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	**Next Generation Super Hero**
Economic Cluster	Human Performance
Targeted Grades	8-10
STEM Disciplines	Science, Technology, Engineering and Mathematics
Non-STEM Disciplines	English Language Arts

Section I: STEM Unit Overview

Unit Overview

Student teams are challenged to genetically alter a Superhero so that the Superhero is able to conquer a major disaster facing the nation. In order to effectively overcome the disaster, students will acquire knowledge of the disaster and the skills needed to be successful. Then, student groups will be provided with a list of potential Superheros that they must figure out how to genetically alter and reproduce in order to have the best probability to defeat the disaster. Students will produce an animation detailing the transformation of the Superhero from generation to generation.

Essential Question

How do you create a uniform probability model to predict the likelihood of traits for successive generations applied as compound events?

Enduring Understanding

The likelihood of traits appearing in genotypes and phenotypes can be predicted with theoretical probability models compared and/or contrasted with experimental probability models.

Engineering Design Challenge

Your job is to analyze the ways that traits are inherited from parents and then generate a formula that will ensure that desired traits are inherited and undesired traits are eliminated to create a super hero who proves to be disease resistant. Super heroes need to be able to save the world from natural disasters, BUT have limitations. How do you maximize their super power traits and insure that offspring will inherit the best of each parent? Does the environment that your super hero lives in or is raised in affect the potency of the super power inherited? Develop a written plan outlining the targeted traits, including graphs that show the proportional changes in subsequent generations. You will also design and build physical or virtual prototypes of multiple generations.

Time and Activity Overview

Day	Time Allotment	Actvities
1	50 Minutes	Introduction video clip Pretest
2	50 Minutes	Explore Genetic Traits-"Paste Tasting" Introduction to Punnett Squares
3	50 Minutes	Vocab Activities Class Data Analyze Dominant vs. Recessive
4	50 Minutes	Develop Argument about Breeding Genetic Traits
5	50 Minutes	Math Simulations with genetics
6	50 Minutes	Understanding Disaster Activity

7	50 Minutes	Introduce Design Challenge (whole class activity)
8	50 Minutes	Continue Design Challenge (small group)
9	50 Minutes	Computer Design Scratch Animated Presentation
10	50 Minutes	Computer Design Scratch Animated Presentation + Post-Test

Pre-requisite Knowledge & Skill	Basic Probability Basic Genetics (Offspring resemble their parents)

Academic Content Standards

Add Standard	Mathematics	
Grade/Conceptual Category	Grade 8	
Domain	Exponent Computations and Rules	
Cluster	Work with radicals and integer exponents.	
Standards	1. Know and apply the properties of integer exponents to generate equivalent numerical expressions. For example, 3^2 × 3^–5 = 3–3 = 1/33 = 1/27. 2. Use square root and cube root symbols to represent solutions to equations of the form x2 = p and x3 = p, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that √2 is irrational.	

Add Standard	Mathematics
Grade/Conceptual Category	Grade 7
Domain	Statistics
Cluster	Investigate chance processes and develop, use, and evaluate probability models.
Standards	5. Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring. Larger numbers indicate greater likelihood. A probability near 0 indicates an unlikely event, a probability around 1/2 indicates an event that is neither unlikely nor likely, and a probability near 1 indicates a likely event. 6. Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability. For example, when rolling a number cube 600 times, predict that a 3 or 6 would be rolled roughly 200 times, but probably not exactly 200 times. 7. Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy. a. Develop a uniform probability model by assigning equal probability to all outcomes, and use the model to determine probabilities of events. For example, if a student is selected at random from a class, find the probability that Jane will be selected and the probability that a girl will be selected. b. Develop a probability model (which may not be uniform) by observing frequencies in data generated from a chance process. For example, find the approximate probability that a spinning penny will land heads up or that a tossed paper cup will land open-end down. Do the outcomes for the spinning penny appear to be equally likely based on the observed frequencies? 8. Find probabilities of compound events using organized lists, tables, tree diagrams, and simulation. a. Understand that, just as with simple events, the probability of a compound event is the fraction of outcomes in the sample space for which the compound event occurs. b. Represent sample spaces for compound events using methods such as organized lists, tables and tree diagrams. For an event described in everyday language (e.g., “rolling double sixes”), identify the outcomes in the sample space which compose the event. c. Design and use a simulation to generate frequencies for compound events. For example, use random digits as a simulation tool to approximate the answer to the question: If 40% of donors have type A blood, what is the probability that it will take at least 4 donors to find one with type A blood?

Add Standard	Mathematics
Grade	
Standard	
Benchmark	
Indicator	

Add Standard	English Language Arts	
Grade	6-12	
Strand	Reading Standards for Literacy in Science and Technical Subjects	
Topic	Craft and Structure	
Standard	4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. 5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic. 6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.	

Add Standard	English Language Arts	
Grade		
Standard		
Benchmark		
Indicator		

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

Add Standard	Social Studies
Grade	
Standard	
Benchmark	
Indicator	

Add Standard	Science
Grade	8
Theme	Life Science
Topic	Species and Reproduction
Content Standard	The characteristics of an organism are a result of inherited traits received from parent(s).

Add Standard	Science
Strand	Biology
Course Content	Heredity
Content Elaboration	In high school biology, Mendel's laws of inheritance (introduced in grade 8) are interwoven with current knowledge of DNA and chromosome structure and function to build toward basic knowledge of modern genetics. Sorting and recombination of genes in sexual reproduction and meiosis specifically result in a variance in traits of the offspring of any two parents and explicitly connect the knowledge to evolution. The gene interactions described in middle school were limited primarily to dominance and co- dominance traits. In high school genetic mechanisms, both classical and modern including incomplete dominance, sex-linked traits, goodness of fit test (Chi-square) and dihybrid crosses are investigated through real world examples. Dihybrid crosses can be used to explore linkage groups. Gene interactions and phenotypic effects can be introduced using real-world examples (e.g. polygenic inheritance, epistasis, and pleiotrophy).

Add Standard	Science
Grade	
Standard	
Benchmark	
Indicator	

Add Standard	Fine Arts
Grade	
Subject	
Standard	
Benchmark	
Indicator	

Add Standard	Technology
Grade	
Standard	
Benchmark	
Indicator	

Assessment Plan

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

Performance Task, Projects	Next Generation "Super Hero" Probability Activity
Quizzes, Tests, Academic Prompts	Pre- and Post- Test Genetic Vocabulary Quiz
Other Evidence (e.g. observations, work samples, student artifacts, etc.)	Animated Demonstration Genetically Engineered "Hero"
Student Self- Assessment	Punnett Square Creation Genetic Self Exploration

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.	Video From "BiteSize" regarding genetics Random Video and simulations (TBA)
D	Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display.	Punnett squares for simulating generations
I	Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods.	Research on specific breeding methods for animals-web articles
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.	Math calculations with "scientific Calculator" for probability Scratch simulations reviewed for probability instruction
C	Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration.	Scratch Programming used to present simulated breeding possibilities.
	**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

Actuaries use mathematics, statistics, and financial theory to estimate the probability and likely economic cost of an event such as an accident or a natural disaster, and help businesses and clients develop policies that minimize the cost of that risk and uncertainty. Actuaries' work is essential to the insurance industry. http://www.bls.gov/ooh/math/actuaries.htm#tab-2

Atmospheric scientists study the weather and climate, and how it affects human activity and the earth in general. They may develop forecasts, collect and compile data from the field, assist in the development of new data collection instruments, or advise clients on risks or opportunities caused by weather events and climate change. http://www.bls.gov/ooh/life-physical-and-social-science/atmospheric-scientists-including-meteorologists.htm

Economists research and analyze economic issues using mathematical models and statistical techniques. Economists often study historical trends and use them to make forecasts for the future. http://www.bls.gov/ooh/life-physical-and-social-science/economists.htm#tab-2

Financial analysts provide guidance to businesses and individuals making investment decisions. They assess the performance of stocks, bonds, and other types of investments. They evaluate current and historical data, study economic and business trends and a company's financial statements to determine its value. http://www.bls.gov/ooh/business-and-financial/financial-analysts.htm#tab-2

Genetic counselors assess individual or family risk for a variety of inherited conditions, such as genetic disorders and birth defects. They provide information and advice to other healthcare providers, or to individuals and families concerned with the risk of inherited conditions. http://www.bls.gov/ooh/healthcare/genetic-counselors.htm#tab-2

Genetic engineers and biomedical engineers analyze and design solutions to problems in biology and medicine, with the goal of improving the quality and effectiveness of patient care. For example, they may design instruments, devices, and software; bring together knowledge from many technical sources to develop new procedures; or conduct research needed to solve clinical problems. http://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm#tab-2

Geneticists, biochemists and biophysicists study the chemical and physical principles of living things and of biological processes, such as cell development, growth, and heredity. They plan and conduct complex projects in basic and applied research. For example, they may study the genetic mutations in organisms that lead to cancer and other diseases, or study the evolution of plants and animals, to understand how genetic traits are carried through successive generations. http://www.bls.gov/ooh/life-physical-and-social-science/biochemists-and-biophysicists.htm#tab-2

Mathematicians use advanced mathematics to develop and understand mathematical principles, analyze data, and solve real-world problems. For example, they may work with chemists, materials scientists, and chemical engineers to analyze the effectiveness of new drugs, or work with industrial designers to study the aerodynamic characteristics of new automobiles. http://www.bls.gov/ooh/math/mathematicians.htm#tab-2

Operations research analysts help organizations solve problems and make better decisions. They examine information to figure out what is relevant to the problem and what methods should be used to analyze it, and then use statistical analysis or simulations to analyze information and develop practical solutions to business problems. For example, they may help decide how to organize products in supermarkets or help companies figure out the most effective way to ship and distribute products, or develop production schedules, or set prices. http://www.bls.gov/ooh/math/operations-research-analysts.htm

Statisticians use statistical methods to collect, analyze and interpret data and help solve real-world problems in business, engineering, the sciences, or other fields. They decide what data are needed to answer specific questions or problems, determine methods for finding or collecting data, then design surveys or experiments or opinion polls to collect data. http://www.bls.gov/ooh/math/statisticians.htm#tab-2

Section II: STEM Lesson Plan

Title of Lesson	**Day 1: Pretest/Unit Introduction**
Time Required	50 Minutes
Materials	-Computer with LCD projector -Pre-Test (Appendix A) -Video :http://www.bbc.co.uk/schools/gcsebitesize/science/21c_pre_2011/genetics/inheritanceact.shtml
Objectives	Students will recognize the impact that genetics has the basic formation of human life.
Instructional Process	1. Administer the pretest 2. Share and discuss the hook video (genetics information with alleles and very basic diagrams) http://www.bbc.co.uk/schools/gcsebitesize/science/21c_pre_2011/genetics/inheritanceact.shtml 3. Assign homework question- which of their traits do they think might be directly inherited.
Differentiation	Be mindful of learning style differences as teams are assigned. Provide accommodations as necessary for participation in Pre-Test (follow typical testing protocol).
Assessments	Use the Pre-Test to determine readiness for design challenge. Homework completeness will determine whether students are ready for next day activities.

Section II: STEM Lesson Plan

Title of Lesson	**Day 2: Individual Super Traits**
Time Required	50 minutes
Materials	-PTC paper (can be purchased from Carolina.com) -Genes and Bitter Taste: Article and Sample Organizers (Appendix C) -Punnett Square examples -Hard Candies

Objectives

Students will discover if they have the PTC gene and learn the history behind the PTC gene.
Each student will participate in the PTC test, then as a class analyze the results.
Students will participate in an introduction to Punnett squares.

Instructional Process

1. Explain to students that in today's activity they will discover if they obtain the PTC gene.

2. Distribute one piece of PTC paper to each student. Direct students to place the PTC paper on the tip of their tongue to determine if they are able to taste the paper. Have hard candies available for students who are able to taste the PTC paper.

3. On the board create a tally chart to display PTC test results. Example:
-Taste PTC paper
-No Taste on PTC paper
After students complete the PTC test, instruct students to place a tally on the chart in the correct row based on their results.

4. Explain to students that some people can taste a bitter taste while others cannot. This is because there is a single gene that codes for a protein in our tongues. When applying the PTC paper to the tongue the PTC will bind with the protein (if present) resulting in tasting the bitter taste.

5. Discuss the class results. Compare the number of the students that can taste PTC versus the number of students who are non-tasters. Typically results will show that approximately 2/3 to 3/4 of students should be able to taste. This is because the ability to taste PTC is a dominate trait.

6. Distribute PTC: Genes and Bitter Taste (http://learn.genetics.utah.edu/content/inheritance/ptc/) article. Instruct students to read the article, then as a class discuss the article. Have students who were able to taste provide information in the

discussion.

7. Introduce Punnett square using the information on page two of the article. One parent contains all receptors for taste (TT) the other parent contains all non-taste receptors (tt). Draw a Punnett square and label one side for the first parent and the top for the second parent. Fill in the middle of the Punnett square showing the possible combinations for offspring. The offspring will each have one tasting and one non-tasting receptor.

Differentiation	Students could be given additional pieces of PTC paper to test their families at home.
Assessments	Teacher should make informal observations throughout activity.

Section II: STEM Lesson Plan

Title of Lesson	**Day 3: Guided Exploration of Heredity and Probability**
Time Required	50 minutes
Materials	-Mirror -Take A Class Survey Lab Sheet (Appendix D) -Probability and Heredity Lab Sheet (Appendix E)
Objectives	Students will write a hypothesis reflecting their ideas about dominant and recessive alleles. Students will identify personal traits and input data correctly into a data table. Students will interpret class results from data table. Students will apply their understanding of probability and heredity to complete two Punnett Squares. Students will correctly identify and define key vocabulary.

Instructional Process

Hook: Have you ever heard that everyone has a twin somewhere, two people who looked alike but were not related? On the other hand, you've probably heard of people who think they can't possibly come from the same parents because they do not share any of the same physical characteristics. What causes people to look the way they do, or why do offspring commonly look like their parents? Are traits controlled by dominant alleles more common than traits controlled by recessive alleles?

1. Using Take A Class Survey lab sheet, instruct students to write a hypothesis reflecting their ideas about the question.

2. For each of the traits listed in the data table, instruct students to work with a partner to determine which trait they have.

3. Instruct students to record the number of students in the class who have each trait. Traits listed under Trait 1 in the data table are controlled by dominant alleles. Traits listed under Trait 2 are controlled by recessive alleles.

4. Instruct students to answer the following questions on their lab sheet:
   - -Which traits controlled by dominant alleles were shown by a majority of students?
   - -Which traits controlled by recessive alleles were shown by a majority of students?

Are Your Traits Unique?

1. Instruct students to place their finger on “ear lobes in the center of the circle of traits. Instruct students to select the small central circle that applies to them-either free ear lobes or attached ear lobes.

2. Instruct students to move their finger onto the next description that applies to them. Instruct students to continue using their finger to trace their traits until they reach a number on the outside rim of the circle.

3. Instruct students to record their number on lab sheet.

4. Instruct students to share their results with the class.

5. Instruct students to answer the following questions:
-How many students ended up on the same number on the circle of traits?
-How many students were the only ones to have their number?
-What do the results suggest about each person’s combination of traits?
-Does your data support the hypothesis you proposed?

Probability and Heredity

1. Instruct students to complete two Punnett Squares and then answer questions on lab sheet.

2. When students have completed their Punnett Squares, instruct them to complete the vocabulary assessment.

Differentiation	Students finishing quickly and needing more challenge may be asked to predict the possible results of genetic crosses. Some students may need samples of completed Punnett Squares for guidance.
Assessments	Teacher observation during labs Take a Class Survey Lab Sheet Probability and Heredity Lab Sheet

Section II: STEM Lesson Plan

Title of Lesson — **Day 4: Develop Arguments about Breeding**

Time Required — 50 minutes

Materials
-Malaria Resistant Mosquito Article (Appendix G)
-Argument Organizer and Essay Template (Appendix F)

Objectives — Students will be able to explain and provide evidence to support different points of view regarding a current breeding project.

Instructional Process

1. Distribute the "Malaria Resistant Mosquito" article.

2. Assign students to teams of three.

3. Instruct students to read the article.

4. Assign student teams different points of view:
   -One half of the groups will be genetics professors trying to eradicate disease
   -The second half of the groups will be biologists who are against genetic modification

5. Provide each point of view an "point of View Worksheet" that may be used to frame an essay that they will write to argue their assigned "point of view".

6. Provide time for groups to collect and discuss evidence that supports their point of view.

7. Provide an essay template to each student. Their homework will be to create an essay that argues their point of view while citing the evidence that they collected with their groups.

Differentiation — For students who have trouble reading- the article may be recorded and or read to them orally.

Assessments
Completion- Point of View Worksheet
Composition of Point-of -View essay

Section II: STEM Lesson Plan

Title of Lesson	**Day 5: Simulate with Scratch - Investigating Experimental & Theoretical Probability**
Time Required	50 minutes
Materials	-Paper Clip -Graphing Calculators (one per team) -Coins -Number Cubes -Computers -Perspectives on Probability and Exit Ticket (Appendix H) -Coin Toss Activity (Appendix I)

Objectives	Students will compare and contrast the difference between experimental and theoretical probability through written expression and include simulations within their description. Students will model an experimental probability of a scenario using a tool to conduct a simulation and analyze the results with the theoretical findings.
Instructional Process	Hook: A Halloween costume store is having a sale to give away a free costume for every 8 customers that make a purchase during the first weekend of October. The winners are chosen randomly after recording their contact information at the store. The store had 75 customers the first weekend of business. Use the randInt function on a graphing calculator to generate a list of 75 random integers between 1 and 8. Keystrokes: MATH <- 5 1 , 8 , 75) ENTER 1. Let 6 be representative of a winning costume. What is the experimental probability for winning a costume? 2. What is the theoretical probability of winning a costume? Introduction: Powerpoint of Terms & Mathematical Models What are the total number of outcomes of the scenario and the model? How are the probabilities of the event(s) distributed (equally or unequally)? Activity Model: Coin Toss Activity to Demonstrate Genetic Simulation

Technological Model:
http://scratch.mit.edu/projects/11015386/ contains several modeling options that could be applied to model different scenarios.

Assessment:

•Compare and contrast the difference between experimental and theoretical probability. Include how simulations impact both in your answer.

Exit Ticket
•Create and describe a scenario requiring a simulation. Be specific as you create your setting. What is the theoretical probability of your event?

•Justify the math model chosen for your description above. Complete the simulation using technology and analyze the results

Differentiation	Tier 0: Creation of own simulation model with Scratch programming language Tier 1: As listed / Models within scratch / Compound probability Tier 2: As listed / Models within scratch / Simple probability Tier 3: Venn diagram / Guided Notes from Powerpoint
Assessments	Venn Diagram to compare and contrast Experimental & Theoretical Probabilities Creation of a probability scenario and the modeling equipment to complete a simulation

Section II: STEM Lesson Plan

Title of Lesson	**Day 6: Natural Disaster Superheros**
Time Required	50 minutes
Materials	National Geographic natural disaster photographs, excerpt copies of Nature's Fury: Eyewitness -Reports of Natural Disasters by Carole G. Vogel http://environment.nationalgeographic.com/environment/natural-disasters/ -Nature's Fury Phenotype Brainstorm Handout (Appendix J)
Objectives	Students will examine natural disaster photographs to spark their interest and deepen their thinking about natural disasters. Students will read an eyewitness report from a natural disaster survivor and identify specific phenotypes that may have helped the person overcome adversity. Students will prepare for introduction to the Next Generation Super Hero design challenge by studying specific natural disaster scenarios and identifying beneficial phenotypes.
Instructional Process	1. Choose several striking National Geographic photographs of natural disasters to display, one at a time, in front of the whole class. Each photograph should contain a human in the midst of the natural disaster in order to evoke a stronger emotional response from the students. http://environment.nationalgeographic.com/environment/natural-disasters/ 2. Complete a "See-Think-Wonder" thinking routine for each photograph as it is shown to the class. ● "See"- Have students state what they notice about the photograph. Students are to share observations only, something they can actually point to in the photograph. ● "Think"- Have students share what they think is going on in the photograph. Prompt students to support their guess with evidence of what they can see in the photograph. ● "Wonder"- Have students share what they are wondering based on what they've seen and have been thinking. 3. Distribute a copy of a natural disaster survival story from Nature's Fury: Eyewitness Reports of Natural Disasters by Carole G. Vogel to each pair of students. Have them read the story and complete the Nature's Fury Phenotype Brainstorm handout. Once partners have completed the handout, have students report out and compile answers to create a class list of phenotypes that would help a person survive during a natural disaster.

4. Introduce Next Generation Superhero Design Challenge.

Differentiation	Students in need of accommodation for reading/writing may have his/her partner read/scribe for them. Photographs may also be used in place of reading the eyewitness reports in order to complete the handout.
Assessments	Nature's Fury Phenotype Brainstorm Handout

Section II: STEM Lesson Plan

Title of Lesson	**Day 7: Learn to Create a Genetic Super Hero**
Time Required	50 Minutes
Materials	-Sample Allele Strips (Appendix Q) -Class Activity: Next Generation Super Hero(Appendix M) -Teacher Instructions: Next Generation Super Hero- Class(Appendix K) -(Differentiation) Exponent Rules and Practice (Appendix O)
Objectives	Using one random and one chosen allele students will work as a class to create Punnett Squares for multiple generations of "Super Heroes" Students will use probability rules to analyze the probability of "Super Heroes" in each generation.
Instructional Process	1. Introduction of a natural disaster (ex. a volcano) for which a person could use a variety of "Super" traits in order to save an individual and/or facilitate rescue efforts. 2. Class (having been divided into pairs) brainstorms which "Super" traits could be most beneficial in dealing with the disaster. 3. Set up the Class Example 4. Select a random parent from the Gene Pool (here I'll work the example with SsEe drawn from the pool). 4. Assume our second parent is a homozygous recessive parent – a superhero on both the features of the random parent. 5. Using the "Class Worksheet" Set up the Punnett Square. 6. Guide students using sample math equations and compare to data in the Punnett Square 7. Continue for a second generation. 8. Guide use of math equations to predict a third generation.

Differentiation	For those who require little guidance- they may be given more autonomy during the activity- only receive beginning genetic material. For teachers who would like to practice the concept of exponents based on the exponential variety in successive generations, practice sheets are available in the appendices. (see materials) Punnett squares may be partially filled-in to ease the activity and facilitate faster simulations. Math equations may also be preloaded with numerical data that corresponds to partially filled Punnett squares
Assessments	Completions of Punnett Squares and math equations. Data should match that of whole group for this portion.

Section II: STEM Lesson Plan

Title of Lesson	**Day 8: Create "Your" Genetic Super Hero**
Time Required	50 Minutes
Materials	-Sample Alleles - cut into strips (Appendix Q) -Team Activity: Next Generation Super Hero (Appendix N) -Teacher Instructions: Next Generation Super Hero - Team (Appendix L) -(Differentiation) Exponent Rules and Practice (Appendix O)

Objectives

Recall population statistics (probabilities of alleles), and rules for combining probabilities.

Instructional Process

Given a set of parents from the gene pool, your challenge is to use your knowledge of statistics and genetics to determine a model that will produce the highest likelihood of a Next Generation Super Hero after 3 generations.

Constraints:
a) One of your first generation parents is homozygous dominant (e.g. AABB).
b) Each student in the team will have one possible parent drawn from the gene pool.
c) Must determine which order to use those randomly selected parents

1. Select the parents: Each student will select a parent from the gene pool grab bag.
    a. Options should be heterozygous or homozygous recessive

2. Using the worksheet, begin to set up a plan:
    a. Generation 1: One homozygous dominant parent, students select one of their random parents, determine the number of offspring and the probability of each type
    b. Generation 2: Choose a second random parent and compute probabilities of various offspring with each type of child from Generation 1.
    c. Generation 3: Choose third random parent and use statistical model to find probabilities of each offspring for that parent paired with each type of child from Generation 2.

3. What is the probability of Next Generation Super Hero for each generation?

4. REDESIGN: Could you get a higher probability if you use the randomly drawn parents in a different order?

5. Students should use the "small group" worksheet to document their combinations

of the different alleles in the Punnett Squares and in mathematical probability problems.

Differentiation	For teachers who would like to practice the concept of exponents based on the exponential variety in successive generations, practice sheets are available in the appendices. (see materials) Provide certain groups of students specific alleles to use set up each generation. (no drawing for gene pool)
Assessments	Completions of Punnett Squares and math equations. Data should be unique based on chosen alleles.

Section II: STEM Lesson Plan

Title of Lesson

Days 9-10: Activate Your Super Hero

Time Required

2 classes 50 minutes each

Materials

-Completed Next Generation Super Hero Activity
-Computer lab with internet connection or previously loaded "Scratch" programming <http://scratch.mit.edu/scratch2download/>
-Getting Started with Scratch - Instructions and Rubric (Appendix P)
-Post-Test (Appendix A)

Objectives

Students will develop a virtual model for the process of inheriting traits over multiple generations.
Students will model the probable representation of genetic material based on ideal genetics combinations.

Instructional Process

1. Instruct students to review their previous activity.

2. Provide direction regrading how they may record the traits evidenced by each generation (notes/pictures)

3. Direct students to open scratch either through the web or on the desktop via downloaded programming

4. Once open, instruct students to follow the guide in Appendix P in order to develop a model that models the changes of their genetic "Super Hero" as it moves through multiple generations of development.

5. Students should submit projects in or on the media format preferred by their teacher.

6. For those students who finish early on the second day, there can be a "project walk" where students can view each others' "Super Heroes".

7. Administer the Post-Test

Differentiation

Students who need extra help with the "Scratch" programming may be provided a prepared template in order to speed up their efforts and/or alleviate frustration.

Assessments	Student efforts should be graded by a rubric in order to see if they have successfully demonstrated their Super Hero with adequately using the animation resource.

Section III: Unit Resources

Materials and Resource Master List

Printable Resources
Appendix A: Pre/Post-Test (2 copies per student)
Appendix B: Pre/Post-Test and Answer Key (1 per teacher)
Appendix C: Genes and Bitter Taste: Article and sample organizers (1 per student)
Appendix D: Take a Class Survey Lab Sheet (1 per student)
Appendix E: Probability and Heredity Lab Sheet (1 per student)
Appendix F: Argument Organizer and Essay Template (1 per student)
Appendix G: Malaria Resistant Mosquito Article (1 per student)
Appendix H: Perspectives on Probability and Exit Ticket (1 per student)
Appendix I: Coin Toss Activity (1 per student)
Appendix J: Nature's Fury Phenotype Brainstorm Handout (1 per student)
Appendix K: Teacher Instructions :Next Generation Super Hero-Class (1 per teacher)
Appendix L: Teacher Instructions: Next Generation Super Hero-Team (1 per teacher)
Appendix M: Class Activity: Next Generation Super Hero (1 per student)
Appendix N: Team Activity: Next Generation Super Hero (1 per student)
Appendix O: Exponent Rules and Practice (1 per student) - Optional
Appendix P: Getting Started with "Scratch" – Instructions and Rubric (1 per student)
Appendix Q: Sample Allele Strips (1 set per student team)

Per Class:
LCD Projector
Computer (with internet access)

Per Team:
Graphing Calculator
Allele Strips
Computer (with internet access)
Free download of "Scratch" programming<http://scratch.mit.edu/scratch2download/>

Per Student:
Coins
Mirror (optional)
Number Cubes
PTC paper (carolina.com)

Key Vocabulary

Allele-one of a pair of genes that determine a specific trait. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Carcinogen-substance that causes cancer. (Globe Fearon (2004). The basis of life.)

Carrier-organism that has a recessive gene for a trait but does not show the trait.

(Globe Fearon (2004). The basis of life.)

Centromere-point of a chromosome where two parts meet. (Globe Fearon (2004). The basis of life.)

Chromosome-a structure located in the nucleus of a cell, made of DNA, that contains the genetic information needed to carry out cell functions and make new cells. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Clone-an organism that is genetically identical to the organism from which it was produced. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Cloning-process of using a cell or tissue from an organism to produce a new organism with an identical genotype; done in a laboratory. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Codominance-pattern of inheritance in which both alleles of a gene are expressed. (Globe Fearon (2004). The basis of life.)

Controlled Breeding-mating organisms to produce offspring with certain traits. (Globe Fearon (2004). The basis of life.)

DNA-deoxyribonucleic acid; the material found in a cell's nucleus, that determines the genetic traits of the organism. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

DNA Fingerprinting-using DNA technology from Human Genome Project to identify people and show whether they are related. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Dominant-in a pair of alleles, the one that, if present, determines the trait. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Dominant Allele-an allele whose trait always shows up in the organism when the allele is present. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Dominant Gene-gene whose trait always shows itself. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Egg-female sex cell; also an object that contains an animal developing from a fertilized sex cell (such as a bird or insect). (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Egg Cell-female reproductive cell, a female sex cell. (Globe Fearon (2004). The basis of life.)

Gamete-reproductive cell. (Globe Fearon (2004). The basis of life.)

Gender-sex of a person or other organism. (Globe Fearon (2004). The basis of life.)

Gene-segment of DNA, found on a chromosome, that determines the inheritance of a particular trait, the set of information that controls a trait. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Gene Splicing-moving a section of DNA from the genes of one organism to the genes of another organism. (Globe Fearon (2004). The basis of life.)

Gene Therapy-the insertion of working copies of a gene into the cells of a person with a genetic disorder in an attempt to correct the disorder. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Genetic Engineering (Genetic Modification)-the transfer of a gene from the DNA of one organism into another organism, in order to produce an organism with desired traits. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Genetic Fingerprinting (DNA Profiling)-DNA is used to produce genetic “fingerprints”, unique to each person unless you are an identical twin. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Genetics-the study of how traits are passed from parent to offspring. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Genetic Testing (Genetic Screening)-DNA testing used to reveal certain disorders or vulnerabilities. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Genetic Variation-differences in traits among organisms of the same species. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Genome-all of the DNA in one cell of an organism. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Genotype-an organism’s genetic makeup, or allele combinations. (Pearson/ Prentice Hall (2009). Prentice Hall science explorer.)

Heredity-passing of traits from one generation to another. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Heterozygous-having two different alleles for a trait. (Pearson/Prentice Hall (2009).

Prentice Hall science explorer.)

Homozygous-having two identical alleles for a trait. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Human Genome Project-project to map the genes and DNA base pairs on each of the 23 pairs of human chromosomes. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Hybrid-in genetics, an organism that carries both a dominant and recessive allele for the same trait. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Hybridization-a selective breeding method in which two genetically different individuals are crossed (donkey+horse=mule, rye plant+wheat plant=triticale). (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Inbreeding-a selective breeding method in which two individuals with identical or similar sets of alleles are crossed. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Incomplete Dominance-pattern of inheritance in which alleles from both parents are blended.   (Globe Fearon (2004). The basis of life.)

Inherited Trait-trait that is passed from parents to their offspring. (Globe Fearon (2004). The basis of life.)

Karyotype-a picture of all the chromosomes in a cell arranged in pairs. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Mass Selection-crossing plants with desirable traits. (Globe Fearon (2004). The basis of life.)

Meiosis (and phases of Meiosis)-cell division that produces sex cells (eggs or sperm), which have only half the chromosomes of the parent cell. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Mutagens-substance that increases the rate of mutation. (Globe Fearon (2004). The basis of life.)

Mutation-a random change in a gene. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Nondisjunction-occurs during meiosis when chromosome pairs do not separate correctly. (Globe Fearon (2004). The basis of life.)

Pedigree-a chart or “family tree” that tracks which members of a family have a particular trait. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Phenotype-an organism’s physical appearance, or visible traits. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Probability-a number that describes how likely it is that an event will occur. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Protein Synthesis-process by which proteins are made. (Globe Fearon (2004). The basis of life.)

Punnett Square-in genetics, table used to predict what traits offspring will have, based on what traits the parents have. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Pure-in genetics: refers to an organism that carries two dominant or two recessive alleles for a given trait. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Purebred-the offspring of many generations that have the same traits. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Recessive-in a pair of alleles, the one that is masked if a dominant allele is present. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Recessive Allele-an allele that is masked when a dominant allele is present. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Recessive Gene-gene of a trait that is hidden when the dominant gene is present. (Globe Fearon (2004). The basis of life.)

Replication-the process by which a cell makes a copy of the DNA in its nucleus. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

RNA-Ribonucleic acid; a nucleic acid that plays an important role in the production of proteins. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Sex-linked Gene-a gene that is carried on the S or Y chromosome. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Sex-linked Traits-traits that are controlled by the sex chromosomes. (Globe Fearon (2004). The basis of life.)

Sperm-male sex cell, produced in the testes. (Great Source Education Group (2006). Sciencesaurus: A student handbook.)

Sperm Cell-male reproductive cell. (Globe Fearon (2004). The basis of life.)

Trait-a characteristic that an organism can pass on to its offspring through its genes. (Pearson/Prentice Hall (2009). Prentice Hall science explorer.)

Technical Brief

The value of studying genetics is in understanding how we can predict the likelihood of inheriting particular traits. (O'Neil, 2013 p.1) The study of genetics has involved a wide variety of organisms. Scientists have studied the ways in which organisms inherit traits and this information has been used formally and informally throughout history in order to try to predict or even guide the inheritance of traits.
An example of genetic study in a straightforward use is in breeding certain types of animals. Animal breeders have used genetics to create certain specialty animals. For example, certain foxes have been bred to be very much dependent on humans in the same way that you might see a pet dog or cat. (Ratliff, 2011) This particular breeding suits the needs of certain individuals, but does significantly change the natural characteristics of the fox.
In other cases genetics has been used to work toward a malaria resistant mosquito. (Johnson, 2011) On the surface this clearly has benefits for disease eradication. The question always remains regarding whether there will be additional less helpful or even detrimental impacts with the desirable genetic change.

As was stated earlier genetics is still a study of “likelihood” of traits appearing. (O'Neil, 2013 p.1) This refers to probability. While there are strong reasons why certain traits should appear in succeeding generations, there are certain inherited traits that are very difficult to predict.
An English scientist, Reginald Punnett, invented the Punnett Square as a means of taking known traits from parent organisms and constructing models that show all the possibilities of those traits being passed to the offspring. (O'Neil, 2013)
Parents who are dominant for a gene have a greater likelihood of passing that gene. At the same time if two parents who carry recessive genes come together, that recessive characteristic may be made manifest in their offspring.

Complications in the study of genetics are in the fact that some traits are not predictable at all. Certain traits including stature, body shape, hair and skin color are called polygenic traits. They are predicted with more than one pair of genes. (O'Neil, 2013)
Other traits have what is called intermediate expression. In this middle ground certain traits might not have complete dominance over recessive traits. A great example of this is a pink flower. Certain red and white flowers can actually produce pink, a color which neither of them actually exhibits. (O'Neil, 2013)

With all of these exceptions exist it might not seem to be a very logical exercise to predict genetic traits. While there are some detractors that do not agree in the logic of probability it still remains a valid experiment. An exercise a simple as flipping a coin produces data points simply regarding which side of the coin is facing up when it lands. (Walpole et. al., 2012) Punnett Squares produce the data points in genetic exercises. This data provided some indication of what the possibilities are of a certain event occurring, but that of course leaves open the possibility of the event not occurring or occurring in a different way.

Regardless of how genetics information is used, it remains an interesting topic for scientists who wish to grow closer to predicting the unpredictable.

Safety and Disposal

As most activities are virtual, the safety concerns mostly regard cleanliness in the taste test. Students will need to use basic precautions while using electronic media including but not limited to classroom computers.

References

Aralin, T. (n.d.) Mendel’s experiment with garden peas. [photograph]. Retrieved from http://www.takdangaralin.com/science/genetics-the-beginning-of-genetics/

California Department of Education. (2004). Biology released test questions. [PDF]. Retrieved from http://www.cde.ca.gov/ta/tg/sr/css05rtq.asp

Coolidge-Stoltz, E., Padilla, M. J., Miaoulis, I., & Cyr, M. (2009). Prentice Hall life science. Needham, Mass: Pearson.

Explore Your Inner Animals | Your Inner Fish | Science | Classroom Resources | PBS Learning Media. (n.d.). Retrieved from http://www.pbslearningmedia.org/resource/1eacb154-b9fd-4775-8918-c913306048aa/explore-your-inner-animals-your-inner-fish/

genecrc.org. (n.d.). Retrieved from http://www.genecrc.org/site/ko/koglokids.htm#chromosome

Genetic Science Learning Center (2014, January 6) PTC: Genes and Bitter Taste. Learn.Genetics. Retrieved May 29, 2014, from http://learn.genetics.utah.edu/content/inheritance/ptc/

Genetic Tool Kit | Science | Classroom Resources | PBS Learning Media [Video file]. (n.d.). Retrieved from http://thinktv.pbslearningmedia.org/resource/tdc02.sci.life.gen.genetictoolkit/genetic-tool-kit/

Genetic Variation | Science | Classroom Resources | PBS Learning Media [Video file]. (n.d.). Retrieved from http://thinktv.pbslearningmedia.org/resource/tdc02.sci.life.gen.variation/genetic-variation/

Genetic Variation | Science | Classroom Resources | PBS Learning Media [Video file]. (n.d.). Retrieved from http://thinktv.pbslearningmedia.org/resource/tdc02.sci.life.gen.variation/genetic-variation/

Genetics: Tour of the Basics | Science | Classroom Resources | PBS Learning Media [Video file]. (n.d.). Retrieved from http://thinktv.pbslearningmedia.org/resource/lsps07.sci.life.gen.whatisdna/genetics-tour-of-the-basics/

Globe Fearon (2004). The basis of life. Parsippany, N.J: Globe Fearon, Pearson Learning Group.

Great Source Education Group (2006). Sciencesaurus: A student handbook. Wilmington, MA: Great Source Education Group.

How Genetic Disorders Are Inherited | Science | Classroom Resources | PBS Learning Media [Video file]. (n.d.). Retrieved from http://thinktv.pbslearningmedia.org/resource/tdc02.sci.life.gen.inherited/how-genetic-disorders-are-inherited/

Inheritance (2014). BBC GCSE Inheritance activity [video]. Retrieved from http://www.bbc.co.uk/schools/gcsebitesize/science/21c_pre_2011/genetics/inheritanceact.shtml

Johnson, Lacey & Climatewire (2012,June 18). Scientific American. Retrieved from http://www.scientificamerican.com/article/malaria-resistant-mosquitoes-lab-bred-first-time/

Knight, A. M., Grymonpre, K. (2014, April). Can you justify that? Tricks and tips to easily assess the justifications in students' arguments. Workshop presented at the annual meeting of the National Science Teachers Association (NSTA), Boston, MA. Learn.Genetics.utah.edu. (n.d.). Retrieved from http://gslc.genetics.utah.edu/units/basics/

Mendel's Laws of Genetic Inheritance | Science | Classroom Resources | PBS Learning Media [Video file]. (n.d.). Retrieved from http://thinktv.pbslearningmedia.org/resource/hew06.sci.life.gen.mendelinherit/mendels-laws-of-genetic-inheritance/

Morris, P. (Producer) (2007). Galapagos The Islands that Changed the World [Motion picture]. Warner Home Video Inc.

National Geographic. (2014). Natural disasters. Retrieved from http://www.

environment.nationalgeographic.com/environment/natural-disasters/

O'Neil, D. (2012). Probability of Inheritance. Retrieved from http://anthro.palomar.edu/mendel/mendel_2.htm

Ratliff, E. (2011). Taming the Wild. National Geographic Magazine. Retrieved from http://ngm.nationalgeographic.com/2011/03/taming-wild-animals/ratliff-text

Ritchhart, R., Church, M., & Morrison, K. (Eds.) (2011). Making thinking visible: How to promote engagement, understanding, and independence for all learners. San Francisco, CA: Jossey-Bass.

The Promise and Perils of Genetic Technologies | Science | Classroom Resources | PBS Learning Media. (n.d.). Retrieved from http://thinktv.pbslearningmedia.org/resource/cygc12.sci.splgen/the-promise-and-perils-of-genetic-technologies/

The Common Genetic Code | Science | Classroom Resources | PBS Learning Media [Video file]. (n.d.). Retrieved from http://thinktv.pbslearningmedia.org/resource/tdc02.sci.life.gen.comgencode/the-common-genetic-code/

The Happy Scientist. (n.d.). Retrieved from http://thehappyscientist.com/life-science-content/genetics
Tigress Productions (Producer) (2003). Journey of Man The Story of the Human Species[DVD]. Public Broadcasting Service.

"Usborne science encyclopedia" in Usborne Quicklinks. (n.d.). Retrieved from http://www.usborne.com/quicklinks/eng/catalogue/catalogue.aspx?cat=1&loc=usa&area=S&subcat=SE&id=3749

Walpole, R.E. et. al. (2012). Probability and Statistics for Scientists and Engineers 9th ed. Boston: Pearson.

Curriculum Developers

Leslie Blaha Ph.D.: Contributing Author
Laura Drager: Contributing Author
Andrea Durham: Contributing Author
Eric Krissek: Contributing Author
Benjamin McCombs: Contributing Author
Carly Monfort: Editor
Chrysa Theodore: Contributing Author
Mary Beth Walters: Contributing Author
Rik Warren: Contributing Author

Section IV: Appendices

Appendix A: Pre/Post-Test
Appendix B: Pre/Post-Test and Answer Key
Appendix C: Genes and Bitter Taste: Article and Sample Organizers
Appendix D: Take a Class Survey Lab Sheet
Appendix E: Probability and Heredity lab Sheet
Appendix F: Argument Organizer and Essay Template
Appendix G: Malaria Resistant Mosquito Article
Appendix H: Perspectives on Probability and Exit Ticket
Appendix I: Coin Toss Activity
Appendix J: Nature’s Fury Phenotype Brainstorm Handout
Appendix K: Teacher Instructions :Next Generation Super Hero-Class
Appendix L: Teacher Instructions: Next Generation Super Hero-Team
Appendix M: Class Activity: Next Generation Super Hero
Appendix N: Team Activity: Next Generation Super Hero
Appendix O: Exponent Rules and Practice
Appendix P: Getting Started with “Scratch” – Instructions and Rubric
Appendix Q: Sample Allele Strips