# Motivate the Unmotivated with Scientific Discrepant Events

**by Emmett L. Wright, Ph.D.**

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Almost any science teacher can relate to the frustration of trying to teach an unmotivated student. How do you involve a student who, for one reason or another, just doesn't like science? One way to engage students is to use ideas and activities that are based on students' prior knowledge. This not only provides all students with familiar entry into the new material but also helps motivate disengaged students by making learning relevant to their own lives.

For example, when a teacher asks, "Why does a shower curtain move toward you when you take a shower?" or "Are peanuts really nuts?", students are presented with questions about familiar topics and phenomena. Even students who normally don't care about science will form an opinion about these questions because they have personal knowledge about the subjects. Regardless of whether their opinion is based on scientific information they have previously learned, on first-hand observations, or on intuition, students will consider the question and try to explain their answer.

Their awakened curiosity about the world around them can become a powerful springboard for learning. Once students begin to understand that science is part of their everyday lives, learning about science becomes relevant. And once this crucial step has been taken, students can begin the lifelong process of self-education.

## Discrepant Events Awaken Curiosity

A discrepant scientific event is a surprising occurrence—such as corn growing faster in the dark than in the light—that challenges learners' preconceptions. Because they at first appear to be nonacademic in nature and frequently differ from what is expected, these tidbits can stir the interest of even the chronically

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disinterested student. The moment a student proclaims, “No, that just isn’t possible; it can’t work that way,” a window of opportunity opens for the student to gain a better understanding of his or her world.

For example, imagine a teacher asks students, “If you wanted to wash a car in freezing weather, would you use cold water or hot water to slow the freezing process?” Most students would choose hot water to wash the car. When students are then asked to explain their answer, they might say that hot water will take longer to freeze because the temperature needs more time to cool to the point of freezing.

When the teacher proposes that hot water will actually freeze faster than cold water, this challenges the students’ preconceived notions (usually based on “common sense”) of the freezing process. Even if students are able to produce the correct answer because they suspect the teacher might be trying to trick them, they will remain interested because they want to know *why*. In either case, the teacher has set the stage for a scientific discovery that can stimulate even the most unmotivated students into eager and active participation.

By using a discrepant event, a teacher can assess students’ prior knowledge of a subject area by asking simple questions and holding relaxed discussions. These discussions can pique students’ interest and generate even more questions about the subject. From this point, students can develop and test hypotheses by designing their own lab or performing a predesigned lab, such as the “Freeze to Believe” example that follows. The “Freeze to Believe” lab is an in-class demonstration that encourages student participation in the learning process.

## Freeze to Believe

### Exploration

Tell students that to delay the freezing of water, people who live in cold climates wash their cars with cold water instead of hot water. Ask them, “Does cold water actually delay freezing?” The majority of students will say no. In order to find out the truth for themselves, students can complete the following experiment:

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## Exploration (continued)

Explain to students that 3 hours and 45 minutes ago you filled two stainless steel containers with 400 mL of cold water. After labeling one container “Hot,” you heated it to 60°C. The second container was labeled “Cold.” Explain that you placed both containers in a freezer at the same time. Next, ask students to write down which container they believe will begin to freeze first, and have them explain their reasoning. Most students will answer that the water in the Cold container will begin to freeze first because its temperature is closer to the freezing point.

Draw up a time chart that has students’ names listed at 10-minute intervals for the first hour of class (this can be done in pairs). The chart should note the time you placed the containers in the freezer. Present the first pair of students with the time chart and a timer set for 10 minutes. When the alarm sounds, the first pair of students will go to the freezer and check the containers. They will record their observations on the data sheet, reset the timer, and pass the materials to the next pair of students.

Students will be checking the containers during the fifth hour that the containers are in the freezer. During this time, the Hot container will begin to show signs of freezing. Once this occurs, ask students to write down why they think this happened.

## Concept Introduction

The water in the container labeled “Hot” transfers its thermal energy to the stainless-steel container faster because the temperature difference between the water and the freezer is greater. In addition, molecules in hot water have more kinetic energy than those in cold water do. As a result, hot water transfers energy to the surrounding air more quickly than cold water does. Finally, hot water evaporates more quickly than cold water does. Thus, the container labeled “Hot” has less water to be cooled. Although the amount of evaporation is very small in the container, it would be much higher if one were washing a car. Each of these points helps to explain why warm water will always reach the freezing point faster than cold water will.

## Application

Students may apply these principles by doing a project or additional research to answer the following questions: How do ice cubes cool a drink? Do the ice cubes absorb or release energy? If you were to perform the same experiment with completely insulated containers, would the hot water still freeze faster than the cold water?

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## Other Examples of Scientific Discrepant Events

The following are additional examples of scientific discrepant events. Some of these can be used for class discussion, while others can be adapted as hands-on demonstrations or labs.

### Sink or Swim Scenario

**True or false?**

When a largemouth bass (*Micropteras salmoides*) takes air into its swim bladder from the gills, the fish rises in the water. When it releases air from the swim bladder, it sinks.

Students will likely answer that this is true; however, it is actually false because the opposite occurs. When air is taken in, a largemouth bass sinks; when it releases air, it rises.

The appropriate equation for this question is:

$$D = M/V$$

($D$ = density, $M$ = mass, $V$ = volume)

When the fish takes air into its swim bladder, the fish's density, or specific gravity, increases to above 1. The air weighs more than the vacuum created when it is released. Since the specific gravity of fresh water is about 1, the fish sinks. Thus, the fish is able to sink, rise, or suspend itself by changing its density.

### A Sugar Fire

**Yes or no?**

A cube of sugar will not ignite from a lit match. Do you think the cube will ignite if you sprinkle ashes on it first?

Students will likely answer that the cube will not ignite. However, the ashes act as a catalyst, which causes the sugar cube to ignite. This example could be used to teach about catalysts and their functions in biochemical systems.

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## Have Some Ground Nuts

**True or false?**

Peanuts are nuts.

Students will likely answer that peanuts are certainly nuts. In fact, peanuts are a legume that grows in the ground. Most nuts grow on trees. In India and other tropical countries, peanuts are called *ground nuts.*

## Does It All Taste the Same?

**Yes or no?**

Can all people detect the same flavors?

Students will probably answer that this is true. Scientists know of four different tastes—sweet, sour, salty, and bitter—that are recognized by the taste buds on different areas of the tongue. Some people, however, have "taste blindness" and cannot taste certain bitter compounds. PTC (phenylthiocarbamide), sodium benzoate, and thiourea are all chemicals that these people cannot taste. Whether or not people can taste these compounds is determined by heredity.

## A Comet's Tail

**In what direction does a comet's tail point?**

Students will probably answer that a comet's tail points away from the direction it is traveling. For example, if the comet is traveling toward Earth, its tail points away from Earth.

Actually, a comet's tail always points away from the sun, no matter what direction it is traveling. The pressure from solar radiation and solar winds cause the comet's tail to point away from the sun. Students can model this effect by holding a ball with streamers attached to it in front of a fan.

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## Making Science Relevant

One of the best ways of motivating unmotivated students is by engaging them in learning that is relevant to their lives. This means starting with information and subjects which students already have experience in. Students' curiosity can then be captured by introducing discrepant events into the discussion. Discrepant scientific events present students with surprising facts about familiar topics. As students try to make sense of discrepant events through investigation and analysis, they become curious about the phenomena, find themselves engaged in their own education, and feel motivated to keep learning.