Teacher's Notes

Natural Selection: Flinn Modeling, Inquiry and Analysis

Materials Included in Kit

Bingo chips, blue, 250

Bingo chips, red, 325

Bingo chips, yellow, 250

Clay, -lb, sticks, 5

Fishing line, 1,425 ft

Dice, 15

POGIL™ Evolution and Selection Student pages, 1 set

POGIL™ Evolution and Selection Teacher pages, 1 set

Paper clips, 1 box of 100

Protractors, 15

Additional Materials Required

Aquarium (29 gal)/Clear Tote (18 gal or larger), 5 or more

Balance*

Meter stick (1 per container)

Scissors, 15 (1 per group)

Sticky notes or permanent marker*

Stopwatch or timer (1 per group)

*For *Pre-Lab Preparation*

Part 1: Evolution and Selection POGIL™

The POGIL™ activity is designed to be completed in class using the POGIL™ teaching method. This includes students working in groups with assigned roles to construct their own learning using modeling. For more information, visit www.pogil.org.

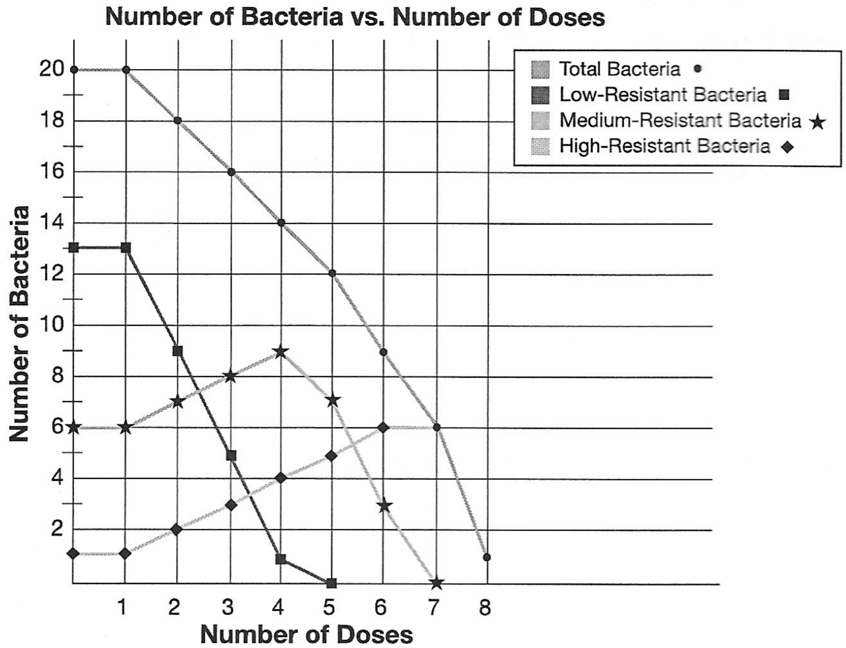
Part 2: Antibiotic Resistance Demonstration

During the simulation, encourage students to compare and discuss their results to see the difference between groups with more antibiotics and those with less. Encourage students to extend beyond the activity and think about selection in nature and how the antibiotics play the role of an environmental change and change the requirements for fitness. Before moving on to the next activity, conduct a class discussion reinforcing the role of environment in fitness and selection.

Sample Data Table *(Student data will vary.)*

Dose Number	Number Rolled	Low Resistance (Red)	Medium Resistance (Blue)	High Resistance (Yellow)	TOTAL
Initial	N/A	13	6	1	20
1	*1*	*13*	*6*	*1*	*20*
2	*3*	*9*	*7*	*2*	*18*
3	*3*	*5*	*8*	*3*	*16*
4	*3*	*1*	*9*	*4*	*14*
5	*1*	*0*	*7*	*5*	*12*
6	*5*	*0*	*3*	*6*	*9*
7	*3*	*0*	*0*	*6*	*6*
8	*3*	*0*	*0*	*1*	*1*

Sample Graph



Answers to Post-Lab Questions *(Student answers may vary but should follow the general trends discussed.)*

1. What general pattern was observed regarding the total number of bacteria present initially and the number remaining after eight doses?

   Overall the number of bacteria decreased from the initial count. Some groups may find the bacteria were completely eliminated.

2. Compare the initial and final counts of the least resistant bacteria. Explain any trends that were observed.

   Initially, the least resistant bacteria were the most abundant bacteria found of the three bacteria present. However, the least resistant bacteria were the first to become eliminated by antibiotics as they are not as able to withstand the antibiotic effects as well as the other two bacteria.

3. Name the strain of bacteria that had the highest fitness without the antibiotic and give one piece of evidence to support this.

   The red strain had the highest fitness because it made up the largest part of the population.

4. Name the strain of bacteria that had the highest fitness with the antibiotic and give one piece of evidence to support this.

   The yellow strain of bacteria had the highest fitness in the presence of the antibiotic because it survived the longest.

5. In this simulation, the three different strains had different reactions to the antibiotic treatment. Describe one way that the strains of real bacteria may be different from one another.

   The genomes of the bacteria had to be different for them to react differently to treatment. Bacteria that can survive in the environment of an antibiotic often have a different gene variant that makes the antibiotic ineffective. In some cases, the gene may change the protein for a binding site on the outside of the bacteria, therefore the antibiotic cannot bind to the bacteria and impact its function.

6. In this simulation, the antibiotic changed the environment. Describe one example of an environment that has changed in a way that challenged the survival of a population of organisms.

   Answers will vary. Some examples include slight changes in the pH of the ocean that challenge the survival of coral; deforestation challenges the survival of shade tolerant plants such as ferns; volcanic eruptions cover soil and make it difficult for plant life to reestablish; loss of sea ice impacts polar bear survival. In order to be correct, students should focus on a single example.

Part 3. Engineering Design for Fitness

Pre-Lab Preparation*

1. Depending on materials available, set up as many water stations as possible for testing speed. Fill the containers (aquariums or clear plastic totes) about half full of water.
2. On a meter stick, mark a starting point 8 cm from the left edge of the container with a sticky note.
3. On the same meter stick, mark a finishing point 8 cm before the right edge of the container with a sticky note.
4. Place the meter stick across the top of the container (see Figure 4 on page 4).
5. With permanent marker, draw a starting line and finishing line on the face of the aquarium to aid in start/stop accuracy. The starting line should line up with the starting mark on the meter stick, 8 cm from the side. The finish line should line up with the finish line on the meter stick, 8 cm from the side (see Figure 4 on page 4).
6. Prepare the protractors for the students by marking (with permanent marker or sticky note) 5° on either side of 90° to show the maximum deflection allowed.
7. Divide the clay into 15.0-g samples. Each individual should receive a piece of clay to create the fish design. Students work in pairs to assist each other with timing, record keeping and brainstorming. However, each student is responsible for independent data.

**Students can prepare the meter sticks and protractors if time is available.*

Safety Precautions

Remind students to wash their hands thoroughly with soap and water before leaving the laboratory.

Answers to Pre-Lab Questions *(Student answers may vary.)*

1. Explain how natural selection leads to changes within a species.

   Individuals with inherited traits well-suited to the environment leave more offspring on average than other individuals. Over time there will be more individuals with traits well-suited for the environment and fewer individuals with traits less suited, which could lead to physical changes within the species.

2. Calculate the average speed of a cheetah that chased an impala 260 meters in 9 seconds before it made the kill.

   Speed = distance/time. 260 m/9 s = 28.9 m/s.

3. Predict the body shape that would allow for the fastest fish, which, in this investigation, indicates the highest level of fitness. Explain your prediction.

   Student answers will vary but should lead toward a streamlined body to reduce drag. Also, students should mention the role of fins in providing stability and preventing rolling.

Sample Data Table. Original Fish Design *(Student data will vary.)*

Data obtained from a 29-gallon aquarium with dimensions: 76 cm 31 cm 47.5 cm. Data for fish design with disk-like, flat body with 1 dorsal fin, 1 anal fin and vertical pectoral fins.

Trials	Distance (cm)	Time (s)	Speed (cm/s)	Observations—Include possible improvements for this design
1	*58.0*	*9.62*	*6.0*	*Head did not stay straight*
2	*58.0*	*8.88*	*6.5*	*Body turned and increased drag*
3	*58.0*	*9.34*	*6.2*	*Make body more streamlined*
Average	*58.0*	*9.28*	*6.2*	

Sample Data Table. Improved Fish Design

Data for fish with streamlined body with 2 dorsal fins, 1 anal fin and vertical pectoral fins.

Trials	Distance (cm)	Time (s)	Speed (cm/s)	Observations—Include possible improvements for this design
1	*58.0*	*5.21*	*11.1*	*Try horizontal fins*
2	*58.0*	*5.38*	*10.8*	
3	*58.0*	*4.53*	*12.8*	
Average	*58.0*	*5.04*	*11.6*	

Answers to Post-Lab Questions *(Student answers may vary.)*

1. Describe the reasoning behind your original design. What features were included to make it have the fastest speed?

   Accept all reasonable responses. Look for answers that include a streamlined body design to reduce drag as it is being pulled through the water. Students should discuss fins chosen, two dorsal fins to prevent rolling, anal fin used for extra stability, etc.

2. Compare your data with other groups. Based on the data, would evidence support or refute the claim that "Your original fish design displayed high fitness"? Explain the reasoning for your answer.

   Student answers will vary but must include data to support or refute the fitness of their fish design. A streamlined body design should demonstrate the fastest times indicating higher fitness for this challenge.

3. Describe an environment where nature would select for your fish body shape.

   Accept all reasonable responses. Answers may include open oceans with few obstacles allowing for maximum speed to be achieved in pursuit of prey or to escape predators.

4. Describe an environment where nature would select against your fish body shape.

   Accept all reasonable responses. Answers may include coral reefs, heavily vegetated ponds or lakes, and other aquatic environments with obstacles that would require a more flexible body shape to provide maneuverability.

5. Describe changes made to the original design in order to improve the speed of the fish. Using evidence, explain whether you were successful or unsuccessful.

   Accept all reasonable responses. Answers must include data to support whether or not the improved design increased speed.

6. Describe any limitations present in your data (discuss possible sources of error).

   Accept all reasonable responses. Answers include precision of measurement; for example, the starting mechanism is imprecise. Estimating when the fish head crosses the finish line may also influence speed calculations. The line itself increases drag and may not be consistent in each trial. Allowing for 5° deflection of the line adds some variability to the data.

7. List the similarities and differences, focusing on the structures and functions, between a real fish and your model.

   Accept all reasonable responses. Similarities may include functions of the fins providing stability and preventing rolling. Differences may include the movement not coming from undulation of the body or the caudal fin, but rather the student. Another difference would be that in the aquarium, the water is still, and in rivers or the ocean there may be currents affecting movement. Fish skin or scales are designed for ease of movement through water, and the clay may affect the movement. Finally, fish have flexible bodies to assist in movement through the water, the model does not.

Teacher's Notes *continued*

Final Analysis (*Student answers will vary.*)

1. Using a claims, evidence and reasoning model, explain how natural selection and artificial selection connect to fitness.
   a. Propose a claim based in scientific understanding.

   Accept all reasonable answers. The claim is a short statement that connects the observed evidence to scientific understanding of a concept. For example: The fish with the lowest profile and smallest pectoral fins had the highest fitness when speed is a characteristic that improves survival and reproduction.

   b. Discuss specific evidence from the engineering design activity.

   Student answers will vary. The evidence must match the observations the student made. For example, if the student claims that the traits that made their fish have high fitness were the size of the fins and the profile, they would present data from their own trials and that of others that had this type of fish.

   c. Discuss the reasoning for the claim based on connections to the POGIL™ activity, the simulation, and the engineering design activity.

   Student answers will vary. This section should include information about researching the types of fish bodies and how they increase fitness depending on environment and niche.

Lab Hints

- Enough materials are provided in this kit for 30 students working in pairs. By doing the simulation in pairs, students can engage in a rich discussion. Enough clay is provided for each student to make an individual fish body design.
- This module can reasonably be completed in four, 50-minute class periods. Complete the POGIL™ activity on day one, the demonstration on day two, the engineering design on day three and the final analysis on day four.
- During Part 2, stress to students the importance of recording the number of each bacterial type on Table 1 before adding one more bingo chip of each type present, as instructed in Step 4. If the population grows before the data is recorded, students may be confused by the results.
- During Part 3, you will need to set the length of the fishing line as a constant variable based on the container used. Ideally the fish should hang in the middle of the water. Students may attach the fishing line in any manner. Through sample trials, a successful method was to bore a hole using a paper clip through the model fish and thread the line through the center of the model.
- Prior to testing, instruct students to manipulate the model so that it hangs from the fishing line horizontal to the ground.
- If the container is large enough, two tests may occur simultaneously. For example, the width of a 29-gallon aquarium is 31 cm. Two meter sticks can be placed on top allowing two groups to test at the same time.
- Depending on the container used, speeds may not vary greatly. Longer containers will result in greater variance in speeds between body forms.

Teacher's Notes *continued*

Teaching Tips

- This module can be utilized during an evolution unit to demonstrate fitness and natural selection while incorporating the practice of model design.
- Student should have background information on heritable traits.
- The simulation of antibiotic resistance is a model of how evolution by natural selection may proceed. Discuss this type of model with students and how it is different from the model built in the engineering task.
- Ideally, a streamlined, sleek body shape with a small cross-section (which reduces drag) is the fittest fish body shape.
- A snake-like body shape will appear to be a better forward swimmer. This is due to the artificial force (student) moving the fish. A fish with this body shape, like the moray eel, would need to undulate the body for motion, slowing the speed.
- Possible extensions for this activity can include varying the materials the students are allowed to use to construct their fish models, varying the water type in which the students are testing the model (fresh, brackish, salt), or determining how mass affects the speed—allowing the use of more or less clay.
- The following student laboratory kits can be used to further explore evolution and natural selection:
  - Stick Bug Survival—Super Value Kit (Flinn Catalog No. FB1607)
  - Beaks—Flinn STEM Design Challenge™ (Flinn Catalog No. FB2130)
- This learning module incorporates the following kits:
  - Antibiotic Resistance Simulation—Student Activity Kit (Flinn Catalog No. FB1928)
  - Fish Fitness—Flinn STEM Design Challenge™ (Flinn Catalog No. FB2129)

References

"Evolution and Selection." *POGIL™ Activities for High School Biology*. Trout, L., Editor; Flinn Scientific: Batavia, IL (2012).

The *Natural Selection: Flinn Modeling, Inquiry and Analysis—Student Laboratory Kit* is available from Flinn Scientific, Inc.

Catalog No.	Description
FB2203	Natural Selection: Flinn Modeling, Inquiry and Analysis—Student Laboratory Kit
FB0213	Aquarium, All-glass, 29 gal
OB2136	Flinn Scientific Balance, Economy Choice, 200 g × 0.1-g
AP8294	Meter Stick, Hardwood, English/Metric, 1 meter, Plain Ends
AP1572	Timers, Stopwatch, Flinn

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.