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# Recombinant DNA Technology and Global Health

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## Content Objectives

**Introduction**

The needs of 21st century learners have transformed modern education. As teachers, we are challenged with instructing students who experience life in a way that is unfamiliar to our generation's norms. Our students acquire information from various sources, especially from social media platforms. As educators, we must adapt our methodologies to meet their needs. This is a very challenging responsibility, but it helps us in our journeys as continuous learners.

As educators, the ability to adapt is one of the cornerstones of our profession. We eagerly embrace new ideas and techniques. Countless hours are spent in professional development meetings to improve our craft. We understand that change is necessary to meet the needs of our diverse body of students, and to help us grow as teachers. One of the main ideas from the seminar – how location affects our health – stirred my interest. How could I use this theme to show how people must adapt to meet their needs?

Changing to meet our needs is crucial for survival. Scientific innovations have eradicated diseases that were once fatal. Humans' innate ability to learn has served as a tool to improving our health. We see change as a catalyst to make our lives better. The constant need for it is an integral part of our lives. As a society, we are not satisfied with remaining stagnant. We eagerly await upgrades, updates, and revisions to products that we use. My students understand what improvements to technology mean in the classroom. I have used past and present examples to explain how classroom tools have changed from a green-screened computer to portable electronic devices. They have patiently waited for their computers to download new applications. We proudly showcase our electronics' abilities to make our lives easier. But how can we move from a self-centered view about technology to possible global benefits?

Our course readings during the seminar introduced me to the broad field of recombinant DNA technology. I had never heard the term before, but as I began to learn more about it, I realized how it was an integral part of our lives. Recombinant DNA (rDNA) technology involves the insertion of one or more individual genes from an organism into the DNA of another.[1] DNA serves as a blueprint for all living organisms, and it can be manipulated in controlled environments. In cases of rDNA technology, specialized enzymes are used in a cut and paste method to place desired genes into an organism. Restriction enzymes are used to cut DNA into gene-sized pieces, and the desired gene is found in the sequence. Ligase enzymes are used to bind the desired gene into the DNA of another organism.[2] As a result of this process, scientists have been able to make human proteins such as insulin and growth hormone in large quantities, by inserting the genes for these proteins into microorganisms. When produced in high quantities, the proteins can be used as drugs. This change in technology has resulted in benefits to our health. However, there is a controversial area of rDNA technology that is seen by some as a detriment to global health – genetically modified organisms.

Most people perceive genetically modified organisms as the product of mad scientists. We are used to receiving information from media sources, instead of sifting through articles to understand topics. There is a general resistance to the use of genetically modified organisms because of the negative slant broadcasted through websites, newspaper articles, and documentaries.  This technology is considered detrimental to our health. Many feel that it is being used to tamper with nature. However, it is important that educators are active learners, and take the time to consider the pros and cons of a subject.

I was not aware of the relationship between rDNA technology and genetically modified organisms (GMOs) until I read the course content for the seminar. This sparked my curiosity about how beneficial technology could receive such a negative slant. I realized my only understanding of GMOs was from social media. I was proud to support companies that banned the use of GMOs in their products. After all, GMOs were accused of being the underlying causes of so many diseases and health problems in America. However, after researching this topic in depth I realized there are potential benefits of GMOs. The negative attributes are not always as clear as presented by detractors. In fact, there are examples in which GMOs can be used to transform a population's health. Living in a developed nation often blinds us to the problems others' face in meeting their basic needs.

As a developed nation, we are accustomed to conveniences. Feeling sleepy? Here is a solution! Unable to concentrate for sustained periods? Try this supplement! We are able to correct our deficiencies quickly, and we have an abundance of dietary options. However, conveniences and options are not common in all global regions. My unit will focus on the use of technology to offset balances in certain regions.

**Rationale**

The theme of adaptability is relevant to the students in my school. I am a third grade teacher in a predominantly Latino school. My school district, Richmond Public Schools, is composed of mostly African American students. However, my school is nestled in an area of the city that has been transformed in recent years. The threat of violence in Central America influenced many students' families to leave Guatemala, Honduras, San Salvador, El Salvador, and Mexico. Our school body is eighty-one percent Latino. We have the largest population of English Language Learners (ELLs) in the metropolitan Richmond area. Grappling with the nuances of a new language is challenging, yet our students also face a multitude of environmental issues as well. They serve as translators for their parents, while completing schoolwork without help at home. They are guides for non- English speaking students in the classroom. Many share their living spaces with several other families. Observing their ability to adapt to meet their basic needs has inspired me to adjust my delivery approach.

My students' experiences affected my perspective on how humans survive when facing critical circumstances – by adaptation. My students' parents adapted to the changing climate in Central America by migrating to another region. Similarly, biomedical engineers have adapted to the disparities in food sources for developing countries by using recombinant DNA technology. Researching the impact of the "Golden Rice" experiment served as a springboard for my unit. My unit will identify the physiological needs for nutrients in the world, and how 21st century learners can use the ideas of communication, collaboration, and creativity to address global issues.

My students are aware of the impact of location. Many of them have related to me the differences in their Richmond neighborhoods versus the threats they experienced in Central America. They understand that their parents migrated to improve their lives. I want to build on their understanding about geographical differences, and how location can affect a population's health. I want them to explore science's use of technology to solve global issues.  The challenge I face is common to many educators. Connecting new ideas to a prescribed list of objectives is challenging. However, with the application of the principle of adaptation, it is possible.

The state of Virginia recently updated our Science Standards of Learning. Rigor and depth were added to the objectives. Students should be proficient in using their observational skills to draw conclusions. They are also required to formulate predictions from a variety of sources of information. We want them to apply the scientific method in lab experiments. This hands-on approach is used to introduce them to the importance of hypotheses. Their ability to analyze information and synthesize it to prior content is assessed through various forms. Like most teachers, I face the daunting task of creating lessons that are relevant and engaging while conforming to mandated guidelines. However, I feel that the seminar's content relates to our Science Standards of Learning.

I also want students to understand how this is a real world problem because of the global impact of vitamin deficient crops. We will discuss how nutrition is important in sustaining our health, and what happens when we do not get the vitamins and nutrients we need. During my initial research for this unit, I discovered multiple sources that identify vitamin A deficiencies in several countries. I will use text and web based sources to highlight the effects of these deficiencies, and how these deficiencies can affect a population's health.

While this unit is tailored for delivery in a primary classroom, modifications can be used for other grade levels. For example, a history teacher could use the content section as a basis for comparing and contrasting different viewpoints in society.  The articles listed in the notes and bibliography section use a variety of charts and graphs. These resources could serve as data for a math teacher to highlight cause and affect scenarios. A physical health instructor could use the lessons to connect to the need for well balanced diets, and how this has affected health in developed nations. Since the topic is relevant to so many societal concerns, it provides flexibility it how its content could be used.

I designed this unit from a primary teacher's perspective. The term, *physiological determinants*, seemed imposing to me at the beginning of the seminar. However, research has allowed me to form a connection. Physiological determinants can be used to describe our basic needs – food, shelter, water, and clothing. Most students at a primary level are aware how these determinants impact their lives. I want my students to understand that basic needs vary from location to location. This unit will focus on how technology can be used to make sure that all populations receive their basic needs.

This will lead to the application of the scientific method from Virginia's third grade curriculum. I will use the big question, "How can countries use DNA technology to help their crops?" This question will help students brainstorm possible hypotheses to address this issue. For example, how does the yearly weather pattern affect a region's soil?  What plant diseases are common in the region? What could be added to the soil or to the organism to fight terrestrial conditions or plant diseases? I want students to understand the differences between the variables that can be changed (soil conditions, altering a plant's resistance to diseases) versus variables that cannot be changed (physical location, weather conditions).

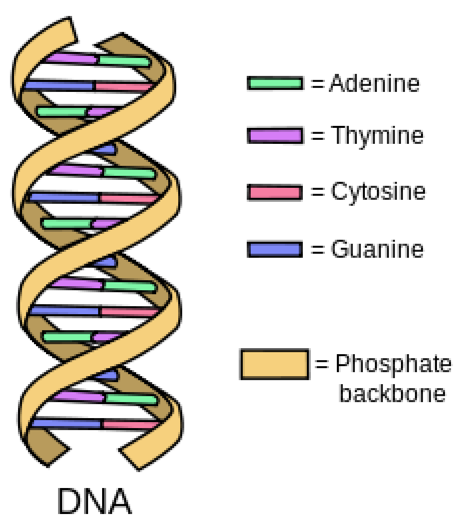
Connecting the world of biomedical engineering to a classroom of third graders is a daunting task. However, I plan to use a systemic and developmental approach blending the seminar's content with relatable lessons for my students. Cultivating interest in a topic is critical to the success of developing coursework for students. I think exploring the needs of regions they are familiar with will provide students with a topic that will fit their schemas.

## Curriculum Content

### The Role of DNA

Students understand that humans, plants, and animals are living organisms. I want my students to understand how living organisms have certain traits in common. Explaining how deoxyribonucleic acid (DNA) is used in technology is essential for this unit. DNA acts a blueprint, or model, for the construction of organisms. It has genetic information that controls how cells work. Encoded within this DNA are the directions for diverse traits. This blueprint determines traits such as the color of your eyes, the scent of a rose, or the way bacteria can infect our bodies.

These traits are determined by the sequence of nucleotides in DNA. Nucleotides serve as the building blocks for DNA. The nucleotides are made from a base (one of four chemicals: adenine, thymine, guanine, and cytosine) plus a molecule of sugar and one of phosphoric acid.[3] The ladder like structure of DNA is derived from these nucleotides. The sugar and phosphates join together to make the sides of the ladder, and the bases join together to make its' rungs. The pairings of the bases, to make the rungs on the ladder, are not random. Adenine is paired with thymine, and guanine is paired with cytosine (Figure 1). The specific sequence of these four nucleotides not only controls how an individual cell works, but it also controls the functions within an organism.




https://fr.m.wikipedia.org/wiki/Fichier:DNA_simple2.svg

Figure 1 Simple diagram of double-stranded DNA

Schematic diagram of double stranded DNA illustrating the structure and position of the nucleotides and phosphates.

The nucleotides' sequential pattern within a gene determines the order of amino acids in the protein specified by that gene. Amino acids are important because they serve as the building blocks for proteins. Organisms need proteins to carry out functions in cells and tissues. They are also responsible for an organism's characteristics.[4] Since DNA is a common blueprint among living organisms, scientists are able to transfer a gene from one species to another species, and that transferred gene can function within the new organism.

Understanding the basic structure of DNA has allowed scientists to manipulate its' sequences. Before a cell can reproduce, it has to replicate its DNA. The double helix structure can unzip down the middle. Each single strand of the unzipped helix can serve as a template for creating a new double-stranded DNA molecule.[5] Enzymes unzip the helix in a particular area, and unwind the structure to allow for replication. Proteins keep the rungs separated while another enzyme "walks" down the structure to make the pairings of adenine to thymine and guanine to cytosine. Once the new DNA is proofread, the fragments are sealed to form a new strand.

Through the use of rDNA technology, scientists can locate a desired gene in the DNA sequence of an organism, and extract it. Enzymes can be used to insert the desired gene into the DNA sequence of another organism. The host organism will display the manifestations of the desired gene. This technology allows plants to display traits from other organisms, such as a greater leaf area or different color.[5] The process can also allow scientists to extract an undesirable gene that could reduce an organism's survival rate. This unit will focus on the insertion of desirable genes instead of extraction.

One benefit of this technology is to meet the basic needs of humans. Through the use of rDNA technology, crops can be fortified to provide populations with their essential dietary needs. This is necessary because the physiological determinants of a population can be based on its' location.

### Regional Needs for GMO

Currently, over one billion people in the world are undernourished. The United Nations has projected the world's population to grow by more than two billion people by 2050.[6] As a result there will be a thirty percent increase in the world's population from six billion people to approximately nine billion. To address the needs of the rising population, better food is needed. Advocates of the use of GMO crops have voiced the need for local food production to increase in developing countries.  Convenience is factored into a population's ability to attain food. While most people in developing nations can easily find sources of food, some regions of the world are very dependent on local sources. As a result, areas in South Asia and sub-Saharan Africa, comprise a large percentage of the world's food insecure population.[7]

Localized crop growth is necessary for food insecure populations. There has been an urgent call for all global populations to have equal access to food. The *Golden Rice* Project is an example of rDNA technology being used to offset inequities in areas.[8] The project began as a possible method to combat Vitamin A Deficiency (VAD) Syndrome. The inventors of *Golden Rice* realized that inserting two desirable genes into rice could enhance the nutritional value of the crop. This discovery was important because the enhanced rice could relieve some of the symptoms of VAD Syndrome. The genetically modified rice would strengthen consumers' immune systems from diseases and infections.

When countries and companies used traditional methods for dietary supplements, only a fraction of people with dietary needs received support. Most populations with health deficits have little or no access to formal health care services. Also, some people prefer a monotonous diet, which makes it difficult to include supplements in food choices. Therefore, the rice used in the project allowed populations to keep their consumption preferences.

The *Golden Rice* project used GMOs, or bio fortified crops, to combat vitamin deficiencies in developing areas. The application of bio fortified crops in food insecure areas allowed people to have availability to desired food when they needed it. The project used rDNA technology to transfer carotenoids normally found in colored fruits, such as carrots and green vegetables, to rice endosperm. Carotenoids can be converted to vitamins, and they also act as antioxidants. They are vital to our health because they can increase our immunity to infection and diseases. It was necessary to insert them into rice because vitamin A is not naturally found in the edible part of rice. By transferring the desired trait into rice, this also provided the golden color for the rice. This example of rDNA technology has helped to solve dietary issues. Once eaten, the carotenoids in the bio-fortified rice can be stored in the fatty tissues of the body, or converted into vitamin A within the body. Therefore, one important role of GMO crops is its' ability to combat deficiencies, such as a deficiency in vitamin A.

**Deficiencies and GMO**

A possible contributory cause of vitamin deficiency is the inadequate intake of that vitamin. Customary eating habits of a region may result in an imbalanced diet. Rice, maize, and wheat are the staples of over four billion people.[9] The abundant use of these staples may be attributed to climate differences, dietary preferences, religious traditions, and regional customs. This leads to the need for better strains of these crops. GMO crops will provide superior nutrition than strains commonly used today.

Selecting desired genes to include in staple crops would improve the absorption of nutrients. Some rice grains contain phytic acid, which acts as a blocking agent during digestion. The acid prevents the body from absorbing iron in the rice. This could lead to the development of anemia, because iron is needed for blood cell production. Also, only the green parts of rice plants contain the precursor needed for vitamin A. Since some populations are dependent on these staple crops, many regions that rely on them have widespread cases of vitamin A and iron deficiencies.[10] Scientists have used rDNA technology to help regions combat crop related deficiencies.

This technology has been used to extract desired genes from green bean plants and specific microorganisms. The desired genes were placed in the DNA sequence of rice grain. The resulting genetically modified rice had double the iron content of conventional rice. Scientists have also used the transfer of desired genes to rice grains to promote the release of phytic acid during cooking. The release of phytic acid has allowed for greater absorption of iron, which can reduce deficiencies in populations.

Meeting daily requirements is necessary to reduce infections caused by vitamin deficiencies. Millions of pre-school age children suffer from vitamin A deficiency. In 2012 the World Health Organization reported that approximately two hundred fifty million children are affected by vitamin A deficiency. The vitamin is necessary in the operation of our immune system. It is also needed as protection for our mucous cell membranes. Due to the deficiency, millions are susceptible to irreversible blindness, infectious diseases, and suppression of skeletal growth. The International Journal of Epidemiology reported that the use of food fortification with vitamin A could make an impact on mortality. Clinical trials in South Asia and Africa suggested a link between bio-fortified foods and a reduction of pre-school age child mortality by twenty-five to thirty percent.[11] This is a significant reduction, since the World Health Organization estimates that vitamin A deficiency kills nearly seven hundred thousand children under the age of five each year.[12]

Genetic modification can also be used to infuse vitamins that are not naturally occurring in plants. For example, vitamin B12 is derived from animal sources. While the daily dietary intake for it is comparatively low, adults older than sixty years of age may experience a deficit. Due to an age related decline in production of the intrinsic factor, deficiencies may occur in senior populations. The intrinsic factor is a protein produced in the cells of our stomach. This protein is important because it transports vitamin B12 through our bodies. If the intrinsic factor is not present in the small intestine, it is difficult for vitamin B12 to travel through the intestines. Bacteria in the intestines can feed off of the vitamin before it can be dispersed throughout our bodies. Therefore, although a person may have an adequate intake of the vitamin, the absence of the intrinsic factor could result in a vitamin deficiency.[13] Vegetarians may also experience deficiencies due to their diet.[14] Deficits of the vitamin can result in nerve damage, such as numbness in hands and feet. A deficiency may also affect cognitive performance. The application of rDNA technology provided plants with the intrinsic factor protein. The desired gene was placed in the DNA sequence of Thale cress, which produced the protein. Therefore, the nutritional supplement of the crop would benefit different dietary needs.

Through the process of deliberating increasing the nutrient value of food, inequities in global health can be reduced. The use of locally grown GMO crops would allow populations to have convenient access to proper food sources. Regions that rely solely on staple crops would have adequate nutrients for their diet. The inclusion of vitamins in GMO crops could prevent deficiencies common in developing nations.

### The adaptability of GMO crops

Pests can also affect the growth of crops. Postharvest loss due to insects is accounts for fifteen percent of the global production.[15] Insects may become resistant to pesticides used in an area. This can result in farmers' frustration. Areas may use more potent chemicals to deal with pests. However, toxins in the soil can be found in food sources. This can be as detrimental to a region as vitamin deficiencies. The climate in tropical areas can provide a fertile environment for the growth of fungi and bacteria. For example, corn in some regions can be affected by poisonous fungi, which produce potential carcinogenic toxins.[16] The toxins, fumonisins and aflatoxins, may also be linked to spina bifida. GMO crops have helped farmers use plant variety protection to decrease the presence of these toxins.

Selecting desired genes have also helped to decrease pesticide use. In Honduras, worms destroyed crops. Genetically altered corn helped farmers adapt to their circumstances.[17] Instead of using sprays, a desired gene was taken from a worm killing bacteria. The gene was inserted into the DNA sequence of corn. This provided the corn with the resistance it needed against the pest. If a worm munches on the corn, it will die. The absence of chemicals also allowed for natural predators of the worm to survive. Farmers in developing lands may resort to using pesticides that are cheap, yet very toxic to the environment. The use of GMO crops could deter the use of harmful chemicals on food sources.

Future uses of GMO crops are constantly being updated. Plants that are susceptible to diseases would benefit from specific genes to boost their resistance levels. As primary staple crops such as corn and rice show nutritional and resistance improvement, other crops could receive altered genes. Eggplant is a staple crop in India, Bangladesh, and the Philippines. There is hope that rDNA technology can be used to make an insect resistant form of the vegetable. The United States uses insect resistant and pesticide tolerant corn. The use of transgenic corn has resulted in crop yield boosts. It has also reduced the need for pesticides.

Technology could also help plants deal with changes in their ecosystems such as droughts, damaging storms, and hot days. One of the most important benefits of GMO crops is their ability to survive droughts or grow with lower-quality water. This benefit would allow farmers to make their land as productive as possible. It would also increase crop yields to boost regional food sources. For example, Egyptian research has isolated a gene from barley to make wheat more tolerant to droughts. This wheat requires less irrigation efforts and can survive on rainfall as its' water source.[18]

Scientists are interested in using specific genes to help plants become more hardy and adaptable to their environment. The versatility of using rDNA technology provides endless possibilities for crops. Gene modification could be used to provide plants with genes to improve their photosynthesis rate and reduce the loss of water through transpiration. This could allow for a reduction of water needed for global production of staple crops. Crops could contain vaccines for mass distribution in an area. Future uses could also involve treating diseases such as cystic fibrosis, AIDS, and cancer. The process of rDNA technology could be used to replace defective genes with desired ones.

The use of rDNA technology in a practical sense would help students to see real world applications of science. I think it is important for students to understand how global issues can result from geographical disparities. My unit will highlight how location affects populations' diet and nutritional intake. It will also provide an opportunity for students to understand how facts and opinions can be classified. We will discuss possible reasons why there is a resistance to the use of GMOs. The big question for this unit will focus on the effects of location in determining health. I am excited to use the content from the seminar to strengthen my instructional delivery in the classroom, and to expose my students to the biotechnology field.

## Teaching Strategies

Our curriculum for Science Standards of Learning heavily emphasizes the scientific method. Our framework for lessons explicitly states that the scientific method should be used in all third grade level content. My first strategy will focus on modeling the scientific method. It is important to use a scaffolding approach. Most of my students are English Language Learners, and providing a framework for sheltered instruction allows them to take risks. It also provides them with assistance if needed. The lessons will involve simple experiments that will be modeled by me. Next, the experiments will involve collaboration. This will provide students with the opportunity for input. Students will see how hypotheses have to be tested and proven during the experiments. After several collaborative experiments, the students will conduct experiments on their own. Gradually releasing control during experiments will provide students with structural support and independent tasks. I want students to understand that mistakes can be made during the process, and how they can use their problem solving abilities to resolve issues.  The collaborative aspect will also keep the students engaged. As the experiments progress, students will write out and document the steps of the scientific method. This will promote critical thinking among them, and provide them with opportunities to formulate their own opinions. Generating and testing hypotheses requires students to bridge their background knowledge to new content. I will also ask students to clarify and explain their hypotheses and their conclusions. This will help students see why scientists have to prove and support their findings.

I will also use the strategy of setting objectives and providing feedback. When clearly defined, standards-based objectives are presented, the instruction can be tailored. This strategy is beneficial because it narrows the content focus. It is also helpful in teaching students how to concentrate on the most important skills. This strategy will be used in the form of entrance and exit slips to gauge students' comprehension. I will also use the think/pair/share format, and the “Take Your Corners” activity for peer interaction. These informal assessments will be used to collect snapshot data of students’ progress during the unit. The inclusion of this strategy will also provide students opportunities for reflection.

Finally, I will use the strategy of identifying similarities and differences. This will be essential due to the complexities of explaining terms such as DNA, GMO, and rDNA technology. I will help students build understanding of these terms by focusing on their similarities and differences. We will also classify the terms by using key attributes. I will provide students with interactive charts, sentence strips, and pictures of the terms to help students compare and contrast them. This strategy will aid students during the unit’s experiments. I will provide visuals of the steps of the task to aid students’ comprehension.

## Classroom Activities

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In Virginia, third grade science emphasizes how we can characterize living things. We build on students’ prior knowledge that organisms have needs that must be met in order to survive. This unit will integrate that major theme in several activities. First, students will brainstorm how we can distinguish living things from nonliving things. I want students to realize that living things have common needs for survival. This will lead to the question, “Why do living things need water, air, and food (nutrients) to survive?” I will display a photo of a cell, and explain how we are made of billions of cells. To help students understand the concept of billion, trade books such as *“How Much Is A Million?”* by David Schwarz and *“Big Numbers”* by Edward Packard could be used to provide visual references. Next, using the photo of a cell, I will explain to students how multicellular organisms (such as humans) start as one cell. It may be helpful to have students generate a list of living things in order for them to understand the impact of cellular reproduction.

Once students are aware of the cellular composition of organisms, I will display photos of a cell and a student in the classroom. I will ask students, “How did this one cell develop into a person?” I will explain that a blueprint is necessary to build things and provide actual copies of blueprints from different objects such as homes, electronic items, and toys. I will discuss how our cells have blueprints to continue to reproduce, and inform students that the blueprint for cellular reproduction is called DNA.

While displaying the DNA diagram from Figure 1, I will explain how DNA is made of different chemical components. I will provide students with an opportunity to think of a common object similar to the structure of DNA. It may be useful to ask the school maintenance team for permission to view a ladder in the building. I will inform students that DNA, like a ladder, has rungs and a backbone. Using Figure 1, I will explain to students how four chemicals are paired together to make the rungs of the ladder. A kinesthetic activity can be used to show students how the pairings are always the same in DNA structure. To accomplish this, students are provided with index cards labeled with the words adenine, thymine, cytosine, or guanine. At the cue of music, students have to find their appropriate partner based on their card. This will provide students with a visual aid in understanding how DNA is formed.

After the activity, I will ask students to find a partner for a portrait activity. Students will draw the face of their partners, and discuss the similarities and differences noted in their drawings. I will ask students, “Why do we have different colors of eyes? Why do some of us have wavy hair, while others have straight hair?” This will provide students with the opportunity to reflect how DNA acts as a blueprint for our cells. I will explain to students that our cells have different specializations the same way that people specialize in different jobs. It may help to provide students with specializations, such as how a firefighter is unable to switch places with a dentist. This example can be used to show students that our DNA tells cells what jobs they will perform in our bodies. DNA determines if we will have certain traits, or characteristics. The book, *“Grandfather’s Nose: Why We All Look Alike or Different”*, can be used to provide students with a text-to-self connection. The book, written by Dorothy Hinshaw Patent, helps students to understand that not DNA is responsible for our traits. It also provides illustrations to explain how DNA acts a blueprint from our parents to determine our physical features. After reading the book, the interactive Family Portrait activity located at www.dnacenter.com gives students a hands-on opportunity to learn more about inheritance of features.

Students can also experiment with DNA extraction to understand how the blueprint is found in living organisms. First, to show students that humans possess DNA, we will extract it from cells obtained from the inside of the cheek. Next, I will ask students to hypothesize if DNA would be present in strawberries. This activity allows students to substantiate why we would find DNA in strawberries by forming a hypothesis. For example, they may support their thinking by arguing that plants are living things, so the fruit would possess DNA. Students can work in pairs and follow a handout to extract the DNA from the strawberry.

The extraction of DNA from various organisms can be used as a springboard to the use of GMO crops. I will ask students, “Is it possible to mix the cheek DNA with the strawberry DNA?” They should be able to support or defend their positions. I will mix the two DNA samples together, and inform students that scientists are able to mix DNA from different organisms. I will display a photo of a malnourished child, and ask the class what could be the causes of the child’s condition. Next, I will explain how nutrition can determine the health of an organism, and ask students, “Why is it easy for us to improve our diets?” This will help students to understand how the availability of food allows us to choose what we can eat in America, but how other regions have limited choices. I will display a photo of rice, and ask students, “If this is the only food source the malnourished child has, what could be done to make sure he or she is healthy?” We will brainstorm what could be done to the rice to make it a super food for the malnourished child. I will display examples of GMO crops such as golden rice or insect resistant corn. I will explain how scientists mix DNA from different organisms to improve the rice or corn, and allow students time to research examples of GMO crops from KidRex. The students can also create a cause and effect diagram to show how the crops improved the health of people.

As a finished product, the students will be given a region in the world, and a scenario describing a vitamin deficiency or malnutrition found in the area. Students will have to research a local plant that could be used to address the deficiency or malnutrition. What would they have to add to improve the nutritional content of the crop? Describe how the weather conditions and soil type could help with the growth of the crop. Does the crop need a specific soil type to grow? Why would they select a crop that is hardy and able to sustain various weather conditions or pests, versus a crop that has specific needs in order to be sustainable? The students will create an advertisement, flier, or power point to persuade farmers in the area to grow the crop.

My goal is to use the content information and classroom activities to show students the benefits of bio-fortified crops. I want to also show students the opposition to GMO crops, and provide them with opportunities to understand why it is important to distinguish facts from opinions. We can use kid-friendly search engines to locate informative websites, and to determine why some websites may not be factual. I think it is important to help learners understand how to collect and analyze information on their own. It is vital for our students to recognize the need to process information and determine its relevance.

## Notes


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19. Lusk, Jayson and Henry Miller, "We Need G.M.O. Wheat," The New York Times, February 2, 2014


## Resources for Students and Teachers

https://www.dnacenter.com/science-technology/dna-education/family-portraits.html This site provides additional content information about DNA, and it also has interactive lessons for use in primary classrooms.

www.livescience.com/37252-dna-science-experiment.html A step-by-step experiment to extract DNA from the lining of your cheek.

www.genome.gov/Pages/Education/Modules/StrawberryExtractionInstructions.pdf This handout can be used for a guided science experiment.

Balkwill, Frances R., and Mic Rolph. *Cells Are Us.* Minneapolis: Carolrhoda Books, 1993. Cartoon images detail the functions of cells.

Packard, Edward, and Sal Murdocca. *Big Numbers: And Pictures That Show Just How Big They Are!* Brookfield, Conn.: Millbrook Press, 2000.

Patent, Dorothy Hinshaw, and Diane Palmisciano. *Grandfather's Nose: Why We Look Alike or Different.* New York: F. Watts, 1989.

Schwartz, David M., and Steven Kellogg. *How Much Is a Million?* New York: Scholastic, 1985.

Wallace, Holly. *Cells and Systems.* Chicago: Heinemann Library, 2001. Explains how living things are made up of cells. It also explains the specialized roles of cells.

## Appendix A: Implementing District Standards

3.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations. The student will

1. Analyze data that have been gathered and organized.
2. Communicate results of investigations by displaying data in the form of tables, charts, and graphs.
3. Make and communicate predictions about the outcomes of investigations.

This standard helps students to understand that investigations require the collection of data to substantiate predictions or hypotheses. Students are expected to distinguish the type of data that is important for investigations.

3.10 The student will investigate and understand that natural events and human influences can affect the survival of species. Key concepts include

a. the interdependency of plants and animals;
b. the effects of human activity on the quality of air, water, and habitat;
c. the effects of fire, flood, disease, and erosion on organisms;

This is the essential standard for the unit. Students are expected to understand the relationships between living organisms. I will use the key concepts from this standard to demonstrate why it is necessary for organisms to adapt to meet their needs, and why organisms on other living things.