



***The Power of Choice:
How Environment Can Change Our Genes and Our Lives***

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This curriculum unit is recommended for:
Grade 5 Science, English Language Arts, Healthful Living, and Social Studies

Keywords: Genetics, Civics, Elementary Science, Persuasive Writing, Epigenetics, Nutrition, School Lunches

Teaching Standards: See [Appendix 1](#) for teaching standards addressed in this unit.

Synopsis: This unit is a multidisciplinary unit with an integration of science, health/nutrition, ELA, and civics. Students will begin by learning about inherited, acquired, and learned characteristics and behaviors. Then, we will move into nutrition and some basic epigenetics effects, such as the impact of maternal nutrition on her developing fetus. The overarching theme for the unit is choice. Students should understand they can make choices now that will affect their health in the present and future, and possibly affect the health of their offspring. We will examine our school's lunch menu for the month and see where healthier choices could be incorporated.

The unit will then transition to identifying a local representative that may be able to help our students make healthy changes in their school cafeteria. The culminating project will be to write persuasive letters to the representative to persuade him/her to help our cause. A rubric will outline requirements. Students will share the writing process together to ensure we write clear, effective arguments with a unified purpose.

I plan to teach this unit to 39 students in fifth grade science in Spring 2019.

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Introduction

This unit will explore how our genes can be affected and altered by the environment. Students will begin by exploring the difference between inherited traits and acquired traits (including instincts and learned behaviors). Students will use Punnett Squares to examine the statistical probability of offspring inheriting traits from parents.

After they have gained a foundational understanding of genetics and heredity, students will study the theory of epigenetics as it relates to social justice. They will develop an understanding of how epigenetics is related to our traditional view of inheritance and genetics, and how environmental factors impact their genes and lives. They will investigate how some environmental factors are a choice (e.g., diet) while others are not (e.g., air quality). The culminating project will require students to write a persuasive letter to a local or state representative regarding the social justice issues addressed within the unit and propose a solution(s) at the city or state level.

Rationale

The broad theme of this unit is choice. Many choices that we make affect our health: our lifestyle can impact our health in profound ways. At this stage, most students know that. They know that eating healthfully is better for their bodies than eating junk food. What they may not realize is that their diets go beyond their own bodies: the field of epigenetics studies how these choices can affect our genes and the genes we pass down to offspring. There are environmental factors that people have less control over, like the quality of air they breathe. This lack of choice ties back to the unit theme of choice. Students need to understand that knowledge and choice will give them power over their health and their lives.

This unit is intended for an upper-elementary or middle school science classroom. Students of this age are able to make conscious lifestyle decisions that can impact their families, their genes (and therefore, their health) and the genes of their offspring for multiple generations. The knowledge they acquire in this unit will inform them of how their choices have consequences.

School & Student Demographics

I teach at Starmount Academy of Excellence in the Starmount neighborhood of Charlotte, North Carolina. We serve approximately 480 students in pre-kindergarten through fifth grade. There are 24 general education classroom teachers, 3 specialist teachers, 10 teaching assistants, 2 exceptional children teachers, a family support advocate, a social worker, 1 school psychologist, and 2 visiting child psychologists.

Approximately 60% of students qualify for English as a Second Language instruction, and many classroom teachers are licensed in English as a Second Language (myself included). About 6% of those students are newcomers (immigrated within the past year) to the United States. Most of our Latinx students' families have immigrated from central and South America within the past 0-10 years.

The student population is 70% Hispanic, 22% black, 5% white, and 3% "other." 99.3% of these students qualify for free lunch. Because of this exceptionally high percentage, we offer free breakfast and lunch to all students. We also send home bagged lunches over the weekends

for families who request additional aid. Teachers are encouraged to privately identify families in need to the school social worker, who helps them with food, housing, clothing, mental health support, and medical healthcare needs.

I teach fifth grade math and science. Our fifth grade is a hybrid departmentalization model, meaning two sets of two teachers share four homeroom classes. Each homeroom has one teacher for reading, writing, and social studies and another teacher for math and science. I teach a total of 39 students in two classes. My students receive 60 minutes of math instruction per day, 45 minutes of science instruction per day, and 80 minutes of small group math instruction per week.

Unit Goals

The broad goal of this unit is for students to recognize their choice and power over their genetics. At first, I looked at epigenetics as somewhat depressing, because I saw all the ways people do not have control over their genetic “destinies.” Then, I started to realize that there are many things they do have control over. A key environmental factor we will study is diet and how it shapes our genes and the genes of our future offspring.

Students will need a foundational understanding of heredity and genetics. They will also need to conduct research on the internet and write a persuasive letter. A basic of understanding of civics and government is also required for full mastery and application of the unit curriculum.

Content Research

Genetics, Epigenetics, & Nutrition

DNA & Genes

Deoxyribonucleic acid, or DNA, was discovered in 1953 by James Watson & Francis Crick. Genes, or units of heredity, account for about 3% of a human’s DNA. It is a macromolecule composed of deoxyribose (sugar), a phosphate group, and a nitrogen base. DNA is debatably a “blueprint” that directs protein production in cells.¹ DNA is made of strings of four bases: adenine (A), guanine (G), cytosine (C), and thymine (T). The sequence of these bases is referred to as our genetic code.²

Most biology students have learned that the inheritance of specific genes is relatively predictable. Our genomes, or complete set of genes, are inherited from our biological parents. You may remember from biology class using Punnett squares to predict the genotype of an offspring, or what genes a child will inherit from their parents.³ Different versions of genes are called alleles. There are dominant and recessive alleles of genes, such as earlobe attachment. For example, the two alleles are free earlobes, F, and attached earlobes, f. The capital letter denotes the dominant allele and the lowercase letter denotes the recessive allele.

¹ Reitzel, “DNA: A Simple Double Helix?”

² Ellis & Pugh, *Introducing Epigenetics: A Graphic Guide*, 4

³ Peck, “What are Punnett Squares and How Do They Work?”

Table 1. Punnett square showing one parent with two recessive alleles (ff) and one parent with two dominant alleles (FF).

	f	f
F	Ff	Ff
F	Ff	Ff

This Punnett square shows the two parent genes: a person who has the recessive gene with attached earlobes (ff) and a parent who has two dominant alleles of the free earlobe gene (FF). Their offspring have a 100% chance of inheriting free earlobes, because all genes have the dominant F, or free earlobes.⁴

If we imagine the same first parent with attached earlobes (ff) and one parent with one dominant allele and one recessive allele (Ff), their offspring would have a 50% of chance of inheriting attached earlobes. See Table 2.

Table 2. Punnett square showing one parent with two recessive alleles (ff) and one parent with a dominant allele and a recessive allele (Ff).

	f	f
F	Ff	Ff
f	ff	ff

Since I have an Australian shepherd, I am going to teach Punnett squares with the various fur coat color genotypes an Australian shepherd can have. The American Kennel Club recognizes black, blue merle, red, and red merle, though there are other unofficial color possibilities. Markings can include tan points, white markings, and both tan points with white markings.⁵ The genotypes of each Australian shepherd lead to their unique coat colors. Students will first learn about what a genotype is and the move into the phenotypes associated with each color. The Australian Shepherd Health & Genetics Institute has a helpful chart to show the various genotypes and accompanying phenotypes that are most likely in an Australian shepherd.⁶ They will each be assigned a different Australian shepherd puppy and create Punnett squares to predict what the parents of their puppy look like.

Inherited Versus Acquired Traits

In fifth grade, students are expected to understand that organisms can be different or similar to their parents. They also need to be able to identify that some similarities are inherited while others are acquired. Students need to be able to differentiate between inherited traits, acquired traits, inherited behaviors (instincts), and learned behaviors.

⁴ Cory, "Predicting Inheritance Using Punnett Squares"

⁵ American Kennel Club, "Australian Shepherd"

⁶ Australian Shepherd Health & Genetics Institute, "Coat Color Genes"

Table 3. Examples of Inherited and Acquired Traits and Behaviors

	Inherited	Acquired
Trait	Inherited physical characteristics Examples: attached earlobes, ability to roll tongue, eye color	Acquired physical characteristics Examples: scar, tattoo, loss of limb in an accident
Behavior	Instincts Examples: turn to direction of loud sound, dog circling before lying down, fight or flight	Learned behavior Examples: saying “thank you,” studying for a test, riding a bike

Epigenetics

The way genetics is presented to most students is that *we don't have a choice*. As Dr. Sharon Moalem argues in *Inheritance: How Our Genes Change Our Lives and Our Lives Change Our Genes*, we are taught that, “our genetic legacy was completely fixed when our parents conceived us. But that’s all wrong.”⁷ Epigenetics is the study of changes in organisms caused by modification of gene expression, rather than alteration of the genetic code itself.

Stated by Ennis & Pugh,

Epigenetics is about how the genes we inherit from our parents are controlled, and how they interact with our environment: how our genes make us, well, us. ‘Epi-’ means upon, or in addition; epigenetics is the study of how additional factors interact with genes to direct the processes that make our cells and bodies work.⁸

Epigenetics goes beyond the classic “nature versus nurture” conversation, as it states that gene expression can be permanently altered based on choices we make (or choices that are made for us) in our environments.

A French biologist, Jean-Baptiste Lamarck, argued in the nineteenth century that the inheritance of acquired traits is a component of evolution.⁹ Lamarck’s ideas were originally well-received (even by Charles Darwin), but by the twentieth century his ideas had been rejected. Biologists now know that the Lamarckian idea of acquired trait heredity is a hallmark of epigenetics. Of course, this does not mean that tattoos or the loss of a limb are traits that can be inherited by offspring. Changes that occur in the epigenome, the structures and mechanisms that control how genes are expressed, however, could possibly be passed on to children. This phenomenon is being investigated in a wide variety of organisms by biologists who study epigenetics.

⁷ Moalem, *Inheritance: How Our Genes Change our Lives and Our Lives Change Our Genes*, x

⁸ Ennis & Pugh, *Introducing Epigenetics: A Graphic Guide*, 3

⁹ Moore, *The Developing Genome*, 148

Wilhelm Johannsen argued in 1911 that offspring inherit “raw materials” from their parents but have to “construct” their own characteristics. The only things actually transmitted generation to generation is what is in the sperm and egg.¹⁰ Moore provides a useful comparison in *The Developing Genome* (pg. 148): you cannot inherit your parents entire house, but you can inherit the raw materials (e.g., granite, glass, lumber) to build your own house.

Epigenetics as a process is without question true. However, one component of epigenetics research that is controversial is the idea of transgenerational inheritance, where we can inherit traits our ancestors acquired during their lifetimes. This means that we inherit part of the environment our ancestors lived in. When a fetus is developing, of course it is inheriting parts of the environment from its mother: its mother *is* its environment. We know during gestation that maternal nutrition^{11 12}, maternal stress¹³ and alcohol consumption¹⁴ can permanently affect her offspring’s health.

The inheritance of environmental exposures can happen via DNA methylation, changes of histone and chromatin, RNA differences, and prions; however, the most researched is DNA methylation. In DNA methylation, methyl molecules bind to DNA (only on one of the four nucleotides, cytosine), and restrict access, which prevents DNA transcription. Demethylation of DNA can happen right after fertilization and in primordial germ cell development.¹⁵

Some changes do not experience this demethylation process, which leads to the inheritance of epigenetic changes. Epigenetic studies of humans are limited because ethically, we cannot use experimental designs on humans to the same extent as in other animals. Basic studies in human epigenetics focus on nutritional deficits, parental smoking, arsenic and lead exposure, radiation exposure, BPA and phthalates exposure, and some reproductive treatments.¹⁶

Nutrition

A balanced diet is important in maintaining long and healthy lives. The United States Department of Agriculture (USDA) currently offers the MyPlate tool to guide healthy meal portions for children and adults. MyPlate recommends half a plate of fruit and vegetables (with slightly more vegetables) and half a plate of grains and protein (with slightly more grains) per meal. An emphasis is placed on variety, portion size, and limiting fats, sodium, and added sugar.¹⁷ Historically, these recommendations have varied greatly. Most parents of today’s students were taught the Food Guide Pyramid, which was the USDA’s recommendation from 1992-2005.¹⁸ The Food Guide Pyramid recommended daily serving amounts of the food groups, while MyPlate gives a visual model of a plate for each meal. MyPlate also omits a category for fats, oils, and sweets altogether, which was previously included on the Food Guide Pyramid.

¹⁰ Moore, *The Developing Genome*, 147

¹¹ Moore, *The Developing Genome*, 128-130

¹² Mukherjee, *The Gene*, 393-394

¹³ Francis, *Epigenetics: How Environment Shapes Our Genes*, 42

¹⁴ Kobor & Weinberg, “Focus On: Epigenetics and Fetal Alcohol Spectrum Disorders”

¹⁵ Rothstein, Harrell, & Marchant, “Transgenerational epigenetics and environmental justice,” 1

¹⁶ Rothstein, Harrell, & Marchant, “Transgenerational epigenetics and environmental justice,” 2

¹⁷ United States Department of Agriculture, “What is a Healthy Eating Style?”

¹⁸ United States Department of Agriculture, “A Brief History of the USDA Food Guides”

School lunches in the United States are considered by many to be unhealthy.¹⁹ Since many American schoolchildren experiencing poverty eat both breakfast and lunch at school, this is a significant and urgent problem. For many students, they do not have a choice in where they eat these meals. In Oberst's article from the Food Revolution Network, nutritious school lunches can have the following positive impacts in the "right now": (1) better learning and memory, (2) improved concentration, (3) better overall health, (4) better behavior and fewer problems, (5) better academic performance, (6) reducing rates of obesity, and (7) better habits for the future. An investigation by USA Today found that school lunch meat standards are *lower* than standards for fast food meat.²⁰ Though school meals are required to meet MyPlate standards, the quality of food is shockingly low in many schools.

The USDA has a curriculum available for teachers and parents to help children understand their nutrition and make better dietary choices. The teacher version incorporates the 5E model of instruction. This resource²¹ would be a great introduction or extension to this unit.

Nutrition can impact the health of that person, as well as their future offspring. Carey argues in *The Epigenetics Revolution* that the global obesity epidemic may have already caused a suboptimal epigenetic environment for our descendants, generations from now.²² Though much research is still required, the current literature supports the theory that nutrition and diet have long-lasting epigenetic consequences (both good and bad).

For example, pregnant women are now almost universally advised to take folic acid supplements to prevent spina bifida in the developing child.²³ In a study by Robert Waterland and Randy Jirtle at the Duke University Medical Center in North Carolina, the diet of pregnant mice were found to have permanent epigenetic effects in offspring with identical genomes. A mother's diet supplemented with methyl donors (e.g., folic acid, vitamin B12, and choline) had lasting impacts on the development of the *agouti* gene, which is expressed in coat color and possible cancer development later in life.²⁴ Clearly, the diets of pregnant mothers have lasting epigenetic effects on offspring. The addition of folate supplements to the diet of pregnant women has decreased miscarriage rates in countries which have adopted this strategy.

Persuasive Letter Writing

The final product of this unit is for students to write a persuasive letter to their legislators. Persuasive letters (or argument writing) require specific components to be effective. Students will need to write a polished and compelling letter. A complete persuasive letter includes an introduction with a thesis, body paragraphs with supporting evidence, and a conclusion.

The introduction is arguably the most important part of a letter. The introduction should include the context and general information, state the importance of the main idea, and a thesis statement.²⁵ While fifth graders have experience with introductions, they may not have experience with writing a thesis. As quoted in the Purdue Online Writing Lab, the *MLA*

¹⁹ Oberst, "Why School Lunches in America are Unhealthy and 10 Ways You Can Take Action to Improve Them"

²⁰ Eisler, Morrison, & DeBarros

²¹ USDA, "Serving Up MyPlate: A Yummy Curriculum"

²² Carey, *The Epigenetics Revolution*, 309

²³ Carey, *The Epigenetics Revolution*, 309

²⁴ Moore, *The Developing Genome*, 140

²⁵ Purdue Online Writing Lab, "Argument Papers"

Handbook for Writers of Research Papers states, “A thesis statement is a single sentence that formulates both your topic and your point of view.” Students will need a strong background in the subject area to state their position while demonstrating an argument grounded in logos, pathos, and ethos.

The ReadWriteThink website has an excellent lesson plan²⁶ to help students compose a persuasive letter. It includes building background knowledge, an interactive web-based graphic organizer, cooperative learning opportunities, and a thorough rubric. This is a resource I plan to use prior to the unit to acquaint students with the persuasive writing model. The whole lesson is four sessions of forty minutes each.

The Branches of Government and Writing to Legislators

The North Carolina State Government is similar to the federal government, with legislative, executive, and judicial branches. For the purposes of this unit, we will be focusing on identifying appropriate legislators in the legislative branch.

In North Carolina, the legislative branch is comprised of the General Assembly, which includes the Senate and the House of Representatives. Senators and Representatives serve two year terms.²⁷ We will be contacting appropriate Representatives from the House. Students will research to find their representative in the House. The North Carolina General Assembly offers a tool²⁸ to identify your legislators.

The National Education Association (NEA) advises that letters written to legislators be brief, formal, and provide information for the letter receiver to follow up.²⁹

Instructional Implementation

General Teaching Strategies

This unit will utilize a variety of instructional methods to meet the needs of diverse learners. Teaching strategies will focus on vocabulary acquisition, concept development, cooperative learning, and application of knowledge.

Fruyer Model of Vocabulary Acquisition

The Fruyer model of vocabulary helps students develop a deep understanding of content-specific terminology. I will use this vocabulary model as a “bell ringer” activity that students will complete for the first five (5) minutes of class. The Fruyer model³⁰ is a 2 x 2 graphic organizer with the term in the middle. They define the term, illustrate the the term, and provide examples and non-examples. My students use the Fruyer model for all math and science vocabulary. As an accommodation, I allow some students to work in partners. I always also students to use the

²⁶ Manning, “Can You Convince Me? Develop Persuasive Writing”

²⁷ Department of the Secretary of the State of North Carolina “Organizational Chart of North Carolina State Government”

²⁸ North Carolina General Assembly, “Who Represents Me?”

²⁹ NEA, “Writing to Your Legislators”

³⁰ The Teacher Toolkit, “Fruyer Model”

internet for research while completing their models, but they are instructed on paraphrasing sources and avoiding plagiarism.

Kagan Cooperative Learning Structures

Cooperative learning structures will be used to facilitate effective and purposeful group work. The goal of using these strategies is embed the “PIES” principle: positive interdependence, individual accountability, equal participation, and simultaneous interaction. Positive interdependence encourages students to contribute to good of the group, and embodies the “all for one, one for all” concept. Individual accountability is important to motivate all students to participate in equitable way, as all students will be accountable for their part and the whole product. Equal participation is ideal for fair and effective projects. The goal of simultaneous interaction is to “increase engagement and decrease off-task time.”³¹

Thinking Maps

Thinking maps are similar to graphic organizers, but each thinking map has a specific purpose and defining key words.³² We will use several of the thinking maps during this unit:

- Circle map - describing inherited characteristics
- Bubble map - describing specific characteristic variations, like dog coat colors
- Brace map - analyzing the part to whole relationships in the government
- Double bubble map - compare and contrast inherited versus acquired traits and characteristics
- Cause and effect map - show the causes and effects of an event (such as poor diet)
- Flow map - sequence the events that lead to the inheritance of a trait

Sheltered Instruction Observation Protocol

The Sheltered Instruction Observation Protocol (SIOP) is an instructional model that allows teachers to “shelter” instruction for all learners, but is specifically used to aide English-language learners in accessing grade-level content. This model also provides multiple modalities to develop English language acquisition and academic vocabulary.³³ I will incorporate specific SIOP strategies in lessons, including an anticipation guide, total physical response, guided listening and reciprocal teaching. I have found these strategies very valuable in content-area instruction for English-language learners, as well as all other students. I like to think of it as just “good teaching.”

³¹ Kagan & Kagan, *Kagan Cooperative Learning*, 13.3-13.4

³² Hyerle & Alper, *A Language for Learning*

³³ Echevarría, Vogt, & Short, *Making Content Comprehensible for English Learners: The SIOP[®] Model*.

Learning Pathways

Learning pathways is a voice-and-choice-based differentiation strategy.³⁴ Students are given choices for how to learn, practice, and extend their learning of particular concepts. Teachers compile varied resources that target different learning profiles. There are several ways to do this: organized by multiple intelligences, previous assessment data, or student interest (to name a few). Students are not required to complete all activities. They create a “pathway” for their learning based on parameters provided by the teacher (e.g., how many activities, a particular column or row, one of each color). I have worked with a BetterLesson instructional coach, Romain Bertrand, since 2017-2018 school year to develop pathways in science, math, and English language arts. Since implementing pathways in my classroom, I have seen tremendous growth in mastery, motivation, and ownership of students’ learning in the classroom.

Unit-At-A-Glance and Suggested Implementation Schedule

Day 1	Day 2	Day 3	Day 4	Day 5
Unit kick-off: anticipation guide, KWL, “Monster Genetics”	Categorizing human characteristics (inherited, acquired, learned)	Inherited vs. Acquired Traits	Instincts vs. Learned Behaviors i	Investigation: Punnett Squares - Australian Shepherds dominant vs. recessive
Day 6	Day 7	Day 8	Day 9	Day 10
Epigenetics and nutrition	The 5 food groups and healthy meals	The 6 nutrients and healthy meals	Analyzing the school cafeteria menu: problems	Analyzing the school cafeteria menu: solutions
Day 11	Day 12	Day 13	Day 14	Day 15
How does a bill become a law?, local & state representatives Discuss why we’re not just writing to the President	Researching appropriate and amenable representatives; examine real examples of this working	Drafting, revising, and editing persuasive letters	Drafting, revising, and editing persuasive letters	Revising and editing persuasive letters; author share; send letters Revisit anticipation guides

³⁴ Bertrand, “Hyperdoc Pathway to Mastery”

Classroom Lessons

Building Background (1 day)

We will kick off the unit with an anticipation guide. The anticipation guide will allow the teacher to understand what the students know, do not know, and their misconceptions. I usually give anticipation guides in the form of agree/disagree statements. See [Teacher Resources](#) for a link to agree/disagree statements for fifth grade genetics. Students complete the anticipation guide once prior to the unit. At the end of the unit, they complete a blank copy. They always like comparing their before and after versions to see all that they have learned.

During our unit opening, we will explore inherited traits, and the difference between dominant and recessive traits with a “Monster Genetics” lesson. There are many versions of this lesson available with a quick Google search. See [Appendix 2: Monster Genetics](#) for the version of Monster Genetics I have adapted for fifth graders. This activity will allow students to explore the role chance plays in our inherited traits. Students will flip a coin to create the genotype, and then match their genotype to the corresponding phenotype.

This lesson will prompt some great discussion about how we inherit traits. A big idea for students to grasp is that parents and offspring cannot choose which traits the offspring will inherit. Students will also be introduced to the concept of dominant versus recessive alleles.

Once we complete the Monster Genetics, we will create a Know-Want to Know-Learned (KWL)³⁵ chart as a class. Over the course of the unit, we will use the KWL chart to add “Want to Knows” and “Learned” items. It will bring together our learning and wonderings in one place.

Inherited Traits, Acquired Traits, and Learned Behaviors (2-3 days)

Next, we will move into heredity and genetics. To begin, students will be given sorting cards with inherited traits, acquired traits, instincts, and learned behaviors. They will work in partners or small groups to sort the cards. With concept sorts, the categories can be teacher or student defined.³⁶ I suggest allowing students to define their own categories to start. This allows for more critical thinking on the students’ parts. It is also a great strategy for ESL students with developing vocabularies. Students will share out how they sorted their cards while the teacher records the different categories students developed. Based on how the students sorted, the teacher may need to provide some guidance on either traits versus behaviors or inherited versus acquired and learned. See [Appendix 3: Traits & Behaviors Sorting Cards](#) for the cards.

After conducting our concept sort, students will work on learning pathways to delve into the science content. I plan to use a “HyperDoc”³⁷ to provide students with varied resources that are meaningful for them. I have provided a sample pathway in [Appendix 4: Genetics & Heredity Pathway](#) and the Note Catcher for recording their learning ([Appendix 5](#)). Please note that this pathway requires access to a device and the internet for each student or small group of students. If students do not have their own devices, the teacher could select activities from each section of the pathway to complete in a whole-group setting. This would still provide students with multiple modalities to access the content.

³⁵ National Education Association, “K-W-L”

³⁶ Reading Rockets, “Concept Sort”

³⁷ Bertrand, “Hyperdoc Pathway to Mastery”

Punnett Squares: Finding the Genotype & Phenotype with Australian Shepherds (1-2 days)

Now that students have a foundational understanding of heredity and genetics, we will do a case study on Anna the Australian Shepherd. As explained in the [content area research](#), Australian Shepherds have 4 different fur coat colorations: black, red, red merle, and blue merle. First, the teacher will post a picture of Anna ([Appendix 6](#)). Students will discuss what they think her parents looked like. Since Anna is a black tri-colored Australian Shepherd (meaning she is black with white paws and neck and tan markings), this discussion will reveal students' understanding of how genes are inherited.

Next, the teacher will model using a Punnett square. Students should understand how the genotypes of both parents are used in creating a Punnett square. They should also understand how each genotype and corresponding phenotype is based on the dominant and recessive alleles of the parents, as well as statistical chance.

The students will read through the handout on Anna's genes ([Appendix 7](#)) and create Punnett squares based on what her "mystery" parent's genotypes for black or brown fur and merle or no merle fur. The Australian Shepherd Health & Genetics Institute has detailed information about dominant and recessive alleles in canines.³⁸ At the end of this lesson, students should be able to explain how particular genotypes are expressed in physical appearance. They should also be able to apply their knowledge of dominant and recessive alleles.

Epigenetics & Nutrition (1 days)

Now that students have developed an understanding of the inheritance of characteristics, we will look at the concept of epigenetics. This is where our theme of choice begins. Some students may have heard of "nature versus nurture." The teacher will explain that the "nurture" or environment can actually alter the "nature" – our epigenomes. The teacher will discuss how the nutrition of a pregnant mother impacts the health of her baby. Then, we will discuss how our nutritional choices now can have an impact on our health. The field of epigenetics postulates that these nutritional choices could alter our genes, which can also be passed down to offspring. Teachers may want to show a video published by TED-Ed to aid in today's discussion.³⁹

The big idea for students to understand is that lifestyle choices can permanently affect their health in both positive and negative ways. A multi-flow map will be especially helpful to make meaning of the concepts today. See the [teacher resources](#) for an example of this graphic organizer.

The 5 Food Groups, 6 Nutrients, and Healthy Meals (2 days)

In this section of the unit, students will study nutrition and healthy diets using the MyPlate tool by the USDA. First, students will learn about the 5 food groups: vegetables, grain, protein, fruits, and dairy. We will sort various common foods into categories. The teacher should be mindful to include foods that the students frequently eat (perhaps make a list at the start of class). Then, we will discuss how to plan a healthy meal based ([Appendix 8](#)) on the food groups, considering the portion sizes. Students will create their own healthy meal plans for 2 days.

³⁸ Australian Shepherd Health & Genetics Institute, "Color"

³⁹ Guerrero-Bosagna, "What is epigenetics?"

After students have developed an understanding of the 5 food groups, we will examine the 6 main nutrients. These include carbohydrates, proteins, fats, vitamins, minerals, and water. Students will look back at their meal plans and identify where they are getting their 6 nutrients from. If they are missing nutrients, they will need to add in some different foods.

Our School Cafeteria: Problems & Solutions (2 days)

We will take two days to examine our school's lunch and/or breakfast menu. We will identify all the problems in the menu. Students will be expected to look for the five food groups and six main nutrients. Another problem that I anticipate students will bring up is how appetizing the meals are, especially the healthier parts of the meals. Students can also start thinking about alternatives. On the second day, we will examine our list of problems and choose 1-2 that we can realistically solve. Then, we will brainstorm solutions to our selected problems. These solutions need to be evaluated for feasibility and affordability, as we will be using them to propose solutions in our letters.

Civics and Persuasive Letter Writing (5 days)

The last section of the unit is where students will apply their learning of genetics, nutrition, and epigenetics. The teacher will describe the assessment task and the rubric ([Appendix 9](#)). Students will discuss the concept of free speech and our civic duty to act for the common good. The teacher may elect for students to work independently, in pairs, or in small groups to write their letters. As a class, we will select one problem from our list, explain the science behind the problem (i.e., the epigenetics), and propose solutions that could be implemented in our school or district.

The teacher will review the components of an effective argument, as fifth graders have written persuasive letters in the past. Students will be expected to prewrite, draft, revise, edit, and publish their letters. Additional support for letter writing can be found in the [teacher resources](#) section. Their final product will be the summative assessment for the unit.

Final Discussion (1 day)

Since the main theme of this unit is “choice”, a final discussion with students about the ways they can still make positive decisions that lead to a healthier future, regardless of whether or not school lunches are altered. Some suggested discussion points include:

- What choices can you make in the cafeteria given the food that is available?
- What can you choose to eat after school? At dinner?
- What choices can you make when you shop with families that will lead to healthier meals and snack options at home?

Assessment (see [Appendix 9](#) for student task and rubric)

Students will integrate their knowledge of genetics, epigenetics, and social justice to inform a North Carolina representative about one issue they are concerned about. An effective letter will include a description of the problem, evidence/data to support the problem, how the problem affects the state and its people, and a proposed solution. Successful completion of this letter will demonstrate an understanding of:

- heredity & genetics
- epigenetics
- adequate nutrition and healthy eating
- the state government & legislation in North Carolina
- writing a thesis statement
- persuasive writing techniques, including writing with supporting evidence

Students will mail their final letters to their chosen representative.

Appendix 1: Teaching Standards from the North Carolina Standard Course of Study

Subject & Standard	Commentary
Science	
5.L.3.1 Explain why organisms differ from or are similar to their parents based on the characteristics of the organism.	Students will identify similarities and differences between parents and offspring. They will use Punnett Squares as a means to explain why offspring are not exactly the as their parents.
5.L.3.2 Give examples of likenesses that are inherited and some that are not.	Students will generate examples of inherited, acquired, and learned characteristics and behaviors.
English/Language Arts	
RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer quickly or to solve a problem efficiently.	Students will read various media to collect information about the impact of nutrition on their health. They will also research healthy alternatives that could be incorporated into the school lunch menu.
W.5.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information.	Students will write a persuasive letter to a local representative, arguing for more nutritious options in their school cafeteria. They will use a science and nutrition-based argument to persuade the reader.
W.5.9 Draw on evidence from informational texts to support analysis, reflection, and research.	Students will use informational texts and other media to inform the argument they formulate in their persuasive letter.
Social Studies	
5.C&G.2.2 Analyze the rights and responsibilities of United States citizens in relation to the concept of “common good” according to the United States Constitution (Bill of Rights).	Students will analyze the first amendment of the United States Constitution as it applies to their rights and responsibilities of US citizens. They will gain an understanding of how to respectfully express their opinion to their local representative.

<p>5.C&G.2.4 Explain why civic participation is important in the United States.</p>	<p>Students will write letters to their representative and understand why their individual participation is important for the common good of all (all in this case being the students at their school).</p>
<p>Healthful Living</p>	
<p>5.NPA.1 Apply tools (MyPlate) to plan healthy nutrition and fitness.</p>	<p>Students will use the MyPlate tool to analyze their current school lunches and plan for healthy alternatives to meals or portions of meals.</p>
<p>5.NPA.2 Understand the importance of consuming a variety of nutrient dense foods and beverages in moderation.</p>	<p>Students will apply epigenetic principles to understand the importance of their nutrition and diet both now and in the future.</p>
<p>5.NPA.3 Understand the benefits of nutrition and fitness to disease prevention.</p>	<p>Students will integrate their understanding of nutrition and genetics to explain the benefits a healthy diet and lifestyle will have on them and their potential future offspring.</p>

Appendix 2: Monster Genetics (Student Handout)⁴⁰

Monster Genetics: Inherited Traits

Directions: You are creating a monster! Flip a coin **twice** for each inherited trait. Record a capital letter **T** (dominant trait) if your coin lands HEADS side up. Record a lower-case **t** (recessive trait) if your coin lands TAILS side up. Combine your two letters in the last column (possibilities are tt, Tt, or TT). *HINT: If you get tT, change it to Tt.*

My Monster Parts: Dominant/Heads (T) or Recessive/Tails (t)

Trait	Coin Flip 1	Coin Flip 2	Combined Result (genotype)
Body shape			
Number of legs			
Type of feet			
Type of tail			
Wings			
Number of eyes			
Fangs			
Ears			
Skin			
Coloration			

⁴⁰ Lesson adapted from Arizona State University's Ask A Biologist, "Monster Manual"

Next, circle the trait that applies to your monster (based on its genotype above).

Trait	Dominant- Dominant (TT)	Dominant- Recessive (Tt)	Recessive- Recessive (tt)
Body shape	Long	Long	Round
Number of legs	2	3	4
Type of feet	Elephant-like	Elephant-like	Dog-like
Type of tail	Spiky	Spiky	Heart-tipped
Wings	Bird wings	Bird wings	Bat wings
Number of eyes	1	2	3
Fangs	Point down	Point down	Point up
Ears	Pointy	Pointy	Droopy
Skin	Furry	Furry	Scaly
Colorations	Cool colors (blue, green, purple)	Cool colors (blue, green, purple)	Warm colors (red, orange, yellow)

On your blank sheet of paper, illustrate your monster. You must include all of the inherited traits above, and LABEL the traits on your sketch. You can name your monster too! Then, answer the questions on the back of this page.

Reflection Questions: Answer in complete sentences.

1. Describe the inherited traits of your monster.
2. Based on this activity, define "inherited trait."
3. Study the Dominant-Recessive trait table (the second table). What conclusions can you make about dominant traits? What conclusions can you make about recessive traits?
4. Based on your conclusions in #3, define **dominant trait** and **recessive trait**.
5. All humans have inherited traits. Can you think of any inherited traits that you have? Describe.

Appendix 3: Traits & Behaviors Sorting Cards

hair color (without hair dye)	hair style	a dog bringing his owner the newspaper	a love of sports
a bear catching fish for food	scar	dimples	dirty fingernails
height	weight	fast swimming stroke	large feet
muscular legs	reading music	food preferences	ability to roll tongue
hibernation	taste in clothing styles	turning in the direction of a loud sound	a spider spinning a web
index finger being longer than ring finger	attached earlobe	a dog rolling over for a treat	eye color

Appendix 4: Genetics & Heredity Sample Pathway

Genetics & Heredity Pathway

5.L.3 Understand why organisms differ from or are similar to their parents based on the characteristic of the organism.

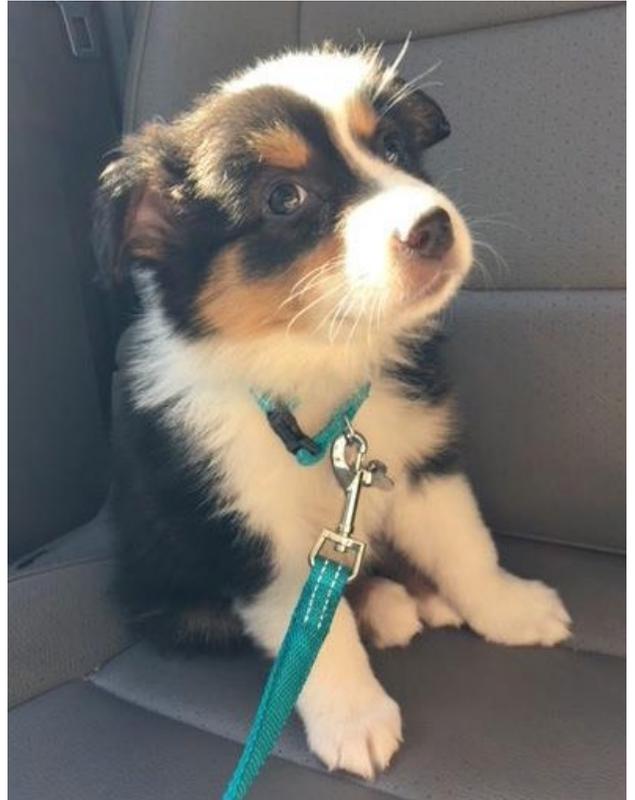
Resource(s)	Description & Directions	Student Reporting
Interactive Practice		
<ul style="list-style-type: none"> • Michael's Inside Scoop • Where Did You Get Those Genes? • Tiki the Penguin & Genetics • Build a Fish 	Click on the link to each interactive. Take notes in the INTERACTIVES section of your Note Catcher.	Which interactive resource was most helpful? Explain.
Vocabulary		
Genetics Quizlet	<p>Choose AT LEAST 3 of the following activities to practice the words:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Learn <input type="checkbox"/> Flashcards <input type="checkbox"/> Write <input type="checkbox"/> Test <input type="checkbox"/> Match <input type="checkbox"/> Gravity 	<p>Which words are you confident with?</p> <p>Which words are you still learning?</p>
Videos		
<ul style="list-style-type: none"> • What is a Trait? • Heredity - why do you look the way you do? • What is a Gene? 	Click on the link to each video. Take notes in the VIDEOS section of your Note Catcher.	Which video was most helpful? Why?
Practice Questions		
Grade 5 NCES Practice Scroll down to "Evolution & Genetics"	Click on the link. Record any misconceptions you have (i.e., incorrect answers) in PRACTICE QUESTIONS section in your Note Catcher.	<p>Tally questions you had correct.</p> <p>Tally questions you had incorrect.</p>

Appendix 5: Note-Catcher for Pathways

Note Catcher: Genetics & Heredity

Notes from the Interactives:	Questions I have:
Notes from Videos:	
Notes from Practice Questions:	

Appendix 6: Anna the Australian Shepherd, 3 years (left) and 4 months (right)
Original photos by unit author, Shauna McCarthy



Appendix 7: Punnett Squares for Anna's Parents

Genotypes & Phenotypes: Anna the Australian Shepherd

Describe what Anna's fur looks like. This is called her *phenotype*.

Every phenotype has a corresponding genotype. In Australian Shepherds, there is an allele called dominant "black," represented by the letter K.

- A dog with the KK or Kk genotype will be all black.
- A dog with the kk genotype will have black fur with tan and white points.

Which genotype(s)/phenotype is dominant? _____

Which genotype(s)/phenotype is recessive? _____

Since Anna is black with tan and white points, what genotype *must* she have? Why?

Anna's father has the Kk genotype. Use a Punnett Square to determine what phenotypes Anna's mother might have. The father's genotype is already in the Punnett square.

	K	k

On the back of this paper, explain how you determined what genotypes Anna's mother could have. Use the Punnett Square in your explanation.

Appendix 8: Meal Planning

My 2-Day Meal Plan

When creating your daily meal plans, be sure to include the five main food groups in each meal: grains, vegetables, fruits, proteins, and dairy. Snacks should have 1-2 of the food groups.

	Day 1	Day 2	Nutrients
Breakfast			<input type="checkbox"/> Carbs <input type="checkbox"/> Proteins <input type="checkbox"/> Fats <input type="checkbox"/> Vitamins <input type="checkbox"/> Minerals <input type="checkbox"/> Water
Snack			<input type="checkbox"/> Carbs <input type="checkbox"/> Proteins <input type="checkbox"/> Fats <input type="checkbox"/> Vitamins <input type="checkbox"/> Minerals <input type="checkbox"/> Water
Lunch			<input type="checkbox"/> Carbs <input type="checkbox"/> Proteins <input type="checkbox"/> Fats <input type="checkbox"/> Vitamins <input type="checkbox"/> Minerals <input type="checkbox"/> Water
Snack			<input type="checkbox"/> Carbs <input type="checkbox"/> Proteins <input type="checkbox"/> Fats <input type="checkbox"/> Vitamins <input type="checkbox"/> Minerals <input type="checkbox"/> Water
Dinner			<input type="checkbox"/> Carbs <input type="checkbox"/> Proteins <input type="checkbox"/> Fats <input type="checkbox"/> Vitamins <input type="checkbox"/> Minerals <input type="checkbox"/> Water

Appendix 9: Student Writing Task & Rubric

Summative Assessment: Persuasive Letter to a Representative

You will integrate your learning of genetics, epigenetics, and nutrition to inform a local or state representative about one issue affecting your school cafeteria menu.

An effective letter will include a description of the problem, evidence/data to support the problem, how the problem affects people, and at least one idea for a solution.

Successful completion of this letter will show an understanding of:

- heredity & genetics
- epigenetics
- adequate nutrition and healthy eating
- the state government & legislation in North Carolina
- writing a thesis statement
- persuasive writing techniques, including writing with supporting evidence

You will mail your final letters to your chosen representative.

Flip over for the rubric I will use to grade your letter.

Persuasive Letter Rubric

This is how your letter will be graded. Be sure to review this rubric as you edit your letter.

	4	3	2	1
Audience	Letter shows an understanding of the audience and their point of view. Language and word choice are appropriate for audience.	Letter shows an understanding of the audience and their point of view. Language and word choice may be appropriate for audience.	Letter does not always show an understanding of the audience or point of view. Language and word choice may not be appropriate for audience.	Letter does not show an understanding of the audience or point of view. Language and word choice are not appropriate for audience.
Goal/ Thesis	The reader can clearly identify the writer's goal or position. The statement is strong.	The reader can clearly identify the writer's goal or position.	The reader may not be able to clearly identify the writer's goal or position.	The writer's goal or position is unclear or is not stated.
Reasons	Includes 3+ reasons (facts, experiences, data) to support the goal.	Includes 2 reasons (facts, experiences, data) to support the goal.	Includes 1 reason (facts, experiences, data) to support the goal.	Does not include reasons (facts, experiences, data) to support the goal.
Science	All reasons are supported by nutritional or epigenetic concepts.	Some reasons are supported by nutritional or epigenetic concepts.	Few reasons are supported by nutritional or epigenetic concepts.	Reasons are not supported by nutritional or epigenetic concepts.
Sequence	The letter is written with a logical flow that aids in the writer's position.	The letter mostly flows but may have some minor items out of order.	The letter does consistently not flow well. Some sections may flow, while others do not.	The letter does not have an apparent flow or sequence.
Letter Format	Proper business letter format is maintained. Correct punctuation, capitalization, and grammar.	Proper business letter format is maintained. Mostly correct punctuation, capitalization, and grammar.	Some elements of a business letter are missing. Some incorrect punctuation, capitalization, and grammar.	The letter does not follow a business format. Proper punctuation, capitalization, and spelling are not used.

TOTAL: _____/24

Comments:

Resources

These are suggested resources for both students and teachers to use to deepen their understanding of the content introduced in this unit.

Student Resources

- <http://schoolnutrition.org/AboutSchoolMeals/TipsForStudents/>
Ideas and tips for students looking to help change their school lunch menu.
- <https://learn.genetics.utah.edu>
A comprehensive resource for learning about evolution, genetics, and heredity.
- <https://askabiologist.asu.edu/monster-manual>
The story behind Monster Genetics (day 1 of the unit).
- <https://kidsbiology.com/biology-basics/incomplete-dominance/>
Various articles on all things genetic in student-friendly language.

Pathways Resources

These resources are linked in the Pathway as well.

- <https://www.cdc.gov/bam/body/scoop-game.html>
A game to review inherited characteristics.
- <http://www.beaconlearningcenter.com/WebLessons/ThoseGenes/default.htm#page1a>
An interactive article that reviews how genes are passed from parent to offspring.
- <http://tiki.oneworld.net/genetics/>
A collection of articles written by “Tiki the Penguin” that reviews genetics and evolution concepts for elementary students.
- <https://www.pbslearningmedia.org/resource/lsp07.sci.life.evo.buildafish/build-a-fish/#.WvzCyNMvxE4>
Students build a fish with adaptations to help it survive in its environment.
- <https://quizlet.com/296288370/513-genetics-flash-cards/>
Interactive flashcards to review key vocabulary introduced in this unit.
- <https://www.youtube.com/watch?v=SldwzOJ23J8>
In “What is a Trait,” students learn about how traits are passed down from parent to offspring
- <https://www.youtube.com/watch?v=6bWssRDAHw4>
In “Heredity - why you look the way you do,” students learn about how genes are expressed in our physical appearance
- https://www.youtube.com/watch?v=5MQdXjRPHmQ&index=4&list=PL_ypB_XNdS7W13HxUkzuTW9thUYXLhv50
This is a more advanced video to explain to students, “What is a gene?”
- <https://www.ixl.com/standards/north-carolina/science/grade-5>
Various practice question sets (scroll down to 5.L.3 Evolution & Genetics).

Teacher Resources

- <https://www.nlm.nih.gov/exhibition/harrypottersworld/education/lessonplan1.html>
This has many different lessons and activities about science, “magic,” and medicine, all based on *Harry Potter*.
- <http://www.nea.org/tools/k-w-l-know-want-to-know-learned.html>
A description and sample of a KWL chart.
- http://www.readingrockets.org/strategies/concept_sort
A description and sample of a concept sort.
- <http://rg5thgradeassessments.cmswiki.wikispaces.net/Science>
Many different NC-specific assessments for fifth grade science, specifically the agree/disagree statements suggested in this unit.
- <https://studylib.net/doc/6838609/speed-dating-genetics-5.1.3>
A variety of teaching resources to teach 5.L.3.
- <https://www.youtube.com/watch?v=aAhcNjmvhc>
A TED-Ed video that describes the foundational mechanisms and applications of epigenetics.
- <https://www.dvusd.org/Page/3740>
An example of a multi-flow map, used to show cause-effect relationships.
- https://owl.purdue.edu/owl/general_writing/common_writing_assignments/argument_papers/index.html
Tips on how to write argument papers.
- <http://penpals.web.unc.edu/2013/03/07/what-are-punnett-squares-and-how-do-they-work/>
A description of how to use Punnett squares to predict genotypes and phenotypes.
- <https://www.fns.usda.gov/tn/serving-myplate-yummy-curriculum>
More lessons on nutrition and healthful eating from the USDA.
- <http://www.nea.org/home/19657.htm>
Suggestions from the NEA on how to write to legislators.
- <http://www.readwritethink.org/classroom-resources/lesson-plans/convince-developing-persuasive-writing-56.html>
Lessons on writing persuasive arguments. Suggested to be used with students who do not have background with writing persuasive letters.

Bibliography

- “Argument Papers.” Purdue Online Writing Lab. Accessed September 21, 2018.
https://owl.purdue.edu/owl/general_writing/common_writing_assignments/argument_papers/index.html
- “Australian Shepherd.” American Kennel Club. Accessed September 22, 2018.
<https://www.akc.org/dog-breeds/australian-shepherd/>
- Bertrand, Romain. “Hyperdoc Pathway to Mastery.” Accessed September 19, 2018.
<https://betterlesson.com/strategy/119/hyperdoc-pathway-to-mastery>
- “A Brief History of USDA Food Guides.” United States Department of Agriculture, last modified May 11, 2017. <https://www.choosemyplate.gov/brief-history-usda-food-guides>
- “Build a Fish.” PBS Learning Media. Accessed October 27, 2018.
<https://www.pbslearningmedia.org/resource/lsp07.sci.life.evo.buildafish/build-a-fish/#.WvzCyNMvxE4>
- Carey, Nessa. *The Epigenetics Revolution*. New York, New York: Columbia University Press, 2012.
- Centers for Disease Control & Prevention. “Michael’s Inside Scoop.” US Department of Health & Human Services. Last modified May 9, 2015. <https://www.cdc.gov/bam/body/scoop-game.html>
- “Color.” Australian Shepherd Health & Genetics Institute. Accessed September 22, 2018.
<http://www.ashgi.org/home-page/genetics-info/color>
- Cory, Micah. “Predicting Inheritance Using Punnett Squares.” Slideplayer. Accessed September 21, 2018. <https://slideplayer.com/slide/1728323/>
- Echevarría, Jana, MaryEllen Vogt, and Deborah J. Short. *Making Content Comprehensible for English Learners: The SIOP[®] Model*. 4th ed. Boston, Massachusetts: Pearson, 2013.
- Ennis, Cath and Oliver Pugh. *Introducing Epigenetics: A Graphic Guide*. Edited by Kiera Jamison. London, England: Icon Books, 2017.
- “Frayer Model.” The Teacher Toolkit. Accessed September 19, 2018.
<http://www.theteachertoolkit.com/index.php/tool/frayer-model>
- Guerrero-Bosagna, Carlos. “What is epigenetics?” TED-Ed. Youtube video, 5:02. Posted [June 2016]. https://www.youtube.com/watch?v=_aAhcNjmvhc

- Howell, Shauna M. "5.L.3 Genetics Flashcards." Quizlet. Last modified May 2018.
<https://quizlet.com/296288370/513-genetics-flash-cards/>
- Hyerle, David and Chris Yeager. *A Language for Learning*. 2nd ed. Cary, North Carolina: Thinking Maps, 2017.
- Kagan, Spencer and Oliver Kagan. *Kagan Cooperative Learning*. San Clemente, California: Kagan Publishing, 2009.
- Kobor, Michael and Joanne Weinberg. "Focus On: Epigenetics and Fetal Alcohol Spectrum Disorders," *Alcohol Research & Health* 34, no. 1 (2011). Accessed September 21, 2018, <https://pubs.niaaa.nih.gov/publications/arh341/29-37.pdf>
- "K-W-L (Know, Want to Know, Learned)." National Education Association. Accessed October 27, 2018. <http://www.nea.org/tools/k-w-l-know-want-to-know-learned.html>
- Manning, Emily. "Can You Convince Me? Develop Persuasive Writing." International Literacy Association. Accessed September 21, 2018. <http://www.readwritethink.org/classroom-resources/lesson-plans/convince-developing-persuasive-writing-56.html>
- Moalem, Sharon. *Inheritance: How Genes Change Our Lives and Our Lives Change Our Genes*. New York, New York: Grand Central Publishing, 2014.
- MooMoo Math and Science. "Heredity- Why you look the way you do?" Youtube video, 2:04. Posted [October 2016]. <https://www.youtube.com/watch?v=6bWssRDAHW4>
- MooMoo Math and Science. "What is a trait?-Genetics and Inherited Traits." Youtube video, 2:06. Posted [October 2016]. <https://www.youtube.com/watch?v=SldwzOJ23J8>
- Moore, David S. *The Developing Genome*. New York, New York: Oxford University Press, 2015.
- Mukherjee, Siddhartha. *The Gene*. New York, New York: Scribner, 2016.
- "North Carolina fifth-grade science standards." IXL. Accessed October 27, 2018.
<https://www.ixl.com/standards/north-carolina/science/grade-5>
- Oberst, Lindsay. "Why School Lunches in America Are Unhealthy and 10 Ways You Can Take Action to Improve Them." Food Revolution Network. Last modified August 29, 2018.
<https://foodrevolution.org/blog/school-lunch-in-america/>
- "Organizational Flow Chart of the North Carolina State Government." Department of the Secretary of the State of North Carolina, last modified 2016.
<http://digital.ncdcr.gov/cdm/ref/collection/p249901coll22/id/704114>

- Peck, Kayla. "What are Punnett Squares and How Do They Work?" UNC Biology Penpal Program, last modified March 7, 2013. Accessed September 21, 2018.
<http://penpals.web.unc.edu/2013/03/07/what-are-punnett-squares-and-how-do-they-work/>
- Reitzel, Adam. "DNA: A Simple Double Helix?" Lecture presented at UNC Charlotte, Charlotte, North Carolina, May 3, 2018.
- Reitzel, Adam. "Environmental Signals and Your DNA: Looking Beyond the Central Dogma." Lecture presented at UNC Charlotte, Charlotte, North Carolina, May 10, 2018.
- "RG 5th Grade Science Assessments." Accessed October 27, 2018.
<http://rg5thgradeassessments.cmswiki.wikispaces.net/Science>
- Rothstein, Mark A., Heather L. Harrell and Gary E. Marchant. "Transgenerational Epigenetics and Environmental Justice," *Environmental Epigenetics* 3, no. 3 (2017). Accessed April 18, 2018, <http://academic.oup.com/eep/article-abstract/3/3/dvx011/4061580>.
- "Serving Up MyPlate: A Yummy Curriculum." USDA Food and Nutrition Service. Last modified December 6, 2017. <https://www.fns.usda.gov/tn/serving-myplate-yummy-curriculum>
- Stated Clearly. "What is a gene?" Youtube video, 4:56. Posted [November 2012].
https://www.youtube.com/watch?v=5MQdXjRPHmQ&index=4&list=PL_ypB_XNdS7W13HxUkzuTW9thUYXLhv50
- "Find Your Representative." United States House of Representatives. Accessed September 22, 2018. <https://www.house.gov/representatives/find-your-representative>
- "What is a Healthy Eating Style?" United States Department of Agriculture, last modified December 21, 2017. <https://www.choosemyplate.gov/what-healthy-eating-style>
- "Where Did You Get Those Genes?" Beacon Learning Center. Accessed October 27, 2018.
<http://www.beaconlearningcenter.com/WebLessons/ThoseGenes/default.htm#page1a>
- "Who Represents Me?" North Carolina General Assembly. Accessed September 22, 2018.
<https://www.ncleg.net/Representation/WhoRepresentsMe.aspx>
- "Whose Genes?" One World. Accessed October 27, 2018. <http://tiki.oneworld.net/genetics/>
- "Writing to Your Legislators." National Education Association. Accessed September 21, 2018.
<http://www.nea.org/home/19657.htm>