Curriculum Sample Template

Grade Level	10	**Content Area**	Science
Course Title (grades 9-12 Only)	Biology/Genetics STEM In Action		
Expected Prior Knowledge *The knowledge/skills mastered earlier in the year foundational to the mastery of the required Standard in the current sample.*	Students understand the following concepts: mitosis, meiosis, DNA replication, chromosomes, genetics, heredity, protein synthesis, genetic mutations, gametes versus somatic cells. Students can recognize behavioral and structural adaptations like camouflage, mimicry, thorns, toxins. Students have a familiarity with the various evidence for evolution: biogeography, fossil record, comparative anatomy (homologous and analogous structures), vestigial structures, embryology, universal genetic code, molecular biology.		
Alignment to Program of Instruction *Briefly outline methods of instruction found in this sequence of lessons that align to the Program of Instruction described in A.3.*	This sample also demonstrates the three distinctive features of SySTEM Phoenix's Program of instruction: 1) Integration: Math and Science standards are taught in a mutually reinforcing manner 2) Problem-Based Learning: The standard is introduced to students within the context of a real-world problem that they continually hook their new knowledge into in order to create a viable solution or make an evaluative judgment 3) All final products are authentic documents that students will present to an audience of stakeholders.		
Standard Number and Description *List the Number* and the full description for the Required Standard or Science Performance Objective listed in section A.6.*	HS.4.4.3 Describe how the continuing operation of natural selection underlies a population's ability to adapt to changes in the environment and leads to biodiversity and the origin of new species.		
Materials/Resources Needed	School yard biodiversity field lab: http://www.fishwildlife.org/files/ConEd-Schoolyard-Biodiversity-Guide.pdf "Sources of Genetic Diversity" http://biology.arizona.edu/sciconn/lessons2/Furr/GeneticDiversity/GeneticDiversityHome.htm Adaptive advantage of camouflage game. Any biology lab text or online. Flashy Fish: http://www.pbs.org/wgbh/evolution/educators/lessons/lesson4/act2.html Graphic illustrations of directional, stabilizing and disruptive natural selection. Any text or online. Allelic frequency exercise Natural selection simulation with bunnies. pHET http://phet.colorado.edu/en/simulation/natural-selection		

* ***Standard Number****: For English Language Arts (Reading and Writing), use Grade, Strand, Standard (e.g., 3.RI.2). For K-8 Math, use Grade, Domain, Standard (e.g., 6.EE.7). For HS Math, use Conceptual Category-Domain, Standard (e.g., A-REI.6). For Science, use Grade, Strand, Concept, PO (e.g., 4.1.3.1).*

Lesson (add as needed)	**Instructional Strategies**	**Student Activities**
1	***1. Essential Question:*** How does natural selection operate as the major mechanism underlying adaptation to a population's environment and how does this lead to speciation and biodiversity? ***2. Launch/Introduction:*** Teacher will present startling statistics on colony collapse disorder of honeybees. **The Case:** As a new employee for Arizona Department of Agriculture you are assigned a project to develop an educational public outreach program detailing the potential impact of 'colony collapse disorder' in honeybees on food production. The program needs to include possible causes and your solution to the problem. ***4. Presentation/Direct Instruction:*** The teacher will provide an overview of how natural selection operates. Biological evolution accounts for the diversity of species developed both gradually over many generations and rapidly as well. Species acquired many of their unique characteristics through genetic diversity that produced adaptive traits involving changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment. Concepts covered include: a) pressure placed on a population due to over-production of offspring increases competition for limited resources in a population of organisms b) variation through random mutation and recombination leading to trait(s) that provide a survival advantage c) greater fitness leads to more offspring carrying the trait and who are also reproductively fit. d) Over generations the trait proliferates through the population. e) Geographic and reproductive isolation eventually leads to speciation. ***4. Vocabulary:*** Natural selection: random mutation, recombination, fertilization, random assortment, variation, allele pool, stabilizing selection, directional selection, disruptive selection, genetic variation, speciation, genetic drift, founder's effect, gene flow, gradualism, punctuated equilibrium, species, reproductive isolation, geographic isolation, gene pool, genetic equilibrium. ***7. Debrief/Summarize:*** The teacher will provide guidance as each student works through the allelic frequency exercise. The teacher will ensure the following learning target is generalized: *1) Students*	3. ***PBL Casework:*** **Meet the Problem:** Students will be organized into collaborative working groups of four, which will stay consistent throughout the entire case. *S*tudents will examine the case and get familiar with the provided case material. **Know/Need to Know:** Students will identify information and ideas into a KWHLS (see Resources) chart. The group facilitator will prompt group members to **Define the Problem Statement.** Though the definition of the problem may evolve as the team progresses. ***5. Accessing Prior Knowledge:*** The teacher will lead students in identifying dominant and recessive alleles and how they combine to form heterozygous or homozygous dominant/recessive genotypes. ***6. Allelic Frequency Analysis Game***. Students will calculate the allelic frequency of 2 generations of organisms and determine if the population is in genetic equilibrium. ***8. Reflection/Closure:*** For a population in genetic equilibrium, infer what this means about the surrounding environment. Students should state that the environment is fairly stable. ***9. Differentiation/Additional Exploration:*** how did the use of chemical DDT effect organisms exposed to the spray? ***10. Formative Assessment:*** Students are given allelic frequency data of two populations of frogs living in the desert southwest and asked to determine if any are not in genetic equilibrium. Students will be assessed on correctly identifying the populations in and not in genetic equilibrium. ***11. PBL Casework:*** **Explore:** Students will revisit their KWHLS chart and reflect on how their new knowledge relates to the case. In teams, students will create a plan to: gather information, acquire skills/knowledge, share information, and generate possible solutions. The group may delegate tasks to individual group members.

	understand the concept of allelic frequency and how it is calculated 2) Students can properly sequence the general events pertaining to natural selection	
2	***1. Introduction:*** What is genetic variation and how does it occur in individuals of a given species? ***2. Presentation/Direct Instruction:*** The teacher will present the DNA mutation involved in sickle cell anemia and how homozygotes for this disease differ from heterozygotes who otherwise have an adaptive advantage to malaria. Additional information will encompass concepts relating to random genetic mutations causing individual trait variation within a population but other sources of genetic diversity arise from random assortment, recombination and fertilization. These events provide the substrate upon which natural selection will operate. ***5. Debrief/Summarize:***. The teacher will provide guidance and assist students as they work through the online learning module. The teacher will ensure the following learning objectives are formalized: *1) students can differentiate between mutations types, random assortment, recombination and fertilization. 2) Students can articulate why recombination and DNA mutation are the most likely cause of novel traits.*	***3. Accessing Prior Knowledge:*** Using illustrations, the teacher will lead a review the various types of genetic mutations covered in the genetics unit. ***4. Investigate/Explore:*** Students will explore the web activity "Sources of Genetic Diversity" and work through each set of analysis problems. Students will construct their drawings to show possible chromosomal combinations, assortments and destinations of recombinant genes caused by crossing over. As such, students will observe how trait variation arises in a population. ***6. Reflection/Closure:*** In written form, students will note which sources of genetic diversity are suitable for changing environments. Suitable answers will identify recombination and mutation as the options that provide new traits. ***7. Formative Assessment:*** Students will draw a meiotic recombination event where the trait of a grandfather crossed over to the grandmother's homologous chromosome and how this trait was eventually inherited by the grandchild. Students will be assessed on showing the recombination event and all three generations of transmission. ***8. PBL Casework:*** **Explore:** Students will revisit their KWHLS chart and reflect on how their new knowledge relates to the case. In teams, students will create a plan to: gather information, acquire skills/knowledge, share information, and generate possible solutions. The group may delegate tasks to individual group members.
5	***1. Introduction:*** How do certain traits provide for a survival advantage in individuals and how do these traits proliferate through a population? ***2. Presentation/Direct Instruction:*** Natural selection starts when overpopulation creates competition for resources and places pressure on a population of species. Individual traits arising from genetic diversity lead to different abilities of individuals to compete for resources. If the trait provides a survival advantage, then that individual will likely live longer and produce more offspring with the same trait.	***3. Investigate/Explore:*** Students can rotate through the following lab stations: • Selective pressures: allelic frequency analysis game revisited but now with selective pressure added and 5 generations. Students graph the frequencies (y axis) vs generation (x axis) using different colored pencils for the dominant and recessive alleles. ***Formative Assessment:*** students should determine if allelic frequency changed, if any allele disappeared and predict what would happen if there was a decline in predator population.

	4. Debrief/Summarize: For natural selection to work, the teacher will emphasize that traits must already be present in gene pool and expressed in the population as a range of phenotypes. Clear guidance will be given to help dispel Lamarkian concepts of adaption and redirect student understanding toward natural selection which is random, unpredictable, unplanned, and has no goal of 'helping' any organism to survive better in its environment. The teacher will ensure the following learning target is generalized: *1) students identify natural selection as three processes - directional, disruptive or stabilizing and articulate how each effects the population's gene pool.* **Vocabulary:** fitness, Lamarck, allelic frequency, directional, disruptive and selective selection	Students will be assessed on precision of their answers. • Camouflage Adaptation Game: Students play this common simulation where a portion of a population of organisms blend well with their background and the remaining portion do not. One student predates the population for short time period. ***Formative assessment***: Students will make a prediction of what will happen over many generations. They will be assessed on correctly stating the population's coloration will eventually change to blend with the environment. • Natural selection simulation: pHet Bunnies http://phet.colorado.edu/en/simulation/natural-selection • PBS Flashy Fish: http://www.pbs.org/wgbh/evolution/educators/lessons/lesson4/act2.html ***Formative assessment***: students calculate predation frequencies between the individuals with adaptive coloration and those without then make predictions about what will happen over successive generations. • Narration of Natural Selection Graphs: Students study line graphs depicting directional, stabilizing and disruptive natural selection and write a brief narrative explaining the structure and meaning of each graph. ***Formative Assessment*** – students compare and contrast these three natural selection mechanisms in written essay form. Students will be assessed on correctly identifying each type of graph and stating it's effect on the gene pool.
	Introduction: How are new species created? ***Presentation/Direct Instruction:*** Scientists estimate that _____ species have already lived on Earth and gone extinct. The number of preexisting species joined with those extant, lead us a realization of vast biodiversity. Biodiversity is measured in terms of species richness and diversity found in varying habitats of the biosphere. Speciation occurs when either interbreeding or the production of fertile offspring is somehow prevented. This occurs through reproductive or geographic isolation arising after a population is separated off from the original and then adapts to the local environment through natural selection. Over time gene pools become very different. Reproductive isolation can include behavioral, mating	***Formative Assessment:*** Students will write their thoughts on how punctuated equilibrium might explain gaps in the fossil record. They will be assessed on the clarity of explanation.

	mechanic, zygotic or seasonal differences that prevent interbreeding or fertile offspring. Geographic events might split a population by volcanic eruption, earthquake, river shifts, drought patches, sea-level changes, sky islands, mountain ranges, streams, lakes, roads. It can simply be because wind or water carries individuals away from the founding population. The teacher will present different scenarios depicting various types of reproductive or geographic isolation and lead a discussion discerning each type. The concepts of gradualism and punctuated equilibrium are explained with illustrations showing how the fossil record supports both. ***Debrief/Summarize:*** The teacher will ensure the following learning target is generalized*: 1) Students will correctly distinguish geographic from reproductive isolation and how each eventually leads to a new species of organism from the original. 2) Students will understand the fossil record is transitional and gaps may be explained by punctuated equilibrium, loss of fossil matter to geographic events or simply undiscovered as of yet.* Vocabulary: speciation, geographic isolation, reproductive isolation, polyploidy, gradualism, punctuated equilibrium, species richness, biodiversity.	***Reflection/Closure:*** Students articulate population evolution via natural selection: variability that is heritable leading to differential reproduction.
6	***1. Introduction:*** What is biodiversity and how is it measured? ***3. Debrief/Summarize:*** The teacher will ensure the following learning target is generalized*: 1) Students will correctly define biodiversity as species richness and diversity.* Vocabulary: biodiversity, species richness, species diversity.	***2. Investigate/Explore:*** Students will investigate biodiversity of their own school campus or local park using instructional material from "Schoolyard Biodiversity Investigation". The teacher may choose to use only parts of this comprehensive guide to studying local biodiversity. b) Students can research honey bee species richness maps ***Formative Assessment:*** Assessment matter is included in the investigation and appropriately pertains to student exploration on local biodiversity. ***Differentiation/Additional Exploration:*** Students can read a scientific journal article describing species richness of bees. One suggested article:http://winfreelab.rutgers.edu/documents/BartomeusEtAl2013_PNAS.pdf

7	***1. Introduction:*** Teacher will review the product expectations/rubric for the PBL case. ***3. Conferencing/Feedback:*** As students continue their casework, the teacher may observe or participate in group dialogue. The teacher will conference with each group to ask probing questions and discuss components of the rubric. The teacher will record level of mastery of the standard demonstrated by the product thus far (adequate, proficient, expert)	***2. PBL Case:*** **Resolve:** Student groups will **determine the best fit solution** to the case and draft their report. Students will send their draft to an employee of Arizona Division of Agriculture for feedback. ***4. Closure/Self-Assessment:*** Individually, each student will self-assess their learning through a written summary which details how their individual contributions furthered the group's effort in addition to a reflection of learning. Students will provide evidence of their efforts.
8	3. Throughout the revision/completion process, the role of the teacher is facilitative. The teacher will actively observe groups, help students with group dynamic issues if needed, ask probing questions and/or direct towards further resources.	***1. Summative Assessment:*** Students will take summative assessment. ***2. PBL Case:*** **Resolve:** Students will continue to refine their report and presentation based on the feedback received. 4. ***Closure/Group-assessment:*** Groups will meet for group self-assessment and score their presentation on final rubric. Each score must be supported with clear evidence.
9	2. The presentation cycle for each group will include: a) Group solution presentation, b) Open forum clarifying questions , c) Open forum probing questions, d) Community member feedback ***3. PBL Case: Resolve:*** After all presentations are finished, teacher will facilitate a **debrief of the problem**.	***1. PBL Case:*** **Resolve:** Student groups will **present the solution** to the case. 2. As groups present, all audience members, teachers, students, and community members will write down key points and questions. All participants will have the opportunity to ask follow up questions after each presentation. ***4. Closure:*** After group debrief, students will incorporate synthesis of learning experience into individual self-assessment.

Summative Assessment Items: *Attach here.* For each summative assessment item, include an answer key or scoring rubric describing how points are to be awarded.

Type I:

Which of the following is NOT an example of natural selection?

A. Galapagos finches with varying beak types

B. Breeding dogs with desirable characteristics

C. Insects developing resistance to pesticides

D. Humans not becoming lactose intolerant as they mature

SOLUTION: B **SCORING:** This item represents a level 2 mastery of the standard.

Type II:

Choose one of the five possible causes of speciation below. Write a paragraph that defines speciation, and describes how the occurrence you chose causes speciation.

A. An earthquake disrupts river flow

B. Birds adapt to different elevations

C. Mating calls start to differ

D. Chromosome numbers in gamete cells differ

E. Mating seasons are different

RUBRIC

Level 4 (Expert)	Level 3 (Proficient)	Level 2 (Adequate)	Level 1
Correctly defines speciation, and provides at least three sentences accurately describing how their chosen cause leads to speciation.	Correctly defines speciation, and provides at least two sentences accurately describing how their chosen cause leads to speciation.	Correctly defines speciation, and provides one sentence describing how their chosen cause leads to speciation.	Attempts to answer one part of the question, but either speciation or sentence describing how their chosen cause leads to speciation is lacking.

Type III:

Short essay: Discuss the sources of genetic diversity and resulting variation in a population upon which natural selection operates. How is this reflected in the fossil record?

RUBRIC

Level 4 (Expert)	Level 3 (Proficient)	Level 2 (Adequate)	Level 1
Discusses recombination, mutation, fertilization, and assortment. Relates allelic frequency changes over generations and gives reference to the fossil record as transitional and punctuated equilibrium as a possible explanation for gaps.	Discusses recombination, mutation, fertilization and assortment. Relates allelic frequency changes over generations.	Discusses less than three of the possible causes of genetic diversity.	Attempts to identify possible causes of genetic diversity, but lacks any discussion.