Nature of Science: Observations
Teacher Version

A series of group of activities that illustrate the importance of accurate observation by teaching students to distinguish between observations and inferences. In this activity, students will learn about the dangers of false assumptions and how to recognize their own false assumptions using a live demonstration.

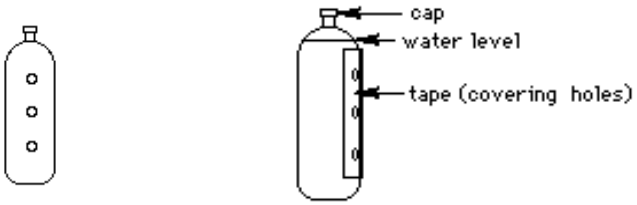
Prerequisites: none

Complete List of Materials:

- Computer with PowerPoint presentations: "Footprints.pptx", "Powers of Observations Quiz.ppt", and "False Assumptions.ppt"
- Two-liter plastic bottle with lid
- Nail ~4-5mm in diameter
- Blue painters tape or masking tape
- Bin to capture water
- Towel
- Straw

Preparation and Lab Notes:

- Heat the nail by holding one end with a rag or paper towel and heat the pointy end with a lighter for 30-40 seconds. Use the heated nail to melt three holes 4-6 cm apart in the 2-liter plastic bottle. Cover the holes with tape. We recommend using three dog-eared pieces of tape making it easy to peal the tape off uncovering each individual hole. Fill the bottle with water and tightly seal.



- Download and preview the three PowerPoint presentations: "Footprints.pptx", "Powers of Observations Quiz.ppt", and "False Assumptions.ppt".

Key Concepts:

- An **observation** is the act of noting something that can be sensed directly or with the aid of an instrument (i.e. the final score of a basketball game). Direct observations are made through the five senses: (1) sight, (2) hearing, (3) smell, (4) touch, and (5) taste.
- An **inference** is an attempt to explain a specific event or object by using thinking and reasoning skills (i.e. the final score of a basketball game was the result of poor officiating by the referees). Inferences describe what the observer believes is there and hidden from view or perception based on prior knowledge and logic.

- A **hypothesis** is a proposed explanation made on the basis of limited evidence as a starting point for further investigation.

Introductory Mini-lecture:

Science is based on studying and learning about the natural world. Scientists do this by using their senses: sight, hearing, smell, touch, and taste. When scientists sense something directly or with the help of an instrument it is called an **observation**. **Observations** are the foundation of good science. They are what all the scientific discoveries and conclusions are based on. Sometimes observations can be confused with **inferences. Inferences** describe what the observer believes is there and hidden from view or perception based on prior knowledge and logic. An example of an observation would be that the ground outside is wet. An inference would be that it had been raining earlier. We don't know if it had been raining earlier, but based on experience, the ground gets wet after it rains, so we infer that it rained earlier. Inferences can be dangerous in science because they often take scientists down incorrect paths and make it harder to determine the true causes of events. So, as scientists, we need to be careful to make observations and avoid inferences.

Scientists use observations to come up with possible explanations of why something occurs. A possible scientific explanation is called a hypothesis. In the process of determining why something occurs, scientists will often go through a series of hypotheses modifying their original hypothesis as they learn more. In the last portion of this lab we're going to come up with hypotheses, making predictions and possible explanations of what will occur during a demonstration.

Part 1 – Observations and Inferences: Footprints

This activity takes approximately 30-minutes to complete, but can vary based on how much discussion takes place regarding the differences between observations and inferences and how much time is given for students to write or share observations and inferences. Students will view three images (one at time) that will provide practice making distinct observations and inferences. The three images can be presented with power point slides ("Footprints.pptx") or printed pages.

Prior to viewing the images, students should be given a copy of the observations/inferences data table. As students view each image separately, they should be given time to write down as many observations and inferences as possible for each image. After students have viewed each image and had an opportunity to write down their observations and inferences, the teacher can go through each image (again, one at a time) and ask students to give responses from their data tables. Inevitably, students will write or state inferences for their observations (e.g. "The footprints are from birds" or "The two animals are fighting"). A true observation is only what can be noted using a tool or instrument as well as the five senses. Any reference to "footprints" is an inference as we don't *know* that the objects are really footprints; we are inferring this.

An alternate approach is to treat this as a group discussion, where the students are shown an image and suggest inferences or observations. A volunteer writes all these suggestions down. Do not correct the students, just write down whatever the say. After each image discuss their suggestions helping them understand the differences between observations and inferences. By the final image the students grasp of observations and inferences should have improved.

Part 2 – Powers of Observation Quiz

This group presentation tests how well students observe everyday things. Show the "Powers of Observation Quix.ppt" PowerPoint to a group of students. The Quiz asks a series of questions about everyday objects. The students can each raise a hand when they have an answer or they can write their answers down and keep track of how well they do. This quiz isn't about getting a high score, it's more about recognizing the need for careful observation.

Part 3 – False Assumptions

Explain to students that you are going to display a series of short stories using "False Assumptions.ppt". Point out that their challenge is to solve the mystery, but they can only ask questions (one at a time) which can be answered with a "yes" or "no", and you will answer those questions truthfully. Encourage students to begin with general questions, then narrow them down to finally asking "Is it [their conclusion]?" To those initial general questions, I might answer "Not necessarily" or "Possibly."

For example, with the second story (Victorian mansion with bodies), they could ask "Were Bill and Monica very old?" and I might answer "Not necessarily - they could be." I wouldn't answer "yes" or "no" unless their question could be answered that way (for that particular story). For example, a student could finally ask "Were they fish that suffocated when their fish bowl broke?" To which I would reply "Yes!" If they seem stymied, suggest that they "Think outside the box; try to consider if any of the words could have different meanings."

Procedure:

1. Show and read the first story.
2. Answer their "yes/no/possibly/not necessarily" questions until someone asks the key question (the answer, phrased as a yes/no question), and you will answer "yes".
3. When it is solved, ask the class about their false assumption(s).
4. Repeat for all stories (if time).

After the stories, have the class write down or discuss examples of false assumptions that they/we make in our daily lives. Also, ask them to think about (and record or discuss) what kinds of false assumptions people have made about the natural world, the problems this created, and how they solved the problems. some examples might be "that the world is flat" or "that the earth is the center of the solar system".

Part 4 – Three Hole Bottle Demonstration

This is a good follow up demonstration to the false assumptions activity. In this demonstration, a 2-liter bottle with 3 tape-covered holes is filled with water. One-by-one, the tape is removed from each of the holes in the bottle. The students make predictions/hypotheses about what will occur and why. This is typically with group discussions and predictions. It could also be done in a more formalized manner where students write down predictions and come up with hypotheses. Before each tape removal, make sure the water level is above all three holes and the cap is on tightly.

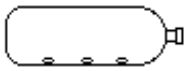
Procedure:

1. Show the students the bottle and explain that the top piece of tape is going to be removed. Ask them to make predictions about what will occur. They can write down the predictions or each of them can say out loud what they think will occur. Have them be specific. For example, "Water will come shooting out." "Water will slowly dribble out." "No water will come out."
2. Place the bottle upright in the bin and peel off the top piece of tape.
3. Lead a discussion about why no water came out. Try not to give answers, let the students speculate. Formulate some hypotheses about what happened.
4. Have the students predict what will happen when the middle piece of tape is removed.
5. Peel off the middle piece of tape.
6. Lead a discussion about why water only comes out the lower hole. Have the students make observations about what is happening. They should observe air coming in the top hole and water flowing out the lower hole. They should now make a new prediction about what will happen when the third piece of tape is removed. Their prediction/hypothesis should build on their earlier prediction.
7. If needed, replace the tape over the holes and re-fill the bottle so that the water level is still above all 3 holes. Then you can remove the top and middle pieces of tape quickly.
8. Peel off the bottom piece of tape.
9. Lead a discussion about what happened with all three holes open. Have the students observe what is happening; air flowing in the top hole, a little water flowing out the middle hole and more water flowing out the lower hole. Have the students come up with an explanation of what is happening.
10. Explain what happened:
    - Top tape removal – For any water to be able to come out of the bottle something has to go into the bottle replacing the water. There is no way for anything to get into the bottle so no water leaves. An example of this that most of us know is a straw. Most of us have played with straws in restaurants, where you put the straw in some liquid and plug the other end with your finger. When you pull the straw out of the liquid all the liquid stays in the straw. Like the bottle, there is only one hole in the straw, nothing can get into the straw so no water leaves. Demonstrate this with a straw.
    - Middle tape removal – Now there is a way for something to get into the bottle, air, which allows water to leave the bottle. Going back to the straw example, when we remove our finger from the end of the straw the liquid flows out because air can now enter the straw from the hole our finger was covering. The reason water comes out the middle hole is because there is more water pressure pushing out the lower hole in

the bottle. So, air enters where there is less pressure and water leaves where there is more pressure.

- Bottom tape removal – This is an extension of the situation with the middle tape removal. Again, air enters through the top hole where there is the least water pressure. Two streams of water leave the lower holes. A more powerful stream from the bottom hole where there is more water pressure and a weaker stream from the middle hole where there is less water pressure

11. Now tell the students you're going to hold the bottle horizontally with no tape covering the holes. Have them make predictions about what will happen.



12. Tilt the bottle horizontally over the bin, being careful to not squeeze the bottle.
13. Lead a discussion about what happened having the students come up with explanations/hypotheses.
14. Explain what happened. No water leaves any of the holes because water flows out of the holes and air flows into the holes based on the difference in water pressure between the holes. When the holes all have the same height of water above them, there is no difference in water pressure between the holes. So nothing changes. If you tilt the bottle slightly to one side you'll see air start to enter the highest hole and water come out the lower holes.

References:

Footprints Material adapted from: Lederman, Norman, Ph.D., Illinois Institute of Technology, Chicago, Illinois, Department of Mathematics and Science Education. 2003.
False Assumptions and Three Hole Bottle Demonstration adapted from
http://www.indiana.edu/~ensiweb/natsc.fs.html

	Observations	Inferences
Image 1		
Image 2		
Image 3		