

FIGURE 3**Questions for a classroom orange investigation***

Questions and answers for a classroom orange investigation. Originally published in The Human Flower Project (Wandersee and Clary 2010c); directions have been adapted and reprinted by permission of Julie Ardery, The Human Flower Project.

1: Are your two oranges still alive? How can you tell?

Yes, each was alive during all of the time that they were growing on orange trees and they will stay alive for an interval of one week to one month after they're picked (depending on storage temperature; refrigeration extends their shelf life). While they are still alive, you should eat them, cook with them, dry them in a food dehydrator, or can them.

What do we mean by saying an orange is alive? We mean that many of the metabolic processes of life inside the orange's cells are continuing, and that the orange is still breaking down available nutrients (undergoing respiration) to release energy that sustains its life. The seeds inside the fruit are also alive. It is hard to ascertain this without special scientific equipment and chemicals. However, you will know that an orange is no longer alive if it does not look and smell edible.

2: How are the sweet-smelling orange blossoms (white flowers) of an orange tree related to how oranges develop?

The orange has become the most commonly grown tree fruit in the world. All oranges begin as orange blossoms, which are the tree's flowers. No flowers, no oranges! Look at the oranges. Can you tell which pole of each orange was attached to the tree? The clue will be a green and/or star-shaped stem-end. Can you tell which pole of your oranges is where the flower was attached? The clue will be a small, sunken, "belly-button-like" area or hole.

Most oranges are bee-pollinated, but navel oranges develop into ripe fruit without the need for pollination—which is very unusual! How can that be? All of the world's navel oranges come from one strange orange blossom bud cut from a single mutant, seedless orange tree that appeared on a plantation in Bahia, Brazil, in 1820. In nature, a mutant tree that produced seedless fruit would simply die out, but the Brazilian orange growers thought that seedless oranges would be easier for their customers to eat, so they grafted that one odd bud onto another orange tree, then they grafted seedless buds from that tree onto another, and so on—until now we have lots of navel orange trees producing seedless oranges. Note that seedless orange trees are not self-sustaining; they would die out without continual human intervention.

3: What are the age possibilities for the trees that produce oranges? How many years does an orange tree bear fruit?

If a hybrid orange tree starts bearing fruit at age 5, by age 40 some orange growers consider it to be ready for removal and replanting. However, orange trees can actually continue to yield fruit for 100 years or more. Once it starts producing oranges, a tree will yield between 100 to 300 oranges per growing season for many decades.

4: Imagine standing in an orange grove, facing an orange tree full of oranges. Draw the shape of such an orange tree and then use labeled arrows to predict where on the tree you would be able to pick the best fruit.

Plant science researchers who have studied many orange trees tell us that the following locations on an orange tree are the best for picking oranges: (a) the south side of the tree has the sweetest oranges, while the oranges on the north side are least sweet—with the east and west sides yielding moderately sweet ones; (b) the same directional pattern is true for the oranges having the most juice and the least; (c) the same directional pattern is true for oranges with the most vitamin C and the least; and (d) the sweeter oranges grow at the top of the tree, as compared to the low-hanging fruit that you don't need a ladder to pick. So your "best" arrows should be pointing at the south side and top of your tree drawing.

5: Choose and hold one of your oranges in your hand so that the blossom end faces upward—just as it did when it was growing on the tree. Which parts of this orange would you choose if you wanted to eat only the sweetest part?

Plant science researchers who have studied many oranges tell us this about the sweetness of any orange: If you slice the orange in half along its "equator" (mid-way between its blossom-end and stem-end), the blossom half will be sweeter than the stem half of the orange. Note: If you have several navel oranges, the one with the biggest navel opening will be the sweetest.

6: Cut your two oranges in half, vertically, from blossom-end downward. Keep the parts of each orange together. Notice there are seeds inside of one of the two oranges—namely in the Valencia orange or in the blood orange—but not inside the navel orange. If you planted some of those orange seeds you saw, would they eventually grow to become orange trees that produced more oranges just like the one you have?

Simply put, unlike many other kinds of plants, successfully growing orange trees from seed is a tricky process. Some seedlings never bear fruit, or the seedlings may take an excessive number of years to yield fruit, and even then, you may be disappointed because the oranges you get from such trees may be inedible. However, if you simply would like to watch an orange plant germinate and grow, then planting some orange seeds makes sense. You should also know that commercial orange growers do not plant seedlings—instead, they plant grafted hybrid trees. Using a sharp knife and budding tape, growers graft a disease-resistant, hardy lemon tree rootstock (root system) to a desirable orange tree scion (a budded branch—also called a budstick—which was cut off from an already productive orange tree). This "plant merger" works because all citrus plants (lemons, oranges, grapefruit, limes) belong to the same plant genus, and are thus quite closely related. These newly grafted hybrids are cultivated for one year before planting them in an orange grove (Florida term) or in an orange orchard (California term). These hybrids also bear fruit quicker—in just 5 years, as opposed to at least 15 years for seedlings!

7: Examine the blossom end of your sliced navel orange. Can you see what some people call a "baby orange" inside of it, near the "navel" of the orange? What is the explanation for this very surprising "orange inside an orange?"

Plant science researchers who have studied navel oranges tell us that the seedless orange is the result of spontaneous change in this fruit tree's genetic code (a mutation). The same mutation led to the formation of a kind of undeveloped mini-twin orange embedded inside the main orange's peel. When viewed from the outside of the orange, this smaller, undeveloped twin leaves a human-navel-like concavity (opening) at the blossom end.

8: Oranges can be green, red, or orange. What does an orange's color tell you?

Plant scientists have found that growing oranges where there are cold nights with a low temperature of about 40°F turns the skin color of oranges from green to bright orange. In contrast, oranges grown in hot, tropical Thailand remain green. Some varieties of oranges even have a red-orange skin. In short, the skin (rind) color of oranges tells us nothing about when they are ripe and full of mature juice. They can be green, orange, or red-orange and still be ripe. Some oranges even revert from orange to green color when the growing weather warms up. It is a comfort to know that it is unlawful to sell unripe oranges because, unlike other fruit, oranges do not continue to ripen once they have been picked. So, as a rule, if they are for sale in a grocery store or fruit market, they are ripe.

9: The two major U.S. orange-growing states are Florida and California. How might you be able to tell a Florida orange from a California orange?

In general, Florida oranges have a thinner skin (rind), higher sugar levels, and more juice than California oranges—making them more desirable for making juice. In contrast, California oranges have a bright and beautiful orange color and have fewer blemishes, for greater presentation appeal. Thus, they are often considered best for use as hand-peeled "eating oranges." Quality also depends on the variety of oranges and the time of year, as the two states' orange crops are at their best at different times. Florida navel oranges are best from November to January; Florida Valencia oranges are best from March through May. California navels are market available from December through May and California Valencias are sold in stores from May through October.

10: What layers do you expect to find inside an orange? Look and see!

Orange fruits have a thick, orange-colored, outside layer called the rind, skin, or peel. The outer-most layer of the rind can be grated to produce orange zest, which is popular in cooking because it contains the oil glands and has a strong flavor similar to the inner fleshy fruit itself. The side of the rind on the inside of the fruit is a bright white color and is called the pericarp or albedo (al-BEE-dough). There is a thin, white material attached to the inside of the rind that also attaches to the edible fruit flesh. This thread-like material, part of the pericarp, is known as the pith. The edible flesh of the orange fruit is divided evenly into pieces called segments or more properly, carpels. Approximately 12 carpels contain fruit pulp and the juice sacs that hold the orange's juice. These sacs burst and release juice when the orange is squeezed. The carpels also contain the orange's seeds, known as pips.

11: What are the world's favorite food and drink flavors?

Although world consensus is difficult to determine, one respectable data set reveals the following: (1) chocolate, (2) vanilla, and (3) orange! Note that all three flavor favorites come to us from plants. Chocolate is produced using the beans from the tropical cacao tree; vanilla is obtained from vanilla orchid seed pods; and orange flavor is derived from the fruit of the sweet orange tree.

Note: These questions and answers can be adapted to suit the needs, ability, curiosity, patience level, and interest of the individual. Teachers can shorten, paraphrase, or expand upon our answers.

Safety note: Remind students not to eat any food that has been used in the lab. Chemical-splash goggles should be worn during any activities using fruit that contain citric acid.

