Genetic Testing and Bio-Engineering

Science, Life Science | **Middle School**

Common Assignment 1
Fish in a Pond Investigation

Table of Contents

Middle School Science

Fish in a Pond Investigation

Learning Targets

Students will:

- Model how an organism's characteristics are controlled by genes and how these genes, in turn, may be inherited by offspring.

- Generate a hypothesis based on their background knowledge.

- Conduct and gather data during the simulation.

- Complete Punnett squares representing multiple generations.

- Calculate probabilities of offspring over multiple generations.

- Graph and analyze data from the simulation.

- Write conclusions based on data.

Criteria for Success

Complete the pre-lab, procedure, data table, graphing, and conclusion portions of this lab with 90 percent success.

Purpose

In this lab, students will investigate how natural selection can lead to changes in a species over time. Students will make predictions in the form of a hypothesis, model the events involved in a genetic cross, and explore how both genetic and environmental factors play a part in natural selection.

Student Materials for Each Group

- 30 orange goldfish

- 30 pretzel goldfish

- 30 white goldfish

- Bowl or bag to be used as fish pond

- Three napkins labeled "prey," "female," and "male"

- Graph paper

Teacher Materials

Baggy with nursery fish—this bag holds a variety of offspring fish to be delivered to each group after they have mated their parent fish using the Punnett squares. When students pull prey fish, they can go into this bag to be reused later as offspring.

Background Information

- The orange goldfish represent fish that have the smooth scale phenotype and are **homozygous dominant (DD).** Orange goldfish <u>are delicious</u> to predators.

- The white goldfish represent fish that have the smooth scale phenotype, the spike allele, and are **heterozygous dominant (Dd).** White goldfish are <u>also tasty</u> to predators.

- The pretzel goldfish represent fish with the spike scale phenotype, are **homozygous recessive (dd),** and are <u>avoided by predators</u> because of the spikey scales.

Student Procedures

Round 1: PLEASE DO NOT EAT THE GOLDFISH

1. Wash your hands.

2. Write the words "prey," "female," and "male" on your napkins.

3. Place the goldfish in the lake (bowl), and mix them around.

4. Choose one person to be the predator. While someone else counts to three, the predator picks a fish out of the pond one-by-one and places it on the "prey" napkin (try to pick smooth fish and avoid pretzel fish). Your prey fish are now dead and no longer part of the population.

5. Repeat step 4 until everyone in your group gets one chance to be a predator.

6. Close your eyes and choose, at random, **five fish** from the bowl and place them on the **"female" napkin.**

7. Close your eyes and choose, at random, **five fish** from the bowl and place them on the **"male" napkin.**

8. a) Now choose, at random, one male fish and one female fish from the napkins, and enter their genotypes (**male—top** of Punnett square, **female—left side** of Punnett square) into the Punnett square under generation one (F_1).

   b) Whichever square is shaded in each of the Punnett squares (1–5) will be the outcome of the offspring in the F_1 generation and needs to be introduced into the pond population. Take the offspring fish out of the nursery, and introduce them into the bowl. Reintroduce the parent fish back into the pond as well. If you do not have the phenotype (appropriate kind of goldfish) in your nursery, ask your teacher for a fish of that phenotype.

9. Repeat step 8 until you have five Punnett squares completed. You should have placed 15 fish back into the bowl (10 captured parent fish and five offspring).

Generation F_1 Punnett Squares

Students will complete 5 Punnett squares in Generation F_1. This is one sample.

1.	D	d
D	DD	Dd
d	Dd	dd

Using Mathematics—Generation F_1

Calculate the probability of the offspring for two of the above Punnett squares.

1st Punnett square
orange fish = ___of ___or ____ %
white fish = ___of ___or ____%

pretzel fish = ___of ___or ____%

2nd Punnett square
orange fish = ___of ___or ___%
white fish = ___of ___or ___%

pretzel fish = ___of ___or ____%

Round 2: PLEASE DO NOT EAT THE GOLDFISH

Repeat steps 4–9 using the Generation F_2 Data Table and the Generation F_2 Punnett Squares. Make sure that you introduced the offspring and reintroduced the parents back into the pond (bowl). Count the total number of each type of fish, and record it in the ending total for Generation F_1 and the starting total for Generation F_2.

Round 3: PLEASE DO NOT EAT THE GOLDFISH

Repeat steps 4–9 using the Generation F_3 Data Table and the Generation F_3 Punnett Squares F_3. Make sure that you introduced the offspring and reintroduced the parents back into the pond (bowl). Count the total number of each type of fish, and record it in the ending total for Generation F_2 and the starting total for Generation F_3.

Representing Data

Complete a graph on attached graph paper for data analysis that includes the following:

- A line graph using each generation of fish on the X-axis and ending population of fish on the Y-axis. You will have three lines, one for each fish phenotype: DD—red, Dd—blue, and dd—green.

- Remember your graphing rules:
  1. Title of your graph—what are you representing?
  2. Key—what do the different colors stand for?
  3. Even numbering/scale—use the squares on the graph paper equally.
  4. Labels on both axes—X and Y.

  The directions for the graphing section are very specific, but you may want to do a mini-lesson on graphing before students begin to create their graphs.

Helpful Hints

1. When purchasing goldfish for a class of 30, estimate 1.5 bags of parmesan (white), 1.5 bags of cheddar (orange), and 2 bags of pretzel (spikey).

2. Orange goldfish can easily be purchased in bulk for a significant savings.

3. Bags of fish (ponds) can be reused for several class periods if students use their beginning and ending population numbers as a place to pause the lab. In this case, each day would begin with students counting their fish, referring to data, and trading fish with the teacher to get the proper beginning numbers for the day.

4. Pre-bagging the fish is very important.

5. The lab procedures state that students may not eat the fish. For the wellness of students, consider prohibiting the eating of lab materials, especially since these fish have been handled by multiple students. If you want to treat your students to a snack, bring in additional goldfish crackers that are not used in the investigation.

6. Groups should consist of three to four students.

7. Once data have been collected, student work can be done individually. If left in groups, emphasize that each student is responsible for all questions. Questions should not be divided between members in order to prevent copying answers.

Possible Student Responses to the Pre-Lab Questions

Read over laboratory and answer the following questions:

1. What do you think will be the possible **phenotypes** of the offspring for future generations? Why?

   Student answers should include both phenotypes (spikey and non-spikey). Although smooth scaled fish are desirable prey, they have a dominant allele that will show up in the phenotype if present, and the lab begins with twice as many smooth fish as spikey fish.

   Many students will say that there are three phenotypes (pretzel, orange, and white) because that is what they observe. This is a great time to address misconceptions and reinforce that the color of the goldfish is a code for phenotype. Some students might say that only spikey fish will survive. This inference is acceptable at this point, but you may want to address this misconception in class discussion.

2. What do you think will be the possible **genotypes** of the offspring for future generations? Why?

   There are three possible genotypes in the future generations (DD, Dd, and dd,) because all of these genotypes are present in the pond with equal populations at the beginning of the lab. Different combinations of alleles in remaining fish (after the 1st prey removal) will result in a variety of genotypes in the offspring.

   Many students will say that only spikey fish (dd) will survive, because they are not desired prey. You can address this as a misconception or allow students to revisit their pre-lab questions after all of the data are collected.

Hypothesis (if … then … because)

Based on what you read, create a hypothesis for the lab: What type of fish will be present in future populations?

If spikey fish are avoided by predators, **then**

   Example—answers will vary: *The spikey fish population will increase over time in each generation because more spikey fish will survive and reproduce.*

Possible Student Responses to Generation F₁ Punnett Squares

Answers will vary for Punnett squares because students draw random fish and choose mating pairs. In the mating pairs represented below, the teacher would provide the following offspring from the nursery: one orange, two pretzel, two white. Students add the mating pairs and the offspring back into the pond.

1.	D	d
D	DD	Dd
d	Dd	dd

4.	D	d
d	Dd	dd
d	Dd	dd

2.	d	d
d	dd	dd
d	dd	dd

5.	D	D
d	Dd	Dd
d	Dd	Dd

3.	D	D
D	DD	DD
d	Dd	Dd

Generation F₁ Data Table

	Population of pretzel fish (dd)	Population of white fish (Dd)	Population of orange fish (DD)	General observations
Starting	30	30	30	*Prey—3 white, 5 orange*
Ending	*30 + 2 offspring = 32*	*30 - 3 (prey) + 2 offspring = 29*	*30 - 5 (prey) + 1 offspring = 26*	**Students do not need to show the math.**

Using Mathematics—Generation F₁

Calculate the probability of the offspring for two of Punnett squares from round 1.

1st Punnett square

orange fish = _1_ *of* _4_ *or* _25_ *%*

white fish = _2_ *of* _4_ *or* _50_ *%*

pretzel fish = _1_ *of* _4_ *or* _25_ *%*

2nd Punnett square

orange fish = _0_ *of* _4_ *or* _0_ *%*

white fish = _0_ *of* _4_ *or* _0_ *%*

pretzel fish = _4_ *of* _4_ *or* _100_ *%*

Generation F₂ Punnett Squares

1.

4.

2.

5.

3.

Generation F₂ Data Table

	Population of pretzel fish (dd)	Population of white fish (Dd)	Population of orange fish (DD)	General observations
Starting	*32*	*29*	*26*	*Ending population of F₁ Generation*
Ending				

Using Mathematics—Generations F₂

Calculate the probability of the offspring for two of the Punnett squares from round 2.

3rd Punnett square
orange fish = _____ of _____ or _____%
white fish = _____ of _____ or _____%
pretzel fish = _____ of _____ or ___✔%

4th Punnett square
orange fish = _____ of _____ or _____%
white fish = _____ of _____ or _____%
pretzel fish = _____ of _____ or _____%

Generation F₃ Punnett Squares

1.

4.

2.

5.

3.

Generation F₃ Data Table

	Population of pretzel fish (dd)	Population of white fish (Dd)	Population of orange fish (DD)	General observations
Starting				
Ending				

Using Mathematics—Generations F₃

Calculate the probability of the offspring for two of the Punnett squares from round 3.

5th Punnett square
orange fish = _____ of _____ or _____%
white fish = _____ of _____ or _____%
pretzel fish = _____ of _____ or _____%

2nd Punnett square
orange fish = _____ of _____ or _____%
white fish = _____ of _____ or _____%
pretzel fish = _____ of _____ or _____%

Data Analysis

1. Discuss what happened to the population of your orange fish, white fish, and pretzel fish. Make sure to include increases and decreases in the population.

   Students should track each genotype through three generations using data evidence. The graph is a useful visual aid for this question.

2. How does the phenotype of the population change from Generation F_1 to Generation F_3? Remember to refer to your data tables and graph.

   Students should combine the orange and white fish populations in order to correctly express numbers for the smooth scale phenotype. Students can use data for evidence and show calculations.

Communicating Findings

3. Compare your graph to another group's graph. What similarities and differences do you find in your graphs?

   Students should look for increases and decreases in populations, angle of slopes, scale and size of graph, ending populations, and any other patterns. Students should use specific details instead of general information. For example "both graphs had a line for orange fish that rose in Generation F_2 and fell in Generation F_3" is better than "the graphs had similar shapes." A graphic organizer is an organized way to address this with some students.

4. Discuss with another group the possible human errors that could have occurred or did occur.

   A common error is that students forget to place the female on the side of the Punnett square and the male on top. When group members are not uniform, the genotype offspring may be affected. Students should take time to reflect and self-evaluate.

Conclusion

5. What was your hypothesis? Was it supported or rejected? Why? Refer to your data.

   Example: My hypothesis was that if spikey fish are avoided by predators, then the spikey fish population will increase over time in each generation because more spikey fish will survive and reproduce. This hypothesis was supported. This is evidenced in the data table for each generation. The pond began with 30 pretzel fish. Generation F_1 ended with 32, F_2 ended with 35, and F_3 ended with 36. This demonstrates a steady increase.

6. Infer what the phenotypes of the Generation F_4 population would be? What leads you to this inference?

   Students may make inferences based on the slope of their graph and/or patterns in the graph over generations. Students may also calculate the average increase or decrease of the population over the past generations and apply that to Generation F_3 to make an inference about F_4.

7. How can patterns in the inheritance of traits be used to predict how frequently they appear in offspring?

   Patterns in the inheritance of traits can be used to predict how frequently they may appear in future generations. Traits are controlled by alleles, and when a recessive trait appears from a dominant phenotype parent, one can infer that each parent carried the recessive version of the gene. Genotypes, when entered into Punnett squares, can help predict the probability of traits occurring in following generations.

8. What new learnings did you obtain from completing this laboratory activity?

   Answers will vary. Students may discuss the differences between genotype and phenotype. Others may discuss how adaptations influence the ability of an organism to survive and reproduce. Some may discuss predator/prey relationships or effects of population fluctuation on an ecosystem.

Scientific Practices Rubric

INITIATING THE INQUIRY

What is the evidence that the student can formulate questions and models that can be explored by scientific investigations as well as articulate a testable hypothesis?

SCORING DOMAIN	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
Stating a Hypothesis (When Appropriate)	• Articulates a prediction that has limited relationship to the question under investigation		• Articulates a relevant prediction of the expected results, but variables are unclearly stated		• Articulates a hypothesis about the investigated question, with a basic and accurate description of the variables ("if ... then …")		• Articulates a hypothesis about the investigated question, with accurate and specific explanation of the relationship between variables ("if ... then … because")

REPRESENTING, ANALYZING, AND INTERPRETING THE DATA

What is the evidence that the student can organize, analyze, and interpret the data?

SCORING DOMAIN	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
Using Mathematics and Computational Thinking (When Appropriate)	• Expresses relationships and quantities (units) using mathematical conventions with major errors • Evaluation of whether the mathematical computation results "make sense" is omitted		• Expresses relationships and quantities (units) using mathematical conventions with minor errors • Makes note of whether the mathematical computation results "makes sense" without reference to the expected outcome		• Accurately expresses relationships and quantities (units) using appropriate mathematical conventions • Explains whether the mathematical/computation results "make sense" in relationship to the expected outcome		• Accurately and consistently expresses relationships and quantities (units) using appropriate mathematical conventions • Consistently evaluates whether the mathematical/computation results "make sense" in relationship to the expected outcome

Genetic Testing and Bio-Engineering
Common Assignment 1

Analyzing the Data							
Analyzing the Data	• Analyzes data using inappropriate methods or with major errors or omissions • Consistency of outcome with initial hypothesis, when appropriate, is not compared		• Accurately analyzes data using appropriate methods with minor omissions • Compares consistency of outcome with initial hypothesis, when appropriate		• Accurately analyzes data using appropriate and systematic methods to identify patterns • Compares consistency of outcome with initial hypothesis, when appropriate, and identifies possible sources of error		• Accurately analyzes data using appropriate and systematic methods to identify and explain patterns • Compares and explains consistency of outcome with initial hypothesis, when appropriate, and explains possible sources of error and impact of errors

CONSTRUCTING EVIDENCE-BASED ARGUMENTS AND COMMUNICATING CONCLUSIONS
What is the evidence that the student can articulate evidence-based explanations and effectively communicate conclusions?

SCORING DOMAIN	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
Communicating Findings	• Attempts to use multiple representations to communicate conclusions with inaccuracies or major inconsistencies with the evidence • Implies conclusions with no discussion of limitations		• Uses multiple representations (words, tables, diagrams, graphs, and/or mathematical expression) to communicate conclusions with minor inconsistencies with the evidence • States conclusions with general discussion of limitations		• Uses multiple representations (words, tables, diagrams, graphs, and/or mathematical expressions) to communicate clear conclusions consistent with the evidence • Explains conclusions with specific discussion of limitations		• Uses multiple representations (words, tables, diagrams, graphs, and/or mathematical expressions) to communicate clear and detailed conclusions consistent with the evidence • Explains conclusions and impact of limitations or unanswered questions

©2013 Stanford Center for Assessment, Learning, and Equity (SCALE) *Scientific Practices*

COMMON ASSIGNMENT STUDY

Fish In A Pond Investigation

Name:_____   Period:_____

Lab partner(s):_____

Learning Targets—I Can:

• Model how an organism's characteristics are controlled by genes and how these genes, in turn, may be inherited by offspring.

• Generate a hypothesis based on my background knowledge.

• Conduct and gather data during the simulation.

• Complete Punnett squares representing multiple generations.

• Calculate probabilities of offspring over multiple generations.

• Graph and analyze data from the simulation.

• Write conclusions based on data.

Criteria for Success

Complete the pre-lab, procedure, data table, graphing, and conclusion portions of this lab with 90 percent success.

Purpose

In this lab, you will investigate how natural selection can lead to changes in a species over time. You already know that making predictions can be a sign that you understand the event you are studying. In this lab, you will make predictions in the form of a hypothesis, model the events involved in a genetic cross, and explore how both genetic and environmental factors play a part in natural selection.

Background Information

• The orange goldfish represent fish that have the smooth scale phenotype and are **homozygous dominant (DD).** Orange goldfish <u>are delicious</u> to predators.

• The white goldfish represent fish that have the smooth scale phenotype, the spike allele, and are **heterozygous dominant (Dd).** White goldfish are <u>also tasty</u> to predators.

• The pretzel goldfish represent fish with the spike scale phenotype, are **homozygous recessive (dd),** and are <u>avoided by predators</u> because of the spikey scales.

Pre-Lab Questions
Read over the lab instructions and answer the following questions.

1. What do you think will be the possible **phenotypes** of the offspring for future generations? Why?

2. What do you think will be the possible **genotypes** of the offspring for future generations? Why?

Hypothesis (if … then … because)
Based on what you read, create a hypothesis for the lab: What type of fish will be present in future populations?

If spikey fish are avoided by predators, **then …**

COMMON
ASSIGNMENT
STUDY

Materials

- 30 orange goldfish
- 30 pretzel goldfish
- 30 white goldfish
- Bowl or bag to be used as a pond
- Three napkins labeled "prey," "female," and "male"
- Graph paper

Procedure

Round 1: PLEASE DO NOT EAT THE GOLDFISH

1. Wash your hands.

2. Write the words "prey," "female," and "male" on your napkins.

3. Place the goldfish in the lake (bowl), and mix them around.

4. Choose one person to be the predator. While someone else counts to three, the predator picks a fish out of the pond one-by-one and places it on the "prey" napkin (try to pick smooth fish and avoid pretzel fish). Your prey fish are now dead and no longer part of the population.

5. Repeat step 4 until everyone in your group gets one chance to be a predator.

6. Close your eyes and choose, at random, **five fish** from the bowl and place them on the **"female" napkin.**

7. Close your eyes and choose, at random, **five fish** from the bowl and place them on the **"male" napkin.**

8. a) Now choose, at random, one male fish and one female fish from the napkins, and enter their genotypes (**male—top** of Punnett square, **female—left side** of Punnett square) into the Punnett square under generation one (F_1).

   b) Whichever square is shaded in each of the Punnett squares (1–5) will be the outcome of the offspring in the F_1 generation and needs to be introduced into the pond population. Take the offspring fish out of the nursery, and introduce them into the bowl. Reintroduce the parent fish back into the pond as well. If you do not have the phenotype (appropriate kind of goldfish) in your nursery, ask your teacher for a fish of that phenotype.

9. Repeat step 8 until you have five Punnett squares completed. You should have placed 15 fish back into the bowl (10 captured parent fish and five offspring).

Generation F₁ Punnett Squares

<table>
<tr><td>1.</td><td></td><td></td></tr>
<tr><td></td><td>☐</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td>4.</td><td></td><td></td></tr>
<tr><td></td><td></td><td>☐</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td>2.</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>☐</td></tr>
</table>

<table>
<tr><td>5.</td><td></td><td></td></tr>
<tr><td></td><td></td><td>☐</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td>3.</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td>☐</td><td></td></tr>
</table>

Generation F₁ Data Table

	Population of pretzel fish (dd)	Population of white fish (Dd)	Population of orange fish (DD)	General observations (increases, decreases, errors, broken pieces, group dynamics)
Starting	30	30	30	
Ending				

Using Mathematics—Generation F₁

Calculate the probability of the offspring for two of the Punnett squares from round 1.

1st Punnett square

orange fish = ____ of __4__ or ____%

white fish = ____ of __4__ or ____%

pretzel fish = ____ of __4__ or ____%

2nd Punnett square

orange fish = ____ of __4__ or ____%

white fish = ____ of __4__ or ____%

pretzel fish = ____ of __4__ or ____%

Round 2

Repeat steps 4–9 using the Generation F_2 Data Table and the Generation F_2 Punnett Squares. Make sure that you introduced the offspring and reintroduced the parents back into the pond (bowl). Count the total number of each type of fish and record it in the ending total for Generation F_1 and the starting total for Generation F_2.

Generation F_2 Punnett Squares

1.

4.

2.

5.

3.

Generation F_2 Data Table

	Population of pretzel fish (dd)	Population of white fish (Dd)	Population of orange fish (DD)	General observations
Starting				
Ending				

Using Mathematics—Generations F$_2$

Calculate the probability of the offspring for two of the Punnett squares in round 2.

3rd Punnett square

orange fish = ____ of ____ or ____%

white fish = ____ of ____ or ____%

pretzel fish = ____ of ____ or ____%

4th Punnett square

orange fish = ____ of ____ or ____%

white fish = ____ of ____ or ____%

pretzel fish = ____ of ____ or ____%

Whichever square is shaded in each of the Punnett squares (1–5) will be the outcome of the offspring in the F$_2$ generation and needs to be introduced into the pond population. Take the offspring fish out of the nursery, and introduce them into the bowl. Reintroduce the parent fish back into the pond as well. If you do not have the phenotype (appropriate kind of goldfish) in your nursery, ask your teacher for a fish of that phenotype.

Round 3

Repeat steps 4–9 using the Generation F$_3$ Data Table and the Generation F$_3$ Punnett Squares. Make sure that you introduced the offspring and reintroduced the parents back into the pond (bowl). Count the total number of each type of fish and record it in the ending total for Generation F$_2$ and the starting total for Generation F$_3$.

Generation F$_3$ Punnett Squares

Generation F$_3$ Data Table

	Population of pretzel fish (dd)	Population of white fish (Dd)	Population of orange fish (DD)	General observations
Starting				
Ending				

Using Mathematics—Generations F$_3$

Calculate the probability of the offspring for two of the Punnett squares in round 3.

5th Punnett square

orange fish = _____ **of** _____ **or** _____%

white fish = _____ **of** _____ **or** _____%

pretzel fish = _____ **of** _____ **or** _____%

2nd Punnett square

orange fish = _____ **of** _____ **or** _____%

white fish = _____ **of** _____ **or** _____%

pretzel fish = _____ **of** _____ **or** _____%

Representing Data

Complete a graph on attached graph paper for data analysis that includes the following:

- A line graph using each generation of fish (1st, 2nd, 3rd) on the X-axis and ending population (number) of fish on the Y-axis. You will have three lines, one for each fish phenotype: DD—red, Dd—blue, and dd—green.

- Remember your graphing rules:
   o Title of your graph—what are you representing?
   o Key—what do the different colors stand for?
   o Even numbering/scale—use the squares on the graph paper equally.
   o Labels on both axes—X and Y.

Data Analysis

1. Discuss what happened to the population of your orange fish, white fish, and pretzel fish. Make sure to include increases and decreases in the population.

2. How does the phenotype of the population change from Generation F_1 to Generation F_3? Remember to refer to your data tables and graph.

Communicating Findings

3. Compare your graph to another group's graph. What similarities and differences do you find in your graphs?

4. Discuss with another group the possible human errors that could have occurred or did occur.

Conclusion

5. What was your hypothesis? Was it supported or rejected? Why? Refer to your data.

6. Infer what the phenotypes of the Generation F_4 population would be? What leads you to this inference?

7. How can patterns in the inheritance of traits be used to predict how frequently they appear in offspring?

8. What new learnings did you obtain from completing this laboratory activity?