DNA, Mutants and Superheroes

Curriculum Unit for Grades 6-8

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Introduction

Rationale

The fields of DNA technology and genetic engineering are expanding at an explosive rate. Less than a century ago, scientists did not believe DNA held hereditary information. In 1953, Watson and Crick deduced the structure of DNA. Twenty years later, the first foreign gene was inserted into another organism. Genetic modification of DNA is now a standard high school AP biology lab. Today's science fiction of DNA modification is tomorrow's routine technology.

Our students are surrounded by references to DNA on TV, videos, movies, and social media. Science fiction and comics include genetically modified superhumans as both protagonists and antagonists. Crime and medical dramas refer to genetic testing and gene manipulation regularly. Tabloid TV loves to use DNA fingerprinting to find out "Who's the daddy?" and who is not. Some of these sources provide accurate information about of the current state of DNA technology; others rely on speculation and exaggeration to embellish their story. The more students know about DNA, they better they will be able to flesh out fact from fiction in these media sources.

The genetic basis of many diseases is under intense study. DNA testing identifies of genetic disorders in patients. Early trials use genetic modification to correction patients' DNA in cases of diseases such as cystic fibrosis and sickle cell anemia. The DNA found in immune cells of cancer patients can now be modified to attack cancer cells. Pandemic flu viruses are identified and tracked by their DNA signature. Medical scientists envision personalized medical treatment based on your DNA profile for all diseases and ailments. Today's students will be faced with genetic decisions about their health and that of their families. The better they understand the processes, the more informed decisions they can make.

Even our day to day lives are permeated with genetically modified organisms (GMOs). International debate rages over the identification and use of GMO crops. Many medications, such as insulin and flu vaccines, are produced by GMOs. The human genome was sequenced thanks to GMOs. You can purchase genetically modified GloFish® at many pet stores. Genetically modified mosquitoes are used to eradicate wild mosquitoes that carry the Zika virus. Therefore, it is imperative that students today understand DNA technology and genetic engineering because they will be tomorrow's citizens and leaders. They will make difficult moral and ethical decisions for themselves, their children and the country regarding DNA technology. They will be responsible for monitoring the technology

and legislating its control. Better comprehension of the processes will lead to more informed debate and decision making them better citizens in societies of the future.

Differentiation for Gifted Learners

This unit addresses curricular needs of gifted learners through differentiation of content, process, product, and learning environment layered with the features of complexity, challenge, depth, creativity and acceleration. The content for this unit is accelerated two to four years for the student population it was designed. The subject matter and reading involves complex technical terminology unfamiliar to most students.

In the course of the unit, students will use multiple types of process differentiation. Learning through hands on activities include DNA extraction, building DNA models, and creating a paper GMO as they apply and analyze technical processes. Students are asked to make meaning from text and visual representations of the content by studying and discussing infographics. Collaborative group work help students reach a common goal as they develop questions based on readings, work through technical processes, and develop a solution to a complex problem. Students are asked to analyze and resolve the multifaceted problem of an eminent Zombie attack. Therefore, they must utilize research skills to gain knowledge about the characteristics and vulnerability of Zombies and analyze the information gathered. They must prioritize possible solutions and create persuasive arguments in favor of their choice. Critical thinking and problem solving are required for resolution of the challenge.

Product differentiation is offered in two activities. First is the creation of DNA code for a new Teenage Mutant Ninja Turtle (TMNT). Students are provided examples of TMNT DNA code. Then, they create their own TMNT by combining genes for some codes and have the option to create new ones. The second occurs in the solution of Zombie attack and the presentation mode. Students are allowed to select the organism to be genetically modified and the gene they want to change or insert. Presentations can be drawings, electronic display, 3-D models or any other method they choose.

The learning environment of the classroom is open and welcoming. As a teacher, I try to develop an easy rapport with the students. I accept a fair amount of classroom chaos as long as learning occurs. In the classroom, multiple models, posters, and infographics are utilized to support the content and student learning. Additionally, when selecting videos, posters, etc., I try to choose culturally and ethnically diverse representations of people and places, such as the variety of characteristics demonstrated in “What are Traits?”. The video from HHMI Biointeractive, “Genetically Modified Mosquitoes”, shows Hispanic scientists, both male and female, working on the problem of eliminating mosquitoes that transmit the

Zika virus. My goal is to try to provide a safe and inclusive environment in my classroom where learning takes place.

Differentiation also has five different features that often overlap or coincide with the dimensions - complexity, challenge, depth, creativity and acceleration. For example, the content of this unit is accelerated two to four grade levels; students are challenged with content typically part of the ninth or tenth grade curriculum. In this unit, students express their creativity through problem solving and products from Teenage Mutant Ninja Turtle genome and protection from the Zombie attack. Increased depth in the unit is achieved when students learn to use the language of the discipline. In the morality activity, students are asked to consider multiple viewpoints about genetic modification as well as the long-term implications of this technology. When determining the best solution for the Zombie attack, students must think about moral considerations, so they are do not harm humans or the environment in which we live. Students are challenged in this unit to uncover the big idea, the Essential Understanding, that technology controls change through scaffolding and climbing Bloom's / Costa Levels of Questioning.

Addressing the features and dimensions of differentiation makes this unit an appropriate challenge for gifted, middle school students. Students interact with the content in multiple ways that increase challenge and engagement.

Target Student Population

As mentioned previously, this unit is designed for a precocious group of middle school students in grades six to eight because the content is two to four levels beyond the curriculum for that age group. Of that group, students interested in superheroes, DNA, and mutants will be quickly engaged. An active imagination and creativity will be beneficial in solving the problems they are given. Advanced abilities in mental imagery will help students understand DNA structure and technology.

Most middle school students will have some knowledge of DNA and GMOs through home, social media, and educational experiences, but it not a prerequisite for the unit of study. They will also likely have some exposure to superheroes that have special genetic make-up; but again, it is not a requirement.

Students who are looking for the single, right answer will be most challenged by this study. The nature of science is uncertainty and ambiguity, characteristics which are woven into this study of DNA and GMO's. The problem-based lesson is open ended, with multiple suitable solutions. Perfectionists will also struggle with getting the solution "just right". Students with these traits will be challenged with the morality lesson as well because no perfect answers exist; individuals must choose what they believe is right.

Finally, because this is nascent research, scientists do not always know the answer to all questions. Almost all students dislike the uncertainly of science. They have been taught most of their lives that science is a series of facts; each question has a distinct, correct answer. However, science is mostly a series of questions or answers with caveats that lead to more questions. Plus, in science, failures often lead to better answers. Therefore, studying science challenges many gifted students to be willing to fail, accept ambiguity, and to learn from their mistakes.

Goals and Outcomes

Content Goals and Outcomes

Goal 1: to develop an understanding of the structure of DNA, how DNA enables organisms to survive and reproduce, how biotechnology is used to affect living organisms, and the application of DNA technology.

Based on NC standards for Science Education:

Seventh Grade Science:

7.L.1 Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life.

Eighth Grade Science:

8.L.2 Understand how biotechnology is used to affect living organisms.

High School Biology:

Bio.3.3 Understand the application of DNA technology.

Students will be able to…

A. Describe the structure of DNA and how it determines the structure and function of living organisms.
B. Compare and contrast DNA, genes and chromosomes.
C. Describe and apply technology to extract DNA from living things.
D. Describe and apply technology to modify DNA in living things.
E. Describe and apply how DNA modification affects organisms.
F. Describe how DNA technology is used to control changes in organisms.
G. Compare and contrast DNA technologies.
H. Design a genetically modified organism.
I. Analyze and apply technical processes.
J. Explain the universality of DNA and DNA technologies.

<u>Process</u> Goals and Outcomes

Goal 2: to develop collaboration skills, problem solving, research, and reasoning skills with application to science.

Students will be able to…

A. Define a problem when given ill-structured, complex information.
B. Collaborate with peers to analyze and solve complex problems.
C. Make inferences based on evidence or research.
D. Provide evidence and data to support a claim, issue or statement.
E. Formulate and respond to questions that require upper level thinking.
F. Collaborate with peers to understand advanced content.
G. Work as an expert in the field.
H. Make meaning from text and visual representations.
I. Evaluate information.
J. Make predictions based on content knowledge.

<u>Concept</u> Goals and Outcomes

Goal 3: to understand the concept of technology.

Students will be able to…

A. Use appropriate language to identify the input, output, and elements of technology.
B. Analyze the components of technology and how they interact in both real world and model systems.
C. Analyze how technology controls change in both real world and model systems.
D. Transfer the knowledge about technology to a new system.

<u>Assessment Plan</u>

Evaluations will include a series of formative assessments for student understanding followed by a summative assessment of the performance task. On the first day, students begin with an ice breaker in which they describe their favorite superhero and how the superhero became "super". Many modern superheroes have modified DNA or a special X gene that gives them special powers. Following the icebreaker, I facilitate a discussion about what students already know about DNA. These activities serve as informal pre-assessments to learn what students know and understand about DNA, identify misconceptions, and determine if they are familiar with the source of strength for superheroes. This information helps divide students into groups by readiness and guides me on planning any needed scaffolding.

Continuing with the first day, students read three short articles from yourgenome.org about DNA technology. After a short explanation of Blooms / Costa Levels of Questioning, each group of three or four students are asked to create two to three higher level (second and third story) questions. During this activity, I move about the room to monitor student progress as they work and scaffold the questioning process as needed. Student questions are collected and shared as a part of the whole class discussion of the articles.

Finally, students share with a partner their answer to the question "How does technology control change?" I will move around the class to assess student understanding based on their responses.

Each subsequent day begins with an informal review of what was learned in the previous day's lesson. Throughout all the lessons, planned questioning and student response serves as formative assessments of student understanding. Questioning can be addressed to the entire class, student groups or individual students.

The second day of the lesson includes several hands-on activities to support the content. Students progress through three separate stations as they work as an expert in the field of molecular biology. Each station requires students to watch a video and follow instructions to complete a task. When complete, I check their work, quiz them on their learning from the task and, if all is complete and correct, I stamp the form and they can move on.

Have your DNA and Eat it Too	Decoding Teenage Mutant Ninja Turtle DNA	*E. coli* Insulin Factory

Sample Paper GMO from *E.coli* Insulin Factory

Once all the tasks are completed, I facilitate a class discussion on what students learned in the day's activities. Questioning during the discussion help guide students to uncover the Concept and Essential Understandings.

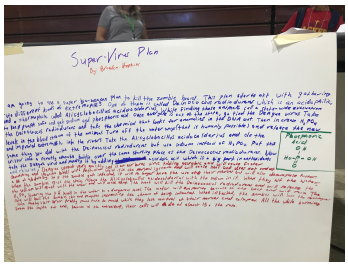
On the third day, students participate in problem-based learning where they must determine how to defeat an eminent Zombie attack. The performance task is assessed at the end of the fourth day.

Zombie Attack Performance Task

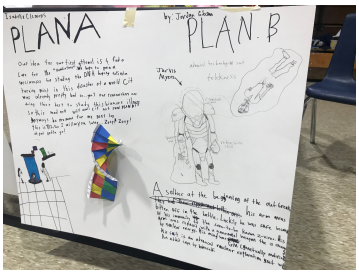
Performance Task: Defeat the Zombies!
Use your expertise in DNA technology to design a super hero with a super power that can defeat the Zombies. Create a presentation for ZAC Attack showing the super hero in action using the new super power. Provide details of the super gene you created with technology and how it changed the individual to a super hero. Consider how the changed individual might feel about the new super power and include his or her perspective in your presentation. Convince the ZAC Attack that your novel approach will be successful at defeating the Zombies.

Three examples of Performance Task Products:

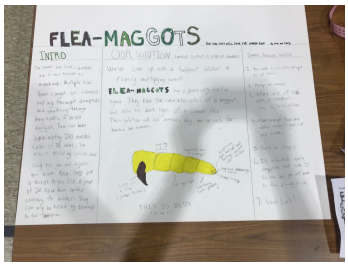
Super Virus Plan:



Study Zombie DNA / GM Mind Control:



Flea-Maggot:



Rubric for Performance Task: Defeat the Zombies!

Criteria	1-Novice	2-Proficient	3-Distinguished	Score
Research the Issue	Demonstrates some understanding of Zombies' characteristics	Demonstrates a general understanding of Zombies' characteristics	Demonstrates substantial understanding of Zombies' characteristics	____ X 1
Proposed changes(s)	Does not identify any changes to reach a solution	Identifies adequate changes to defeat the Zombies; utilizes DNA technology to achieve the change; provides adequate description	Identifies substantial changes to defeat the Zombies; utilizes DNA technology to achieve the change; provides extensive description	____ X 3

Perspective of changed individual	Affect and perspective of changed individual is poorly thought out and presented or not included.	Affect and perspective of changed individual is well adequately thought out and presented.	Affect and perspective of changed individual is exceptionally well thought out and presented.	____ X 2
Presentation	Product is poorly prepared, messy and unpolished; poor choice of presentation method; many errors in grammar, spelling or punctuation	Product is well prepared, adequately neat and polished; conventional presentation method; infrequent errors in grammar, spelling or punctuation	Product is very well prepared, neat and polished; creative presentation; almost no errors in grammar, spelling or punctuation	____ X 2
Persuasiveness of Presentation product	Presentation product is uninteresting and not persuasive	Presentation product is engaging and moderately persuasive	Presentation product is very engaging and persuasive	____ X1
On-Time	Presentation is turned in 4 school days late	Presentation is turned in 2 school days late	Presentation is turned in 1 school day late	____ X 1
Grade / Total Points:				/30

Lesson Plans:

TEACHER NAME			Lesson #
Melanie W. Stancill			1
MODEL	**CONTENT AREA**	**GRADE LEVEL**	
Questioning	Biology	Grades 7-9	

CONCEPTUAL LENS	LESSON TOPIC
Technology	DNA / Heredity

LEARNING OBJECTIVES *(from State/Local Curriculum)*

Seventh Grade Science:

7.L.1 Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life.

Eighth Grade Science:

8.P.1 Understand the properties of matter and changes that occur when matter interacts in an open and closed container**.**

8.L.2 Understand how biotechnology is used to affect living organisms.

High School Biology:

Bio.3.3 Understand the application of DNA technology.

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	THE ESSENTIAL QUESTION *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Technology Controls Change	**How does technology control change?**

CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)	PROCESS SKILLS (What will students be able to do as a result of this lesson?)
Students will know that: • All living things have DNA. • Cells are made of many different biochemical components. • Chemicals can be used to change the properties of DNA. • Different properties of cell components can be used to isolate DNA. • DNA can be visualized when isolated with chemicals. • Isolating DNA is the first step of many types of DNA technology. • Safety is required in scientific labs and experiments. • Technology can be used to control changes in DNA. • DNA technologies include DNA fingerprinting, genetically modifying organisms, treating genetic disorders, and genetic engineering. • DNA technology is universal across all living things.	Students will be able to: • Demonstrate proper safety procedures. • Analyze and apply technical processes. • Compare and contrast physical and chemical properties. • Collaborate with peers to reach a common goal. • Create and respond to higher order thinking questions. • Analyze content and determine relevant information. • Make predictions and generalizations based on content knowledge. • Use research skills to gain knowledge.

GUIDING QUESTIONS *What questions will be asked to support instruction?* *Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding*		
Pre-Lesson Questions:	**During Lesson Questions:**	**Post Lesson Questions:**
Partner Talk Debriefing Questions 1. What superpower did you give yourself? 2. What could or would you do with your superpower? 3. What changes would have to be made to become "super"? 4. What technology would make those changes? 5. How would your life be different if you had these changes? **Interest Grabber Questions:** 1. What do you know about DNA? 2. Why do living things need DNA? 3. What is the relationship among genes, chromosomes and DNA? 4. What does DNA control? 5. What technologies control changes in DNA? 6. What would you do if you could control what DNA controls? 7. What could you control if there was technology to change DNA? 8. How could you use that control to affect change? 9. What control over change does technology give you?	**Questions for DNA extraction technology** 1. Why are we using strawberries / peas instead of something else? 2. What do you think mushing / blending the strawberries / peas does? 3. What do you think the extraction solution is? What is your evidence? 4. What does the extraction solution do to the strawberries / peas? 5. What part of the cell is broken down? 6. What does DNA look like? 7. How would you describe DNA to some who had never seen it before? 8. How could this technology be used by scientists to control changes in DNA? **Questions for Reading** 1. What technology is used to create a GMO? 2. Why do scientists create GMOs? 3. How would you classify the different uses of GMOs? 4. What can be controlled by DNA technology? 5. What does DNA control? 6. Why do these technologies control changes in DNA? 7. What do each of the technologies have in common? 8. How are each of the technologies different? 9. Why is technology used to control changes in plants / animals / medicine? 10. What control results from	1. How have your ideas about GMOs changed after today's learning? 2. How have your ideas about DNA technology changed after today's learning? 3. What are some helpful / harmful ways to use technology to control changes in plant DNA with this technology that you can imagine? Why are they helpful / harmful? 4. What are some helpful /harmful ways to use technology to control changes in animal DNA with this technology that you can imagine? Why are they helpful / harmful? 5. How would you use technology to control changes in your own DNA if you could? What effect would that have on your life? How would that change affect your friends and family? 6. How does the manipulation (control) of DNA in these technologies give humans control over their lives? 7. How does the manipulation of DNA in these technologies give humans control over the world they live in? 8. What are some other technologies you can think of – not just those with DNA? 9. How do these other technologies allow us to make changes? 10. How do these other technologies give us control

	this technology? 11. Is the control of DNA beneficial, harmful, or make no difference at all? Why? 12. How do scientists use technology to control what DNA controls? 13. Why do scientists use technology to control what DNA controls? 14. How does the manipulation of DNA in these technologies give humans control over their lives? 15. How does the manipulation of DNA in these technologies give humans control over their futures? 16. What other technologies do we use? 17. What changes do those other technologies allow us to do? 18. How do those other technologies allow us to control changes? 19. How does technology control change?	over change? 11. What are some helpful / harmful ways to use other technologies to control other changes? What effect would that have on your life? How would that change affect our friends and family? 12. Why do humans strive for control over their lives and the world they live in? 13. Why do humans develop technologies like these that enable so much control? 14. What is the relationship between control and technology? 15. How does technology control change?

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.

Content	Process	Product	Learning Environment
Content is above grade level for middle school students.	Students will use critical thinking, collaboration, speaking and writing skills throughout this lesson.		

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

Warm-up / Get-to-know-you activity
Students will be divided into pairs for Partner Talk / Active Listening activity.

a. Partner Talk Prompts / Questions: If you could have a superpower, what would it be? What could or would you change with your superpower? What changes would have to be made to become "super"? How would your life be different if you had these changes?
   i. Partner 1 talks for 90 sec. while Partner 2 listens. Only Partner 1 talks. Both partners maintain eye contact.
   ii. For 2 minutes, Partner 2 restates what Partner 1 said and ask questions. Partners discuss possible outcomes of changing to become "super".
   iii. Repeat with Partner 2 sharing and Partner 1 listening.
b. Debriefing Questions
   i. What superpower did you give yourself?
   ii. What could or would you change with your superpower?
   iii. What changes would have to be made to become "super"?
   iv. How would your life be different if you had these changes?
   v. What technology could make those changes?
   vi. What control over change does technology give you?

Students are provided a series of photographs, diagrams and models of DNA and asked what they all have in common. Pre-lesson questions elicit prior knowledge and pique student interest.

Interest Grabber Questions:

1. What do you know about DNA?
2. Why do living things need DNA?
3. What is a gene?
4. What is a chromosome?
5. What is the relationship among genes, chromosomes and DNA?
6. What does DNA control?
7. What technologies control changes in DNA?
8. What would you do if you could control what DNA controls?
9. What could you control if there was technology to change DNA?
10. How could you use that control to affect change?
11. What control over change does technology give you?

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

Students extract DNA from food such as strawberries or peas using a process from Learn Genetics by University of Utah (see attachment).

During Lesson questions on DNA Extraction Technology will help students elicit prior knowledge, explore DNA extraction technology, begin thinking about how technology controls change.

Questions for DNA extraction technology

1. Why are we using strawberries / peas instead of something else?
2. What do you think mushing / blending the strawberries / peas does?
3. What do you think the extraction solution is? What is your evidence?
4. What does the extraction solution do to the strawberries / peas?
5. What part of the cell is broken down?
6. What does DNA look like?
7. How would you describe DNA to some who had never seen it before?
8. How could this technology be used by scientists to control changes in DNA?

Students will be divided into 3 groups to further explore the possibilities of DNA technology through reading articles on the web. Each group will read a different article.

Group 1: What is Genetic Engineering? https://www.yourgenome.org/facts/what-is-genetic-engineering
Group 2: What is a GMO? https://www.yourgenome.org/facts/what-is-a-gmo
Group 3: What is Gene Therapy? https://www.yourgenome.org/facts/what-is-gene-therapy

Students will receive a mini lesson on Costa's Levels of Thinking and Questioning and provided "Costa's House" as a resource. (See document at the end.) Students will be asked to create 2-3 each of Level Two and Level Three questions. They must not include fact-based or "yes/no" questions about their articles. Students will record each question on a separate note card.

"During Lesson Questions on Reading" will be posed to help guide students to think more deeply about the concept of control.

Questions for Reading

1. What technology is used to create a GMO?
2. Why do scientists create GMOs?
3. How would you classify the different uses of GMOs?
4. What can be controlled by DNA technology?
5. What does DNA control?
6. Why do these technologies control changes in DNA?
7. What do each of the technologies have in common?
8. How are each of the technologies different?
9. Why is technology used to control changes in plants / animals / medicine?
10. What control results from this technology?
11. Is the control of DNA beneficial, harmful, or make no difference at all? Why?
12. How do scientists use technology to control what DNA controls?
13. Why do scientists use technology to control what DNA controls?
14. How does the manipulation of DNA in these technologies give humans control over their lives?
15. How does the manipulation of DNA in these technologies give humans control over their futures?
16. What other technologies do we use?
17. What change do those other technologies allow us to do?
18. How do those other technologies allow us to control change?
19. How does technology control change?

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

New student groups will be formed by selecting students from each of Groups 1-3 (jigsaw method). Students will take turns summarizing their article to the rest of the group. Then, students will share their questions and discuss their responses based on the articles they read and what they learned from the other groups.

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Groups will select the best questions and provide them to the teacher for whole group discussion.

The teacher will facilitate a whole group discussion that includes the "During Lesson Questions" as well as the best questions selected by student groups.

The teacher will continue to facilitate whole group discussion that includes the "After Lesson Questions" to help students understand that technology controls changes.

After Lesson Questions

1. How have your ideas about GMOs changed after today's learning?
2. How have your ideas about DNA technology changed after today's learning?
3. What are some helpful / harmful ways to use technology to control changes in plant DNA with this technology that you can imagine? Why are they helpful / harmful?
4. What are some helpful /harmful ways to use technology to control changes in animal DNA with this technology that you can imagine? Why are they helpful / harmful?
5. How would you use technology to control changes in your own DNA if you could? What effect would that have on your life? How would that change affect your friends and family?
6. How does the manipulation (control) of DNA in these technologies give humans control over their lives?
7. How does the manipulation of DNA in these technologies give humans control over the world they live in?
8. What are some other technologies you can think of – not just those with DNA?
9. How do these other technologies allow us to make changes?
10. How do these other technologies give us control over change?
11. What are some helpful / harmful ways to use other technologies to control other changes? What effect would that have on your life? How would that change affect our friends and family?
12. Why do humans strive for control over their lives and the world they live in?
13. Why do humans develop technologies like these that enable so much control?
14. What is the relationship between control and technology?
15. How does technology control change?

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Students will be asked to think individually about the question "How does technology control changes?" Students will be paired for a Partner Talk / Active Listening exercise in which one student will speak for 90 seconds elaborating on their answer to the question "How does technology control change?" The second student listens without responding during that time. After 90 seconds, the listener will summarize what the speaker said for 2 minutes and add any comments or ask questions of his or her own. Then, students will reverse roles and repeat the activity. Both students remain attentive and maintain eye contact during the entire activity.

The teacher will move around the room to monitor student responses as an informal assessment of understanding.

Before students leave for the day, the teacher will introduce the PBL Assignment that will be the lesson a few days hence.

PBL Assignment:

Zombies!

"Zombies have been spotted in Canada, and they are moving south! The governor has called. We must protect the citizens of NC! You are a DNA expert and advisor to the Zombie Apocalypse Committee – code-name "ZAC Attack". Your mission is to research Zombies to find out all you can find out about them. How could you use technology to change the potential zombie invasion? What can you create to defeat these fiends?"

Use your expertise in DNA technology to design a superhero with a superpower that can defeat the Zombies. Create a presentation for ZAC Attack showing the superhero in action using the new superpower. Provide details of the super gene you created with technology and how it changed the individual to a superhero. Consider how the changed individual might feel about the new superpower and include his or her perspective in your presentation. Convince the ZAC Attack that your novel approach will be successful at defeating the Zombies.

Three-Story House (Costa's Levels of Questioning)

To better understand the content being presented in their core subject areas, it is essential for students to learn to think critically and to ask higher levels of questions. By asking higher levels of questions, students deepen their knowledge and create connections to the material being presented, which in turn prepares them for the inquiry that occurs in tutorials. Students need to be familiar with Costa's (and/or Bloom's) levels of questioning to assist them in formulating and identifying higher levels of questions.

Directions: Read the poem below and review the "Three House Story" on the next page. Both set the stage for Costa's Levels of Questioning.

One- Two- Three-Story Intellect Poem

There are one-story intellects,
two-story intellects,
and three-story intellects with skylights.

All fact collectors who have
no aim beyond their facts
are one-story people.

Two-story people compare, reason,
generalize, using the labor of
fact collectors as their own.

Three-story people idealize,
imagine, predict—their best illumination
comes through the skylight.

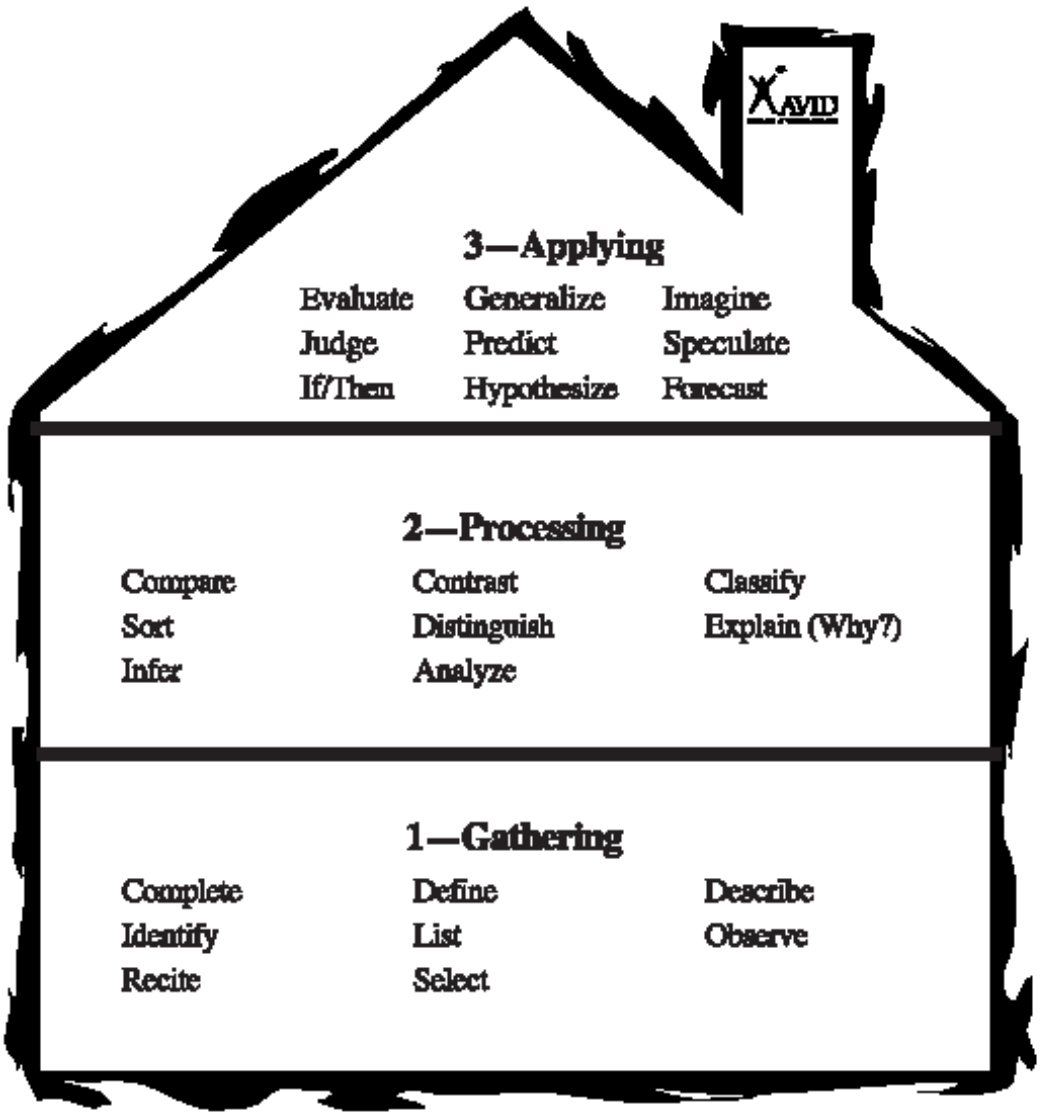
Adapted from a quotation by Oliver Wendell Holmes

The Three-Story House

Level 1 (the lowest level) requires one to gather information.

Level 2 (the middle level) requires one to process the information.

Level 3 (the highest level) requires one to apply the information.



TEACHER NAME			Lesson #
Melanie W. Stancill			2
MODEL	**CONTENT AREA**	**GRADE LEVEL**	
Bruner Model	**Biology**	**Grades 6-8**	
CONCEPTUAL LENS		**LESSON TOPIC**	
Technology		**DNA / Heredity**	

LEARNING OBJECTIVES *(from State/Local Curriculum)*

Seventh Grade Science:
7.L.1 Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life.

Eighth Grade Science:
8.L.2 Understand how biotechnology is used to affect living organisms.

High School Biology:
Bio.3.3 Understand the application of DNA technology.

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	**THE ESSENTIAL QUESTION** *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Technology Controls Change	**How does technology control change?**
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)	**PROCESS SKILLS** (What will students be able to do as a result of this lesson?)
Students will know that: • All living things have DNA. • Technology can be used to control changes in DNA. • DNA technologies include DNA fingerprinting, genetically modifying organisms, treating genetic disorders, and genetic engineering. • DNA technology is universal across all living things. • DNA technology can be used to control changes in an organism. • DNA technologies include DNA fingerprinting, genetically modifying organisms, treating genetic disorders, and genetic engineering.	Students will be able to: • Analyze and apply technical processes. • Evaluate information • Make predictions and generalizations based on content knowledge. • Make meaning from text and visual representations. • Participate in high level discussion and / or debate.

GUIDING QUESTIONS
What questions will be asked to support instruction?
Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding

Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
• What do you notice? • What kinds of technology are explained in these infographics? • What biological processes are explained in these infographics? • How do these processes control how our bodies work? • How might a scientist use these technologies? • What changes can you envision using these technologies?	• What is a molecular biologist? • What are some characteristics of a molecular biologist? • What do molecular biologists do? • What do molecular biologists study? • Where do molecular biologists work? • What does their "laboratory" look like? • What types of technology do molecular biologists use?	• What new knowledge did you gain in this lesson? • How would you use technology to control changes in your own DNA if you could? What effect would that have on your life? How would that change affect your friends and family? • How does the manipulation (control) of DNA in these technologies give humans control over their lives?

• How could a scientist control changes in how our bodies work by using these technologies?	TMNT Questions: • What is the relationship among genes, chromosomes and DNA? • What does DNA control? • What technologies control changes in DNA? • What would you do if you could control what DNA controls? • What could you control if there was technology to change DNA? • How could you use that control to affect change? • What control over change does technology give you? • What control results from this technology? • Why is the control of DNA beneficial? • How do scientists use technology to control what DNA controls? • Why do scientists use technology to control what DNA controls? • How does the manipulation of DNA in these technologies give humans control over their lives? • How does the manipulation of DNA in these technologies give humans control over their futures? • What other technologies do we use? • What changes do those other technologies allow us to do? • How do those other technologies allow us to control changes?	• How does the manipulation of DNA in these technologies give humans control over the world they live in? • What are some other technologies you can think of – not just those with DNA? • How do these other technologies allow us to make changes? • How do these other technologies give us control over change? • What are some helpful / harmful ways to use other technologies to control other changes? What effect would that have on your life? How would that change affect our friends and family? • Why do humans strive for control over their lives and the world they live in? • Why do humans develop technologies like these that enable so much control? • What is the relationship between control and technology? • How does technology control change?

	• How does technology control change?	

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.

Content	Process	Product	Learning Environment
Content is above grade level for middle school students.	Students will experience the process of the essential understanding and concept by working as an expert in the field. Students will use critical thinking, collaboration, speaking, problem solving and writing skills throughout this lesson.		Culturally and ethnically diverse societies are represented in the videos selected.

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

Students will enter the room to find four tables covered with bulletin board paper.
Infographic posters about DNA will be at the center of each table.

Student instruction:

- Without talking, walk around the room and study each infographic.
- On the bulletin board paper, students will write down what they notice about the infographics.

Students will study each infographic and add observations for 5-10 minutes.

Teacher will facilitate a whole class discussion about observations students have made about each infographic.

Pre-Lesson Questions:

- What do you notice?
- What kinds of technology are explained in these infographics?
- What biological processes are explained in these infographics?
- How do these processes control how our bodies work?
- How might a scientist use these technologies?
- What changes can you envision using these technologies?
- How could a scientist control change in how our bodies work by using these technologies?

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

Teacher will redirect and facilitate the discussion by asking the following questions. Students create a group list of descriptive words and phrases that the teacher posts on the board.

During Lesson Questions:

- What is a molecular biologist?
- What are some characteristics of a molecular biologist?
- What do molecular biologists do?
- What do molecular biologists study?
- Where do molecular biologists work?
- What does their "laboratory" look like?
- What types of technology do molecular biologists use?

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

Students will then watch "Genetically Modified Mosquitoes", a video showing molecular biologists using these technologies. Students are then asked to review their initial list on the board. The teacher facilitates as students make changes and additions based on new learning.

During Lesson Questions:

- What is a molecular biologist?
- What are some characteristics of a molecular biologist?
- What do molecular biologists do?
- What do molecular biologists study?
- Where do molecular biologists work?
- What does their "laboratory" look like?
- What types of technology do molecular biologists use?

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Students will rotate among 3 stations to learn more about the work of molecular biologists.

Station 1: Have your DNA and Eat it Too!
Students will watch video What are DNA and Genes? Then students will build their own DNA molecule using the instructions from LearnGenetics.org, Have your DNA and Eat it too!
The goal is to help students to understand the structure of DNA and how that structure forms a code for trait found in all living things. Molecular biologists understand this structure and code found in DNA and use that information to change and manipulate DNA.

Station 2: A Recipe for Traits
Students will watch the video What are Traits? Then, students will use DNA "recipes" to decode DNA and create a Teenage Mutant Turtle through genetic modification following the instructions in the activity below.
The goal is to help students understand that DNA holds a code for the traits found in all living things. Each gene codes for a different trait. Molecular biologists understand this structure and code found in DNA and use that information to change and manipulate DNA.

Station 3: How GMO's are made.
Students will watch the video Genetic Engineering. Then students will complete a simplified version of the activity The E. coli Insulin Factory.
The goal is to help students understand the technology used to change the DNA of an organism. This paper activity accurately depicts the work of molecular biologists to genetically modify *E. coli* bacteria to produce human insulin for diabetic patients.

As students are completing the Stations or if they are waiting, they are given the following questions to consider.
During Lesson Questions:

- What is the relationship among genes, chromosomes and DNA?
- What does DNA control?
- What would you do if you could control what DNA controls?
- How could you use that control to affect change?
- What technologies control changes in DNA?
- What control results from this technology?
- Why is the control of DNA beneficial?

When everyone has finished the stations, the teacher will debrief the activities and facilitate a discussion on the following questions.
During Lesson Questions:

- What control over change does technology give you?
- What could you control if there was technology to change DNA?
- How do scientists use technology to control what DNA controls?
- Why do scientists use technology to control what DNA controls?
- How does the manipulation of DNA in these technologies give humans control over their lives?
- How does the manipulation of DNA in these technologies give humans control over their futures?
- What other technologies do we use?
- What changes do those other technologies allow us to do?
- How do those other technologies allow us to control changes?
- How does technology control change?

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

In small groups, students will discuss the following questions. The teacher will move around the room, monitoring student discussions and evaluate student understanding.

After Lesson Questions:

- What new knowledge did you gain in this lesson?
- How would you use technology to control changes in your own DNA if you could? What effect would that have on your life? How would that change affect your friends and family?
- How does the manipulation (control) of DNA in these technologies give humans control over their lives?

- How does the manipulation of DNA in these technologies give humans control over the world they live in?
- What are some other technologies you can think of – not just those with DNA?
- How do these other technologies allow us to make changes?
- How do these other technologies give us control over change?
- What are some helpful / harmful ways to use other technologies to control other changes? What effect would that have on your life? How would that change affect our friends and family?
- Why do humans strive for control over their lives and the world they live in?
- Why do humans develop technologies like these that enable so much control?
- What is the relationship between control and technology?
- How does technology control change?

Introduce Lesson for Day 3:

Performance Task:

Zombies!

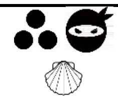
"Zombies have been spotted in Canada, and they are moving south! The governor has called. We must protect the citizens of NC! You are a DNA expert and advisor to the Zombie Apocalypse Committee – code-name "ZAC Attack". Your mission is to research Zombies to find out all you can find out about them. How could you use technology to change the potential zombie invasion? What can you create to defeat these fiends?"

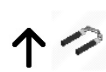
Use your expertise in DNA technology to design a super hero with a super power that can defeat the Zombies. Create a presentation for ZAC Attack showing the super hero in action using the new super power. Provide details of the super gene you created with technology and how it changed the individual to a super hero. Consider how the changed individual might feel about the new super power and include his or her perspective in your presentation. Convince the ZAC Attack that your novel approach will be successful at defeating the Zombies.

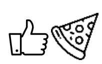
Name: ____

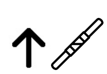
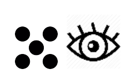
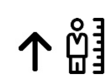
DNA sequences

Decode a chromosome from four different organisms to determine the traits for each. What organisms are they?

Gene 1	**Gene 2**	**Gene 3**	**Gene 4**	**Gene 5**	**Gene 6**	**Gene 7**
						
Organism:						

Gene 1	**Gene 2**	**Gene 3**	**Gene 4**	**Gene 5**	**Gene 6**	**Gene 7**
						
Organism:						

Gene 1	**Gene 2**	**Gene 3**	**Gene 4**	**Gene 5**	**Gene 6**	**Gene 7**
						
Organism:						

Gene 1	**Gene 2**	**Gene 3**	**Gene 4**	**Gene 5**	**Gene 6**	**Gene 7**
						
Organism:						

Name: _____

Use the same code to create a new Teenage Mutant Ninja Turtle. Add new codes or new genes if needed. Give your new TMNT a name and draw a picture at the bottom of this paper.

Symbol	Trait	Symbol	Trait	Symbol	Trait

Gene 1	Gene 2	Gene 3	Gene 4	Gene 5	Gene 6	Gene 7
Name:						

TMNT Genetic Code

Like 	Less / Small 	Artist 
Dislike 	Muscle 	Talk 
Green 	Pizza 	Height 
Blue 	Carrot 	Eyes 
Brown 	Ice Cream 	Sword 
Feather 	Guitar 	Nunchuk 
Shell 	Drums 	Sai 
Great / Large 	Ninja 	Bo staff 

TEACHER NAME			Lesson #
Melanie W. Stancill			3
MODEL	**CONTENT AREA**	**GRADE LEVEL**	
PBL	**Biology**	**Grades 6-8**	
CONCEPTUAL LENS		**LESSON TOPIC**	
Technology		**DNA / Heredity**	

LEARNING OBJECTIVES *(from State/Local Curriculum)*

Seventh Grade Science:

7.L.1 Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life.

Eighth Grade Science:

8.L.2 Understand how biotechnology is used to affect living organisms.

High School Biology:

Bio.3.3 Understand the application of DNA technology.

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	**THE ESSENTIAL QUESTION** *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Technology Controls Change	**How does technology control change?**

CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)	**PROCESS SKILLS** (What will students be able to do as a result of this lesson?)
Students will know that: • All living things have DNA. • Technology can be used to control changes in DNA. • DNA technologies include DNA fingerprinting, genetically modifying organisms, treating genetic disorders, and genetic engineering. • DNA technology is universal across all living things. • DNA technology can be used to control changes in an organism.	Students will be able to: • Analyze and apply technical processes. • Use research skills to gain knowledge. • Evaluate information • Generate novel ideas • Analyze and resolve complex situations

GUIDING QUESTIONS

What questions will be asked to support instruction?

Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding

Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
Step 1 Questions: • What is the problem? • What are the important facts of this problem? • What is the mission? • Who is involved? • What else do you need to know? • What needs to change in this scenario/problem? • How could you use technology to solve this problem? • How might the use of technology control change as it relates to this problem?	**Step 2 Questions:** • What do you know? • What do you need to find out? • How can you find out? • What changes could you make? • What technology could you use? • What DNA technology could you use? • How could technology help you make changes? • What needs to change in this scenario/problem?	**Step 5 Questions:** • What new knowledge did you gain in this lesson? • What were the advantages of working with others to solve a problem? • What were the advantages of discussing and defending your solutions? • What modifications would you make to your proposed solution? • What were the merits of each group's proposed solutions? • What is the advantage of creating multiple possible solutions?

	• How could you use technology to solve this problem? • How might the use of technology control change as it relates to this problem? **Step 3 Questions:** • What knowledge did you gain? • What questions did you answer? • How did you rank your possible solutions? • What knowledge supports your prioritized list? • What knowledge supports your chosen solution? • Why do you think your chosen solution will work? • What changes have you chosen to make? • What DNA technology have you chosen to use? • How does DNA technology help you make changes? • How does technology control change? **Step 4 Questions:** • What knowledge supports your chosen solution? • How can you justify the solution you have chosen? • What changes have you chosen to make? • What DNA technology have you chosen to use? • What differences do you notice among the possible solutions? • What similarities do you notice among the possible solutions presented? • What critiques can you offer each group's solution presented?	• How did each group utilize DNA technology to make changes? • How does DNA technology help you make changes? • How does technology control change?

	• What modifications will you make to your proposed solution? • How did each group utilize technology to make changes? • How does DNA technology help you make changes? • How does technology control change?	

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.

Content	Process	Product	Learning Environment
Content is above grade level for middle school students.	Students will use critical thinking, collaboration, speaking, problem solving and writing skills throughout this lesson.		

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

Step 1: Problem Engagement

Upon arriving, students are handed an URGENT MESSAGE in an envelope labeled "TOP SECRET". They are instructed not to open the envelope until everyone arrives.

"Zombies have been spotted in Canada, and they are moving south! The governor has called. We must protect the citizens of NC! You are a DNA expert and advisor to the Zombie Apocalypse Committee – code-name "ZAC Attack". Your mission is to research Zombies to find out all you can find out about them. How could you use technology to change the potential zombie invasion? What can you create to defeat these fiends?"

Performance Task:

Use your expertise in DNA technology to design a super hero with a super power that can defeat the Zombies. Create a presentation for ZAC Attack showing the super hero in action using the new super power. Provide details of the super gene you created with technology and how it changed the individual to a super hero. Consider how the changed individual might feel about the new super power and include his or her perspective in your presentation. Convince the ZAC Attack that your novel approach will be successful at defeating the Zombies.

Pre-Lesson Questions:

- What is the problem?
- What are the important facts of this problem?
- What is the mission?
- Who is involved?
- What else do you need to know?
- What needs to change in this scenario/problem?

- How could you use technology to solve this problem?
- How might the use of technology control change as it relates to this problem?

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

Step 2: Inquiry and Investigation
Students will work in small groups of 2-3 to complete a "Need to Know Board".

Need to Know Board		
What do we know?	**What do we need to know?**	**How can we find out?**

After students have worked in small groups to complete the "Need to Know Board", the teacher will compile a comprehensive "Need to Know Board" based on input from all groups.

During Lesson Questions:
- What do you know?
- What do you need to find out?
- How can you find out?
- What changes could you make?
- What technology could you use?
- What DNA technology could you use?
- How could technology help you make changes?
- What needs to change in this scenario/problem?
- How could you use technology to solve this problem?
- How might the use of technology control change as it relates to this problem?

Students work in their groups of 2-3 to research and acquire knowledge and information to support multiple possible solutions using resources and technology available. Research tasks will be assigned within the group and deadlines created.

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

Step 3: Problem Definition

Student groups will restate the problem in their own words. Then, they will share knowledge gained within their group. The problem can be rewritten as new information is shared.

Student groups will formulate at least 3 possible solutions. Student groups will compare and evaluate the possible solutions to create a prioritized list. Then each group will select one solution as their group's best or preferred choice.

During Lesson Questions:

- What knowledge did you gain?
- What questions did you answer?
- How did you rank your possible solutions?
- What knowledge supports your prioritized list?
- What knowledge supports your chosen solution?
- Why do you think your chosen solution will work?
- What changes have you chosen to make?
- What DNA technology have you chosen to use?
- How does DNA technology help you make changes?
- How does technology control change?

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Step 4: Problem Resolution

Each student group will create a detailed presentation to explain their chosen solution that includes the problem statement, the "Need to Know" Board, knowledge gained, analysis of information, and support for their conclusions. In a "board meeting", each group will present, provide evidence, and defend their solution. Solutions will be discussed in detail, compared and contrasted. Possible outcomes will be explored.

During Lesson Questions:

- What knowledge supports your chosen solution?
- How can you justify the solution you have chosen?
- What change or changes have you chosen to make?
- What DNA technology have you chosen to use?
- What will be the outcome of the solution you have chosen?
- What differences do you notice among the possible solutions presented?
- What similarities do you notice among the possible solutions presented?
- What critiques can you offer each group's solution?
- What modifications would you make to your proposed solution?
- How did each group utilize technology to make changes?
- How does DNA technology help you make changes?
- How does DNA technology control change?
- How does technology control change?

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Step 5: Problem Debriefing

Teachers and students will reflect on the process and their learning through a teacher-facilitated classroom discussion.

After Lesson Questions:

- What new knowledge did you gain in this lesson?
- What were the advantages of working with others to solve a problem?
- What were the advantages of discussing and defending your solutions?
- What modifications would you make to your proposed solution?
- What were the merits of each group's proposed solutions?
- What is the advantage of creating multiple possible solutions?
- How did each group utilize DNA technology to make changes?
- How does DNA technology help you make changes?
- How does DNA technology control change?
- How does technology control change?

Pre Lesson for Day 4:

Performance Task:

Use your expertise in DNA technology to design a super hero with a super power that can defeat the Zombies. Create a presentation for ZAC Attack showing the super hero in action using the new super power. Provide details of the super gene you created with technology and how it changed the individual to a super hero. Consider how the changed individual might feel about the new super power and include his or her perspective in your presentation. Convince the ZAC Attack that your novel approach will be successful at defeating the Zombies.

TEACHER NAME			Lesson #
Melanie W. Stancill			4
MODEL	**CONTENT AREA**	**GRADE LEVEL**	
Kohlberg's Stages of Moral Development	**Biology**	**Grades 6-8**	
CONCEPTUAL LENS		**LESSON TOPIC**	
Technology		**DNA / Heredity**	

LEARNING OBJECTIVES *(from State/Local Curriculum)*

Seventh Grade Science:

7.L.1 Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life.

Eighth Grade Science:

8.L.2 Understand how biotechnology is used to affect living organisms.

High School Biology:

Bio.3.3 Understand the application of DNA technology.

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	**THE ESSENTIAL QUESTION** *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Technology Controls Change	**How does technology control change?**
CONTENT KNOWLEDGE **(What factual information will students learn in this lesson?)**	**PROCESS SKILLS** **(What will students be able to do as a result of this lesson?)**
Students will know that: • Technology can be used to control changes in DNA. • DNA technologies include DNA fingerprinting, genetically modifying organisms, treating genetic disorders, and genetic engineering. • DNA technology can be used to control changes in an organism. • Students will know that morals are the principles that represent what we consider to be right or wrong. • Students will know that a dilemma is a problem for which the solution can be complex; that the problem and solution may have moral and/or ethical implications.	Students will be able to: • Compare and contrast • Create persuasive arguments • Prioritize • Consider multiple perspectives • Evaluate information • Analyze and resolve complex situations

GUIDING QUESTIONS

What questions will be asked to support instruction?

Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding

Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
Questions for "hook" • What do you see in the picture? • What else do you see in the picture? • What is going on in the picture? **Pre-Lesson questions:** • What is a dilemma? • What is an example of a dilemma? • What makes dilemmas difficult? • How might you go about solving a dilemma? • What is morality?	**Step 2 Questions:** • What are the important facts of this dilemma? • Who is involved? • How are the individuals affected? • What else do you need to know? • What options are available to parents? • What options are available to the children? • How do morals relate to this dilemma? • How is technology involved in this dilemma?	**Step 6 Questions:** • What do you think about the role of technology in controlling change? • Now what do you think about parents changing the genome of their children? • What is the most important reason for this stance? • How does technology control change?

• How do you think morals relate to a dilemma? • What factors inform morals? • When do/should people use their morals? • How would you define moral development? **Step 1 Questions:** • What is the dilemma? • How is this an example of a dilemma? • What makes this dilemma difficult?	• How might the use of technology control change as it relates to this dilemma? **Step 5 Questions:** • What are the important facts of this dilemma? • Who is involved? • How are the individuals affected? • What options are available to parents? • What options are available to the children? • How do morals relate to this dilemma? • How is technology involved in this dilemma? • How might the use of technology control change as it relates to this dilemma? • How do you think the children would feel if their parents could have used technology to control changes in their genes and did not? • How do you think the children would feel if their parents used technology to control changes in their genes? • How would individuals with genetic disorders feel about others who used technology to control changes in their genes before birth? What about the opposite situation? • How do you think this technology controls changes in people? • How do you think this technology that controls changes in humans also changes our relationships	

	with other people? • How do you think this technology that controls changes in humans also changes our societies? • How do you think any technology that controls changes affect people and societies? • How does technology control change?	

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.

Content	Process	Product	Learning Environment
Content is above grade level for middle school students.	Students will use critical thinking, collaboration, speaking, problem solving and writing skills throughout this lesson.	Students may select any presentation method they prefer, including drawings, electronic representations, 3-D models, audio recordings, video recordings, or any other method they envision as long as it is approved by the teacher.	

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

As students enter the room, the teacher displays (so that everyone can see) a picture of divergent paths. Students are instructed to view the picture individually and quietly.

Teacher asks:
What do you see in the picture?
What else do you see in the picture?
What is going on in the picture?

Students will have the opportunity to respond to the questions and to share their thoughts. (Answers should include something about trying to make a decision. Each decision leads takes you down different paths with different outcomes.)

The teacher will facilitate with pre-lesson questions:

- What is a dilemma?
- What is an example of a dilemma?
- What makes dilemmas difficult?
- How might you go about solving a dilemma?
- What is morality?
- How do you think morals relate to a dilemma?
- What factors inform morals?
- When do/should people use their morals?
- How would you define moral development?

Step 1: Introduce and Clarify Dilemma
Students are provided a condensed version of the Introduction section of "Should you edit your children's genes" by Erica Cheek Hayden found in *Nature*, 530, 402–405 (25 February 2016).

Teacher will facilitate with Step 1 Questions:

- What is the dilemma?
- How is this an example of a dilemma?
- What makes this dilemma difficult?

Step 2: Clarify the facts and identify the issues involved.
Teacher continues to facilitate group discussion about the dilemma.

Teacher will facilitate with Step 2 Questions:

- What are the important facts of this dilemma?
- Who is involved?
- How are the individuals affected?
- What else do you need to know?
- What options are available to parents?
- What options are available to the children?
- How do morals relate to this dilemma?
- How is technology involved in this dilemma?
- How might the use of technology control change as it relates to this dilemma?

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

Step 3: Students identify tentative position.

The teacher asks students to individually choose a position for themselves decision (Parents should or should not edit children's genes.) and jot down one or two reasons for their decision. The teacher asks for students to group themselves by response. Students discuss reasons for their choice within their group and selects the best 2-3 reasons. Then each group reports back to the class after 5 minutes of discussion. Each group reports their best 2-3 reasons.

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

Step 4: Divide class into small groups

Prereading video: How CRISPR works.

After viewing the video, students will be divided randomly into 2 groups. Half of the students will read the condensed version of "Case for…" and the other half will read "Case against" from "Should you edit your children's genes" by Erica Cheek Hayden found in *Nature*, 530, 402–405 (25 February 2016). Within

the groups, they will discuss the cases for and against possible choices in this dilemma and choose the best 2-3 reasons from the article. A student from each group will be chosen to provide a summary of the article and the best 2-3 reasons chosen by the group.

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Step 5: Students reconvene for full class discussion of the dilemma

Students will return to the whole group and, if possible, sit in a circle where everyone can see each other. Teacher will facilitate a whole group discussion of the dilemma in light of the new information presented by each group (Case For and Case Against). Discussion will begin with a representative from each group summarizing the article and identifying the best 2-3 reasons from the article.

Teacher will facilitate with Step 5 questions.

- What are the important facts of this dilemma?
- Who is involved?
- How are the individuals affected?
- What options are available to parents?
- What options are available to the children?
- How do morals relate to this dilemma?
- How is technology involved in this dilemma?
- How might the use of technology control change as it relates to this dilemma?
- How do you think the children would feel if their parents could have used technology to control changes in their genes and did not?
- How do you think the children would feel if their parents used technology to control changes in their genes?
- How would individuals with genetic disorders feel about others who used technology to control changes in their genes before birth? What about the opposite situation?
- How do you think this technology controls changes in people?
- How do you think this technology that controls changes in humans also changes our relationships with other people?
- How do you think this technology that controls changes in humans also changes our societies?
- How do you think any technology that controls changes affect people and societies?
- How does technology control change?

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Step 6: Students Reevaluate original position

Students will reflect on the process and their learning. Students will be asked to reevaluate their original position (from Step 3) and answer two follow up questions.

Teacher will facilitate with Step 6 questions.

- What do you think about the role of technology in controlling change?
- Now what do you think about parents changing the genome of their children?
- What is the most important reason for this stance?

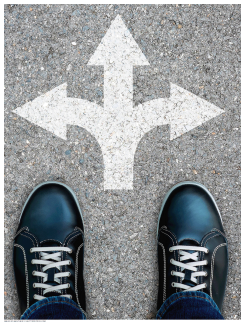
- How does technology control change?

Remainder of class:

Students will complete their performance task from the problem-based learning lesson. Students will be reminded that the task includes reflective piece that considers how the changed individual might feel about the new super power. Students should re-evaluate their response based on today's learning.

Performance Task:
Use your expertise in DNA technology to design a super hero with a super power that can defeat the Zombies. Create a presentation for ZAC Attack showing the super hero in action using the new super power. Provide details of the super gene you created with technology and how it changed the individual to a super hero. Consider how the changed individual might feel about the new super power and include his or her perspective in your presentation. Convince the ZAC Attack that your novel approach will be successful at defeating the Zombies.

Engage and Connect Picture:



Condensed version of "Should you edit your children's genes" by Erika Check Hayden Nature Vol. 530 25 Feb 2016

Introduction

Ruthie Weiss's basketball team seemed to be minutes away from its fourth straight loss. But even as she stood on the sidelines for a brief rest, the nine-year-old had not given up. She convinced the coach to put her back in the game. Then, she charged out onto the court, caught a pass from a teammate and drove straight to the basket. Swish! Ruthie scored a quick two points, putting her team in the lead. As the game clock wound down, she scored again, clinching the victory. The team had earned its first win of the season, and celebrated as if it had just taken the national championship. A couple of parents from the opposing team even stopped by to congratulate Ruthie, who had scored all of her team's 13 points: "Wow, she's unbelievable!" they told her mum and dad.

What makes Ruthie's performance even more extraordinary is her DNA. Because of a misspelling in one of her genes, she has albinism: her body produces very little of the pigment melanin, which means that her skin and hair are fair, and that she is legally blind. Her visual acuity is ten times worse than average. She is still learning to read and will probably never be able to drive a car, but she can make out the basket and her teammates well enough to shoot, pass and play.

In January, Ruthie's dad Ethan asked her whether she wished that her parents had corrected the gene responsible for her blindness before she was born. Ruthie didn't hesitate before answering — no. Would she ever consider editing the genes of her own future children to help them to see? Again, Ruthie didn't blink — no.

The answer made Ethan Weiss, a physician–scientist at the University of California, San Francisco, think. Weiss is well aware of the rapid developments in gene-editing technologies — techniques that could, theoretically, prevent children from being born with deadly disorders or with disabilities such as Ruthie's. And he believes that if he had had the option to edit blindness out of Ruthie's genes before she was born, he and his wife would have jumped at the chance. But now he thinks that would have been a mistake: doing so might have erased some of the things that make Ruthie special — her determination, for instance. Last season, when Ruthie had been the worst player on her basketball team, she had decided on her own to improve, and unbeknownst to her parents had been practising at every opportunity. Changing her disability, he suspects, "would have made us and her different in a way that we would have regretted", he says. "That's scary."

The cases for

John Sabine, now 60, was once described as one of the brightest legal minds of his generation in England. Now, he is in the advanced stages of Huntington's disease: he cannot walk or talk, is incontinent and requires constant care. Charles Sabine, his younger brother, carries the same genetic glitch that causes Huntington's disease, and therefore knows that, like his brother and his father before him, he is destined to undergo the same deterioration of brain and body.

Charles and his brother have five children between them, each of whom as a 50% chance of having inherited the mutation that causes Huntington's disease. To Charles — and to many others who live with the mutation that causes Huntington's — there is no legitimate ethical argument about whether gene editing should be used, either to treat people living with the condition now or to spare their children from it.

"Anyone who has to actually face the reality of one of these diseases is not going to have a remote compunction about thinking that there is any moral issue at all," Sabine says. "If there was a room somewhere where someone said, 'Look, you can go in there and have your DNA changed,' I would be there breaking the door down."

Matt Wilsey, a technology entrepreneur in San Francisco, would be there too. His daughter Grace was one of the first people in the world to be diagnosed with a disease caused by a mutation in the gene *NGLY1*, which makes it difficult for her cells to get rid of misshapen proteins. Grace, now six years old, has severe movement and developmental disabilities. She can barely walk and cannot talk. Because her condition is new to medicine, doctors cannot even predict how long she might live.

Wilsey is bullish on CRISPR. He says that if he had had the chance to detect and fix the mutation in Grace's genome before she was born, he would have. But he is frustrated that the debate over editing embryos seems to have monopolized discussions about the technology. He is hopeful that a gene-therapy-like approach using CRISPR, which would be free of the ethical concerns about altering the genes she passes on, could help Grace within several years. And he wonders whether a temporary moratorium on embryo editing might allow the field to focus on such approaches sooner.

The cases against

Some disability-studies researchers do not oppose the idea of gene editing, but do think that society needs to understand that it is not possible to eliminate all disability, and that humans might lose something important if they try to do so.

Rosemarie Garland-Thomson, a literature scholar and co-director of the Disability Studies Initiative at Emory University in Atlanta, Georgia, adds that legislative mandates, such as the 1990 Americans with Disabilities Act in the United States, have helped to integrate people with disabilities into society — in workplaces, schools and other public spaces. As a result, the world

is much more humane for everyone, says Garland-Thomson. “These kinds of interactions significantly change our attitudes about what kinds of people matter in the world.”

The idea that parents should edit out characteristics that are considered debilitating goes against this drive towards inclusion, Garland-Thomson warns, and could create a harsher social climate for everyone. The experience of disability, she adds, is universal; all people inevitably experience sickness, accidents and age-related decline. “At our peril, we are right now trying to decide what ways of being in the world ought to be eliminated,” she says.

Even if gene editing were safe, effective and everyone opted to use it, it would not eliminate genetic diseases, because researchers still have a long way to go to understand the genes involved. Padden notes, for instance, that some mutations that predispose to genetic disease, such as the sickle-cell mutation, confer population-level benefits, such as resistance to malaria. So, editing out one disease could backfire by increasing the risk of another. She argues that very little is known about the potential benefits of other mutations associated with disease, and applying genome editing too freely could have unintended consequences.

People without disabilities consistently underestimate the life satisfaction of those with them. People with disabilities argue that scientists, policymakers and bioethicists should take steps to ensure that the CRISPR debate reflects what is best for patients and their families, to ensure its most humane use now and for future generations.

Unit Resources:

American Chemical Society. (2016, September 6). *Genetically modified humans? CRISPR/Cas 9 explained*. [Video file]. Retrieved from https://www.acs.org/content/acs/en/pressroom/newsreleases/2016/september/genetically-modified-humans-crisper-cas-9-explained-video.html.

This video explains how a new, more precise method of genetic modification works and explores the possibility of use in humans.

Avid. *Three Story House (Costa’s Levels of Questioning).* [PDF file]. Retrieved from http://blog.adambabcock.com/wp-content/uploads/2013/03/Costa-House-Levels-of-Questions.pdf.

This PDF provides an easy to understand explanation of Costa’s Levels of Questioning as well as questions stems for each level.

Biology Junction. (2019). *The* E. coli *Insulin Factory*. [PDF file]. Retrieved from https://www.biologyjunction.com/ecoli%20insulin%20factory.pdf.

This activity models genetic modification using paper DNA.

Eco-Wise Videos. (2015, March 28). *What is Genetic Engineering?* [Video file]. Retrieved from https://www.youtube.com/watch?v=3IsQ92KiBwM.

This video explains genetic engineering.

Genetic Science Learning Center. (2004). *Have your DNA and Eat It Too!* [PDF file].

Retrieved from

https://teach.genetics.utah.edu/content/dna/HaveYourDNAandEatItToo.pdf.

This activity models DNA structure using candy and toothpicks.

Genetic Science Learning Center. (2004). *How to Extract DNA from Anything Living*.

[PDF file]. Retrieved from

https://learn.genetics.utah.edu/content/labs/extraction/howto/DNA_Extraction.pdf.

This experiment uses household products to extract DNA from anything.

Genetic Science Learning Center. (2016, March 1). *What are DNA and Genes?* [Video

file]. Retrieved from https://learn.genetics.utah.edu/content/basics/dna/.

This video explains the structure of DNA and the relationship between DNA and genes.

Genetic Science Learning Center. (2016, March 1). *What are Traits?* [Video file].

Retrieved from https://learn.genetics.utah.edu/content/basics/traits/.

This video explains how DNA codes for traits and the effect of environment on some traits.

Harrison, C. (2018). The HCI innovator's dilemma. *Interactions*, 25, 6, 26-33. DOI:

https://doi.org/10.1145/3274564. Retrieved from

http://interactions.acm.org/archive/view/november-december-2018/the-hci-

innovators-dilemma.

This article contains a photo suitable for as a hook for a dilemma.

Hayden, E. C. (2016). “Should you edit your children’s genes?” *Nature*, 530, 402–405.

Hayden explores the moral dilemma of editing your children’s genes. Multiple perspectives are provided. Students are given an abridged version of the article.

HHMI Biointeractive. (2018, March 12). *Genetically Modified Mosquitoes*. [Video file].

Retrieved from https://www.biointeractive.org/classroom-resources/genetically-modified-mosquitoes.

This video explores how scientists in Brazil have genetically modified mosquitoes to combat transmission of the Zika virus.

White, M. (2109). *Teenage Mutant Ninja Turtle Genetic Code Activity*. Unpublished.

This is an activity that I developed on my own.

Yourgenome.org. (2017). *What is a GMO?* [PDF file]. Retrieved from

https://www.yourgenome.org/facts/what-is-a-gmo.

This webpage explains what a GMO is and how it is produced.

Yourgenome.org. (2016). *What is Gene Therapy?* [PDF file]. Retrieved from

https://www.yourgenome.org/facts/what-is-gene-therapy.

This webpage explains how genetic modification can be used to correct genetic disorders.

Yourgenome.org. (2017). *What is Genetic Engineering?* [PDF file]. Retrieved from

https://www.yourgenome.org/facts/what-is-genetic-engineering.

This webpage explains the process of genetic engineering.