BIO FAX!
FLINN SCIENTIFIC, INC
"Your Safer Source for Science Supplies"
P.O. Box 219 • Batavia, IL 60510
(800) 452-1261 • Fax (866) 452-1436
www.flinnsci.com • E-mail: flinn@flinnsci.com

Catalog No. FB2036
Publication No. 11133

Artificial Selection

AP* Biology Big Idea 1, Investigation 1

An Advanced Inquiry Lab

Introduction

How does natural selection drive evolution? Can we make changes on purpose to cause an organism to evolve? In this investigation the techniques of artificial selection will be explored as one method to study the process of evolution.

Concepts

- Artificial selection
- Evolution
- Germination
- Natural selection
- Plant growth
- Plant life cycle
- Pollination

Background

The inherited change of characteristics within a population over successive generations is *evolution*. These changes within a population may or may not be visible to the naked eye because they originate from changes in the genetic code. In nature these changes occur when one specimen produces more live offspring. More of its genes survive in the next generation. Over time this leads to one variation of the gene becoming more prevalent in the overall population. Recall it is variation within DNA that gives rise to a range of characteristics within a population, the species, and eventually the entire ecosystem within which it lives. An increase or decrease in the frequency of one genotype based upon the ability of the organism to reproduce and pass that gene to the next generation, and the ability of the offspring to survive to reproduce, are fundamental driving forces for the process of *natural selection*. Over time as an area's local ecosystem changes, becoming more marsh-like for example, the population of plants that survive to reproduce will, on average, tolerate wet roots better than those that thrived when the soil was drier. A gradual shift in the genotype toward an average of wet-tolerant plants occurs. This gradual change due to natural selection is an important factor in evolution.

Artificial selection is the term used when humans or other animals control the process of evolution by allowing only certain select individuals to reproduce. Crops and livestock are all examples of artificially selected organisms, as are domesticated pets such as dogs and cats. Artificial selection is not new. What is new is our awareness that certain other species also have the ability to artificially select their crops. For example, some species of farming ants artificially select their crops. It was partially his observations and knowledge of artificial selection that Charles Darwin relied upon to identify natural selection as a major mechanism that drives evolution.

Researchers have artificially selected certain traits in numerous species of bacteria, fungi, plants, and animals so these organisms can be used in the lab as model organisms in scientific experiments. One such model organism, called Fast Plants®, was developed at the University of Wisconsin–Madison by Dr. Paul H. Williams. Over the course of 30 years Dr. Williams successfully bred a type of wild turnip to be dependent upon the researcher. For example, the pollen does not cross-pollinate or self-pollinate. This allows the researcher to control fertilization. The researchers chose to breed flowers with heavy, sticky pollen so that now the plant is totally reliant on a researcher. The starting plant, a weed, would have died out if bees could not cross pollinate the flowers. Another great research aspect of these plants is their short life cycle, about 40 days from seed to seed. For further control the plant requires specific conditions that must be met for the plant to thrive. The temperature must be kept between 60 and 80 °F. Above 80 °F the plant will have sterile flowers. Fast Plants require constant light from grow lights. The grow lights must be kept 5 to 10 cm from the top of the plant. If the plant touches the light it will scorch the leaf or flower. Regular soil is too heavy and the roots must stay wet with a dilute fertilizer solution at all times. The seeds must be covered with a thin layer of light planting mix, vermiculite or other lightweight cover for germination to occur. Light will stop germination from starting and heavy soil is too much for the new seedling to overcome. All of these controls are important for a research organism, but it is the many easily studied phenotype changes that make this plant ideal for use in studying artificial selection.

*AP is a registered trademark of the College Board, which was not involved in the production of, and does not endorse, this product.

Experiment Overview

In the *Baseline Activity,* students will observe, measure, and characterize natural variation of traits in a population of Fast Plants and identify characteristics for artificial selection in a second generation. The results of this baseline activity will be analyzed for statistical significance and provide a procedure and model for open inquiry and student-designed experiments—see the *Opportunities for Inquiry* section on page 3 for further information. Explore whether specific traits may help a plant grow and survive and investigate environmental conditions that may affect the survival of plants with different characteristics.

Pre-Lab Question

1. Wisconsin Fast Plants are derived from *Brassica,* which is an annual dicot. Review and describe the life cycle of an annual dicot.

Materials

Fast plant® seeds, *Brassica*, 24

Camera (shared)

Cotton swabs, 2

Magnifier

Marker

Paper towels

Planting mix (shared)

Pot marker labels, 4

Pots, square, 2½″, 4

Ruler

Scissors

Wicking cords, 4

Safety Precautions

Bleach solution is a corrosive liquid, which may discolor clothing and may cause skin burns. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Please follow all laboratory safety guidelines.

Baseline Activity

Part A. First-Generation Plants

1. Thread a wicking cord through a hole in the bottom of each pot.
2. Fill each pot with light planting mix and pack gently but firmly into the pot until it is nearly full. Ensure the wicking cord sticks up through the top of the planting mix.
3. Plant six seeds in an appropriately labeled pot. Spread the seeds evenly on top of the planting mix.
4. Cover the seeds with a light layer of planting mix.
5. Place the pots in the grow area. Ensure wicks entend down into the dilute fertilizer reservoir.
6. As the plants grow, observe and identify any variations in the plants that can be reliably measured. Variation can be within a single pot or across several pots but it should offer a continuum. An example would be stem width.
7. After 7–12 days, as a class, identify several variable traits to study and quantify.
8. Measure numerous plants for each trait and determine a mean, median, range, and standard deviation for the trait. Plot a histogram of the frequency distribution for the trait.
9. Decide, as a class, which single trait will be studied. The remainder of Part A and Part B are completed as a class.
10. Isolate from among the classroom plants the top (or bottom) 10% of plants that exhibit the trait to be studied. Use scissors to trim away any plant not identified as a control plant or as one of the trait plants.
11. Once again determine the mean, median, range, standard deviation, and plot a histogram for the remaining trait and control plants.

12. When several flowers are present on each of the plants, approximately day 14 to 16, the flowers are ready to cross-pollinate.
    - *a.* Using a cotton swab roll the cotton end over the anthers to collect the pollen and then deposit the pollen on a different flower within that population. Ensure that every flower is pollinated with pollen from another flower within its respective population.
    - *b.* Use only one cotton swab for all of the flowers within the trait population.
    - *c.* Use a second cotton swab for the control population.
13. Limit each plant to no more than ten seedpods. Use scissors to cut away any excess seedpods.
14. After 3 weeks or more the seedpods will begin to turn yellow. Remove the plants from the pot and dry for several days.
15. After drying for several days remove the seedpods from the plant and place in an open dish such as one half of a Petri dish for a few more days.
16. Dispose of the used planting mix and wicking cord. Wash the plant pots in a freshly prepared 10% bleach solution and allow to them to dry.
17. Open the seedpods and collect the seeds.

Part B. Second-Generation Plants

1. Using new wicking cord and planting mix repeat steps 1–17 placing six of the seeds of the selected trait in each pot. Prepare the same number of pots containing control seeds. All other conditions should remain consistent between the first-generation and the second-generation plants.
2. Once the second-generation plants have reached the same life stage as the first-generation was when the trait was quantified above, determine a mean, median, range, standard deviation, etc. Plot a histogram of the frequency distribution for the trait.
3. If desired, repeat the experiment for a third generation.
4. Compare the data collected regarding the control population and the selected trait population. This includes comparing the mean, median, range, and standard deviation. Compare the histograms as well.
5. Complete a statistical analysis of the data.

Part C. Opportunities for Inquiry

1. Consider the following questions while reflecting upon your knowledge about artificial selection in *Brassica*.
    - *a.* Would altering the environmental conditions affect the rate of survival for plants with a certain characteristic?
    - *b.* Could another characteristic be manipulated?
    - *c.* Could another plant be manipulated through artificial selection to enhance or eliminate a specific trait?
2. Plan, discuss, execute, evaluate, and justify an experiment to test a question regarding transpiration.
    - *a.* Decide upon one question that your group would like to explore.
    - *b.* Develop a testable hypothesis.
    - *c.* Discuss and design a controlled procedure to test the hypothesis.
    - *d.* List any safety concerns and the precautions that will be implemented to keep yourself, your classmates, and your instructor safe during the experimental phase of this laboratory.
    - *e.* Determine what and how you will collect and record the raw data.
    - *f.* How will you analyze the raw data to test your hypothesis?
    - *g.* Share your hypothesis, safety precautions, procedure, data tables, and proposed analysis with your instructor prior to beginning the experiment.
    - *h.* Once the experiment and analysis are complete, evaluate your hypothesis and justify why or why not the hypothesis was supported by your data.
    - *i.* Present and defend your findings to the class.
    - *j.* Make suggestions for a new or revised experiment to modify or retest your hypothesis.

Teacher's Notes

Artificial Selection

Materials Included in Kit (for 8 groups of students)

Fertilizer, liquid, 10 mL	Planting mix, light, 3
Sodium hypochlorite solution (bleach), 475 mL	Planting tray, 11″ × 22″
Cotton swabs, 75	Pot marker labels, 100
Cups, polypropylene, 9	Pots, square, 2½″, 32
Greenhouse cover, 11″ × 22″	Wicking cord, 48 feet

Additional Materials Needed (for each lab group)

Fast Plant seeds, 200 for class	Marker
Camera (may be shared)	Paper towels
Fluorescent grow lights (shared)	Ruler
Magnifying glass	Scissors

Additional Material Needed (for *Pre-Lab Preparation*)

Water, aged-tap or bottled	Erlenmeyer flask, 1-L
Bottle with cap, 2-L	Scissors, dissection or cork borer

Pre-Lab Preparation

Prepare the fertilizer water.

1. The fertilizer water can be made in advance but will grow algae if exposed to light.
2. Add 2 mL fertilizer concentrate to 2 L of aged tap water or bottled water in a labeled container
3. Store in a cool dark place in a sealed bottle.

Prepare the wicking cord.

1. Use scissors to cut wicking cord into 5- to 6-inch lengths.

Prepare the grow area.

1. Place the 32 pots upside down on a table.
2. Place the greenhouse cover over the pots and use a permanent marker to mark the center of each pot.
3. Use dissection scissors or a cork borer to create 32 holes in the greenhouse cover (see Figure 1).
4. Place the nine polypropylene cups into the planting tray (see Figure 2).
5. Place the greenhouse cover upside down onto the nine cups. This raises the lid allowing the tray to become the water reservoir.
6. Place the tray assembly under the grow lights.
7. After the students place the pots on the lid, fill the reservoir with the dilute fertilizer solution. Do not overfill or the pots will float.

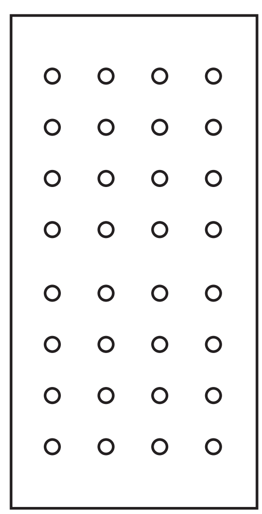

Figure 1.

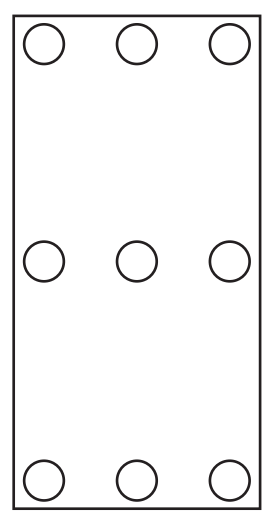

Figure 2.

Prepare the bleach (sodium hypochlorite) solution when pots need to be cleaned.

1. Prepare a 10% bleach solution no more than one week in advance. Bleach solutions have a poor shelf life—discard after one week.
2. Add 80 mL bleach to 720 mL of water in an Erlenmeyer flask or a bottle with a cap.

Safety Precautions

Bleach solution is a corrosive liquid that may cause skin burns and may discolor clothing. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Remind students to wash their hands thoroughly with soap and water before leaving the laboratory. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. All plant material and planting mix can be disposed of according to Flinn Biological Waste Disposal Type VI, common garbage waste. All excess solutions may be disposed of down the drain with plenty of excess water according to Flinn Suggested Disposal Method #26b.

Alignment with AP Biology Concepts and Curriculum Framework

Big Idea 1: The process of evolution explains the diversity and unity of life.

Enduring Understandings

1A1: Natural selection is a major mechanism of evolution.

1A2: Natural selection acts on phenotypic variations in populations.

Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

Enduring Understandings

2A3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.

2B2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.

2D1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.

Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

Enduring Understandings

4A4: Organisms exhibit complex properties due to interactions between their constituent parts.

4A6: Interactions among living systems and with their environment result in the movement of matter and energy.

Learning Objectives

- The student is able to convert a data set from a table of numbers that reflect a change in the genetic makeup of a population over time and to apply mathematical methods and conceptual understandings to investigate the causes and effects of this change (1A1, SP 1.5, and SP 2.2).
- The student is able to evaluate evidence provided by data to qualitatively and quantitatively investigate the role of natural selection in evolution (1A1, SP 2.2, and SP 5.3).
- The student is able to apply mathematical methods to data from a real or simulated population to predict what will happen to the population in the future (1A1 and SP 2.2).
- The student is able to evaluate data-based evidence that describes evolutionary changes in the genetic makeup of a population over time (1A2 and AP 5.3).

- The student is able to connect evolutionary changes in a population over time to a change in the environment (1A1 and SP 7.1).

Science Practices

1.5: The student can reexpress key elements of natural phenomena across multiple representations in the domain.

2.2: The student can apply mathematical routines to quantities that describe natural phenomena.

5.3: The student can evaluate the evidence provided by data sets in relation to a particular scientific question.

7.1: The student can connect phenomena and models across spatial and temporal scales.

Lab Hints

- Enough materials are provided in this kit for 8 groups of students. This lab will last for many weeks. Most days only a few minutes will be needed to check the water level, and to take notes or photos of the plants. Planting days, pollination days, evaluation days, and harvest days will take most or all of a 50-minute lab period.
- The minimum number of plants for Parts A and B is 180 plants per class.
- Potential characteristics—number of trichomes, plant height, plant color, stem color, flower size, and flower color.

References

AP Biology Investigative Labs: An Inquiry-Based Approach. College Entrance Examination Board: New York, 2012.

Biology: Lab Manual. College Entrance Examination Board: New York, 2001.

Ants That Farm. http://news.sciencemag.org/sciencenow/2010/04/farming-ants-update-their-crops.html (accessed April 2012).

Lauffer D; Williams, P. (2007). Wisconsin Fast Plants®. www.fastplants.org (accessed April 2012).

Artificial Selection and supporting supplies are available from Flinn Scientific, Inc.

Catalog No.	Description
FB2036	Artificial Selection
FB2044	Wisconsin Fast Plants®, Standard
AB1460	Planting Mix
FB0676	Fertilizer, All-Purpose, Liquid, 32-oz.
FB0651	Pots, Plastic, 2½″
FB1459	Grow Lab II—Compact Indoor Garden
FB0494	Jewel 74″ Plantmobile

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