



Unit Title: Genetics, Ethics, and Evolution

Subject/target grade: High School Biology (9th/10th Grade)

Keywords: genetically modified organisms; applied genetics, species definitions, wildlife genetics, phylogenetic tree

Unit Summary:

In this unit students will use their knowledge of genetics to think critically about the interface of science and society. Advances in science impact our daily lives by affecting food supply, human health, and wildlife management. Scientific advances precede changes in state or federal laws, and ethical issues may arise. Members of the general population may need to make decisions about how science impacts their daily lives. In this unit, in addition to learning about how society is impacted by science, students will further build upon their knowledge of genetics, learn how genetics can be used to distinguish species, and learn how genetics can be used in understanding evolutionary linkages.

This unit should follow lessons on basic genetic concepts including simple and complex inheritance, DNA, RNA, protein synthesis, pedigree analysis, and environmental influences on heredity.

Michigan Content Expectations:

B1.2A Critique whether or not specific questions can be answered through scientific investigations.

B1.2B Identify and critique arguments about personal or societal issues based on scientific evidence.

B4.2h Recognize that genetic engineering techniques provide great potential and responsibilities

B4.r5b Evaluate the advantages and disadvantages of human manipulation of DNA

B5.3f Demonstrate and explain how biotechnology can improve a population and species.

B1.2B Identify and critique arguments about personal or societal issues based on scientific evidence

B1.2k Analyze how science and society interact from a historical, political, economic, or social perspective

L4.p2A Explain that the traits of an individual are influenced by both the environment and the genetics of the individual. Acquired traits are not inherited; only genetic traits are inherited.

L5.p1A Define a species and give examples

L3p4A Recognize that and describe how, human beings are part of Earth's ecosystems. Note that human activities can deliberately or inadvertently alter the equilibrium in ecosystems.

B5.r2d Interpret a cladogram or phylogenetic tree showing evolutionary relationships among organisms

Learning Objectives:

- Students will be able to identify and critique arguments about personal and societal issues using their knowledge of genetics.
- Students will be able to argue viewpoints of how science and society interact.
- Students will be able to explain that the genetics of an individual and the environment are important in determining traits of an individual.
- Students will be able to describe how genetics are important in defining a species.
- Students will provide examples of species.
- Students will evaluate genetic and behavioral evidence to evaluate whether populations should be considered separate species.
- Students will be able to understand how federal or state laws may protect a species and why genetics plays a key role in which organisms may be protected by law.

- Students will be able to interpret a cladogram or phylogenetic tree showing evolutionary relationships among organisms.
- Students will be able to create their own cladogram or phylogenetic tree showing evolutionary relationships among organisms.

Table of Lessons:

Lesson Title- Brief Description	Learning Objectives	NGSS Addressed	Materials
<p>I. Selective breeding and Genetically Modified Organisms: feeding a world of 7 billion people (and growing)</p>	<ul style="list-style-type: none"> • Students will be able to collect and categorize data about desirable and undesirable characteristics of different apple varieties. • Students will be able to define selective breeding. • Students will be able to give examples of common genetically modified organisms. • Students will be able to select traits that may be desirable in organisms such as apples and cattle. • Students will be able to identify that genetic engineering techniques provide great potential and responsibilities. • Students will be able to evaluate the advantages and disadvantages of human manipulation of DNA. • Students will be able to formulate arguments for or against labeling of GMOs. 	<p>B1.2A Critique whether or not specific questions can be answered through scientific investigations. B1.2B Identify and critique arguments about personal or societal issues based on scientific evidence. B4.2h Recognize that genetic engineering techniques provide great potential and responsibilities B4.r5b Evaluate the advantages and disadvantages of human manipulation of DNA B5.3f Demonstrate and explain how biotechnology can improve a population and species.</p>	<p>Powerpoint Student Handouts Apples: 1 set of 4 varieties (Granny Smith, Gala, Fuji, Honeycrisp) per group of 4 students. You may choose to cut the apples to allow students to taste them during the activity.</p>
<p>II. From the Human Genome Project to Home Genetic Testing Kits</p>	<ul style="list-style-type: none"> • Students will be able to identify and critique arguments about personal and societal issues using their knowledge of genetics. • Students will be able to argue viewpoints of how science and society interact. • Students will be able to explain that the genetics of an individual and the environment are important in determining traits of an individual. 	<p>B1.2B Identify and critique arguments about personal or societal issues based on scientific evidence B1.2k Analyze how science and society interact from a historical, political, economic, or social perspective L4.p2A Explain that the traits of an individual are influenced by both the environment and the genetics of the individual. Acquired traits are not inherited; only genetic traits are inherited.</p>	<p>Student Handouts Student Copies of one of the articles:</p> <ul style="list-style-type: none"> • 1. Wilson J. (November 26th, 2013) 23andMe raises questions about at-home genetic testing CNN, http://www.cnn.com/2013/11/26/health/23andme-fda-genetic-testing/ • 2. Green RC, and Farahany NA (2014) The FDA is overcautious on consumer genomics. Nature: 505: 286-287, http://www.nature.com/polopoly_fs/1.14527!/menu/main/topColumns/topLeftColumn/pdf/505286a.pdf <p>Clipboards Timer</p>
<p>III. Importance of Genetics in Wildlife Management</p>	<ul style="list-style-type: none"> • Students will be able to describe how genetics are important in defining a species. • Students will provide examples of species. • Students will evaluate genetic and behavioral evidence to evaluate whether populations should be considered separate species. • Students will be able to understand how federal or 	<p>L5.p1A Define a species and give examples L3p4A Recognize that and describe how, human beings are part of Earth’s ecosystems. Note that human activities can deliberately or inadvertently alter the equilibrium in ecosystems.</p>	<p>Student Handouts Construction paper or colored pencils for some formats of RAFT activity</p>

	state laws may protect a species and why genetics plays a key role in which organisms may be protected by law.		
IV. Genetics and the path to Evolution	<ul style="list-style-type: none"> Students will be able to interpret a cladogram or phylogenetic tree showing evolutionary relationships among organisms. Students will be able to create their own phylogenetic tree showing evolutionary relationships among organisms. 	B5.r2d Interpret a cladogram or phylogenetic tree showing evolutionary relationships among organisms	<ul style="list-style-type: none"> Cards of phylogenetic trees (print and cut so each group has one) Highlighters (yellow, orange, pink, green, blue) Pencils or pens Computer lab

Safety Considerations: None

Evaluation Plan:

Lesson 1:

In class, there will be a class discussion based on students' written responses. Each student will have an opportunity to express whether he/she supported labeling of genetically modified food and whether it should be supported by law. Students should be asked to support their answers with a justification. To determine students' understanding of the lesson, ask the provided questions while facilitating the discussion.

Lesson 2:

In class the Socratic Circle will provide the teacher with an opportunity to assess student thinking and provide additional questions to promote student thinking. The *Student Handouts: Socratic Circle feedback* and *Socratic Circle reflection* will also provide opportunities for evaluation of student ideas on the topic. For grading during the Socratic Circle activity, please see the *Additional Teacher Information: Socratic Circle teacher grading guide*.

Lesson 3:

Student evaluation will take place in the form of the in-class activity (Student Handout: Genetic Analysis Desert Tortoise and Brook Trout) and subsequent sharing of answers through class discussion. Additionally, the RAFT activity provides another opportunity to assess student thinking. Use the grading rubric provided on page two of the *Student Handout: RAFT Activity*.

Lesson 4:

Informal evaluations will be conducted throughout the Explore activities focused on interpreting phylogenetic trees and identifying similarities and differences among species for each speciation event. The teacher will walk around the room to check student's thinking by asking questions throughout the activity. Students will also hand in their Phylogenetic tree cards, the phylogenetic trees from the Tree of Life website, and their own phylogenetic trees for the 9 organisms provided. These deliverables can be used to further evaluate student understanding and their ability to apply the concepts of this lesson to the creation of their own phylogenetic trees.

Resources (websites):

Lesson 1:

Recombinant DNA Video. This video shows how recombinant DNA works.

<http://www.youtube.com/watch?v=8rXizmLjegI>

Lesson 2:

Human genome project. The website provides a wealth of knowledge about the human genome project and other educational materials.

<http://www.genome.gov/10001772>

US Department of Energy website. There is information on genetically modified organisms available here.

<http://genomics.energy.gov>

CNN Article about at-home genetic testing. This article discusses the recent FDA decision to ban some aspects of at-home genetic testing.

<http://www.cnn.com/2013/11/26/health/23andme-fda-genetic-testing/>

Lesson 3:

USGS press release. This press release summarizes the results of the research article that led to splitting the desert tortoise from one species into two.

<http://www.usgs.gov/newsroom/article.asp?ID=2842>

IAGLR press release. This press release summarizes the results of a brook trout genetics study.

http://www.iaglr.org/jglr/release/38/2011.11.009_scribner.php

Lesson 4:

Tree of life. This website provides examples of phylogenetic trees for all organisms.

http://tolweb.org/Life_on_Earth/1

Brief description of how this unit relates to your graduate research. (1 page):

This unit focuses on genetics, which is not the focus of my doctoral research. I have prior work and research experience in a broad range of biological disciplines. In this lesson I have drawn upon my previous work experience in wildlife management and genetics. I have included examples from locations where I have previously worked including the Lake Superior watershed and the deserts of the American southwest. The development of these lessons on human genetics and ethical considerations were inspired by my previous work experiences in research on human health at Boston University and at Johns Hopkins University. While a neuroscience researcher at Boston University, I gained extensive experience in genetic analysis and implemented studies seeking to find treatments for human genetic diseases (focused on neurodegenerative diseases such as Huntington's, Parkinson's, Alzheimer's). In the lessons of the present unit, I have sought to show students how genetics relates to the daily lives of all humans by providing examples from Ecology and management, food production, and human medicine. These lessons show students the importance of understanding science so that we may make informed decisions as citizens about important issues that arise as science progresses.

The third lesson describes how genetics plays a role in Ecology by providing examples of wildlife management. In this lesson I have used brook trout as an example of two populations where, as a result of genetic analysis, the populations were not identified as distinct species. I also used another example, two populations of desert tortoise, to show two populations where genetic analysis revealed these populations were genetically distinct, and thus were split from one species into two. The desert tortoise population was already listed under the Endangered Species Act as a threatened species, and with the splitting it is expected that the newly identified species may also become listed under the Endangered Species Act. Similarly, there is concern about conservation of migratory brook

trout (coasters) within the Lake Superior watershed, but since it is not considered a separate species it is not afforded protections under the Endangered Species Act. My graduate research takes place in Lake Superior tributaries where brook trout and coaster brook trout are present. Prior to becoming a graduate student at Michigan Tech I worked as an ecologist with the U.S. Geological Survey and was involved in various research projects related to the Desert Tortoise and the Mojave Desert.