzing my hope is that the students will be able to see how a healthy cell becomes a cancer cell and how it spreads rapidly. Can this be prevented? I don't know. If it could, there would be a lot less incidences of cancer in our world. There are many factors that contribute to the creation of a cancer cell. I want my students to conclude that carcinogens imposed upon us by self exposure can contribute to the changing of healthy cells. Hopefully the students will learn to make informed decisions about eliminating

carcinogens from their lives whenever possible.

Although the theme of the unit is about the effects of carcinogens on cells, it is also intended to target other skills. Students will read and create graphs, engage in simulations of cell division, distinguish differences between normal cells and cancer cells and draw and label the major organelles of a normal cell. They will also be able to define what a carcinogen is. It is my hope that these skills will enhance understanding and give opportunity to make their own connections between carcinogens and the effects they have on the human body.

Content

What is a Carcinogen?

A carcinogen is a substance capable of causing cancer in living tissue. The word's English origin comes from carcinoma. According to Wikipedia carcinogens can be radioactive such as radiation from gamma rays, alpha particles or ultraviolet rays from the sun.¹ Other carcinogens can be chemicals such as tobacco smoke, some pesticides, alcohol or asbestos. The public generally has the notion that most carcinogens are synthetic chemicals. However, they are equally likely to show up in both natural and synthetic substances.

It can be hard to determine if a substance is carcinogenic because it is not ethical to expose humans to a suspected substance and see if cancer develops. Also, some carcinogens do not cause cancer all the time in every instance. There are many factors that can affect the carcinogen's cancer-causing potential. These factors might include how the person was exposed, amount and intensity of exposure and the person's genetic make up.² Sometimes when a cancer cluster is observed, a closer look to see if the cancers are caused by a common carcinogen is warranted. A cancer cluster is described by the US Centers for Disease Control and Prevention (CDC) and the National Cancer Institute as a "greater-than-expected number of cancer cases that occurs within a group of people in a defined geographic area over a period of time".³ Rarely an actual cause for the cancer cluster is determined but factors that could be linked to the increase in cases can be recognized.

Scientists do studies in the laboratory to determine if a substance is a carcinogen. They can look at cell cultures and expose lab animals to potential carcinogens and see if the animals develop cancer. According to the American Cancer Society many of the experiments expose lab animals to doses much higher than common human exposure.⁴ It is not always clear if the substance will cause cancer in a human just because it caused cancer in a lab animal. However, it is assumed for human safety that if a substance is carcinogenic in a lab animal it will also cause cancer in humans. It is also assumed that a decrease in exposure could possibly limit the risk of developing cancer.

The International Agency for Research on Cancer (IARC) has the job of identifying causes of cancer. Over the past 30 years they have evaluated over 900 potential carcinogens and have placed them into groups according to probability of causing cancer.⁵ Some recognizable carcinogens include radon, asbestos, hair dyes, smart meters in your home which give off radiation, cellular phone towers, antiperspirants, perfluorooctanoic acid which is in Teflon, talcum powder, fluoride in water, cosmetics, lead, recombinant bovine growth hormone, aspartame and pesticides. There are other national and international groups that have devised similar groupings of probable carcinogens.

A Look at the Word "cancer"

Cancer pronounced 'kansər is a noun. It is the disease caused by an uncontrolled division of abnormal cells in a part of the body. It can also be used to describe a malignant growth or tumor resulting from the division of abnormal cells. The word can also refer to a practice or phenomenon perceived to be evil or destructive and hard to contain or eradicate. Its origin is from the Old English word *cancer*. In Latin it means 'crab or creeping ulcer. It can be translated to the Greek word *karkinos*. It is said that these words have been used to name such tumors because the swollen veins around them resembled the limbs of a crab. Canker was the usual form until the 17th century when the term cancer began to be used.⁶

According to the National Cancer Institute, cancer is the name given to a collection of related diseases.⁷ In all types of cancer some of the body's cells begin to divide without stopping and spread into surrounding tissue. A description of how healthy cells become cancer cells is found in the subheading "*How do Carcinogens Affect Cells?*"

When you hear the word "cancer", what comes to mind? Is it a scary word for you? Approximately 13 million Americans have cancer and more than 1 million are diagnosed every year.⁸ You might think of someone you know who has lost a battle with cancer. You might experience a fear of being diagnosed with cancer. Maybe you have watched someone close to you get news that they have cancer. There's also the possibility you associate the word with a triumphant feeling of knowing someone who has battled cancer until it has gone into total remission. Remission is the happy news, for an individual diagnosed with cancer, that a treatment has been effective: according to all tests and scans there are no longer signs of cancer.

Cancer on the Map

No country in the world is safe from cancer. It is the world's leading cause of death. In 2014 the highest cancer rate for men and women together was found in Denmark with 338 people per 100,000 according to the International Agency for Research on Cancer. France came in second with 325 cases per 100,000. Australia had 323 cases per 100,000 and Belgium had 321 cases per 100,000. Closing the top five countries with the highest rates of cancer per 100,000 people was Norway with 318 cases. It is important for the purpose of this unit to mention that the United States came in sixth for the highest cancer rate worldwide at 318 cases per 100,000.⁹ This information reflects the relevance of the impact of cancer on our own country.

Cancer affects the health of humans and it also attacks the economy. According to a report on the economic costs of death authored by Dr. Rijo John and Dr. Hana Ross of the American Cancer Society, cancer causes the greatest economic impact from premature death and disability.¹⁰ Not including the direct cost of treating cancer, the economic impact worldwide in 2008 was \$895 billion. This would include prevention costs and the costs from premature death and disability. Interestingly, lung, colon/rectum and breast cancer are the top three cancers in terms of economic impact globally.¹¹ To assist in measuring the global burden of cancer they determined that 83 million years of "healthy life" were lost due to death or disability. Lung, stomach and liver cancers account for the highest numbers of healthy life years lost.¹²

To narrow the significance of cancer down to our own country, let's take a look at the top three causes of death in the United States. There are around 2.5 million registered deaths nationally each year. The top three causes account for about 50% of all deaths in our country. Heart disease, which accounts for 24% of national deaths is the leading cause. Cancer follows closely being responsible for 23% and chronic lower respiratory disease comes in third but only represents a small 6% of annual deaths in the United States.¹³

There are approximately 580,000 deaths each year in the United States because of cancer. More males than females die of cancer and it kills people at a rate of 185 per 100,000. Last year it was projected that about 1,600 people a day would die from cancer. Lung cancer gets credit for the majority of deaths caused by cancer in our country. Cancer costs the United States hundreds of billions of dollars annually just in medical costs.¹⁴

Risk Factors for Cancer

Informatively, the World Cancer Research Fund estimates that one-third of cancers in the United States are related to obesity, being overweight or poor nutrition.¹⁵ Therefore, these cancers are potentially preventable. Also, limiting tobacco use, sun exposure and alcohol intake along with seeking regular medical care can prevent cancer. Despite these risk factors, anyone can get cancer, even someone who takes good care of their health. Risk increases with age even though there are other contributing factors. Cancer has many possible causes because it is a complex group of diseases. The risks and carcinogens discussed here include genetics, cigarette smoking, radiation exposure of varying frequencies, lack of physical activity, alcohol consumption and chemical pesticides.

You may hear people say cancer is genetic or that it runs in their family. Sometimes it runs in the family due to certain risk factors that family members share, such as smoking or obesity. In a few cases there is an abnormal gene that is passed from generation to generation. The cancer itself is not inherited, just the abnormal gene that can cause a predisposition to cancer. Genes are pieces of DNA (deoxyribonucleic acid) that have instructions on them for how to make proteins that we need to live and also to keep our cells in balance. Genes control our physical features such as eye color, height and nose shape but they can also affect our chances of getting a certain disease, such as cancer. There are genes called tumor suppressor genes that slow down cell growth and tell cells when to die. Cells in our body often die in an orderly process called apoptosis: in many cases they are replaced by new cells that arise from cell division. When the tumor suppressor in a cell does not work the way it is supposed to, cells can grow out of control, which can lead to cancer. Only about 5% to 10% of all cancers result directly from gene defects inherited from a parent.¹⁶

"Cigarette smoking is the major single cause of cancer mortality in the United States" is the statement reported by Surgeon General in 1982. This statement is as true today as it was 33 years ago. One in 5 deaths in the United States are because of tobacco use. About 480,000 people will die each year because of tobacco use. To put this into perspective, smoking cigarettes kills more people in our country than alcohol, car accidents, suicide, AIDS, homicide and illegal drugs combined. Cigarette smoking is responsible for at least 30% of all cancer deaths. Some cancers caused from smoking include lung, larynx, oral cavity, nose and sinuses, esophagus, pancreas, bladder and the list goes on. Lung cancer is the leading cause of cancer deaths in both men and women in the United States. Smoking causes 87% of lung cancer deaths in men and 70% of lung cancer deaths in women. In our society, smoking is the most preventable cause of cancer because it is a behavior that people choose to do. In 2012 it was reported by the Center for Disease Control that 42 million Americans were cigarette smokers. This translates to about 1 in 5 people.¹⁷

Radiation surrounds us in the form of x-rays and lower energy waves such as radio waves. Sun and ultraviolet radiation exposure is another cause of cancer. These are rays that come directly from the sun or manmade sources such as tanning beds and welding torches. They fall in the middle between low energy and high energy. The energy from these rays can damage DNA in the cells, which can lead to cancer. The rays cannot typically penetrate deeply into the body so the cancer is usually formed on or within the skin. Two of the most common types of skin cancers are basal cell and squamous cell cancers. Melanoma is another more serious

type of skin cancer which is less common. Melanoma of the eye has also been linked to sun exposure. According to the American Cancer Society there have been studies on lip cancer but the research has not been definitive in determining a link to sun exposure. Interestingly, one study showed that the artificial rays produced in a tanning bed were more likely to cause mutations than natural ultraviolet rays from the sun. Skin cancer is the most common type of cancer and most skin cancers can be treated effectively if they are found early.¹⁸

High frequency radiation such as in the form of x-rays, radiation from radon or nuclear testing also cause cancer. Many studies have been done on people who have had high radiation exposure. Atomic bomb survivors, including people exposed during the Chernobyl nuclear accident, nuclear weapons testing, in which radioactive iodine was found in milk, uranium miners and people deliberately exposed to radiation for cancer treatment have been the subjects of these studies. In all of these cases cancer did develop in a range of 2 to as long as 15 years after exposure. However, it has been harder to measure the incidence of cancer in those who have had lower levels of radiation exposure.¹⁹

Research has shown that lack of physical activity and poor diet can increase your risk of cancer. One third of the approximately 580,000 deaths each year from cancer are linked to poor diet, being overweight, or physical inactivity. Excess body weight can increase cancer risks through a number of mechanisms such as its effect on the immune system and inflammation, levels of certain hormones such as estrogen and insulin, factors that regulate cell growth and proteins that influence how the body uses certain hormones. It is important to maintain a healthy weight for your age and height. To reduce cancer risks, most people need to keep their body mass index below 25.²⁰ It is also important to stay active. It can help improve hormone levels and the way your immune system works. The foods you eat affect everything about the way your body functions. That's why it is important to choose healthy foods. It is recommended to limit processed meat and red meat, eat 2 ½ cups of vegetables and fruits each day, choose whole grains instead of refined grains and limit alcohol intake.²¹

There are several ways alcohol can raise cancer risks. The American Cancer Society discusses alcohol use and cancer. In the mouth and throat alcohol can act as an irritant: damaged cells that are trying to repair themselves can incur DNA changes, which lead to cancer. In the colon and rectum, bacteria changes alcohol to a chemical which has been shown to cause cancer in lab animals. Alcohol also damages the liver and the cells must try to repair themselves just as in the mouth and throat. Alcohol can also act as a solvent to help the body absorb chemicals from cigarettes which doubly increases risk. It also inhibits the body's ability to absorb folate which is a vitamin the cells need to stay healthy. It increases estrogen production, which not only increases belly fat, but also is important in the growth of breast tissue which could affect the risk of breast cancer. It is the amount of alcohol that is consumed and not the type that causes the cancer risk. The American Cancer Society recommends men limit their alcohol consumption to 2 drinks a day and women consume only 1 drink. The difference is that women tend to break down alcohol more slowly than men.²²

Pesticides are chemicals used to kill living organisms. The Environmental Protection Agency (EPA) is the government body that controls and regulates pesticide use in the United States. Pesticides account for a small percentage of cancer incidences but many of them are labelled as carcinogenic. There are over 300 registered active ingredients in pesticides for food use. More than 100 of them have been classified as carcinogens. According to the EPA a pesticide is any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest. The active ingredient listed on the label is chemically and biologically active against a certain type of pest. Sometimes these active ingredients are cancer-causing.

Sometimes it's the contaminants and impurities of the pesticide that is the carcinogen. Metabolites are breakdown products that are formed when the pesticide mixes with air, water, soil or living organisms. Sometimes it's the metabolites of the product that are more hazardous than the actual pesticide. Pesticide products also contain inert ingredients which do not have to be labeled. Pesticide manufacturers use inert ingredients as a carrier or sticking agent and if they were listed their product could be duplicated and that would not be good for the manufacturer. The inert ingredients are often as toxic as the active ingredient.²³ So you can see, that the simple use of a pesticide might seem safe, but there are "hidden" carcinogens within many of them.

How do Carcinogens Affect Cells?

So what happens when these carcinogens enter your body? A healthy cell does not turn into a cancer cell overnight. Our body is always making new cells for a few different reasons. New cells allow our bodies to grow as well as allow the body to repair itself when cells are damaged. Also, cells wear out and need to be replaced. In order to understand the process of carcinogenesis, which is the formation of cancer, it is important to understand how cells reproduce.

In order to make new cells a cell has to go through a division process called mitosis. During this process the cell makes an exact copy of itself and divides in two. Before mitosis begins the cell must go through interphase in which it makes a copy of all its DNA. There are four stages of mitosis. The first stage is prophase in which the DNA condenses into compact structures called chromosomes. The nuclear envelope around the DNA begins to break down so the DNA can be accessed by the rest of the cell. Next is metaphase in which the chromosomes align in the center of the cell and organelles called centrioles move to the polar ends of the cell in preparation to project thin spindle fibers to connect to the center of the chromosomes. During anaphase the centrioles begin to pull each chromosome into two halves called sister chromatids. The chromatids are identical. Finally, in telophase, a nuclear membrane forms around the chromatids located on opposite ends of the cell and the spindle fibers disappear. During a process called cytokinesis the cell pinches off into two identical daughter cells which are exact copies of the parent cell before the DNA was duplicated during interphase.

The genetic material in the cell makes sure everything goes the way it's supposed to in regards to controlling cell growth, division and life span. However, when carcinogens are introduced in the body they can affect the genes and cause them to change in a bad way.²⁴ These mutations occur when the DNA makes a copy of itself before mitosis. Therefore, the new cell that has been replicated also has a mutation in its DNA. A cancer cell is born. Cancer cells don't get the right message from genes to stop growing or die and therefore they grow uncontrollably and divide too often.

Cancer cells can live forever. In normal cells the ends of the chromosomes become shorter whenever the cell divides. The cell dies when the chromosomes are worn down. Cancer cells retain their long chromosomes by continually adding bits back on.²⁵ This is what allows the cancer cells to live forever. They continue to reproduce and grow forming lumps called tumors. The tumors can damage the tissue that surrounds it. Sometimes cancer cells from the tumor break off and are carried by the blood stream to other parts of the body. That is how the cancer spreads which means it has metastasized.²⁶

Decreasing Risk: What Can We Do?

Nobody is exempt from the possibility of cancer. There are so many potential carcinogens in our environment.

We expose ourselves without even knowing it most times. The best thing a person can do to decrease risk is be informed about potential carcinogens and eliminate them as much as possible whenever possible. Also, living a healthy lifestyle in regards to eating habits and exercise has potential to decrease risk.

Teaching Strategies

For the presentation of this unit I plan to incorporate a number of strategies targeted specifically at teaching 12 year olds. I will teach to their developmental needs. At this age the students need opportunities for self-definition, physical activity, creative expression, structure and limits and meaningful participation. It is through the activities described in the next section that these needs will be met.

I will also take the approach of treating any struggles the students might have as a strength. Students at this age want to be accepted and are afraid sometimes of being embarrassed in front of their peers. I plan to do this by asking questions of them that even I do not know the answer to and demonstrate how to find answers to these questions. I'd like the students to understand and feel comfortable not knowing the answers to questions in front of their peers, but to demonstrate strength in knowing how to find the answer.

I will use a differentiated learning approach for students at different levels and give formative feedback so that students can self-reflect on what they have learned and the projects and activities they have completed.

Classroom Activities

Each of the following activities can be adapted to make them differentiated depending on your teaching environment or group of students. Students can work independently or in groups. They can do reading lessons as a listening activity or oral reading activity.

Introduction Activity: Make it “Good” Paragraph

The teacher will read aloud the introductory scenario presented at the beginning of this unit. In small groups of 4-6, the students will create a list of the facts presented in the scenario. What is this scenario about? The students will make inferences and draw conclusions to answer this question. After a brief discussion about what is “bad” about the things happening in the scenario, the students will rewrite the scenario incorporating new details to make it “good”.

Making Connections: Word Study for Cancer

Either through discussion or writing the students will brainstorm all they know about the word cancer. What comes to mind when you hear the word? Is it scary? Are there any positive feelings associated with the word? Do you have any personal experiences with the word? Do you have any questions about the word? The phonetics and syllables of the word will be displayed along with its Old English, Latin and Greek origins.

Classification Game: Carcinogen or Not?

The International Agency for Research on Cancer (IARC) has devised a list of carcinogens that have been tested. They have created a classification system below. Students will be given a list of substances and will put them into the correct category. They may work with a partner or group and use whatever resources they can to gather information about these substances. After sufficient work time, we will go over the answers and have a discussion about our discoveries from this activity.

(See monographs.iarc.fr/ENG/Classification/ for a complete list of potential carcinogens and their classification.)

Group 1: Carcinogenic to humans

Group 2A: Probably carcinogenic to humans

Group 2B: Possibly carcinogenic to humans

Group 3: Unclassifiable as to carcinogenicity in humans

Group 4: Probably not carcinogenic to humans

Formaldehyde (found in shampoos, cosmetics, permanent press fabrics and plywood)

Styrene (styrofoam)

Phenobarbital (epilepsy medicine)

Mitomycin C (prescription drug used to treat some cancers)

Perfluorooctanoic acid (non stick pans and inside of microwave popcorn bag)

Carrageenan (dairy foods)

HC Blue No. 2 (color)

Talc-based body powder (baby powder)

Vitamin K (vegetables, hot spices and olive oil)

Radon (a gas formed from the breakdown of uranium-found in igneous rock and sometimes well water)

Polyurethane foams (packaging foam)

Coal-tar (used in parking lots, dandruff shampoo and psoriasis medicine)

Crude oil (gasoline, nail polish, shoes, umbrellas, soap, deodorant and many others)

Hydrogen Peroxide (disinfectant and whitener)

Plutonium (bombs)

Nickel (metal)

Mercury (lightbulbs, thermometers, batteries, paint)

Lead (candy, toys, medicine)

Citris Red No. 2 (color in soda and other things)

Diazinon (bug and weed killer)

Benzidine (dyes in leather, textile and paper)

Caffeine (coffee)

Bisphenol-A (BPA in canned foods)

Aspartame (sugar free drinks and food, diet sodas)

Graphing: Global Cancer Rates

Students will divide into groups of 4-6. They will research the top five countries across the globe with the highest cancer rates. Using the data collected they will create a graph of their choice to demonstrate the information. A brief group presentation will be required. Following the presentations will be a discussion and drawing conclusions about the possible links for the areas with the highest cancer rates.

Create a Booklet: Cell Structure

Students will create an 8- page booklet to help them learn and review cell structures. The activities in the booklet will include the following:

A cut and paste activity to match the structure and function to the cell name

Label the structures of a plant cell diagram

Label the structures of an animal cell diagram

Review structures and functions by completing a crossword puzzle

Complete a Venn diagram showing differences/similarities of plant and animal cells.

Create a drawing of a cancer cell with unusual features.

Movement: Cell Simulation (Mitosis)

Students will play a game in which they act out each phase of a cell's life. The students will act out interphase, prophase, metaphase, anaphase, telophase and cytokinesis. The goal is for students to be able to act out the stages of mitosis with their group members as fast as possible. Split the class into two or three teams equally. Two group members will be picked to be centrioles. Everyone else in the group will be a chromosome. Half of the group will be original chromosomes and the other half will be duplicated. For interphase the original chromosomes will stand in the middle of the play area and copy themselves by bringing in someone that has the role of the copied chromosome. Now there are two chromosomes in the middle. For prophase the two

centrioles will come in and stand in the empty space. During metaphase the chromosomes line up down the middle of the area and imaginary spindles are attached to the centrioles. The centrioles will be at opposite ends of the area. In anaphase the centrioles will pull the chromosomes apart and the chromosomes will move toward the closest centriole. The chromosomes will then form a huddle to represent the nucleus that is forming in telophase. Finally, for cytokinesis, the chromosomes start to walk away in their huddle to represent the two daughter cells that have formed.

As an extension to this activity, students will introduce a carcinogen during interphase. The students will have the freedom to discuss, predict, plan and act out what they think will happen when this occurs. Their demonstration of the birth of a cancer cell will show their understanding of the concepts introduced.

Extension Activity: Dirty Dozen

This activity is more of an eye opener than anything else and students also love when they get a chance to eat food in class. The activity will begin with a presentation of strawberries, apples, cherry tomatoes and celery. Each student will get a conventional and an organic piece of fruit or vegetable and we will taste them together and discuss what we thought about the taste differences. Do not tell them which is organic and which is conventional until after they had a chance to predict it themselves. After the short taste test activity present the following information so students can be informed about some of the food choices they make and the possibility of decreasing carcinogen exposure through diet. Eating healthy fresh fruits and vegetables are a vital part of being healthy. It is reported by the Dietary Guidelines Advisory Committee, a panel at the U.S. government's Office of Disease Prevention and Health Promotion, that high levels of fruit and vegetable consumption are strongly associated with a decreased risk of many diseases including cancer.²⁷ However, it has been determined that many pesticides in the produce increase cancer risks.

Take a look at this scenario. You are hungry and decide to eat a ripe, crisp apple full of fiber, vitamins and minerals. Eating an apple should put nothing but good into your body. After all, an apple a day keeps the doctor away. However, the Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) conducted research to show high levels of chemicals and pesticides in commonly consumed foods, apples being one of them. Through their research they derived a list of "The Dirty Dozen-Contaminated Foods"²⁸

1. beef, pork, poultry (chemicals, antibiotics and hormones)
2. milk, cheese, butter (chemicals, antibiotics and hormones)
3. strawberries, raspberries, cherries
4. apples and pears
5. tomatoes
6. potatoes
7. spinach and other greens
8. coffee
9. peaches and nectarines
10. grapes
11. celery
12. red and green bell peppers

So that delicious and "healthy" apple you just consumed was sprayed with almost as many pesticides as strawberries which are the most heavily dosed crop in America. On average, 300 pounds of pesticide are

applied per acre of strawberries as compared to an average of only 25 pounds per acre for other food. Thirty-six different pesticides were detected on apples during FDA testing. Some of these pesticides are against the law to use in the United States but are produced in the United States and exported to other countries who grow food that we import.²⁹ Now that makes a lot of sense (sarcastic tone implied). Also, peeling the apple reduces, but does not eliminate, the danger of ingesting these chemicals. Undoubtedly, there is no question that Americans generally consume hazardous pesticides when eating fruits and vegetables.

Reflection: Connecting Learning

This will serve as assessment for the unit. Students are to complete two parts. During the first part students will write everything they learned about cell organelles, cell division and the introduction of carcinogens and the affects they have on healthy cells. They will also include any information gathered about carcinogens and cancer rates around the world. The second part of the reflection is where the students get the opportunity to take what they have learned and make it meaningful in their own lives. The students are to articulate through writing the things they can do to reduce carcinogen exposure in their lives and their family's lives. It is hoped that students will make informed decisions that will help them live happier and healthier.

Resources

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Appendix

This unit will address the Oklahoma Priority Academic Student Skills for sixth grade life science. Living systems at all levels of organization demonstrate the complementary nature of structure and function. The students will engage in investigations that integrate the process standards of discovery for a few different objectives: cells are the building blocks of all organisms, plant and animal cells have differences and similarities and living systems are organized by levels of complexity.

Notes

1. Carcinogen, July 23, 2015
2. How Do Researchers Determine if Something is a Carcinogen? July 23, 2015
3. Other Carcinogens, July 12, 2015
4. Ibid
5. How Do Researchers Determine if Something is a Carcinogen? July 23, 2015
6. Cancer, July 7, 2015
7. What is Cancer, July 7, 2015
8. Cancer Treatment Centers of America, What is Cancer? July 8, 2015
9. Data for Cancer Frequency by Country, July 8, 2015

10. John and Ross, 3
11. John and Ross, 4
12. John and Ross, 8
13. The Top 10 Leading Causes of Death, July 7, 2015
14. Top 10 Leading Causes of Death in More Detail, July 9, 2015
15. What Causes Cancer?, July 9, 2015
16. Genetics and Cancer, July 10, 2015
17. Tobacco and Cancer, July 10, 2015
18. Sun and UV Exposure, July 11, 2015
19. Radiation Exposure and Cancer Risk, July 11, 2015
20. Diet and Physical Activity, July 12, 2015
21. Ibid
22. Alcohol and Cancer, July 12, 2015
23. What is a Pesticide? July 12, 2015
24. Franks and Teich, 153
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