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Using Your Local Green Market to Teach Artificial Selection

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Did you know that the wild tomato is only the size of a currant? Through many years of artificial selection, farmers have been able to artificially select for traits such as size, taste, color and texture. Students in Biological Evolution and Botany courses participated in tastings of heirloom tomatoes and apples obtained from a local green market. They rated characteristics of these fruits such as color, mass, texture and taste. This exercise was a lead-in to a discussion about artificial selection and genetically modified organisms. The students then presented to the class their findings from peer-reviewed research papers on the genetics of tomatoes and/or apples, and Brassica oleracea varieties.

Keywords: Artificial selection; plant anatomy, evolution

Introduction

I (KN) was struck by a picture I saw in an evolution textbook (Freeman and Heron, 2007) that visually depicted the large size difference between the tomatoes we eat everyday and the wild tomato. Apparently the larger tomato was a product of artificial selection over time. I then visited the farmers' market and witnessed an astonishing array of what are called "heirloom tomatoes" (see Figs. 1 and 2 for examples of a few types), and contemplated the role artificial selection must have played in developing these. I went on to peruse the rows of apples, and noted the variety found there. I decided to develop a lab in which the students would be exposed to this variety, and then allowed to taste samples and try to make judgments about taste, texture, etc. Students then filled out a chart with various attributes such as color, size, density (mass/volume via liquid displacement in a beaker—a.k.a. "bobbing for apples". A column was titled: "Traits you would change and how?" to get students to imagine what it would be like to be a farmer or even a genetic engineer who had the ability to improve crops.

Students then dissected various cruciferous vegetables in which artificial selection was used to develop various portions of the vegetable "at the expense" of other traits. *Brassica oleracea* (Brassicaceae) is an excellent example of a crop species that can be used to illustrate artificial selection and, by extension, natural selection. Wild cabbage is a species found originally in Western Europe and it is thought that most of the cultivars originated from these plants. Of the many *Brassica* species, *B. oleracea* is exclusively a vegetable crop and is used globally. It is believed that the first cultivated B. oleracea crops originated in the Mediterranean approximately 400-300 BC. There are several morphologies that area readily available in the supermarket which can be used for this lab. The different morphological forms resulted from selection of specific organs. A few examples (Gustafsson and Lannér-Herrer, 1997; Hammer *et al.*, 2013; and Labate *et al.*, 2006) are:

Cabbage (var. *capitata*) - leaves of the terminal bud form a head.
Brussels sprouts (var. *gemmifera*) - leaves of the axillary buds form heads
Kale and collard greens (var. *acephala*) - these leafy

forms which do not produce heads
Kohlrabi (var. *gonglodes*) - an enlarged stem.
Broccoli (var. *italic*) and Cauliflower (var. *botrytis*)- Both are formed from immature inflorescences. Broccoli flowers are fully differentiated but are eaten prior to flowering and cauliflower flowers are undeveloped

The students were then guided in choosing papers that they then presented to the class on various aspects of the plant physiology or genetics of apples, tomatoes, or broccoli. Some examples of intriguing information they located follows. Ting *et al.* (2012) reported their results from an experiment conducted with six apple cultivars. Various parameters were measured such as pH and flavor release. Although some of their tests involved a mass spectrophotometer to measure compounds in the apples, a simpler test that could be replicated determined the moisture content. (Students could simply weigh samples before and after placing in a drying oven.) The pH was measured as well, as acidity contributes to taste. Schnitzler *et al.* (2014) examined genetic diversity in wild European apples and noted that they have been declared endangered in Belgium and the Czech Republic. They expounded upon the ecology of the region, and noted how habitat fragmentation has taken its toll in this area. In another study, Celton *et al.* (2014) discussed the genetics behind self-thinning, which is a trait that can improve apple yields. Since self-thinning is not common in apples, chemical thinning is often used, which might have questionable environmental effects. Quantitative trait loci (or QTL's) were found in certain apple cultivars associated with this relatively rare self-thinning. With tomatoes, van der Knapp *et al.* (2014) gave a lavishly ilustrated review of fruit weight and shape genes and suggested pathways for their interactions. Sim *et al.* (2012) showed how single nucleotide polymorphisms were used to type both wild and farm-raised tomatoes. In another study, college students were used to test their perception of odorant molecules in tomatoes (Voder *et al.* (2012). Experiments such as this are conducted in order to potentially improve the flavor of commercially grown tomatoes. Veluchamy *et al.* (2014) tested the activation of various genes of different cultivars of heirloom tomatoes when exposed to bacteria. From this information, disease-resistant cultivars could be selected for. Ravanfar *et al.* (2013) discovered that 76.6% of heat tolerant transgenic broccoli survived at 34oC whereas only 6.7% of the control plants survived at the same temperature. In this study, heat shock proteins had been activated and these helped protect the plant. Another study revealed that mciro-satellites (short sequence repeats or SSR's) could be used to depict variation and phylogenetic trees in *Brassica* (Tonguç and Griffiths, 2004). Lui *et al.* (2012) discovered homology of some broccoli genes with those of *Drosophila*, and elucidated the function of these genes in early development.

Figure 1. Heirloom tomatoes at Farmers Market in Brooklyn Heights, New York (Photo courtesy of Kathleen Nolan).

Figure 2. Tomato with many sections (locules). http://upload.wikimedia.org/wikipedia/commons/0/0d/Cuor_di_bue_3in1.jpg

Student Outline

In this laboratory exercise, participants will taste heirloom tomatoes and apples obtained from a green market (pieces are set out on paper plates with toothpicks on the table in the hall (please---no food in the lab). You will describe characteristics of these fruits in Table 1. For fun, you can vote for your favorite tomato and apple. Next, you will dissect various *Brassica oleracea* varieties (Fig. 3).

Cut cabbage and Brussels sprouts open and observe the cores. These are terminal and axillary buds surrounded by leaves. Are leaf scars and petioles present? Draw what you see. What features are similar in the two vegetables?

Kale and/or Collard greens – Are there similarities between these and any leaves found on the other vegetables? Describe and draw what you see.

Broccoli and Cauliflower – Examine the florets under the dissecting microscope and compare between the two. Draw and describe what you see.

Kohlrabi – the enlarged stem is the part we eat. Describe and draw any similar features of this vegetable and the others.

Figure 3. *Brassica oleracea* varieties (Photo courtesy of Regina Alvarez).

Laboratory Report

Your laboratory report should include the following sections: Abstract, Introduction, Materials and Methods, Results (your table), a short Discussion, and a list of References. The Introduction section will include a citing of the research article you chose. You will also be asked to present the key points noted in your paper to the class. Make it understandable to them; you will become the teacher!!

Table 1. Recorded characteristics of fruits and/or vegetables.

Name of cultivar	Describe traits	Traits you would change? How?
Striped German		
Hawaiian pineapple		
Green zebra		
Macoun		
Ginger gold		
Paula red		

Notes for the Instructor

This is a very simple lab that only requires produce from your local green market; a knife to cut up the tomatoes and apples into pieces for tasting or testing; balances for weighing; beakers for volume determination; paper plates and toothpicks to hold the samples and for tasting; copies of Table 1 and scalpels for cutting the cruciferous vegetables.

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