STEM Curriculum Planning Guide

This instructional design guide serves as the template for the design and development of STEM units of instruction at the Dayton Regional STEM Center in Dayton, Ohio. The guide is anchored to the *STEM Education Quality Framework* also developed at the Dayton Regional STEM Center.

STEM Unit Title	**Mission Survival**
Economic Cluster	Human Performance & Medicine
Targeted Grades	
STEM Disciplines	Science, Technology & Engineering
Non-STEM Disciplines	Language Arts

Section I: STEM Unit Overview

Unit Overview

In this unit, students will investigate the concepts of genetic mutation and genetic engineering. They will construct a phylogenetic tree based upon genomic point mutations, research genetic engineering and genetically modified organisms, participate in a class debate, and create a persuasive artifact on the ethics of genetic engineering.

Essential Question

How can we trace organisms using phylogeny, and if we can modify a genome, what are the ethical ramifications of that decision?

Enduring Understanding

Phylogenetic trees and classification of organisms' characteristics
Logic in identification of random point-mutations
Ethical evaluation of scientific discovery
Synthesis of arguments about a scientific dilemma

Engineering Design Challenge

Students will use their knowledge of point mutations and genetic codons to produce a logical phylogenetic tree for 15 fictitious organisms. Using the given genomes extrapolated from each organism, the students trace mutations back to a common ancestor. Of the existent species, the students must identify which organisms are unsafe to eat following mutations for the "poison gene".

Time and Activity Overview

Day	Time Allotment	Actvities
1	40-50 minutes	Pre-Test Video Clips - Avatar Pre-Activity Discussion
2	80-90 minutes	Construction of Phylogenetic Trees
3	80-90 minutes	Research Genetic Engineering & Genetically Modified Organisms
4	40-50 minutes	Genetic Engineering Debate
5	40-50 minutes	Ethical Dilemma with Phylogenetic Trees Persuasive Artifact
6	20-30 minutes	Submission of Persuasive Artifact Post-Test

Pre-requisite Knowledge & Skill

Students should have a working knowledge of gene transcription and translation, phenotypic identification and point mutations.

Academic Content Standards

Add Standard	Mathematics	Ohio
Grade/Conceptual Category		
Domain		
Cluster		
Standards		

Add Standard	Mathematics	
Grade		
Standard		
Benchmark		
Indicator		

Add Standard	English Language Arts	Ohio
Grade		
Strand		
Group		
Standard		

Add Standard	**English Language Arts**	
Grade	10	
Standard	Writing Applications	
Benchmark	Grade Ten– Benchmark E: Write a persuasive piece that states a clear position, includes relevant information and offers compelling evidence in the form of facts and details.	
Indicator	4. Write informational essays or reports, including research that: a. pose relevant and tightly drawn questions that engage the reader; b. provide a clear and accurate perspective on the subject; c. create an organizing structure appropriate to the purpose, audience and context; d. support the main ideas with facts, details, examples and explanations from sources; and e. document sources and include bibliographies.	

Add Standard	**Social Studies**	
Grade		
Theme		
Strand (pk-8 only)		
Topic		
Content Standard		

Add Standard	**Social Studies**	
Grade		
Standard		
Benchmark		
Indicator		

Add Standard	Science	Ohio
Grade		
Theme		
Topic		

Add Standard	Science	Ohio
Strand		
Course Content		
Content Elaboration		

Add Standard	**Science**
Grade	10
Standard	Life Science
Benchmark	Benchmark C: Explain the genetic mechanisms and molecular basis of inheritance.
Indicator	5. Illustrate the relationship of the structure and function of DNA to protein synthesis and the characteristics of an organism. 6. Explain that a unit of hereditary information is called a gene, and genes may occur in different forms called alleles (e.g., gene for pea plant height has two alleles, tall and short). 7. Describe that spontaneous changes in DNA are mutations, which are a source of genetic variation. When mutations occur in sex cells, they may be passed on to future generations; mutations that occur in body cells may affect the functioning of that cell or the organism in which that cell is found. 8. Use the concepts of Mendelian and non-Mendelian genetics (e.g., segregation, independent assortment, dominant and recessive traits, sex-linked traits and jumping genes) to explain inheritance.

Add Standard	**Science**
Grade	10
Standard	Life Science
Benchmark	Benchmark E: Explain how evolutionary relationships contribute to an understanding of the unity and diversity of life.
Indicator	12. Describe that biological classification represents how organisms are related with species being the most fundamental unit of the classification system. Relate how biologists arrange organisms into a hierarchy of groups and subgroups based on similarities and differences that reflect their evolutionary relationships. 13. Explain that the variation of organisms within a species increases the likelihood that at least some members of a species will survive under gradually changing environmental conditions. 14. Relate diversity and adaptation to structures and their functions in living organisms (e.g., adaptive radiation).

Add Standard	**Science**
Grade	9
Standard	Scientific Inquiry
Benchmark	Grade Nine – Benchmark A: Participate in and apply the processes of scientific investigation to create models and to design, conduct, and evaluate and communicate the results of these investigations.
Indicator	1. Distinguish between observations and inferences given a scientific situation. 3. Construct, interpret and apply physical and conceptual models that represent or explain systems, objects, events, or concepts.

Add Standard	**Science**

Add Standard	**Fine Arts**
Grade	
Subject	
Standard	
Benchmark	
Indicator	

Add Standard	**Technology**
Grade	10
Standard	Designed World
Benchmark	Grade Ten – Benchmark E: Classify, demonstrate, examine and appraise information and communication technologies.
Indicator	2. Communicate technological knowledge and processes using symbols, measurement, conventions, icons, graphic images and languages that incorporate a variety of visual, auditory and tactile stimuli.

Assessment Plan

Assessment Plan

What evidence will show that students have acquired the enduring understandings for this STEM unit?

Performance Task, Projects	Phylogenetic Tree Assembly Genetically Modified Organisms Debate GMO Persuasive Artifact/Checklist
Quizzes, Tests, Academic Prompts	Pre/Post Test Introductory Activity Exit Slip
Other Evidence (e.g. observations, work samples, student artifacts, etc.)	GMO Persuasive Artifact
Student Self-Assessment	Genetic Engineering/GMO Research Guidelines Rubric GMO Debate Rubric Persuasive Artifact Checklist

Technology Integration

ADISC Technology Integration Model*

	Type of Integration	Application(s) in this STEM Unit
A	Technology tools and resources that support students and teachers in ***adjusting, adapting, or augmenting*** teaching and learning to meet the needs of individual learners or groups of learners.	
D	Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display.	Inspiration (optional) use for creation of Genetic Engineering Concept Web
I	Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods.	Internet Research of Genetic Engineering and Genetically Modified Organisms
S	Technology tools and resources that support students and teachers in ***simulating*** real world phenomena including the modeling of physical, social, economic, and mathematical relationships.	
C	Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration.	Inspiration (optional, see above)
	**The ADISC Model was developed by James Rowley PhD, Executive Director of the Institute for Technology-Enhanced Learning at the University of Dayton*	

Career Connections

Career Description

Students interested in DNA could work as laboratory scientists specializing in DNA sequencing. DNA scientists use techniques such as polymerase chain reaction (PCR) which amplifies copies of DNA and allows the scientist to isolate and map specific fragments of DNA. These scientists map out DNA in order to gain information about an organism's DNA to diagnose diseases and develop more effective medical treatments.

DNA scientists also program computers to automate sequencing tasks. They are skilled in the use of statistics and data mining techniques to learn about patterns in DNA from enormous DNA data sets. They also use database technologies and machine learning to store, retrieve, filter, and make sense of DNA information. The DNA scientist typically earns a PhD in Biology, Chemistry, Bioinformatics or a related field to work in this area.

Students could work as a forensic DNA analyst, which examines DNA samples to help solve crimes and investigate other legal matters. A forensic analyst compares and matches samples of DNA to control samples to determine if a person may have committed a crime, or to overturn a wrongful conviction. The DNA analyst typically has a bachelor's degree in Biology, Chemistry, Forensic Science, or a related field and may work as a lab assistant to gain experience.

Students could also work as a geneticist, which is a research scientist or medical doctor that works to solve problems in medicine, agriculture, pharmaceuticals, or related to wildlife or ecology. The geneticist studies for a master's degree or PhD in Biology, Chemistry, or Genetics, or as a medical doctor with special training in genetics.

There are many other career specialties for those working with DNA and the biological sciences, such as a high school biology teacher, a biology professor at a university, or a laboratory worker at a university, in government, or with a research and development company.

Section II: STEM Lesson Plan

Title of Lesson	**Pre-Activity Discussion and Introductory Activity**
Time Required	40-50 minutes
Materials	Avatar film clips Pre-Test (1 per student) Set of "Foamies" (1 per student group)
Objectives	Students will brainstorm about diversity in an unknown ecosystem. Students will participate in a diagnostic assessment to monitor student knowledge prior to instruction. Students will use classification methods to sort a set of materials into logical categories.
Instructional Process	1. Administer the Pre-Test. 2. Show clips of the exposition of the film, Avatar. Pause the video on an image of the ecosystem of the planet. Elicit student identifications of different species, and ask the students to classify the phenotypes of the vegetation that they see. 3. Distribute a set of "Foamies" to each student group. Tell the students to sort the items in the bag, giving little direction other than that. Hold an informal class discussion about the classification schemes that the students develop.
Differentiation	Various "Foamie" sets can be created to provide a range of difficulty in the sorting process. For example, one set might include the same shape in multiple colors, and a more difficult set might include multiple shapes in multiple colors.
Assessments	Use an exit slip for each student group during the "Foamie" classification activity. Have the students describe their sorting methods and which characteristics provided diversity among the items.

Section II: STEM Lesson Plan

Title of Lesson	**Phylogenetic Trees**
Time Required	80-90 minutes
Materials	Organism Set (1 per student group) Phylogenetic Tree Template (1 per student group) Amino Acid Coding Matrix (1 per student group) Organism Genome Coding System (1 per student group) Large paper
Objectives	Students will apply their knowledge of RNA coding schemes to identify point mutations in a phylogenetic tree. Students will locate the poisonous species in the M-Vega ecosystem. Students will develop an organized model of phylogenetic relationships.
Instructional Process	1. Present the students with the following scenario: The year is 2159 and the United Space Agency of Earth (USAE) has established a colony on Planet M-Vega. Several research stations have been established on this Earth-like planet. The USAE calculated that the people working on these stations could survive eating the indigenous organisms since early probes sent back information that the life forms are similar in DNA structure to those found on Earth. Most of the organisms are edible, but tragically, three researchers have died from eating a few that are poisonous. The medical examiner determined that the cause of death for each dead researcher is an unknown digested poison believed to be present in certain M-Vega organisms. Each of you are now on a mission to save the rest of the researchers present on M-Vega. Each station will be given 15 samples of the most common organisms found on this planet. To save the researchers, you must create a phylogenetic tree showing the amino acid sequences of each organism and then determine which ones are poisonous. Your mission is one of survival! DON'T BLOW IT! 2. Distribute the Organism Sets, Phylogenetic Tree Templates, Amino Acid Coding Matrices, Organism Genome Coding Schemes, and large paper. 3. Prompt the students to begin by identifying the phenotypes of the given organisms. Be certain to indicate that the origin species is non-poisonous! 4. Prompt the students to examine the genome codons carefully, and choose logical locations for the organisms in the phylogenetic tree template. For each deviation from the origin species, there is at least one mutation, but there will be no more than two in a single branch. There is no one correct answer, but in the species cards, there is a possible answer key.

5. Allow the students significant time to work on the development of their phylogenetic trees.

Differentiation	Some student groups may require additional support beyond the location of the common ancestor. In this case, provide the students with the completed top half of the phylogenetic tree, and have them complete the bottom half using the same logic.
Assessments	Throughout the activity, it is imperative that the instructor is aware of the problem-solving processes that the students enable. Walking about the classroom and asking questions regarding the placement of organisms might aid student discovery of a logical organization.

Section II: STEM Lesson Plan

Title of Lesson	**Genetic Engineering Research**
Time Required	80-90 minutes
Materials	Computers with Internet access (1 per student group, minimum) Inspiration or other concept map generation program (optional) Genetic Engineering Research Rubric (1 per student) Genetic Engineering Debate Rubric (1 per student)
Objectives	Students will prepare for an ethical debate about genetic engineering and genetically modified organisms. Students will research information about genetic engineering using reputable sources. Students will organize their research into a concept map that outlines both sides of the argument.
Instructional Process	1. Distribute the Genetic Engineering Research Rubric (1 per student) and the Genetic Engineering Debate Rubric (1 per student). 2. Provide students with computer and Internet access. 3. Allow students time to brainstorm possible subtopics for their research. 4. Prompt students to search reputable databases and websites for information and record the information in an organized concept map. 5. Monitor classroom progress by viewing concept maps and asking leading questions about the connections between various elements.
Differentiation	Provide students who are struggling to find adequate information a list of websites to begin their search. Modifications can be made to the concept map requirements to allow students to achieve at multiple ability levels.
Assessments	Students can self-monitor their progress through their research by using the rubrics provided in the appendices. The rubrics can also be used as a formative assessment tool to gauge student progress, and also as the summative assessment of the student groups' final concept maps.

Section II: STEM Lesson Plan

Title of Lesson	**Genetic Engineering and Genetically Modified Organism Debate**
Time Required	40-50 minutes
Materials	Time Keeper (InternetStopwatch.com) Student Generated Concept Maps
Objectives	Students will apply their knowledge of genetic engineering and debate its ethical presence in scientific development.
Instructional Process	1. Divide the class in half (equal numbers of student groups on each side). One side of the class is assigned to argue in favor of genetic engineering. The other side should argue against genetic engineering. 2. Begin the debate with opening arguments from each student group on each side. Allow one minute per team to summarize their stance with a couple of key pieces of evidence. 3. Start the official debate with a series of questions. Allow one side one minute to respond and then allow the other side of the debate to ask questions and respond to the other groups. Provided here is a list of potential questions to be asked. The teacher should keep record of the student groups' involvement in the debate using the GMO Debate Rubric. Questions: 1. What is food biotechnology? 2. What are the potential health benefits of GMO's? 3. What are the potential health risks of GMO's? 4. What do you think are the potential benefits and risks of GMO's on world hunger? 5. What are the potential environmental benefits of GMO's? 6. What are the potential environmental risks of GMO's? 7. Should genetically engineered foods be labeled? Explain. 8. What are genetically engineered foods?
Differentiation	If students have a difficult time with open classroom discussion, a written assignment may be substituted. Have the students choose a side of the genetic engineering debate and support their view in a two-page essay.
Assessments	The GMO Debate Rubric should be used to gauge student involvement in the activity. Students should be provided with the rubric prior to the beginning of the debate.

Section II: STEM Lesson Plan

Title of Lesson	**Ethical Dilemma with Phylogenetic Trees & Persuasive Artifact**
Time Required	40-50 minutes, 20-minutes the following day
Materials	Paper Colored Pencils Markers Scissors Phylogenetic Trees (created on Day 2) Genetic Engineering Concept Maps Persuasive Artifact Checklist (1 per student) Post-Test (1 per student)
Objectives	Students will evaluate whether they should use genetic engineering to genetically modify the organisms on Planet M-Vega. Students will synthesize a persuasive artifact that describes the team consensus on the ethics of genetic engineering.
Instructional Process	Based on the class debate the previous day, the students will apply their ethical understanding to their scenario on Planet M-Vega. 1. Distribute the Persuasive Artifact Checklist (1 per student). 2. Prompt the student groups that they will apply their knowledge of genetic engineering and GMO's to the Planet M-Vega scenario. As a group, they will decide whether they are for or against genetic engineering of the M-Vega vegetation in order to alleviate the issue of poison in a few of the species. 3. Prompt students to create a brochure or other persuasive artifact that includes all items outlined on the checklist. 4. The artifact should be due the next day, and the instructor should administer the Post-Test at the beginning of the following class period.
Differentiation	Allow students to utilize a computer program to generate their brochure (e.g. Microsoft Publisher). Provide debate summaries to student groups that struggle to come to a consensus about the issue.
Assessments	The Persuasive Artifact Checklist should be used in grading the assignment. Post-Test

Section III: Unit Resources

Materials and Resource Master List	Pre-Test (1 copy per student) Avatar Video Clips Set of "Foamies" (1 per student group) Organism Set (1 per student group) Phylogenetic Tree Template (1 per student group) Amino Acid Coding Matrix (1 per student group) Organism Genome Coding System (1 per student group) Large paper Computers with Internet access (1 per student group, minimum) Inspiration or other concept map generation program (optional) Genetic Engineering Research Rubric (1 per student) Genetic Engineering Debate Rubric (1 per student) Time Keeper (InternetStopwatch.com) Student Generated Concept Maps Paper Colored Pencils Markers Scissors Phylogenetic Trees (created on Day 2) Genetic Engineering Concept Maps Persuasive Artifact Checklist (1 per student) Post-Test (1 per student)
Key Vocabulary	Anticodon- A region of tRNA consisting of three bases complimentary to the codon of mRNA. Chromosome- DNA and protein in a coiled, rod-shaped form that occurs during cell division. Clone- A member of a population of genetically identical organisms produced from a single cell. Codon- A group of three sequential nitrogen bases of an mRNA molecule. Deletion mutation- A mutation in which a segment of DNA breaks off a chromosome. Deoxyribonucleic acid (DNA)- A double-helix shaped nucleic acid. Evolution- All the changes that have formed life on Earth from its earliest beginnings to the diversity that characterizes it today. Gene- A segment of DNA that contains coding for a polypeptide or protein; a unit of hereditary information. Genetic engineering- A form of applied genetics in which scientists directly manipulate genes. Genetics- The field of biology devoted to understanding how traits are passed from parents to offspring. Genotype- The genetic make-up of an organism. Hybridization- Breeding technique that involves crossing dissimilar individuals to bring together the best traits of both organisms.

Indigenous- Native, originating or occurring naturally in the place specified.
Mutation- A change in DNA.
Natural Selection- The process by which organisms with favorable variations reproduce at higher rates than those without such variations.
Nucleic acid- An organic molecule, DNA or RNA, that stores and carries important information for cell function.
Nucleotide- A monomer of DNA and RNA, consisting of a nitrogen base, a sugar and a phosphate group.
Pedigree- A diagram of the genetic history of an individual; can show how a trait is inherited over several generations.
Phenotype- The external appearance of an organism that is determined by the individual's genotype.
Phylogeny- The evolutionary history of a species or taxonomic group.
Point mutation- The change of a single nitrogen-containing base within a codon.
Protein Synthesis- The formation of proteins using information coded on DNA and carried by RNA.
Start codon- The codon AUG which engages a ribosome to start translating an mRNA molecule.
Stop codon- Causes the ribosome to stop translating mRNA; UAA, UAG, UGA.
Substitution mutation- A point mutation in which one nucleotide in a codon is replaced with a different nucleotide.
Taxonomy- The science of grouping organisms according to their presumed evolutionary relationships.
Translocation- A mutation in which a broken piece of chromosome attaches to a nonhomologous chromosome.

Technical Brief

DNA/RNA Structure

Deoxyribonucleic acid (DNA) is a twisted helix found in the nucleus of the cell. The DNA carries hereditary information through a sequence of nitrogenous base codes. The "sides" of the DNA ladder are composed of alternating deoxyribose sugar and phosphate groups. The "rungs" of the ladder are composed of two bases. The bases always pair with a certain partner: cytosine always bonds to guanine; thymine always bonds to adenine. mRNA (messenger RNA) consists of only a single strand and the mRNA is formed in the nucleus but then travels outside the nuclear envelope to carry information to the ribosomes. mRNA uses three of the four bases that DNA does: cytosine, guanine, and adenine. The nitrogen base thymine is replaced by the base uracil in mRNA.

Protein Synthesis

DNA must be copied for information to be carried outside of the nucleus to the ribosome, the site of protein synthesis. There is a codon, a sequence of three mRNA (messenger ribonucleic acid) nucleotides, for each amino acid. Some amino acids have more than one codon. This codon language is carried by the mRNA, a single stranded molecule, which is the complement or opposite of DNA. The mRNA passes through the nuclear pores and into the cytoplasm.

The ribosome reads the message on the mRNA and sends chemical messages for the tRNA (transfer ribonucleic acid) to bring in the anticodon, a sequence of three tRNA nucleotides that are opposite to the codon. When the anticodons are brought to the ribosome and released by the tRNA, a string of amino acids or protein is built.

Mutations

Mutations are defined as spontaneous changes in a gene or chromsome. Mutations may occur in many forms (substitution, deletion, addition). Environmental factors may cause mutations or they may occur for no reason at all. Sometimes a mutation can be beneficial for an organism, resulting in a more favorable phenotype. This may allow the organism a better chance of reproducing, leading to an evolutionary advantage.

Phylogenetic Trees

Phylogeny is the study of relationships between organisms. It encompasses the science of taxonomy in determining how closely related species are not only in their present day forms but also throughout the species' evolutionary ancestry. A phylogenetic tree is a graphic representation of an organism's ancestry and possible related species. A key aspect of a phylogenetic tree is the pattern of branches. Each branch point represents a common ancestor of the species above that point. Phylogenetic trees can change as new information about various species evolve.

Genetic Engineering

Genetic engineering is a method of producing organisms with preferred traits, in which scientists transfer genes from one organism to another. Genetic engineering can be used to manufacture proteins, repair damaged genes, produce plants that are herbicide and/or insect resistant, and to modify animals for wide variety of reasons.

In the technique of cloning, an organism is produced that is genetically identical to its parent. Scientists accomplish this task by fusing a cell nucleus from one organism to an empty egg cell. When the cell starts dividing, it becomes an embryo. The scientists then implant the resulting embryo into an organism that will serve as a surrogate mother. Cloning allows an entire organism to be mass-produced with an advantageous set of traits.

There are many ethical and safety concerns with genetic engineering. In the United States, the Food and Drug Administration (FDA) and the Department of Agriculture (USDA) work to ensure that new biotechnology products and procedures are safe.

Safety and Disposal	No disposal or safety considerations.
References	Feldkamp, Susan. (2002). Modern Biology. Holt, Rhinehart, and Winston. Ohio Department of Education. 2011. "Released Test Materials from the Ohio Graduation Test" http://www.ode.state.oh.us/GD/Templates/Pages/ODE/ODEDetail.aspx?page=3&TopicRelationID=1070&ContentID=7835&Content=87538. Test Version 2009. Question 31
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Section IV: Appendices

Pre/Post Test
Pre/Post Test Answer Key
Genetic Engineering Research/Concept Map Guidelines
Genetic Engineering Research/Concept Map Rubric
Persuasive Artifact Checklist