Tutti Frutti

Synopsis

Students are presented with a wide array of "fruits" to examine and are asked to find the one that is different. The odd one is actually not a fruit, but looks like one. Through exploring the various fruits, students come to understand the difference between homologous and analogous structures.

Objectives

This exercise helps develop keen observation skills. After completing it, students should be able to describe the differences between homologous and analogous structures, and give examples of these in plants and animals.

Introduction

This is an exploration exercise aimed at helping students understand the difference between homologous and analogous structures. Students are presented with a wide array of 'fruits' to examine and are asked to find the one that is different. The odd one will be a kohlrabi, which looks like a fruit, but which is actually the edible, swollen stem of a member of the cabbage family. If you do this in the fall, a larger variety of wild fruits will be available. The object is to get students to explore a large number of more or less familiar fruits in some detail and begin to understand the concept of analogous and homologous structures.

Background Material

Prior to this exercise, students should have been presented with *simple and not very detailed* diagrams and explanations showing and explaining the structure and function of 'typical' plants, their flowers and their fruits. Figure 1 is an example of a typical flower, perhaps a tulip. Figure 2 is an example of a fruit, in this case an avocado.

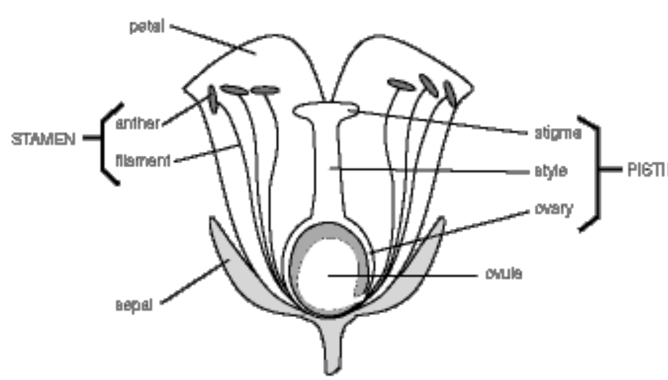

Figure 1.

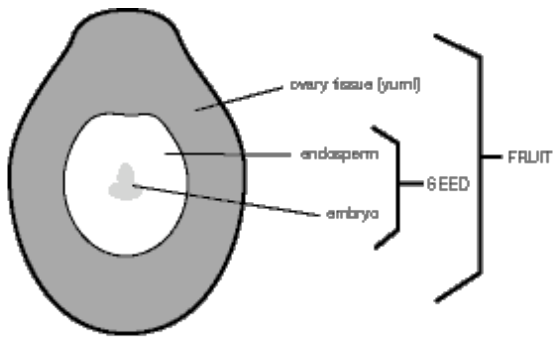

Figure 2.

This modest background material is just so that they can begin trying to name some parts that they will see. They should also be exposed to the notions of homologous and analogous structures. *Homologous* structures have a common evolutionary origin--the flesh of an apple and the wing of a maple seed are both ovarian tissue. *Analogous* structures may look similar and perform similar functions but have different evolutionary origins--the flesh of an apple (ovarian tissue) and the flesh of a coconut (endosperm tissue). *After* this exercise, a much more detailed presentation is appropriate, explaining pollination, double fertilization, and the distinction between endosperm inside the seed and ovary tissue outside the seed. But let the students explore *first*. Some of them may already 'know' some of this and may help their peers in the exploration (though often they do not get it quite right.)

Procedure

Preparation: Collect a variety of fruits. You should have one of each kind of fruit for each student group. You can get familiar ones from the grocery store--apples, oranges, avocados, tomatoes, fresh beans in the pod, peanuts, etc. (*Seedless* oranges or grapes can be compared to the 'seedless' kohl-rabi. Bananas are interesting because they have *vestigial* seeds. Coconuts should have the outer, fibrous husk, not just the seed that is usually all that is available in most stores.) You can get less familiar fruits from your local fields and forests--hickory nuts (with the outer casing), walnuts, acorns, sweet gum and sycamore balls, persimmons, wild paw paws, dandelion and milkweed seeds, cockleburs, any other weed seeds (in their husks or capsules). The critical thing is to have seeds *and their surrounding or attached ovary tissue*.

Finally, if you can find them, get some fresh kohlrabis. These are most easily obtained in the autumn and winter, since they are cool weather crops. They look like a green turnip, but they have leaves sticking out all over them instead of just in one cluster at the top. (There are both green and purple varieties.) If the leaves have been removed, there will still be bumps on the surface that are the bases of the old leaf petioles. The roots (if still present) emerge from the base of the kohlrabi in a taproot. The edible part is actually *stem* tissue that has been modified for carbohydrate storage, and grows *above* the ground. (The bulbous turnip is the *root*, swollen for carbohydrate storage, and grows at least partially covered by soil.)

If kohlrabis are unavailable, another possibility would be to use bananas as the odd one out since their seeds are *vestigial*. However, they are still fruits, and the distinction is not quite so clear.

Other helpful equipment: dissecting tools (scalpels, forceps, pins or probes, etc.) dissecting scopes and glass dishes, microscopes and slides (flat and concave), nut crackers, and anything else which will help students get inside the fruits you have for them.

Exploration: Have students work in teams of 2-4. The give and take of working with a partner (or partners) is essential, so do not let students work alone. In teams of more than 4 students, someone tends to sit and watch.

Though you may wish to hand out written instructions, we suggest you first present the problem orally something like this:

"Here are some things produced by plants. [*Do not* use the word *fruit*, of course.] As you can see [holding up two very different structures like an apple and a milkweed pod], they may look very different from each other. *One* of these things [pointing to the vast array] is different from all the others in a very special and particular way. Your job is to figure out which one. Cut, squash, crack, or mangle in any way that you think will help you to find the odd one. Look for structures which are similar and which are different. Think in terms of the plant structures we have already talked about.

"When you think you know which one is different, get someone in your team to write down your guess, *including your reasons*. The name alone is not sufficient. Show me your guess in private, so as not to reveal your answer to the other groups. I will let you know if you have found the *one* I have in mind. Since this is one of those 'guess what the teacher is thinking' problems, I may also be willing to accept other guesses, if your reasoning is clear, careful, and persuasive."

Play up the secrecy for at least the first half of the time allotted. This makes it *mildly* competitive and may help to keep each team focused. Play up this *intragroup* behavior. However, if no one is getting the correct answer, encourage cross-talk among teams. This can help to promote a whole group atmosphere. There are times when these *intergroup* interactions are very beneficial. While students are working, circulate among them. Ask leading questions. Get them to point out similar structures they have found. Encourage them to *look carefully* so that they actually *see the details*. Remember that you are not really concerned with the one correct answer. You are really just trying to get the students to make careful observations, think about what they are seeing, and apply some analytical reasoning to their observations.

Encourage team interactions. If a student has an idea, get her to explain it to her team rather than to you as the teacher. Try to help her state her reasoning clearly. "This fleshy stuff surrounding the seed is ovary tissue. So this fluffy stuff surrounding the seed must be ovary tissue, too." Encourage arguments. "How can fleshy stuff and sticky stuff come from the same part of the plant? They look so different."

If a team gets the correct answer, make sure they have explained their reasoning carefully *on paper*. Ask them not to reveal their answer, but encourage them to go ahead and dissect other things. Toward the end of class (after clean-up), ask the team to reveal its answer and its reasoning. Challenge them to *convince* the other students that they are right. If no one gets the correct answer, explain your own reasoning, with the promise that you will go into a more careful explanation next class. Stress the notion that it is okay not to know the answer. The only way science can go forward is for a scientist to say, "I don't know what this is or how it works. I will do research in order to find out."

Follow-up

The follow-up lesson should include a more thorough explanation of how double fertilization produces seeds with embryos and endosperm *inside* the ovary tissue of the mother plant. The endosperm nourishes the developing seed after germination. The ovary tissue is typically involved in seed dispersal--food for a passing bird or mammal, wings to ride on the wind, sticky parts to attach to someone's fur. A further explanation of the difference between stem and root tissue may be in order as well. Compare a kohlrabi to a turnip or a carrot.

Extensions

A further exercise to drive home the point from another direction: Get a variety of cabbage related produce from the grocery store. Many of these are actually the same species that has been cultivated by humans to store food in different parts of the plant--broccoli and cauliflower (flowers), kohlrabi (stems), cabbage (leaves), Brussels sprouts (small 'cabbage' heads, actually buds, which form in the larger leaf axils). Collards, kale, and mustard greens are all cultivated for their leaves; turnips, rutabagas, and radishes for their roots and for their leaves. So here is a closely related group of plants that look wildly different from one another, until you look at their flowers and seed heads which all look very similar.

Another possibility is to look at seed dispersal mechanisms specifically. Thus, instead of trying to find the odd one from the reproductive perspective, present students with many examples of fruits that have evolved for different modes of dispersal. Some examples are seeds that are wind blown, seeds that float on water, seeds that are sticky for hitch-hiking, seeds that are carried in animal guts and have to be etched by stomach acids in order to germinate, seeds that are buried by animals, seeds that bury themselves (some grasses), etc. Ask them to speculate on how each system might work. Ask them to speculate on other possible systems. (A follow-up library exercise might be to have them find examples in the literature of plants that use their proposed systems.)

There are also many similar exercises that could be done using animal parts. Students could be asked to compare protective coverings--skin, fur, scales, spines, and feathers. Or students could be given a variety of bones from a variety of animals and be challenged to speculate on the function of each. Each of these can be used to elucidate the notions of analogy and homology.

Evaluation

For evaluation, students can be quizzed on the structures of fruits and seeds. They should be asked to give examples of homologous structures, demonstrating that they understand the difference between the ovarian parts and the seeds themselves. Also, they should be able to explain why the kohlrabi was different.

Instructions for Students

In this exercise, you will be presented with a variety of structures taken from plants. Some will be familiar since you have probably eaten them on many occasions. Some will be familiar since you have probably seen them floating in the air or sticking to your pants after a walk through a field. Some you may be seeing for the very first time. But all come from plants. Some of these structures look similar to each other; some look very different from each other. But all of them are actually *homologous structures*. EXCEPT ONE. Your job is to find that one.

Homologous structures are parts of organisms that have the same evolutionary origin. Sometimes these parts are obviously similar like the hands and feet of humans and the paws of cats and dogs. Sometimes they are not quite so obvious. The wings of birds and the forearms of humans are also homologous, but you have to look closely to figure out where the 'hands' of birds are. (They are *not* the feathers.) And sometimes homologous structures are not at all obvious. A classic example is certain bones that support the gill arches of fish, some bones in the back of the jaw in reptiles, and the tiny bones in the middle ears of humans. Studies of the nerves and muscles that control these bones show that they all have the same evolutionary origins. They have just changed over the millennia to perform different functions.

On the other hand, some structures, though similar, are actually quite different evolutionarily. These are called *analogous structures*. The feet of humans and the feet of snails perform similar functions, but they are totally unrelated in an evolutionary sense. The eyes of an octopus are extraordinarily similar to those of a human, yet they have both evolved separately and independently.

Beware. The similarities and differences you will be looking at may be very misleading. You may have to look very carefully to find the one that is truly *different* in this evolutionary sense. Cut them open, crack them open, squash them, look at them under the microscope. There are various tools of destruction available for your use (more properly known as dissecting implements) as well as microscope slides, small glass dishes, and so forth.

This is a team activity, so work together with other members of your team. Share your observations. Discuss your ideas. Argue with each other. However, restrict your physical assaults to the plant parts you are dissecting!

When your team comes to an agreement on which object is truly different from all the others, *write out a short but clear description of your reasoning*. Do not share your answer with other teams. That may spoil the mystery for them. Present your written description to the teacher. He or she will comment on your observations and tell you whether you are right or not. If you do not have the correct answer, but your reasoning and explanation are well-presented, you will still receive a very good evaluation. And if there is still time, you can continue your exploration to find the correct answer. If you do figure out the correct one, and if your explanation is clear and appropriate, take any extra time to look more carefully at some of the other objects. The microscope might reveal some fascinating patterns you can't see with the naked eye.

Revised: April 28, 2001