

# Solar Drinking Bird

**Overview:** The drinking bird is a classic science toy that dips its head up and down into a glass of water. It's filled with a liquid called methylene chloride, and the head is covered with red felt that gets wet when it drinks. But how does it work? Is it perpetual motion? We'll take a look at what's going on with the bird, why it works, and how we're going to modify it so it can run on its own without using any water at all!

**What to Learn:** You'll learn more about the sun than about the bird itself, and especially about the sun's influence on the Earth, air, and water.

## Materials

- drinking bird
- silver or white spray paint
- black spray paint
- razor
- mug of hot water
- sunlight or incandescent light

## Lab Time

1. Take the bird out of its holder, and carefully remove the tail feather, hat, and felt section. Remove any glue with a scraper or hot water, which will allow the glue to loosen and easily peel off. Be careful not to hold the bird by the head, because it is hollow and can break if you grip too tightly!
2. Paint the top (with the peak, from which the hat was removed) either white or silver. Paint the bottom black. Allow it to dry.
3. When the paint is dry, reattach the bird to its stand, and place it in the sun. Adjust the fastening band until the bird is secure, if needed.
4. Liquid is being heated now in the bird, so the bird will begin tipping as water begins moving from the bottom to the top. The bottom of the bird is now black, and black absorbs more energy and heats up the tail of the bird. Since the tail section is warmer, the pressure goes up and the liquid gets pushed up the tube. By covering the head with white (or silver) paint, you are reflecting most of the energy so it remains cool. Remember that white surfaces act like mirrors to IR light (which is what heat energy is).

# Observations

1. What is happening to your drinking bird?
2. Does it work better with hot or cold water?
3. Does it work in an enclosed space, such as an inverted aquarium?
4. On a rainy day or dry?
5. In the fridge or on a heating pad?

## Reading

The drinking bird in this experiment is an example of a heat engine. The liquid's special properties allow the motion to continue, so long as there is some water provided to the system.

What's so special about the liquid? Methylene chloride is made of carbon, hydrogen, and chlorine atoms. It's barely liquid at room temperature, having a boiling point of 103.5° F, so it evaporates quite easily. It does have a high vapor pressure (6.7 psi), meaning that the molecules on the liquid surface leave (evaporate) and raise the pressure until the amount of molecules evaporating is equal to the amount being shoved back in the liquid (condensed) by its own pressure. (For comparison, the vapor pressure of water is only 0.4 psi.)

The bird needs a temperature difference between the head and tail. Since water needs heat in order to evaporate, the head cools as the water evaporates. This temperature decrease lowers the pressure inside the head, pushing liquid up the inner tube. With more liquid (weight in the head), the bird tips over. The bird wets its own head to start this cycle again.

The trick to making this work is that when the bird is tipped over, the vapor from the bottom moves up the tube to equalize the pressure in both sides, or he'd stay put with his head in the cup. Sadly, this isn't perpetual motion because as soon as you take away the water, the cycle stops. It also stops if you enclose the bird in a jar so water can no longer evaporate after awhile. Do you think this bird can work in a rainstorm? In Antarctica?

Vapor pressure can also change with temperature changes. The vapor pressure goes up when the temperature goes up. Since the wet head is cooler than the tail, the vapor pressure at the top is less than at the bottom, which pushes the liquid up the tube. So it really does matter whether the bird is operating in Arizona or the Amazon. The bird will dip more times per minute in a desert than a rain forest! This is because evaporation will work more quickly in the desert.

**Exercises** Answer the questions below:

1. Where does most of the energy on earth come from?
  - a. Underground
  - b. The sun
  - c. The oceans
2. What is one way that we use energy from the sun?
3. What is the process by which the liquid is being heated inside the bird?
  - a. Precipitation
  - b. Pressure
  - c. Evaporation
  - d. Transpiration

### **Answers to Exercises: Solar Drinking Bird**

1. Where does most of the energy on earth come from? (the sun)
2. What is one way that we use energy from the sun? (plants, solar power)
3. What is the process by which the liquid is being heated inside the bird? (evaporation)