LESSON THE NOSE KNOWS

About This Lesson

In this lesson students will conduct several experiments to determine if they can identify a substance by the scent or remnant of a material. The activity allows the students to explore several approaches to the concept that scientists sometimes must examine only the traces or biomarkers left behind by living organisms. The experiments in this lesson are designed as analogies. Students will detect the presence of a food by it's odor, that is not what astrobiologist scientists do, but they do detect remnant molecules left by ancient microbes.

Objectives

Students will:

- Conduct an experiment.
- Identify substances based upon their derivatives, rather than upon the actual substances.
- Note that identical substances may exhibit differing characteristics, depending upon the conditions to which they have been exposed.

Background

When parents realize that all the blueberry jellybeans are missing, and little Cindy has a blue tongue, they feel justified in "having a talk" with her. It isn't that they actually found the candies on her person, but the evidence is fairly weighty. Similarly, if Mommy's perfume bottle is markedly emptier, and Cindy smells like a make-up counter, she's sure to get into trouble again. There's no visible evidence that she's the perpetrator, but "the nose knows".

Scientists still use some of the same techniques that parents do. For thousands of years, observers have depended upon their senses of sight, touch, smell, and taste to learn about their world. Even though technological advances have greatly enhanced our human senses, observations do have limitations and oftentimes do not result in the discovery of a complete object or substance but rather uncover traces of a substance. Fortunately, these traces or remnants of materials or organisms give powerful information to researchers. Scientists call these fingerprint-like traces "biomarkers".

A fossil is an obvious example of a biomarker. Scientific knowledge has dramatically advanced due to the examination of fossil remains, revealing secrets of Earth's ancient life and environments. But specimens often do not have obvious fossils and scientists must carry out a detailed search for the incredibly small traces of past or present life. Also, work with biomarkers in ancient Earth rocks has led to the examination of materials that are "out of this world" – meteorites. Scientists have pieces of Mars meteorites in their laboratories to examine and test for biomarkers. As we venture farther from Earth, particularly as more information about Mars is gathered, the search for biomarkers may lead to astounding discoveries about life and its origins.

Vocabulary

Biomarker, olfactory sense (smell), signature, waft, meteorite

Materials

1. Ice chest/cooler
2. Tap water
3. Group lab baskets/boxes
4. Cotton balls (2 per lab basket) – *cut up sections of sponge may be substituted for cotton balls; they may be washed and reused, rather than being thrown away.*
5. 15 X 15 cm squares of waxed paper or plastic wrap – size of paper is approximate (2 per group)
6. Flat toothpicks (2 per student)
7. Hand lenses (1 per group)
8. Oil of garlic (may be found in health food/natural food stores)
9. Oil of cinnamon (see above)
10. 2 - 10 ml syringes or graduated eyedroppers (for measuring oils)
11. Large glass containers with closable lids (for storing foods)
12. Sandwich sized zip-lock bags or plastic film canisters with lids (as needed for scent portion of lab)
13. Labels (one per small container) or Sharpie
14. Four large potatoes (two cooked and two uncooked)
15. Four large onions
16. Cooking utensils (knife and cutting board included) and stove/microwave/etc.
17. Student sheets - 1 per student

Procedure

Advanced Preparation

1. Read background.
2. Prepare two large, well-baked or boiled potatoes for each class. Cut into cubes and store in cooler. (Canned, unseasoned potatoes may be used.)
3. Prepare two large, sliced, well-cooked onions for each class, and store in tightly sealed glass container(s) in cooler.
4. Dice two large raw potatoes for each class and store in water in cooler.
5. Slice two large raw onions for each class and store in a tightly sealed glass container in cooler.
6. Place one ml of oil of garlic on two cotton balls in a zip lock bag or film canister, and close tightly. Label container A. Repeat with oil of cinnamon, labeling container B. Prepare one of each container for each lab group and place them in the group lab baskets.
7. Cut waxed paper or plastic wrap into about 15 cm x 15 cm squares (as needed per lab group) and place in the group lab baskets.
8. Place enough toothpicks in each lab basket for each group member to have 4.
   **Teachers of younger students might want to allow the students to prepare the lab for other classes, thus becoming another learning experience. Students can count out items, such as the toothpicks in this lab, and measure and cut the squares of waxed paper or plastic wrap, etc. They are also good at simply loading or re-loading lab baskets. When lab set-ups must be reused, students should be reminded to take care with lab materials. The contamination of materials limits the success of successive groups.*

Classroom Procedure

1. Place students in groups of 3 - 4.
2. Distribute lab baskets and lab sheets.
3. Facilitate lab (see Student Sheet).
   As groups proceed through lab, provide adequate portions of cooked and raw potato for individual students to examine. Label the samples with numbers to facilitate student descriptions. Remind students that you do not eat anything in a real chemistry lab!
4. Repeat with onion when groups are ready.
5. Upon student completion of lab, use debriefing questions to lead students to recognize that scientists may find traces/biomarkers of an organism or material (i.e. scent), or may find traces in an altered state (cooked foods).

Suggested De-Briefing Questions

- From what materials did we get the fragrance in the containers? (Garlic cloves; cinnamon sticks)

- How did you know what each sample was? (Because of past experience in smelling those items; because the receptors in my nose sent a recognizable message to my brain; etc.)

- How might each of these samples have been obtained? (By crushing garlic cloves and cinnamon sticks)

- Might these odors be considered to be proof that garlic or cinnamon is present? (Yes) If so, how? (Because those materials give off those odors; because each of those odors is one of the signatures/biomarkers of a specific material, etc.)

- What are some other examples of odors that indicate the presence of clearly identifiable organisms or substances? (Skunk "perfume", coffee, gardenias, animal feces, etc.)

- Is it possible to positively identify certain items by their scent? (Yes) Justify your answer. (Accept all reasonable answers, being sure that artificially created scents are discussed.)

- What differences did you observe in the raw and cooked potatoes? Onions? (Aroma, color, texture, shape, etc.) What caused those differences? (Application of heat/microwaves)

- Were you able to recognize that the cooked items were the same substances as the raw ones? (Yes) How? (Previous experience)

- Give examples of changes we see that are a result of a force(s) in nature. (Decomposition, weathering, growth, metamorphism of rocks, etc.)

- Is it possible to identify the former condition of a substance from a signature/biomarker (remnant) of that substance? (Yes) Justify you answer. (Dehydrated fruit snacks, partially decomposed leaf -- from veins remaining, frozen Ice Age man/animal, etc.)

- Is it possible for a scientist to identify an organism or substance, with certainty, when no part of that organism remains? (Yes) Justify you answer. (Petrified wood has no wood cells remaining -- minerals have replaced them -- but it retains the same structure of the wood, even at the cellular level.)

- Under what circumstances might a scientist need to identify something that has left behind only a trace signature/biomarker? (When trying to find out where or what something came from; so that he/she might have a better understanding of something; etc.)

Extensions

1. Have student groups suggest other substances/equipment that could have been used for each part of the lab.

2. Have students gather secret traces of materials and present them, challenging classmates to identify the materials they came from.

3. Have students attempt to create fake traces for known materials or organisms, and present them to classmates for possible identification, ex. slime trail of a snail replicated with egg white. Verify whether they were able to fool classmates with their creations.

4. Have students do either step 2 or 3 and present all traces, during the same session, without identifying whether they are real or fake. Assign points if others are able to identify the substance from their signatures, and extra points if they cannot tell if it's real or a fake. Afterwards draw parallels between the exercise and scientific investigation.

STUDENT PROCEDURE SHEET

THE NOSE KNOWS

Materials

- Team lab basket (with jars A and B, toothpicks and plastic wrap/waxed paper squares)
- Individual Student Procedure Sheets and pencils

Procedure

*NOTE: **Please, starting with step 6 -- *DO NOT* speak. Work silently!!!**

1. Remove only the jar labeled A from basket.

2. Teammate 1: Unscrew lid from jar A and slide it partially off the mouth of the jar. Hold the jar and lid in one hand, with the jar slightly open and about 40 cm away from your nose. Use the other hand to waft fragrance toward your nose, moving the jar closer as you waft until you can clearly smell the material inside.

3. As soon as you can identify it, close lid and pass the jar to another member of your group; then privately record what you think the substance is in this blank. _____

   (If you cannot identify the substance after 10 seconds, pass the jar to another teammate and try it again after each one has had a chance.)

4. Repeat for remaining group members until all have smelled first material and recorded data.

5. ONLY AFTER all members of your group have smelled specimen A, tightly close the container and return it to the basket.

6. Reversing the order of students, repeat steps 2 - 5 with container B, privately writing what you think the fragrance is here: _____

7. Place 2 small pieces of waxed paper or plastic wrap from your basket onto the center of your working surface.

8. Raise your hand, signaling that you are ready for your next 2 samples.

9. Upon receipt of those samples, using individual toothpicks, each teammate should transfer a small amount of each sample to a personal piece of paper. Examine both samples carefully with a hand lens and write a comparison of them (how they are alike and different). You may make drawings. Use the bottom of this page to record your data. Do not taste the samples.

10. Set samples aside and repeat steps 7 - 9 with additional samples.

11. Discard all remaining samples appropriately, along with waxed paper/plastic wrap and toothpicks.

12. Share data with your teammates and decide who will speak on behalf of your group, as well as what will be reported.

Data